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GAMES - A new approach

Text message service through GAGAN

The vulnerabilities and challenges of Caribbean SIDS

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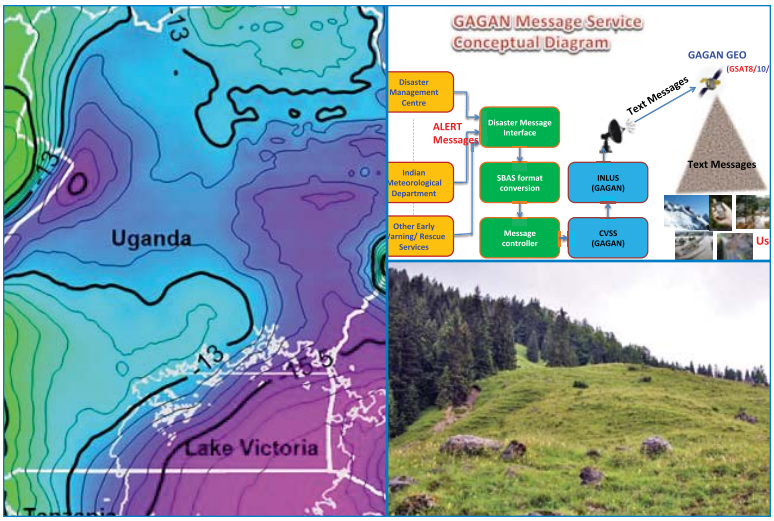

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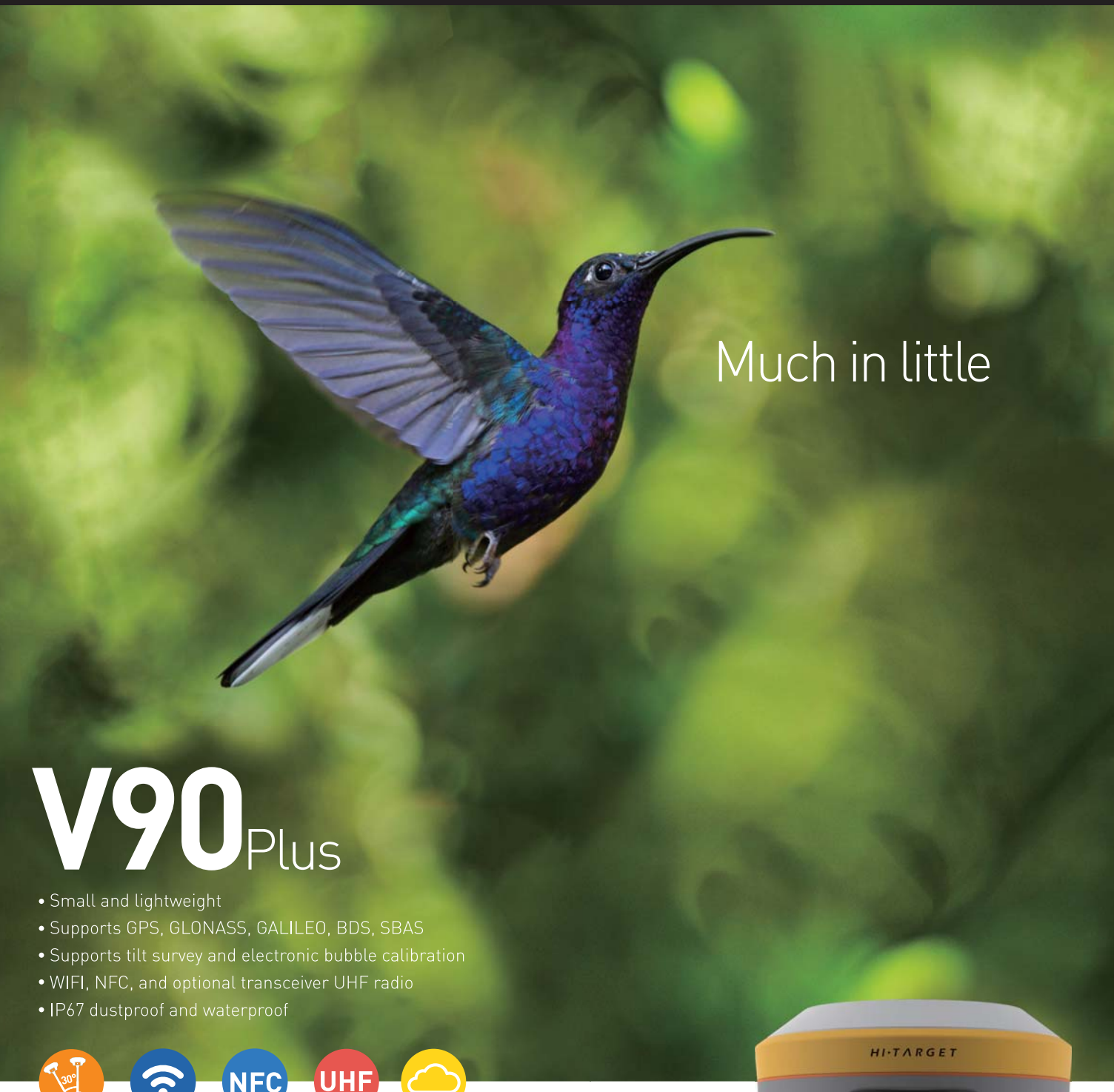

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2016 reflects some desperation for 'the change'.

National aspirations no longer see

Globalization as panacea.

Desperate people and impatient politics.

Unpredictable EU, unstable Middle East

Change'in' America

Slowdown in promising economies like India, China, Brazil, …

Attacks in Brussels, Istanbul, Nice, Uri, …

Ebola, Zika, …

Many more can be added to the list.

Though the cravings for 'the change' may continue

Ironically, 'Climate change' remains

The most threatening challenge.

Let us embrace 2017.

With hope,

And with wishes for health and happines

Bal Krishna, Editor
bal@mycoordinates.org

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GAMES - A new approach

Text Message Service through GPS Aided Geo Augmented Navigation (GAGAN)

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The GAGAN (GPS Aided Geo Augmented Navigation) system is a Space Based Augmentation System (SBAS) developed jointly by AAI and ISRO to deploy and certify an operational SBAS for the Indian Flight Information Region (FIR). GAGAN provides a civil aeronautical navigation signal consistent with International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARPs) as established by the Global Navigation Satellite System (GNSS) Panel. GAGAN system provides NPA (Non Precision Approach) services of RNP-0.1 over Indian FIR and PA (Precision Approach) services of APV-1.0/APV-1.5 (AProach with Vertical guidance) over Indian landmass with effect from December 30, 2013 and May 19, 2015 respectively.

Although primarily meant for Civil Aviation, the GAGAN signal can be used by a vast majority of civilian and non-aviation users. GAGAN will provide benefits beyond aviation to many other user segments such as intelligent transportation, maritime, highways, railways, surveying, geodesy, precision agriculture, security agencies, telecom industry, personal users of position location services etc in the Indian subcontinent. The applications of GAGAN to various users are enabled through GAGAN broadcast messages via the GEO satellites GSAT-8 and GSAT-10. A new messaging service is being proposed through GAGAN by using the available bandwidth in the broadcast message.

GAMES is a free to air service and any user equipped with GAGAN receiver with minor software modification will receive alert messages along with precise position information

GAMES will make it possible to send additional text messages that could cater to early warning messages on the occurrence of natural disasters, calamities, dangers for the safety of life within GAGAN coverage area . The Search and Rescue Messages and associated relief and mitigation related messages, Meteorological information, Alert messages about storms, avalanche etc could be broadcast through GAMES.

Why through GAGAN

The Asia-Pacific region has had to cope with an unprecedented number of disasters. People of the Asia-Pacific region are four times more likely to be affected by natural disasters than those living in Africa, and 25 times more likely than those living in Europe or North America – and while the region generated only one quarter of the world's GDP, it accounted for a staggering 85 per cent of deaths and 38 per cent of global economic losses during 1980-2009. In addition to the growing exposure to disasters, the increasing socio-economic losses due to disasters should also be recognized.

The Asia-Pacific region is very prone to disasters caused by natural hazards. These include droughts, floods, storms, extreme temperatures and wildfires, as well as mass movements such as landslides, volcanoes, earthquakes, avalanches and tsunamis. According to the International Disaster Database, between 1980-1989 and 1999-2009, the number of disaster events reported globally increased from 1,690 to 3,886 and the trend seems to continue. Over the whole period of 1980-2009, 45 per cent of these were in Asia and the Pacific. India ranks second in the number of disasters and number of people affected in the Asia-Pacific regions.

Development of new opportunities for reducing risks and making disaster

Figure 1: Current Communication Methods

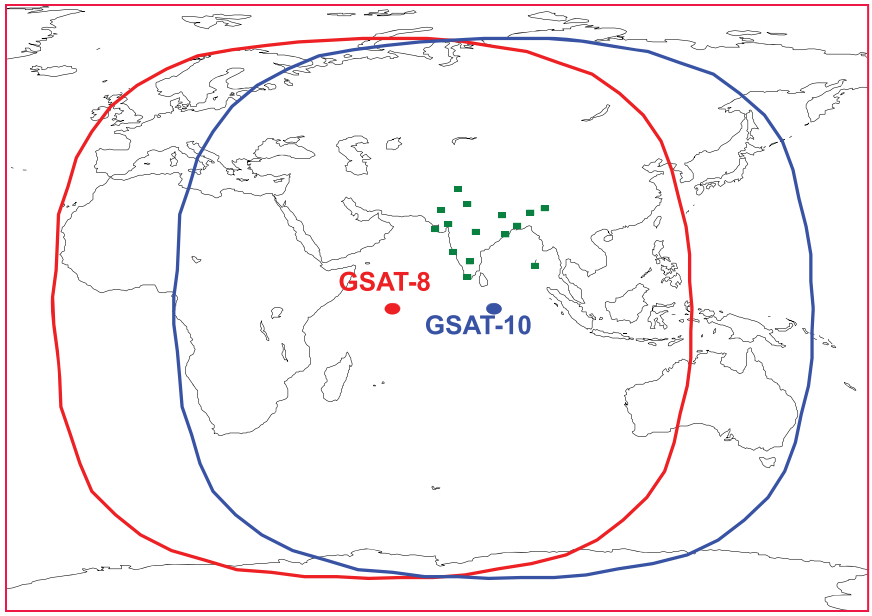

Figure 2: GAGAN coverage foot print

recovery resilient - an opportunity that is often overlooked, is the need of the hour together with improving the use of emerging technologies for more effective and efficient disaster management before and aftermath of the disaster. Timely provision of effective information allows people exposed to hazard to take appropriate action to avoid or reduce the risk and prepare better for effective response.

A variety of techniques have evolved over time to alert the general public, administrative authorities and/or response personnel to an imminent or ongoing danger or potential emergency situation. Typically, warnings are issued in case of significant natural or man-made crises that could lead to loss of life or property. The current early warning systems use one of the following communication methods (Figure 1) to broadcast the messages.

The current/conventional warning systems suffer from the following limitations:

- Warning and location information not available with the same system
- Timely service is not guaranteed
- Coverage area limitations
- And more importantly, the information does not reach the end user in remote areas, deep sea, etc

The deficiencies in the existing dissemination methods such as providing the information in a delayed manner and over a shorter area are to be overcome and ensure that the early warning/ alert messages reach a large number of users within the shortest time period. Satellite systems present a distinctive and efficient solution to the delivery of one-to-many messages. In order to reach the maximum number of people in the target area with a reliable information service, a specific technical solution has to be evolved. GAGAN will provide an excellent opportunity to send alert messages and early warning messages through its GEO broadcast reaching wider area within shortest possible time.

- The GAMES (GAGAN Message Service) concept is concerned with the provision of early warning/Alert messages to all concerned citizens or governmental/local authorities in case of a major event or disaster.
- The GAMES will open up new means to inform people at risk, for instance, through natural events such as earthquakes, landslides, avalanche's, tsunamis, hurricanes, storm surges, extreme precipitation and flooding, so that specific actions can be taken to mitigate the impact of the disaster and ultimately, to save lives
- The GAMES will also support rescue and aid operations in the aftermath of disasters thus reducing the total loss of human lives

As GAGAN foot-print covers a vast area from South Africa to Australia it can be utilized very effectively in the Asia Pacific region to broadcast short service messages.

Knowing the area/location of the possible disaster or event, which is possibly available with agencies like the NDMA (National Disaster Management Authority), Meteorology Department, INCOIS, SASE, etc, the people living in those areas could be warned through GAGAN message broadcast. The data related to nature of disaster, longevity of catastrophe, expected area of disturbance etc., can be fetched from relevant agency and broadcast through GAGAN GEO satellite to reach out all over the GEO coverage area.

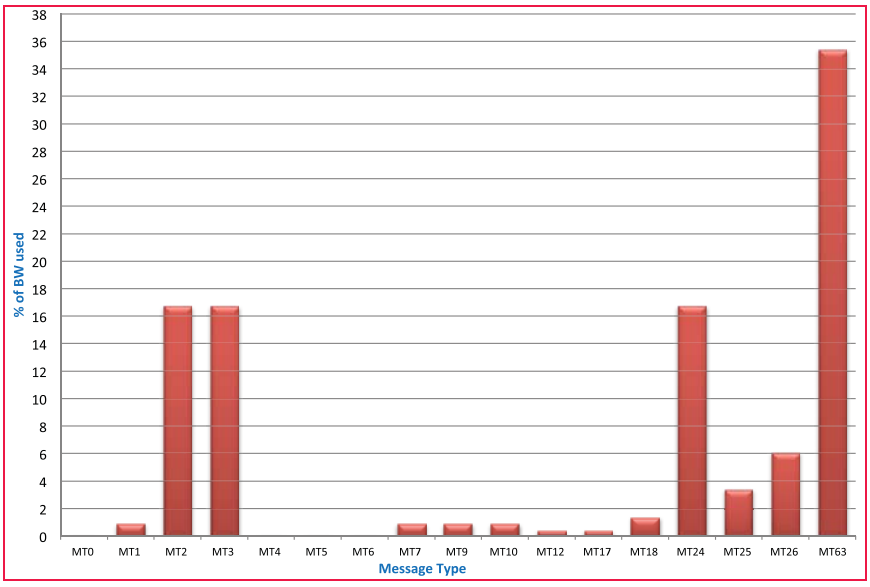

Figure 3: GAGAN Message Band width Utilization

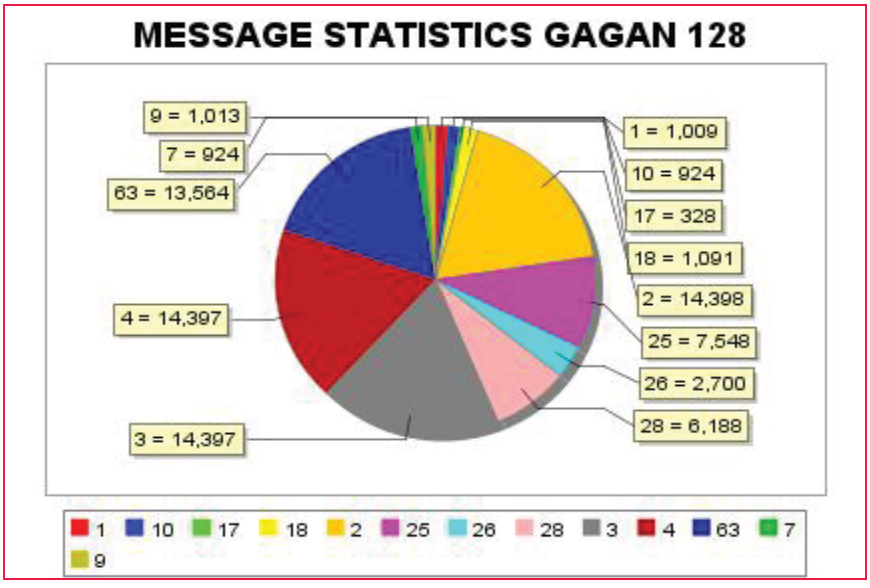

Figure 4: GAGAN Message statistics

The satellite based system offers number of advantages for real-time disaster alerts over the current methods due to faster, reliable delivery and wider coverage.

Special features

1) GAGAN Alert messages with location information can be used effectively by the user to identify whether his area is affected or not.
2) The service can cover wider area because of the larger GEO broadcast foot-print, global reception of the signal and no limitation in the number of people who can use the signal simultaneously.
3) The messages can be received even when terrestrial communications infrastructure is damaged or not available.
4) As the system is independent of mobile phone coverage it would reach people wherever they are, regardless of the existence of mobile phone coverage.

Feasibility of GAGAN message service

GAGAN is primarily intended to meet the aviation requirement of accuracy, integrity, continuity and availability of services over the Indian FIR for en-route support and over the Indian Land Mass for APV1.0 services. These are achieved through transmission of correction and integrity parameters through messages (0-63) in scheduled manner to provide intended service over the coverage area. RTCA DO229C MOPS standard defines the minimum update rate that needs to be respected by SBAS to comply with the safety of life requirements. Even after fulfilling these requirements,

- About 35% of spare data transmission capacity is still available free
- Also, with the availability of L5 in future, the spare capacity will be enhanced allowing for larger data capacity.
- The required data/message capacity of the disaster alert service has not been assessed yet completely, but it is believed to be within the existing spare data capacity of GAGAN (MT63 as shown in the Figure 3 for a typical day)

Use of MT63

GAGAN has the availability of free bandwidth of about 75bps out of 250bps and the message statistics of the GAGAN broadcast shows(Figure 4)that about 13000 null messages (Message Type 63) are being sent whenever no other messages are scheduled, every day. These null message slots can be effectively utilized to transmit short text message information for providing emergency service alerts throughout the GEO footprint.Through MT63 – appr. 250 characters /min per satellite can be transmitted and usable throughout India and the neighboring countries by mobile phone users and anyone else with an SBAS enabled GPS sensor which is configured to read MT-63.

The ICAO SARPS makes very little reference to the format and function of message type 63 stating only that “SBAS may broadcast null messages (Type 63 messages) in each time slot for which no other data are broadcast.” The data link is designed to broadcast a valid message every second to provide a continuity of signal using message type 63 to fill space if no other message is available.

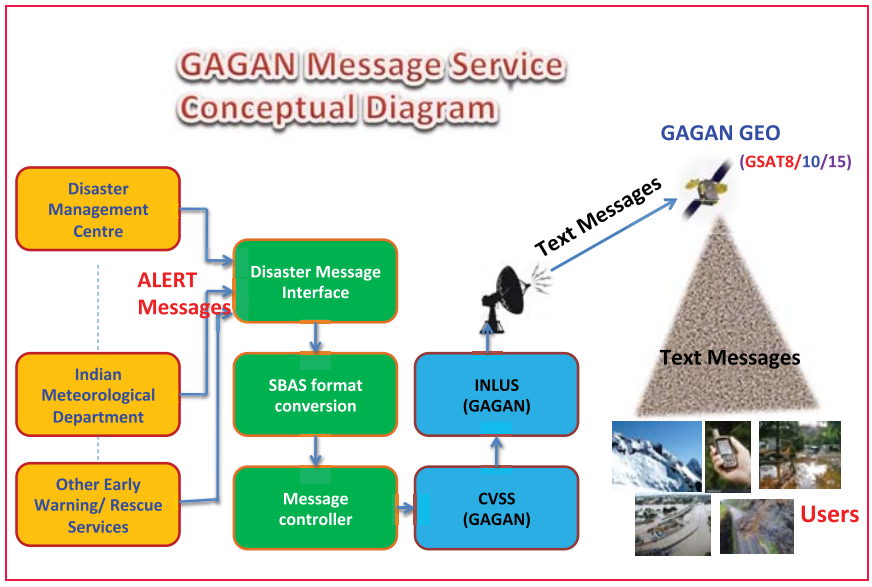

Figure 5: GAMES Concept

The GAMES concept will provide unique opportunity to implement robust broadcasting capacity for alert messages with minimal resources in short time and with an excellent perspective for future extensions

GAGAN architecture to meet GAGAN message service

By adding few components to the existing GAGAN system as shown in Figure 5, short messages can be broadcast over Indian region.

GAMES will consist of three segments namely the Message Control segment, the Space segment and the User segment. A typical working scenario is described very briefly here.

Message control segment

This segment consists of, the Message generation, transmission and monitoring systems.

Following are the major functions carried out in Message Control segment

- Message Generation System (MGS) receives the raw data related to disasters, cyclones, landslides, wild fire etc., from various sources like the Disaster Management Centre, Indian Meteorological Department, INCOIS, SASE and Other early warning/ rescue service centre
- MGS converts the raw data into early/alert warning as short messages in a specific format
- The MGS decides the broadcast priority for providing the information
- The MGS transmits these alert messages to the INMCC for further processing

The information generated by MGS is sent to Message Controller within the GAGAN-INMCC for further processing. The short message is broken up into number of frames by the Message controller for dissemination through GAGAN system. The message controller also verifies that the messages are broadcast correctly through feedback mechanism. The alert text messages are added into the GAGAN message structure and forwarded to INLUS (Indian Land Up Link System) for up-linking to GEO Satellite.

Space segment

The space segment consists of GEO satellites GSAT8 and GSAT10, besides the GPS satellites. The C band signal received from Indian Land Uplink Station (INLUS) is converted into L1 signal without affecting the embedded safety of life navigation message and the early warning/ alert messages are broadcast over the wider area to reach the intended user community. Each GEO satellite can broadcast different messages in a given time to increase the messaging capacity typically up to about 500 characters / minute across two satellites

User segment

The user segment consists of common public in affected areas, fisher man, travelers, hikers, users in high seas, etc. The user equipment available today discards the Null message (MT63) and do not examine its contents. The GAGAN enabled receiver which is configured to read the MT63, will receive the L1 signal from GEO satellites, process it, extracts the ALERT/EARLY WARNING TEXT Messages and display the same. Also the user receiver, being an SBAS compatible, gives the current precise location of the user from which the identification of whether the user is currently in the affected area or not is possible. Separate Apps can be developed to extract these Alert/ Early warning messages from GAGAN signal through mobile phones, dongles, hand held receivers etc and provide the information in the required format in local language. It may be noted that the aviation receivers will not utilize this capability as MT63 is ignored by them.

Conclusion

This paper presented the new approach to broadcast Early Warning/Alert messages through GEO satellites over a wide area to alleviate the last mile communication issues to remote locations and high seas through cost effective and efficient means. GAMES is a free to air service and any user equipped with GAGAN receiver with minor software modification will receive alert messages along with precise position information. Since GAGAN is basically a Safety of Life (SoL) system, the service availability is ensured all the time in all weather condition. As GAGAN system is operated and maintained by AAI, there is better control over message services. GAMES will be able support many types of alert messages simultaneously without the requirement of any additional infrastructure.

Lidar bathymetry from UAVs

The design of a bathymetric lidar depth finder is presented and results from a flight experiment carried out at the pre-alpine Pielach River (Austria) are discussed and compared to UAV-borne lidar scans and terrestrial survey

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We present a novel lidar sensor allowing to measure shallow water depths from an Unmanned Aerial Vehicle (UAV) in sub-decimeter accuracy. The system consists of laser rangefinder (λ=532 nm) for measuring distances to both the water surface and bottom and a navigation device consisting of a Global Navigation Satellite System (GNSS) receiver and an Inertial Measurement Unit (IMU). The sensor is mounted on an octocopter UAV platform and measures water body profiles with an along-track point spacing <10 cm. We report about a flight experiment carried out at the pre-alpine Pielach River (Austria) and discuss the results compared to UAV-borne lidar scans and a terrestrial survey.

Introduction

Measuring the depth of shallow water bodies from the air with pulsed, scanning lasers, commonly referred to as Airborne Laser Bathymetry (ALB), dates back to the 1960ies when the laser itself was invented (Guenther et al, 2000). Among the potential applications are underwater object detection, coastal and inland water mapping, monitoring of morpho-dynamics after flood or storm events, aquatic habitat modelling, underwater archeology and the like (Mandlburger et al, 2015a; Doneus et al, 2015). Due to their weight the operation of traditional ALB sensors was restricted to manned airborne platforms so far. Advances in sensor technology lead to miniaturization of light detection and ranging (lidar) systems. At the same time progress in UAV technology is nowadays enabling higher payloads and longer flight endurances. For these reasons UAV-based mapping is no longer restricted to passive image sensors (Colomina and Molina, 2014) but integrations of lidar sensors on UAV platforms for mapping topography and vegetation are rapidly developing today (Starek and Jung, 2015). In this paper we present the sensor concept of the first commercial UAV–borne bathymetric laser rangefinder (BathyCopter) manufactured by Riegl Laser Measurement Systems. We furthermore report about the results of a flight experiment at the Pielach River in Lower Austria. The captured river profiles are compared with terrestrial measurements carried out with a Leica TPS 1200 total station.

The study showed that capturing linear profiles of the riparian and submerged area is feasible in a single mission and makes the resulting data the ideal input for 1D hydrodynamic-numerical models

Sensor concept

The BathyCopter sensor system comprises a laser rangefinder (BDF-1), a navigation device consisting of an Inertial Measurement Unit (IMU) and a Global Navigation Satellite System (GNSS) receiver mounted on a UAV airborne platform (cf. Figure 1c). The transmitter and receiver axis of the laser range finder are coaxial (Riegl, 2016). The transmitter is a short-pulsed laser operating at 532 nm with a pulse repetition rate of 4 kHz and a pulse energy of about 3 µJ. The emitted pulse is shaped as a circular ring (d=7 cm) which is focussed by the transmitter optics to a footprint diameter on the ground of approx. 2 cm at the nominal measurement range of 15-20 m. The echo signal is digitized at the receiver and full waveform information is stored for every laser shot for the entire range gate. This enables flexible offline

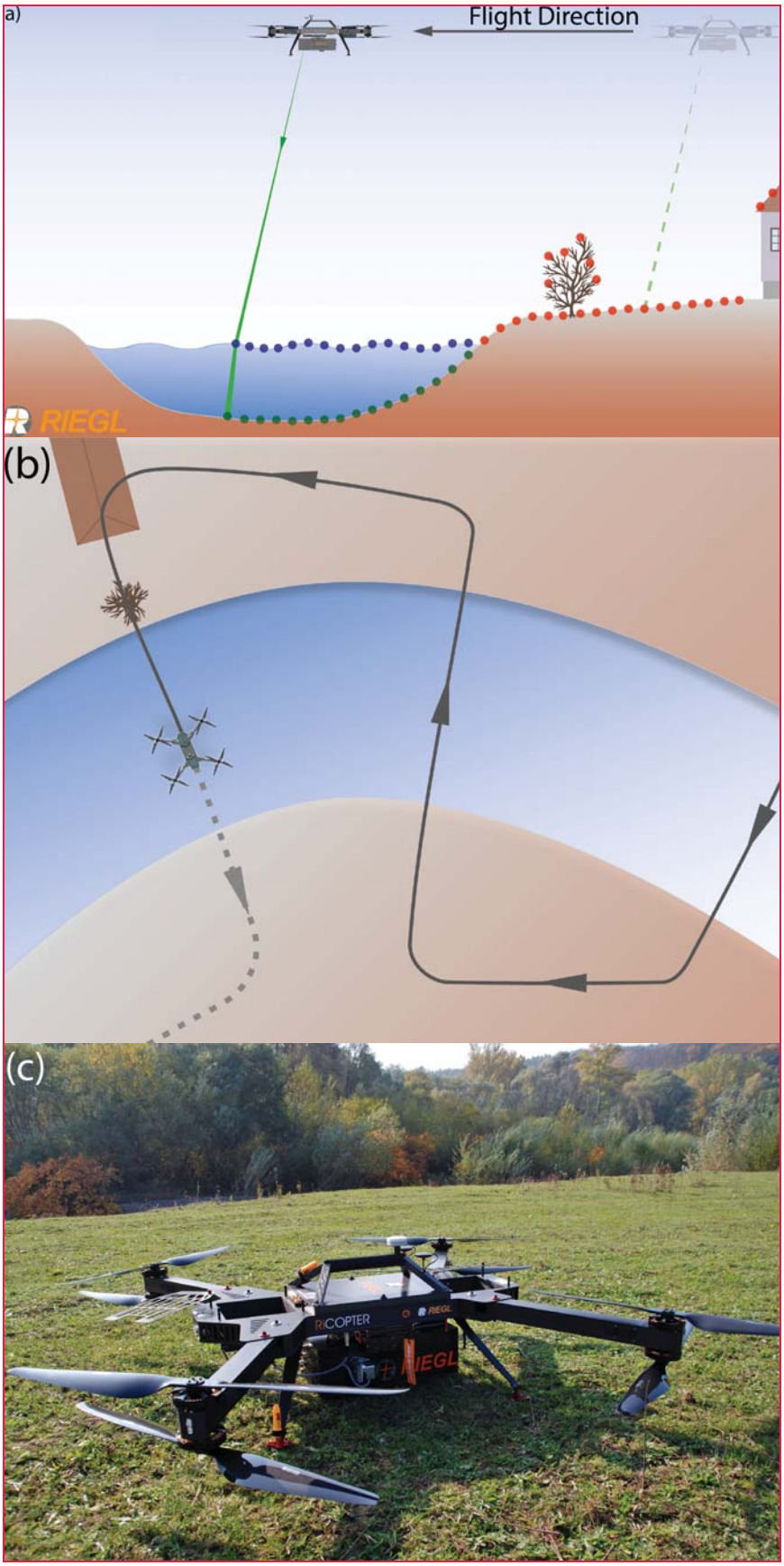

Figure 1: (a) Schematic sketch: laser rangefinder mounted on UAV platform; (b) Profile oriented data acquisition; (c) Riegl BathyCopter ready for take-off at the test site.

echo detection either on a per pulse basis or by averaging an adjustable number of pulses. The laser beam axis is tilted by 15° off-nadir for receiving echoes from both the water surface and the river bottom for each laser pulse (cf. Figure 1a). Knowledge of the exact position of the air-water-interface is a prerequisite for proper range and refraction correction of the raw measurements as no areal water surface model can be calculated from measuring points arranged in linear profiles (cf. Figure 1b). A constant off-nadir direction of the optical axis is ensured by coupling the IMU with a motor-driven laser beam deflection mirror to compensate varying pitch angles during the UAV flight.

The laser rangefinder is tightly coupled to the navigation device (GNSS receiver, IMU). Together with the GNSS antenna mounted on top of the UAV, the navigation system determines the flight trajectory (sensor position and attitude) with high accuracy and resolution. Hence, origin and direction information can be assigned to every single measurement of the laser rangefinder, and 3D-coordinates in a geo-referenced spatial reference system (WGS84) are obtained by combining trajectory and range data. The sensor system is mounted on a Riegl RiCOPTER platform. The RiCOPTER is an X8 octocopter UAV with a maximum take-off weight of 25 kg and a flight endurance of 30 minutes. It is electrically powered, provides redundant flight control hardware, and can perform autonomous waypoint navigation.

Flight experiment

The study area Neubacher Au (48°12’50” N, 15°22’30” E; WGS 84, cf. Figure 2) is located at the lower course of the pre-alpine Pielach River, a medium-sized right side tributary of the Danube. The study site is part of the Natura2000 area Niederösterreichische Alpenvorlandflüsse (area code: AT1219000). Bed-load sediments are dominated by coarse gravel (2–6.3 cm) within the active channel and bars. Cohesive sediments in areas of bank erosion lead to steep bank slopes, which, together with the dense understory

vegetation in the riparian forest issues challenges for terrestrial surveys.

On October 28, 2015, 12 river cross sections were captured with the BathyCopter flying at an altitude of 15-20 m a.g.l. The flight was conducted under good hydrologic conditions (clear water, low discharge) and moderate weather (bright sky, choppy wind). To ensure cm-precision of the directly georeferenced laser points, thorough initialization of the navigation device was performed on the ground and after take-off following a recommended procedure of the IMU manufacturer (Applanix). The positions of the cross sections were defined before take-off based on ortho-imagery and depth maps derived from a previous ALB mission. The waypoints were uploaded to the flight control unit and data capturing was finally conducted by autonomous flight. In a second flight following the bathymetric survey, the entire study area including the alluvial forest was captured independently with the RIEGL VUX1-UAV topographic laser scanner with the following mission parameters: flying altitude: 50 m a.g.l., flight velocity: 8 m/s, measurement rate: 500 kHz. This areal survey served for co-registration and quality assessment of the laser profiler data in the riparian area. An independent terrestrial survey in cm precision was conducted simultaneously using Leica equipment (1200 GPS, TPS 1200 total station) to evaluate the quality of the bathymetry. Additional areal bathymetry data from an ALB flight in April 2015 (Mandlburger et al, 2015c) captured from 600 m a.g.l. with the RIEGL VQ-880-G topo-bathymetric laser scanner were available and served as basis for the quantification of seasonal changes due to fluvial erosion.

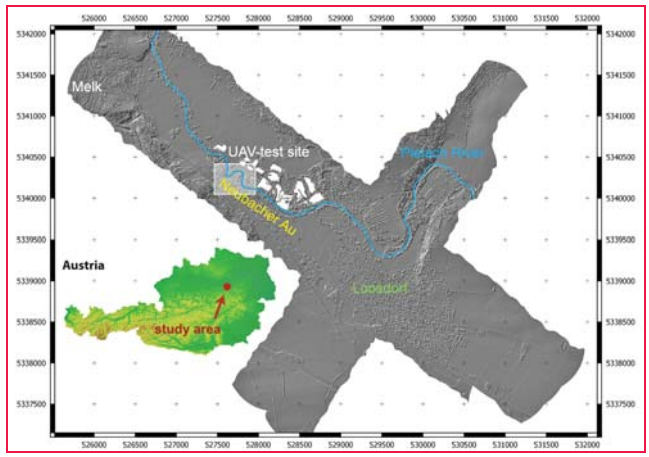

Figure 2: Study area Neubacher Au, Pielach River, Lower Austria. Shaded relief map derived from an ALB flight in April 2015. The white rectangle denotes the UAV test site (BathyCopter and VUX1-UAV).

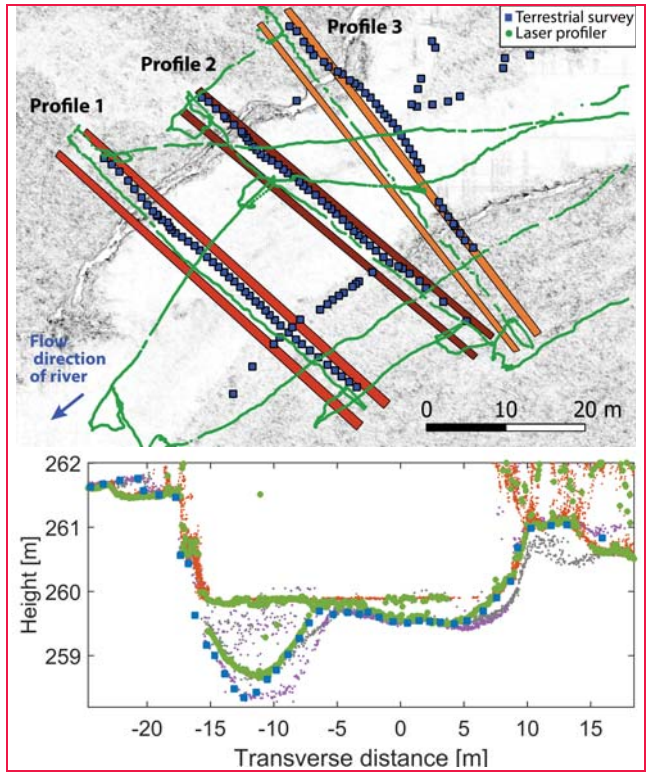

Figure 3: (a) Plan view of Sections 1-3: BathyCopter (green), Terrestrial survey (blue), ALB sections (red/orange); (b) Cross sectional view of Section 2: BathyCopter (green), ULS (orange), Terrestrial survey (blue), ALB (magenta/grey)

Results and discussions

The flight paths of 3 selected cross sections, the corresponding terrestrial survey check points, and the ALB profiles enveloping the domain of the respective cross sections are displayed in Figure 3a. For Section 2 the BathyCopter points (green) are plotted in Figure 3b together with the terrestrial survey points (blue), the points from the topographic UAV-borne laser scanning (ULS) with the VUX1-UAV system (orange), and the ALB cross sections derived from the April 2015 dataset (magenta, grey). Visual inspection of the laser profiler data and the check points shows good coincidence in the shallow part on the right side of Section 2 and systematic deviations in the pool area on the left side of the profile. However, both the laser profiler and the check points are consistent when seen individually. Actually, the observed difference can rather be attributed to the small-scale variability of the river bed and to the fact that the laser profiler and the check points are not perfectly aligned in the ground plan (cf. planimetric deviation in Figure 3a). Although, as pointed out earlier, the laser profiler data acquisition was carried out autonomously based on waypoints, and the flight control system ensures minimum deviations from the planned flight path by continuously correcting the sensor positions, still the attitude (roll component) of the sensor is influenced by turbulences due to varying wind conditions, resulting in lateral displacements of the recorded echoes on the water surface and river bed. On the other hand it was also difficult to exactly position the check points along the planned axis when wading the river bed during the terrestrial survey. The derived ALB sections clearly show (i) the seasonal change of the gravel bed due to fluvial erosion and, even more importantly, (ii)

the high variability of the river bed in flow direction. Concerning the water surface returns, Figure 3b reveals that in most cases the bathymetric depth finder delivers echoes from both the water surface and the river bottom. Only in the shallow littoral area with water depths less than 30 cm (i.e. distance corresponding to the pulse length) only one echo from the bottom but no water surface return is obtained. In the resulting return waveform the two distinct targets cannot be separated as the strong return signal from the bright river bed gravel is much more pronounced than the relatively weak water surface reflection.

A quantitative assessment of the BathyCopter accuracy was possible by comparing the 3D points of the water surface and the riparian (dry) area with the data from the ULS system and by comparing the river bed points with the terrestrial survey points. Comparison of the bare earth points showed a mean deviation of 3 mm and a standard deviation of 2.9 cm. This confirms a good accuracy of both the range estimation and the trajectory. Thorough analysis of the deviations revealed systematic small-term fluctuations of the navigation solution in the order of 3 cm, thus, restricting the achievable accuracy to a few cm as the laser profiler system entirely relies on direct georeferencing. The water surface points showed a clear positive bias (median: 4.5cm) and a standard deviation of 6 cm. The bias can be attributed to the slight penetration of the green laser signal into the top layer of the water column (Guenther et al, 2000). The order of magnitude is in line with the findings in Mandlburger et al. (2013). For utmost accuracy requirements this systematic offset needs to be considered for the range and refraction correction of the river bed returns. As for the higher standard deviation of 6 cm, compared to 3 cm over land, the short-term variability of the water surface has to be taken into account. Whereas previous studies have shown that the in-stationarity of the water surface can be neglected for ALB inland water applications due to the relatively large laser footprint of >50 cm, short-term water surface fluctuations (i.e. waves) need to be considered for UAV-based laser bathymetry as the footprint is much smaller (3.5 cm). Simultaneous capturing of both the water surface and river bed, as aimed by the presented sensor designed, is therefore very important.

The river bed point comparison yielded a bias of 7 cm and a standard deviations of 13 cm. The main reason for the larger deviations is that the height differences are not measured at the coinciding spots but by comparing the laser profiler height with the height of the nearest check point. The positive bias is mainly provoked by the left part of Profile 2 where the water depth at the measuring position of the laser profiler is clearly smaller than at the corresponding position of the check points. When restricting the nominal-actual bathymetry comparison to river bed points with a distance to the nearest check point of less than 1 m the mean deviation drops to 4 cm with a standard deviation of 6

cm. The latter measure can be regarded as a reasonable estimate of the overall accuracy of BathyCopter river bed points.

The BathyCopter was designed as a comprehensive topo-bathymetric sensor, i.e. an instrument for capturing profiles of the bathymetry and the riparian area with a single instrument and in a single mission. The main application for such data is 1D hydrodynamic-numerical (HN) modelling. Especially for large scale flood simulations 1D models are still commonplace. The multi-target capabilities of the sensor resulting from recording and processing the full echo waveform allow capturing of vegetation, bare earth, water surface and river bed data. From these data not only the ground surface can be extracted but the overbank roughness can also be characterized and used in the hydraulic model (e.g. via calculation of Manning *n*-values derived from vegetation height and density). Furthermore, the high along-track point density carries the potential of estimating the grain structure (i.e. pebble sizes) down to the sub-cm level. For the presented quality assessment the waveforms of 100 laser pulses were averaged in post-processing to increase the signal-to-noise ratio. This resulted in a net measurement rate of 40 Hz and a corresponding spatial resolution of about 10 cm. The respective point cloud is smooth and still provides enough geometric details for HN modelling. In contrast, averaging only 10 echo waveforms leads to a point distance of 1 cm and the shape of the resulting dense point array suggests that it is feasible to estimate roughness on the grain size scale together with capturing bathymetry in a single campaign.

Concluding remarks

The Riegl BathyCopter is a novel UAV-borne topo-bathymetric laser profiler consisting of a laser rangefinder operating at λ=532 nm, a navigation unit (GNSS, IMU), a flight control system, and optional cameras tightly connected to an octocopter UAV carrier platform. The 8° off-nadir tilt of the laser beam provides optimal conditions for receiving echoes from both the water surface and the river bed, which could be confirmed for 97% of the laser pulses in areas with a water depth greater than 30 cm. The overall accuracy of the captured topographic and bathymetric laser profiler points strongly depends on the sensor positioning and orientation accuracy (GNSS, IMU) and was calculated to 3-5 cm compared to as reference for bare earth areas. The bathymetric accuracy is slightly lower but still in the sub-dm range. The study showed that the sensor system would benefit from a stabilization of the flying platform. While automatic correction of the pitch movements is already realized in the latest sensor generation, roll movements of the platform lead to a lateral deviation of the laser points from the planned axis.

Whereas the system design as a laser profiler exhibits drawbacks compared to scanning systems concerning (i) system calibration due to a lack of redundant strip overlap area and (ii) refraction correction perpendicular to the flight path, especially the small laser footprint of 3.5 cm enables new applications especially as the spatial resolution within a profile is much higher compared to traditional airborne topo-bathymetric scanning. The study showed that capturing linear profiles of the riparian and submerged area is feasible in a single mission and makes the resulting data the ideal input for 1D HN models. Beyond that, a point spacing of 1 cm on the river bottom (depth: approx. 2.5 m) could be obtained and suggests that fine scale roughness estimation of the bottom is feasible with this sensor, but further experiments are needed to confirm this.

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SURVEYING

River cross-section surveying using RTK Technology

The Yangtze River project case study

BENLIN XIAO , FENGMING WAN , CHANGQING WU AND KEFEI ZHANG

To gain accurate and reliable survey results, our experience suggests that

1. When satellite signals are blocked by objects such as tall buildings or big trees, RTK GPS survey may experience problems. This may lead to a system initialization problem since the requirement for a minimum number of satellites cannot be met and the receiver cannot be initialized. At this circumstance, it is necessary to use conventional surveying techniques for the collection of the field data.
2. When undertaking the bathymetric surveying, the rover receiver is mounted on the boat. Because of the tumbling and rushing of waters, it is paramount important to be sure that the GPS positioning data matches the depth surveying data of water. That is the GPS surveying and the digital echo depth sounder surveying must be synchronized perfectly.

INITIATIVE

SLA
SINGAPORE LAND AUTHORITY

Land Information Online

Singapore Land Authority puts map-based land ownership information on the Net

From November 22, 2006, LandQuery, the map-based information service on land ownership has been made available free to the public. LandQuery can provide information on:

a. Whether the land is State or privately owned;
b. Contact details of the public agency responsible for a particular State land or its managing agent; and
c. Land boundaries and lot numbers.

LBS

Using Assisted-GNSS to locate handsets in wireless networks

This paper discusses the current state of Assisted-GNSS for locating mobile handsets and some results of a Hybrid A-GNSS investigation.

DR NEIL HARPER

There are many different types of technologies employed in calculating the location of handsets in wireless networks with various levels of success and accuracy. Assisted-GPS (A-GPS) is a positioning technology that is presently used for locating handsets in wireless networks and is gaining traction in the market. An A-GPS server provides assistance data to the handset in order for it to have a low Time to First Fix (TTFF), weak signal acquisition and optimize handset battery use. A-GPS is used as a location technology in isolation or hybridized with other positioning technologies that provide range-like measurements.

GOVERNANCE

GIS in local government

The Australian experience

ALLAN K BARNES

Recognition of GIS Benefits

Most local governments in Australia recognise the capacity of GIS to better meet their responsibilities. This hard won recognition flows from the publicised benefits of GIS by high profile local governments, the experience of smaller administrations and user groups and associations. Such is the recognised benefits of GIS to local government that the Spatial Initiative for South Australia was joint initiative of the state's Local Government Association and state government.

The Vulnerabilities and Challenges of Caribbean SIDS

The vulnerabilities of Caribbean Small Island Developing States (SIDS) can be addressed by responsible land governance

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Small Island Developing States (SIDS) globally possess characteristics that render them vulnerable to greater impacts of economic, social and environmental shock than other countries. These characteristics include their small size, and limited useable space, economic dependence on international markets, and vulnerability to climate change impacts, particularly sea level rise. Caribbean SIDS face even greater challenges as a result of their particular features that are additional to the ones listed above. The limitations of useable space are further exacerbated in Caribbean SIDS by the volcanic geomorphology of many of the islands. Most of the islands have very narrow coastal areas suitable for occupation and use, and steeply rising interiors. In most instances, the population has no choice but to occupy these precarious slopes resulting in a situation where both the occupants of the slopes and the downstream communities become susceptible to landslides and floods. In addition, some segments of the population experience insecurity of tenure resulting from the large percentage of informal tenure occurring on either squatted land or communal family land. This informality and insecurity affect disaster management as recovery, redevelopment, and reinstatement of land tenure is rendered difficult post-disaster, particularly since hurricane and storm effects are becoming more prevalent with climate change.

The recent Habitat III declaration of an Urban Agenda means that the Caribbean must focus more on how the urban environment can be empowered through improved land governance models to provide growth and development for the Caribbean SIDS and their societies. Improved land governance can address some of the land related vulnerabilities by providing mechanisms for supporting adaptation to hazards and risks and by building resilience. Lessons for land governance that can be applied in Caribbean SIDS can be learnt from recent outcomes of discussions on SIDS.

In the face of the challenges that SIDS encounter, and given the need to respond by utilising land governance mechanisms, land professionals and land-based organisations in the Caribbean must, therefore, question their standard approaches to land management and the supporting land administration, and be willing to modify and adapt their frameworks to fit within the particular characteristics of the Caribbean, taking into consideration the specific needs of Caribbean SIDS. Land professionals and land-based organisations are best placed to build awareness among the populations, of land governance tools such as the FAO's Voluntary Guidelines on the Responsible Governance of Tenure (VGGT) and FIG's Fit-for-Purpose approaches and how they can be adapted to apply to the specific environments within each country.

Caribbean SIDS, illustrated in spatial relationship in Figure 1, require special attention if the region is to meet development goals and achievements set out in the recently declared Habitat III Urban Agenda that focus on achieving safe, equitably-allocated rights to land in sustainable urban settlements. The Caribbean is not urbanising as quickly as the rest of the world nor Latin America (UNHabitat 2012). World Bank (2009) figures put the percentages of populations living in the urban environment at

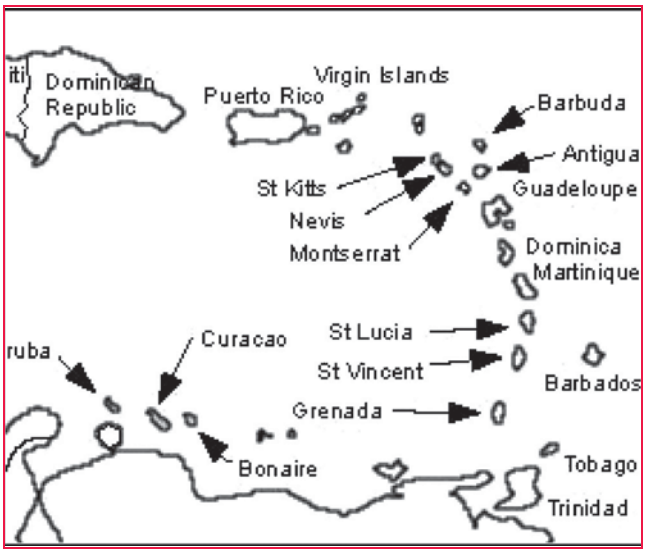

Figure 1: Caribbean SIDS

84.3% for Brazil, and 65% for Panama as opposed to 32% for Barbados and 9% for Trinidad and Tobago. Other definitions of the term 'urban' that include agglomerations or densely populated peri-urban areas, however, put the urbanisation figures as far higher than those stated since population densities outside of strict definitions of city boundaries are high for some Caribbean countries, as shown in Table 1, (World Bank 2016) and it is difficult to make a clear distinction between urban and suburban or even rural. The issues surrounding urbanisation, therefore, still significantly affect the countries of the region. This paper sets out the vulnerabilities present in Caribbean SIDS and suggests ways that the land based professionals and groups can play a role in advancing the application of tools that can address the existing challenges through improving land governance.

Background

The Caribbean comprises several island or archipelagic island groupings between Florida to the north and Venezuela on the South American mainland to the south, scattered over thousands of square kilometres of marine space. The countries have formed themselves into several political groupings and organisations, such as CARICOM and the OECS, some of which include the mainland territories of Guyana and Suriname (CARICOM). The total land area of all islands in the region is approximately 240,000 km^2 with island territories ranging in area from 91km^2 (Anguilla) to 105,806km^2 (Cuba). Most of these are considered to be SIDS. Caribbean SIDS share with other SIDS the challenges of small size, remoteness, dense populations, economies dependent on developed countries, restricted markets, limited resources, physical vulnerabilities to natural disasters intensified by climate change, intensely competing and conflicting land use, high cost of public service provision and low capacity in the public service. Some of these are intensified in the Caribbean. The economies of the countries, for example, have been ravaged by the 2009 global financial crisis which caused a 9.2% drop in tourism and a 21.9% decline in foreign investments in construction leading to a reduction in GDP by 5.7% (World Bank 2011).

There are also land related traits in the Caribbean that are distinctive to the region. These are primarily: the physical structure of some of the islands that demands that occupation be concentrated in the coastal areas, a shared history of colonisation that has left disparities in access to land that still persist, the presence of the informal communal tenure of family land, and the high incidence of spontaneous occupation on both state and private land. These conditions increase the vulnerability of the societies in the Caribbean. Improved land governance can ameliorate the impacts that these circumstances have on the well-being of the societies and the opportunities for equitable growth and sustainable development.

Table 1: Population Densities for the more populous Caribbean Countries

World Ranking	Country	Persons /km^2 (2011-2015)
11	Bermuda	1304
16	Barbados	659
19	Aruba	575
49	Puerto Rico	400
33	Haiti	384
31	India*	436
47	St. Lucia	301
41	Grenada	313
48	St. Vincent and the Grenadines	280
52	Trinidad and Tobago	264
50	UK*	267
46	Jamaica	251
178	US*	35

*Included for reference

Source: World Bank 2016 http://data.worldbank.org/indicator/EN.POP.DNST , Index Mundi 2016, CIA 2016

Vulnerabilities of Caribbean SIDS

Many of the Caribbean countries are volcanic in geomorphology with steep internal slopes and narrow flat coastal areas where most of the built development occurs. This puts a large part of the population and the built construction at risk of inundation and storm surges. Increasing built development in the elevated areas also intensifies the risk of landslides and floods as built development can weaken soil by removing protective grass, shrub, and tree coverage and allowing liquid infiltration. Built development can also increase rainfall runoff speeds and volumes by adding to the area of impervious surfaces, leading

to flooding in lower areas. Land sector agencies and land professionals should seek innovative ways of encouraging development that include risk mitigation at higher elevation and low lying regions while attempting to preserve the environment, the built development, and the society from physical harm. There is usually insufficient available space to completely exclude all hazardous areas from construction and other use. The coastal areas where activity and occupation are concentrated, are low-lying with a significant proportion of the areas below 5 metres above sea level. Investments in infrastructure and tourism related development have also been rendered prone to loss as a result of hazard events.

The large percentages of informal tenure adds to the vulnerability of the affected communities. There are significant linkages between security of land tenure and the ability of the land occupants to recover from natural disaster (FAO 2011; Barnes and Riverstone 2008; Griffith-Charles et al. 2015). The annual hurricane season in the Caribbean usually results in significant damage and destruction but this is periodically, and increasingly more extensive and devastating. Climate change is causing variations in weather patterns that are intensifying impacts and increasing the frequency of particularly destruction storms. When these occur, informal communities lose lives, and livelihoods and find difficulty recovering (Huq and Ayers 2007, Herianto et al. 2007).

Vulnerabilities of urbanisation

Since most urban development is already in the vulnerable coastal zone, any increase in urbanisation puts a greater percentage of the population and a larger part of the economy at risk for damage or loss. The sprawling urban agglomerations of the islands cannot evade this risk as there are limited alternatives for occupation and use. The risk must instead be documented, quantified, and managed as part of an optimised land governance framework.

Urbanisation can also increase the incidence of poverty, inequity of access to livelihoods, land and resources, crime, and conflict. These issues put stress on the ability of the under-resourced land management institutions to address them. The land administration systems cannot keep pace with the growth in the urbanising environment and lack basic information on social and tenure dimensions leading to under informed decision making.

Constraints to improved land governance

Improving land governance requires principled approaches as well as attitudinal change but also tangible institutional structures that are costly to establish and maintain. Fragile and weakening economies in an era of global economic recession can ill afford the establishment and maintenance of high technology information systems, and land administration systems. These systems are, however, vital to the support of responsible land governance. Some of the fundamental principles of transparency and inclusion that ground current theories of responsible land governance may be alien and unfamiliar to many traditional societies including those in the Caribbean that can be community and family oriented and somewhat insular. Publicly displaying land title information can be resisted in these societies.

Some of the few countries in the Caribbean that are assessed in Transparency International's Corruption Perceptions Index, fall low on the scale as shown in Table 2. Since this ranking identifies perceptions about state institutions, it reflects the functioning of the land based institutions and the frustration that persons accessing the land institutions face. It is often thought that accessing services such as land transactions for registration, planning approval, valuations for compulsory acquisition all require the offer of bribes to have the service be sped up or done at all.

There is need for documented and implementable land policy derived from inclusion, and transparency, supported by rich current land information and continuously revised and maintained on the basis of monitored indicators of intervention success. This requires economic and human resources with capacity in the state institutions. In addition to addressing all the vulnerabilities pertinent to the region, this land policy should provide the framework for and support the development of institutional structures that focus on urban land management.

Tools for improved governance

Current land governance tools including those that provide custom built technology promise low cost, efficient and effective systems that can address resource gaps to improved land management. Despite the absence of documentary security of tenure promised by formal titling, many persons in informal settlements or informal holdings on family land in the Caribbean feel a strong sense of tenure security borne of cultural acceptance, community acknowledgement and the states' indulgent attitudes toward informality. Many enjoy access to basic utilities of electricity and water. The incentive of joining the land market through formal titling holds little attraction to homeowners of low

Table 2: Selected countries' ranking on the corruption Perception Index

Ranking of country	Country
17	Barbados
29	St Vincent and the Grenadines
31	Puerto Rico
39	Dominica
63	Cuba
85	Jamaica
85	Trinidad and Tobago
124	Guyana
161	Haiti

Source: Transparency International (2014) https://www.transparency.org/cpi2014/results

value property and credit institutions will seldom see these properties as marketable or fungible even if they were titled. The settlements do not conform to planning and construction standards and are in marginalised land in locations exposed to environmental hazard impacts. Regularisation of planning standards and formal titling projects to regularise tenure do not always provide the solutions to poverty and powerlessness nor do they establish or invigorate a comprehensive land market in stagnant economies (Deininger, et al. 2003, Sanjak 2012; Griffith-Charles 2004; Barnes and Griffith-Charles 2007). Titling and/or recording of tenure can however provide variegated solutions for different segments of the land market. Titling in enclaves of higher valued properties can serve to invigorate land markets. Recording of informal tenure in their communities can have the imperative of providing security of tenure but also providing for the well-being of marginalised members of the society.

Capacity building for improved governance

The land management institutions of the Caribbean, mindful of challenges to availability of land, do not have the power or the will to strictly enforce planning codes and building restrictions and often prefer to offer the occupant options for building that would minimise the impact even in high-risk areas. In other instances they may turn a blind eye to breaches. The countries are densely populated with limited land space yet densifying occupation with high rise dwellings is not a popular option for addressing land allocation and access. Cultural norms and ingrained habits need to be managed. Public awareness is required to introduce populations to the ease of current methods and thinking. Governance does not only take place at the level of government or state institutions. Civil society plays a fundamental role in governance and therefore, communities and community leaders must accept their responsibilities to the society. Establishing, populating and maintaining land administration systems for informal

sectors is a way for civil society to engage with the activity of governance.

The Voluntary Guidelines for Responsible Governance of Tenure suggests that land administration systems should be provided and that these be transparent and accessible but while systems are available in most cases these characteristics are not available in the under-resourced land sector agencies of the Caribbean. Land administration system reforms are often project based and externally funded and designed to use high cost and rigid technological solutions that cannot be maintained after establishment. Adherence to historical bureaucratic regulations in the land administration affects the accessibility of information and the responsiveness to changes in the social and environmental structures in the countries in reaction to global fluctuations. For valuation surveying, for example, the VGGTs advise that information systems on values should be provided and that such information take into consideration non-market values such as social, cultural, religious, spiritual and environmental values. Apart from the lack of resources, and capacity in the institutions to adopt this recommendation, professionals and public officers resist the introduction of new approaches.

Professional and organisational collaboration

Professionals, including those whose disciplines are land related, often feel impelled by their learning to uphold rigid and precise systems. Lawyers demand the continuation of formal titling systems with strict specifications of a few narrow bands of tenure type of freehold, leasehold, and licence. Land surveyors claim the need for precise fixed coordinate systems for physically defining boundaries of land rights. If these land based professionals are to embrace their new role of supporting more flexible systems of operation that are fit for purpose, and that value social benefits over technological advancement, then capacities must be built first of all at this level. Professional and organisation collaboration can result in cross cutting interchanges that can deepen and broaden the understanding of impacts and outcomes of the application of innovative methodologies. Collaborations can also assist in funding practical research and meaningful application of proven tools in underserved and marginalised communities. This is also a way of the land professionals providing inputs to responsible governance.

Conclusion

Land administration systems have seen an expanding role and responsibility over the years and have come from merely recording taxes or title to where they now are a vital component of a land governance system. Similarly, land professionals are now seeing an expanded role from performing the technical aspects of their disciplines and serving their immediate clients to the best of their abilities to now being agents of change in the achievement of larger, more principled societal goals. Land professionals can rise to this challenge by keeping informed of how innovative land tools can be and have been applied to be more effective at attaining overarching social, economic, and environmental goals of the society. They can then provide dissemination roles to their publics, their land governance institutions and their professional groups but beyond this must take part in research and discussion on efficacies of various tools. Blinkered focus on technical issues can no longer be accepted.

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This paper was slightly modified from a paper presented at the SIDS Workshop of the FIG Working Week 2016, Christchurch, New Zealand 2-6 May 2016

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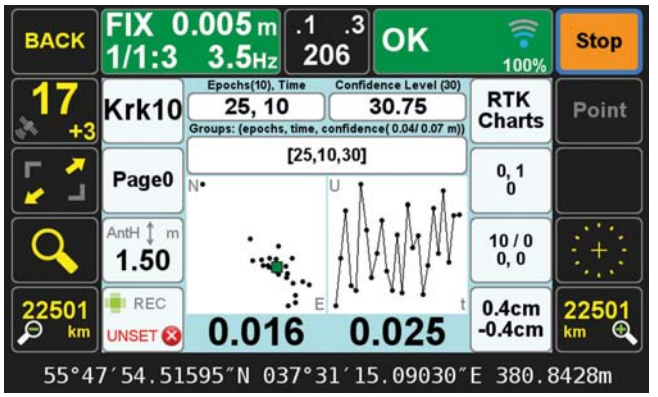
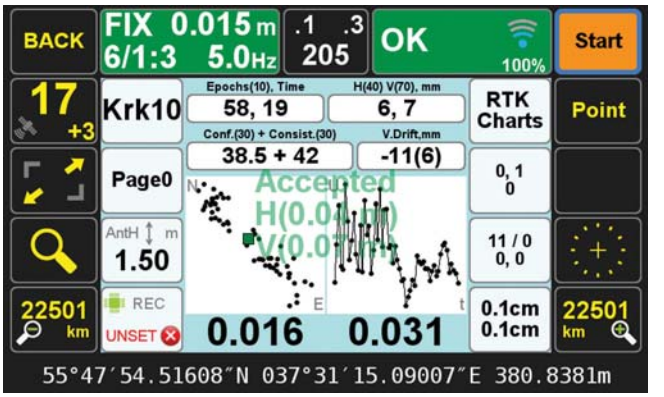
RTK Verification, Phase-1

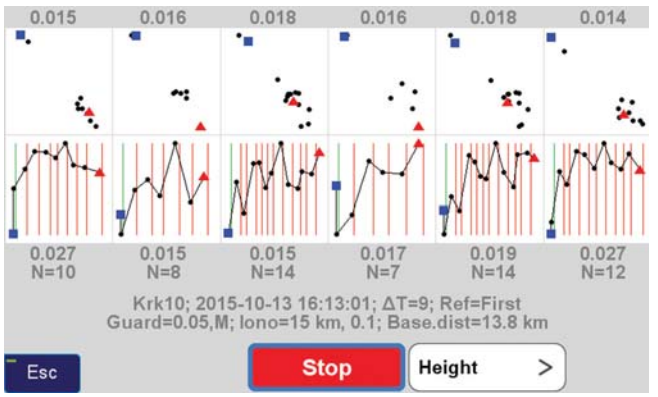


This graph shows the horizontal and vertical RTK epochs of Phase-1 along with their statistics. Each epoch is the average of six RTK engines.

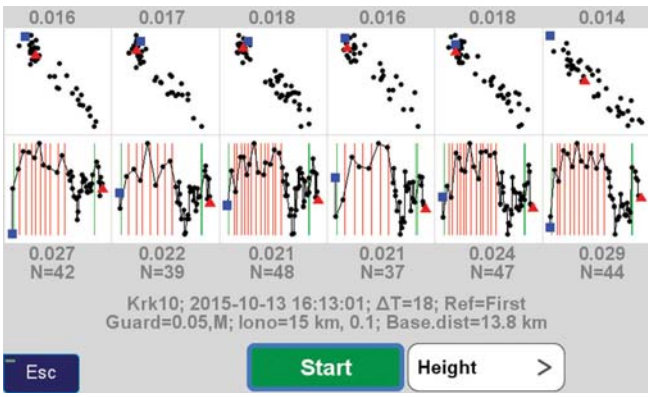
RTK Verification, Phase-2



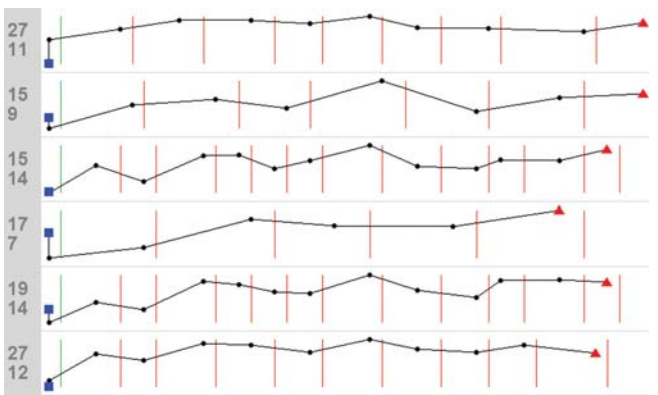
In Phase-2 the best ambiguity solution is selected and RTK is continued with the best ambiguity selection.



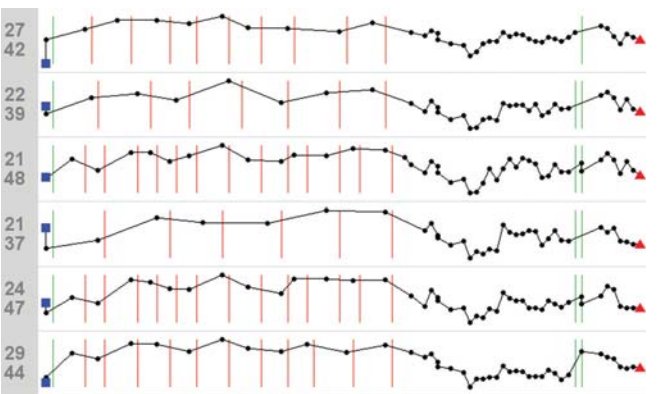
Phase-1 horizontal and vertical solution of each engine for each epoch.



Horizontal and vertical view of each engine in Phase-2. At the end of the process, all engines are reset once more to ensure correct ambiguity resolution.



Expanded view of the vertical solution of each engine. Vertical red lines show the instants in which each engine has been reset and ambiguity solutions recalculated.

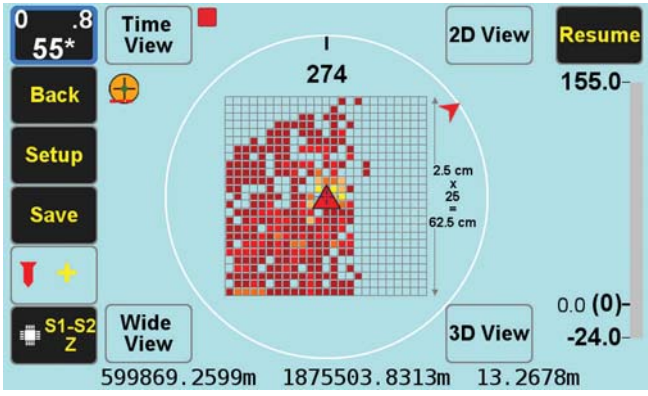


Similar expanded view of the vertical solutions in Phase-1 and Phase-2.

FL

We have planted 19 mag nails, close together, from 16d common nails to 2-3/4 inch Mag Spikes from ChrisNik, in an 18 x 12 feet land in front of our San Jose headquarters.

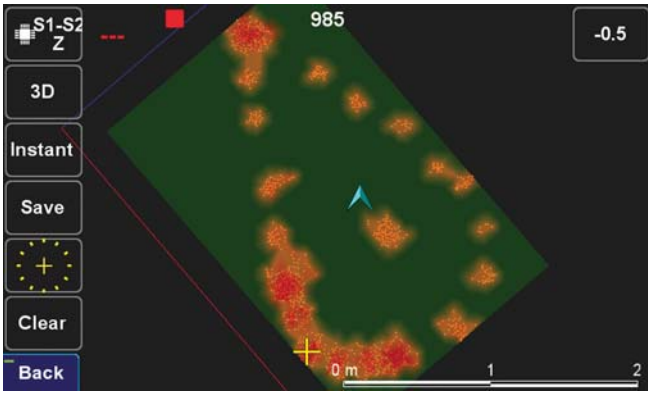
The site has a great deal of ambient noise from a nearby freeway and construction work.



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

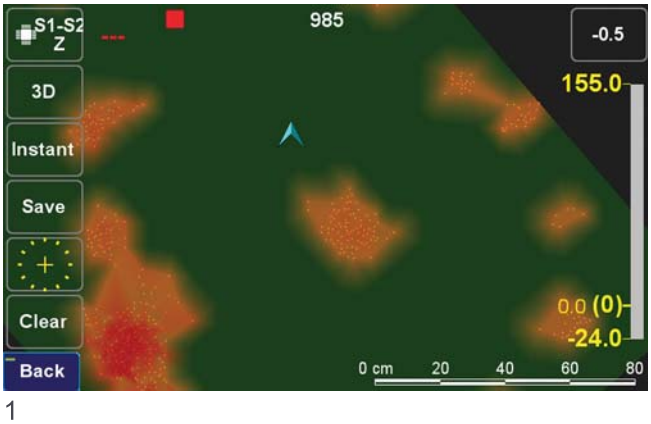
The audio and graphical bar on the right side show the magnitude of the magnetic object.

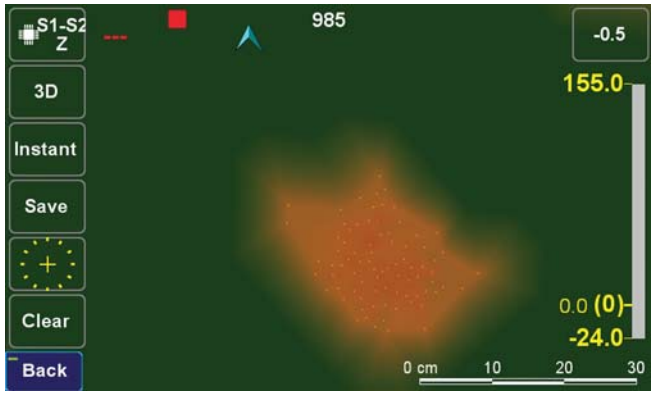
In “Setup” you can select the cell size and the size of the field you want to scan.

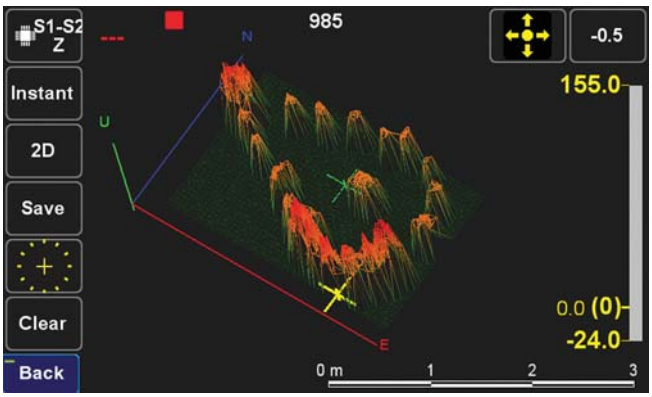


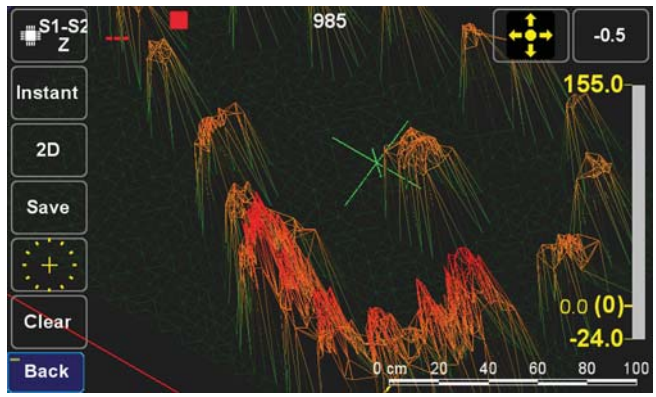
2D view of the field shows the magnetic objects that have been scanned.

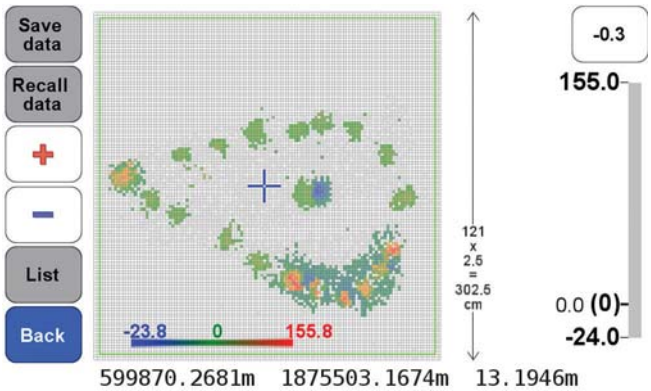
Zooming the 2D screen can show the shape of the magnetic objects under the ground.

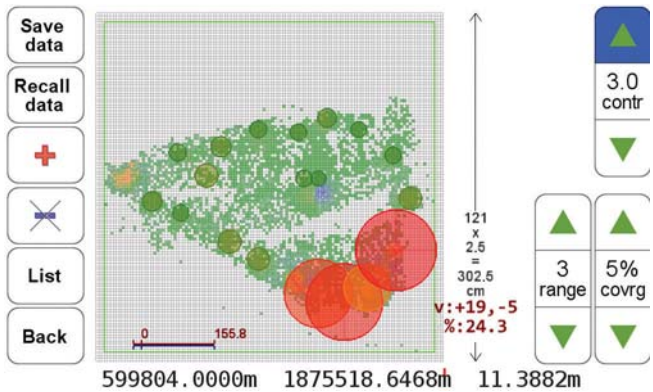


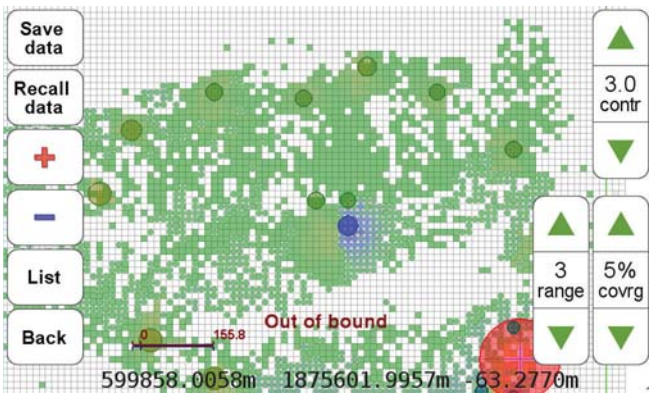


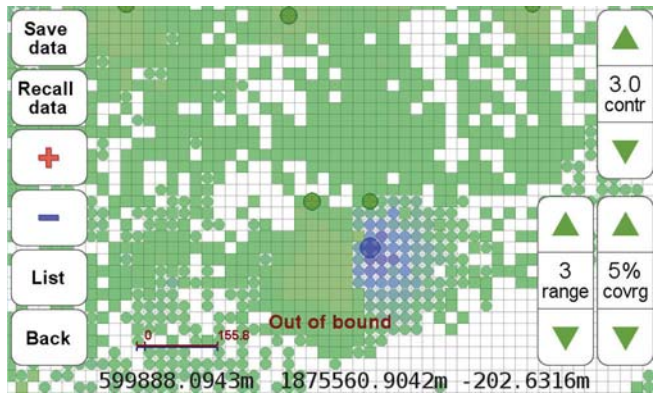


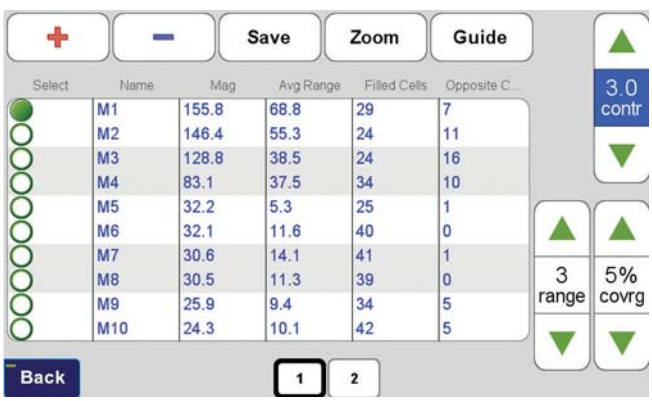




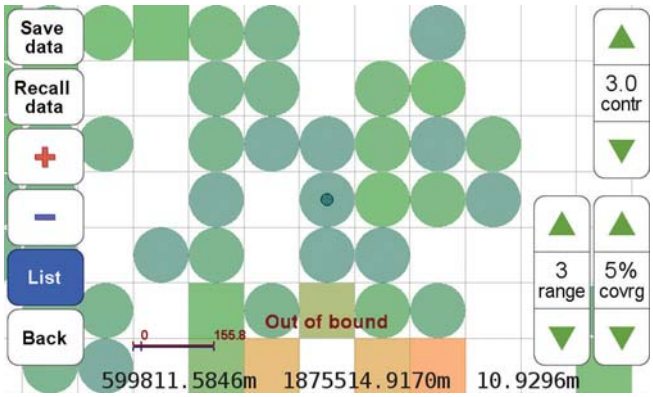






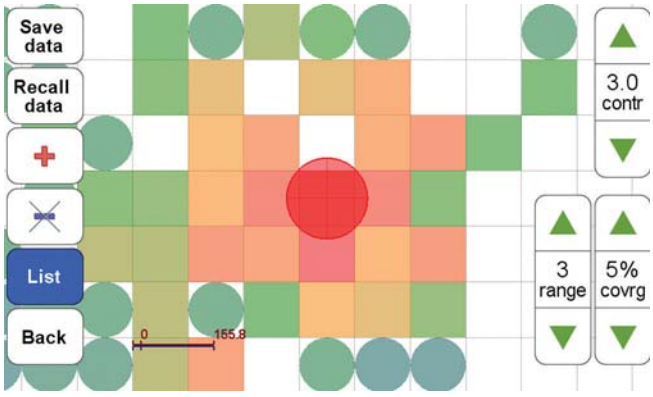


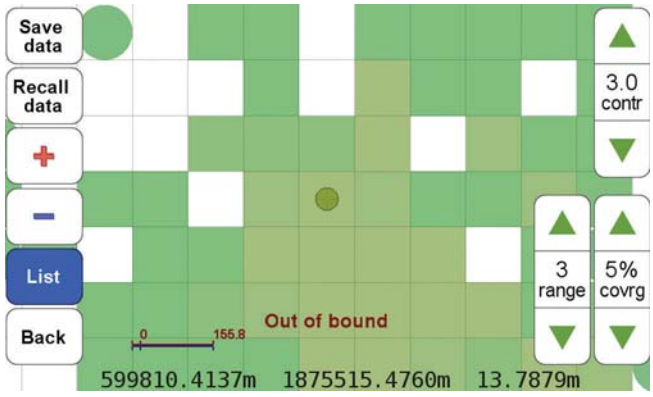
The top two graphs show the 3D view of the magnetic objects in the field. The following four screens show the digitized version of the 2D view. The mag data collected can be saved and recalled for further viewing and documentation. The “List” button lists the magnetic objects detected and their characteristics. Zoom button shows details of the selected object. Guide button will guide to the selected item.

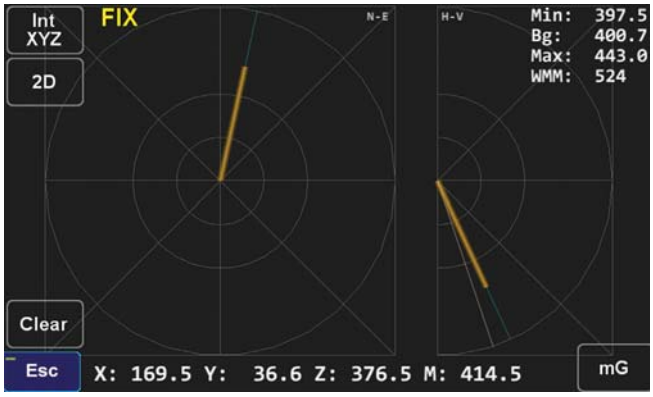


MRI Magnetic Raster Imaging

When zoomed to any selected point, the characteristics of the cells around the peak are shown. Squares show the positive and circles the negative cells. Cell sizes are programmable. Similar to the MRI used by doctors!

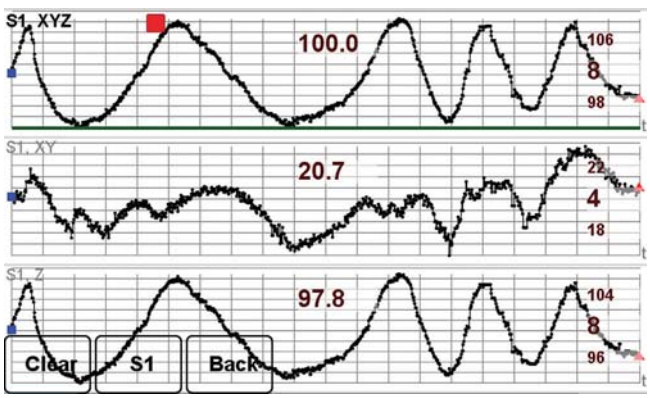


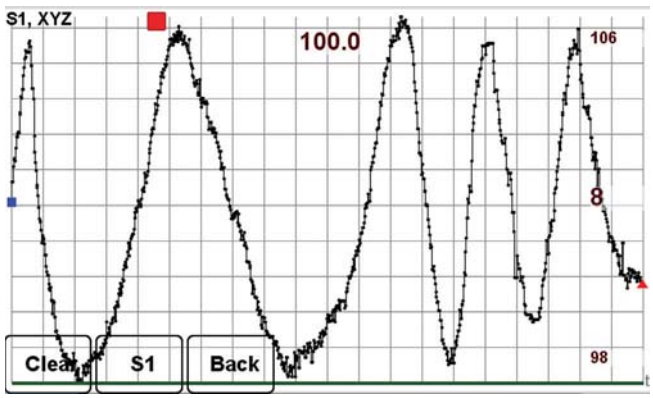


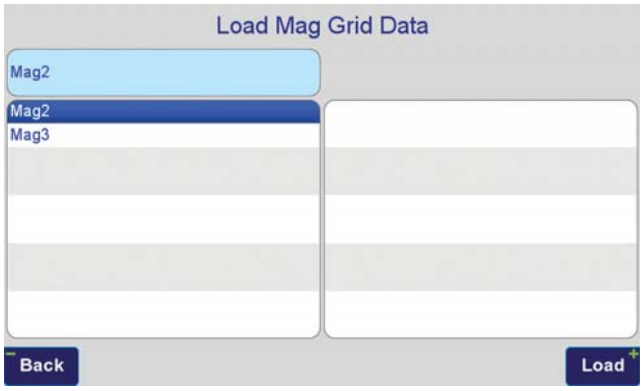


Horizontal and vertical magnetic vectors show the instantaneous vectors from the current position to the mag point.

Below graphs show the Time View of the mag values of the two sensors and their difference as scanning is in progress. Clicking on any graph shows its expanded view.



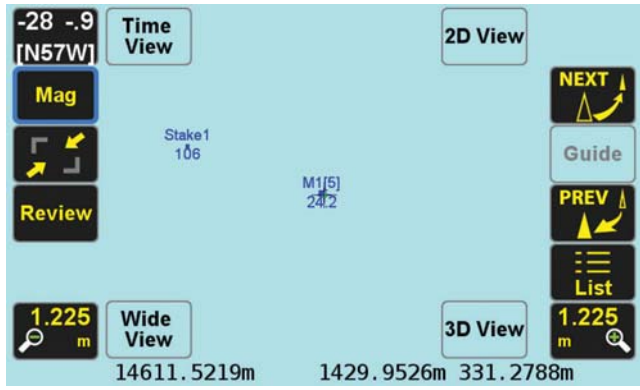




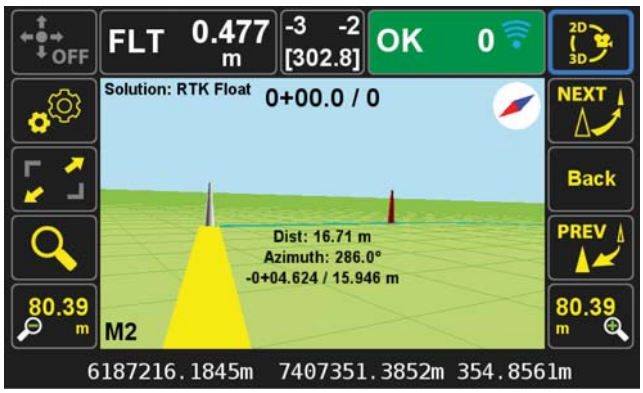
Field View

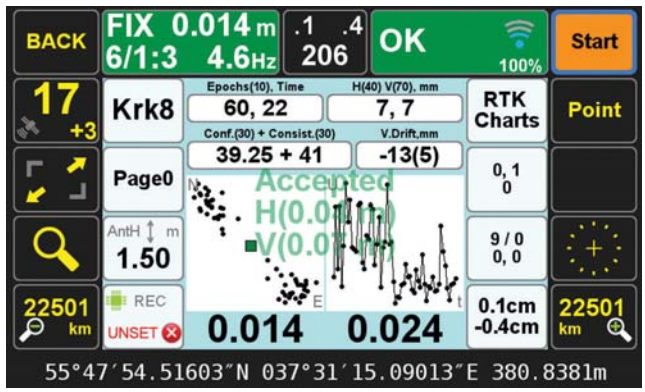
When you scan a large area, you can save all possible peak points, view them on the map and select the point with the highest peak to dig.

When you save a point, you can also save all the raw Mag sensor data for future view and documentation.



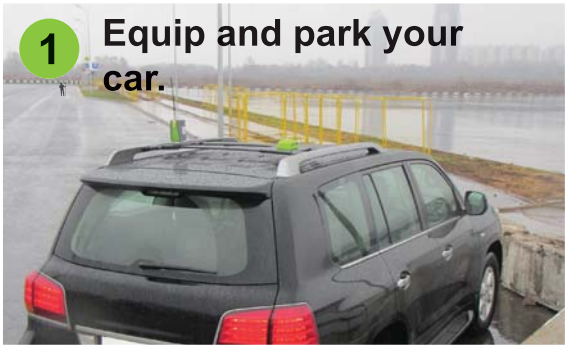
Work Flow



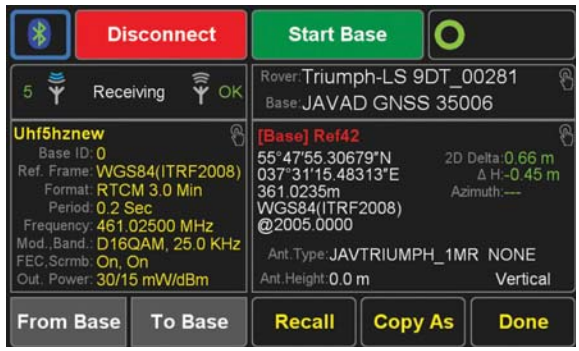


We have not only integrated a sophisticated magnetic locator in the TRIUMPH-LS, but we have also streamlined the whole process. First, the “Stakeout” screen will guide you towards the target.
Then the “Mag” screen locates your underground target and determines its coordinates. You can also save this point.
And finally in the “Collect” screen, you can survey the target point which you have dug up and exposed. This is also the time to use the **built in camera** of the TRIUMPH-LS to photograph and fully document the evidence which you have recovered.

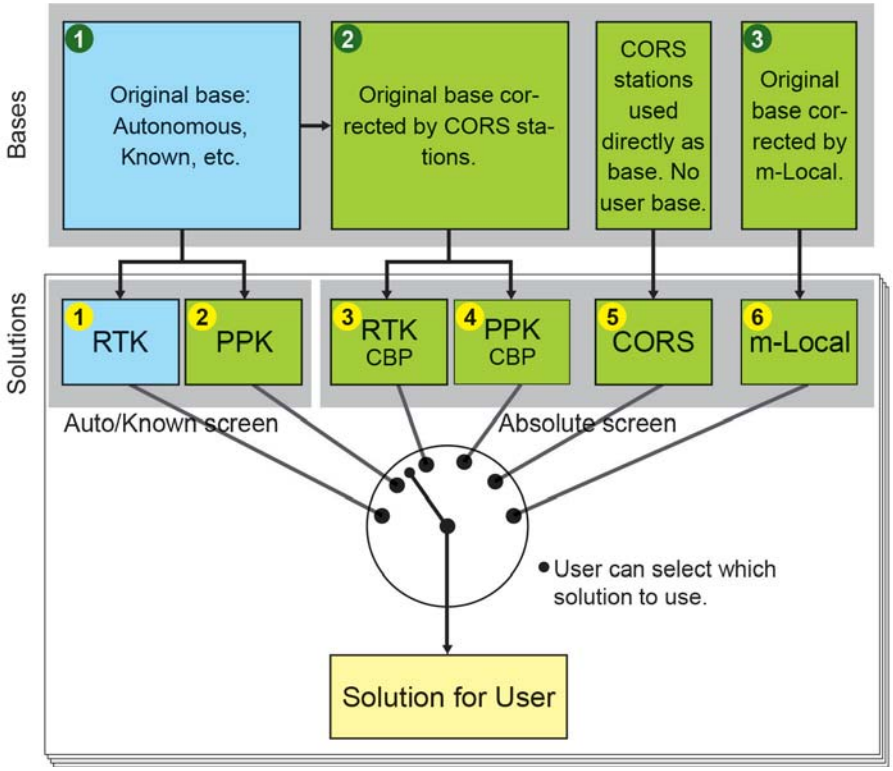
We have shown many J-Tip internal details to show the sophistication embedded in it. Its operation is much easier than conventional magnetic locators.



2
Start Base

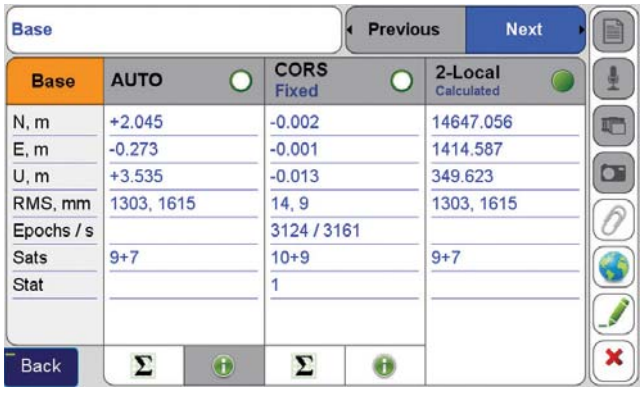


After your field work, sip your favorite drink... ...while we fill the other 5 buckets.



Mount your base on your car, park it in any unknown location and start the base. Perform your RTK work. Then download the base data in your TRIUMPH-LS rover. We will do the rest as follow:

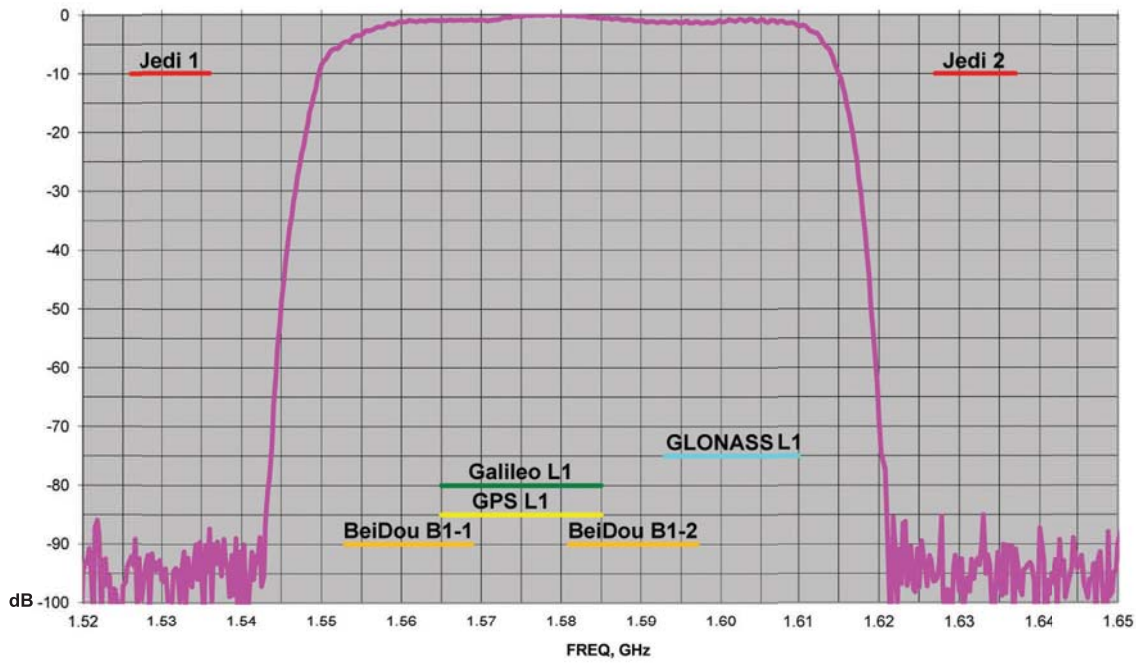
TRIUMPH-LS will send the base data to DPOS, which will process it with CORS stations, and will determine the accurate position of the base and then corrects all of your rover points. DPOS also post processes the rover data and ensures that RTK solutions were correct and applies the base corrections to these solutions as well.

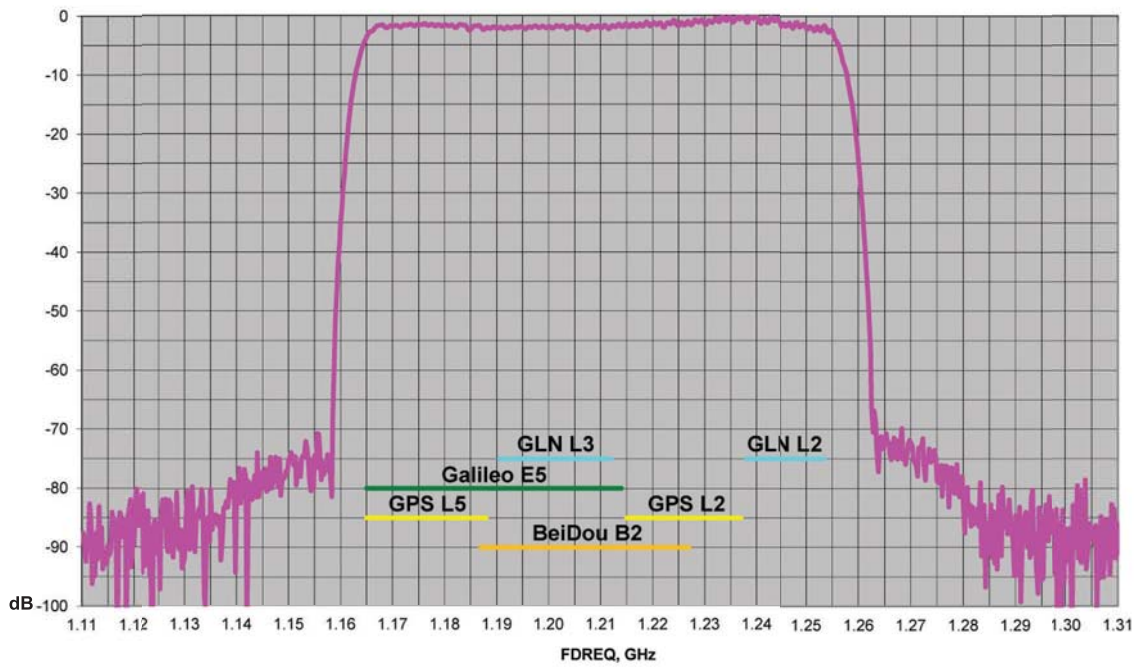


Initial base position can also be corrected by the rover occupying one or more known positions. This screen shows the initial and corrected positions of the base both by CORS and by m-Local known rover occupations.

All rover positions (initial RTK, Post Processed, corrected with CORS and corrected with m-Local) are shown in this screen. User can select the desired solution. Statistics and differences are shown as well.

If the **Jedi** returns
J-Shield is ready for it!





J-Shield in TRIUMPH-LS protects all GNSS Bands

Improved concepts of using natural targets for geo-monitoring

Based on data acquired by a single total station of a landslide area in the Bavarian Alps, three different analyzing concepts are described and evaluated. These methods use images, point clouds, and a fused approach of both data types

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Due to the increasing probability of rock falls and landslides caused by environmental change, the necessity for monitoring of geo-risk areas is growing. In particular, the degradation of mountain permafrost will be a challenge of the future.

In Europe, case-by-case services in the area of geo-risk monitoring and management are mainly provided by small and medium-sized enterprises. Most projects are based on conventional techniques, like Terrestrial Positioning Systems (TPS), Terrestrial Laser Scanners (TLS), (Stereo) Photogrammetry, Global Navigation Satellite Systems (GNSS), or/and geotechnical methods. As shown in Wagner et al. (2014), the geodetic methods generally differ from each other in cost, spatial and temporal resolution, range, dependence from weather or light conditions, energy, communication link requirements, as well as in the necessity to access the possibly endangered surveillance area.

Due to the rapid hardware development most of these techniques/sensors are already unified in a single (universal) instrument (Wunderlich et al. 2014): a modern total station. These devices are equipped with a multitude of sensors for accurate angle and distance measurements to prisms and less precisely to nearly any other surface, tilt correction by 2-axis inclinometers, automatic target recognition and tracking, GNSS positioning, overview and telescope cameras, as well as a scanning function with up to 1000 points per second. This enables us to develop entirely new measurement approaches for surveying tasks and, especially, for (geo-)monitoring projects, where repeated measurements of artificial or natural structures have to be performed. The integration of cameras and the increasingly faster scanning capabilities in modern total station allow us to replace signaled artificial control points by (non-signalized) natural objects. This provides several advantages: No artificial targets have to be placed on-site/on the object which saves equipment and installation costs and prevents access of endangered areas. The observation range of the system can easily be expanded to additional areas without any installation. Depending on the natural features used, an area-based dense acquisition is possible. In total, a higher flexibility and a faster system setup is provided.

At the Technical University of Munich (TUM) - Chair of Geodesy, different geo-monitoring approaches have been and are continually being developed. Most of them are based on modern scanning and image assisted total stations, which are described briefly in this paper.

Modern total stations

The introduction of electronic total stations has already changed the survey processes and the methodology enormously. For example, the electronic data flow, reflectorless (RL) measurements to any surface, and motorized axes have reduced the size of survey teams from previously three or more persons to a single one. The result is a more economic surveying, not necessarily a more enjoyable.

Yet another innovative step forward is the ongoing integration of camera chips and the implementing of scanning functions in the devices. Currently all major manufacturers of total stations have released instruments

with at least one integrated camera. These devices are commonly referred to as Image Assisted Total Stations (IATS). Instruments of the Leica Nova and Topcon Imaging Station series further provide an additional coaxial camera which benefits from the magnification of the telescope, resulting in a very high spatial resolution of the images, especially compared to the additional built-in wide angle overview cameras. An overview of all current commercially available IATS is given in Wagner (2016).

Each image taken by a calibrated total station camera is accurately geo-referenced and oriented. It can be immediately used for direction measurements with no need for object control points or further photogrammetric orientation processes. Currently, the camera images are only used to ergonomically optimize the standard measurement procedure, e.g. by replacing the view through the telescope and/or to transfer it to the range pole via remote control. Furthermore, the image and video function is used as a support capacity for the standard field survey tasks of a total station. In detail these are:

- documentation,
- aiming support,
- overlay of the live video stream with measurements, planning data or sketches,
- photogrammetric post processing,
- scan area selection,
- georeferenced photo texture,
- very simple edge and point detection.

The last three items are implemented to support the scanning function of the devices (if available). In most cases, this scanning function is only an automation of subsequent single RL point measurements. However, recently an instrument with a scan rate of up to 1000 points per second was released. This frequency is comparable to that of a laser scanner of the first generation, such as the Cyrax 2500. It is now possible to generate dense 3D point clouds of the surveillance area in addition to the normal survey task and further to develop new survey and analysis concepts, such as those as described later in this article. It is merely a matter of time until other manufacturers attain comparable scan rates for their total stations.

Test site Aggenalm

The Aggenalm landslide in the Sudelfeld region of the Bavarian Alps near Bayrischzell has been used as an outdoor laboratory for various geo-deformation measurement systems and prototypes since 2007. The slide has been active since 1935; the last big event happened in 1997, when a debris flow originated from the landslide area after extreme precipitation. Currently, displacement rates with a magnitude of 1-2 cm per year makes it ideal for research activities (Thuro et al. 2010).

In the alpEWAS project (Development and Testing of an Integrative 3D Early Warning System for Alpine Instable Slopes, funded by the BMBF R&D program "Geotechnologien II" 2007-2010), several innovative measurement systems were evaluated, consisting of low-cost GNSS modules, time-domain-reflectometry in-hole measurements (TDR), and image assisted tacheometry. Various measuring devices and infrastructure elements have been installed in the area, as shown in Figure 1. A main sensor node is set up at the center of the monitoring area, including a measurement pillar for surveying instruments, 230V power supply, a weather station, and a webcam. Remote sensing technologies are tested with fixed installed corner reflectors. In the surrounding area – distributed at geologically stable areas – a small number of control points are marked, which can be signalized with survey prisms.

This makes it possible to do time-discrete epoch measurements in intervals of several months or even years, as well as to run a permanent monitoring system or experiment. These surveys are always comparable, as the same geodetic reference datum can be used. The resulting spatial displacement vectors of observation points can further be verified by a classical deformation analysis.

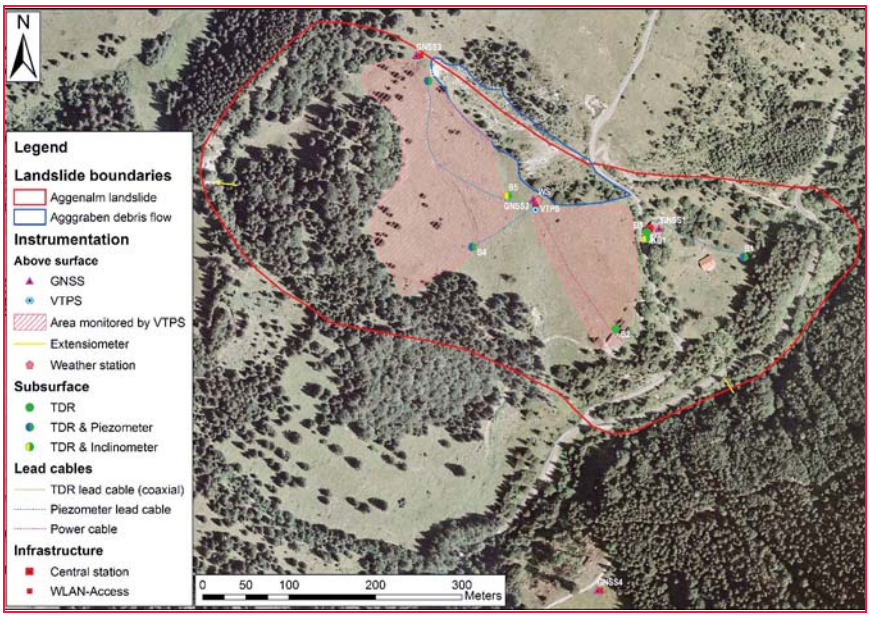

Figure 1: Orthophoto of the Aggenalm Landslide (red boundary) and the 1997 debris flow (blue boundary) superimposed by the elements installed and used during the alpEWAS project (Singer et al. 2009).

Image-based approach

During the previously mentioned alpEWAS project, the first approach of using an IATS prototype for geo-monitoring was developed. The aim was to detect slope movements without artificial targets (i.e. reflectors) solely by monitoring natural objects. This is helpful in particular to avoid the loss of target points by destroyed reflectors, e.g. by grazing livestock, which frequently happens in the Alpine region. Further, the observation range of the system can easily be expanded to additional areas without any installation effort, e.g.

when critical areas are not identified at the beginning of the monitoring task.

In the Aggenalm case, single distributed boulders, lying on the slope and being shifted by a possible slope movement, have been identified as appropriate objects (Figure 2). A prototype of an Image Assisted Total Station was used as measuring device, positioned on the pillar at the main sensor node (labeled as VTPS in Figure 1). The system was designed to automatically measure signalized stable control points to (re-)calculate the position and orientation. As object points, images of the boulders were taken and using image processing techniques these were matched with predefined templates. If a correspondence was found, the reference point of the template was precisely aimed by the instrument and a reflector-less distance measurement was initiated. As a result, a 3D coordinate of the natural target can be calculated and, in case of a movement between subsequent epochs, a spatial displacement vector can be specified.

Edge-based template matching and radiometric operators have been tested as image processing algorithms in the project. In the course of the measurement epochs, performed over four years, a limited set of natural targets could be tracked, but with decreasing matching success in the progressive project flow (Thuro et al. 2010). As limitation factor of such natural scenes, bright sunlight and refraction effects were identified. The images appear blurred and sharp object boundaries are lost against the meadow in the background. In our case, only structures on the boulders themselves (i.e. mainly lichens/fouling) were detected reproducibly and could be re-measured and observed during the project runtime.

Figure 2: Aggenalm Landslide – Alpine pasture with distributed boulders which are used as natural targets.

The conclusion of the project is a basic suitability of Image Assisted Total Stations for geo-monitoring using natural targets, provided that the imaging component is further supported by additional information, e.g. coming from laser scans.

Scan-based approach

In a different approach, automatically generated and orientated point clouds are used. Comparable to image features in computer vision; geometric features are used to find correspondences and to detect displacements in this method. The approach is still under development but we want to present first experiences, as we have strong expectations regarding this analyzing strategy.

Using TLS as an acquisition sensor is well suited to the task of geo-monitoring, as it is an area-based measurement system. Comparable data can now be determined by the scanning function of modern total stations. This makes it possible to use of the same analyzing methods with both sensors. One very common method is to detect deformations and changes in multi-temporal point clouds by a simple calculation of Euclidian distances between nearest neighbor points in two epochs. However, this method bears certain disadvantages. In subsequent point cloud epochs, no discrete points are measured. Instead, the object surface is sampled at different positions in ever successive scan. This may lead to apparent deformations in the range up to half of the scan resolution at the object. To avoid this problem, the point-to-point distance calculation is mostly performed only in the local normal direction, with a meshed or reconstructed reference surface being a compulsory requirement. As a consequence, the deformation analyses provide only one-dimensional displacement information which is most sensitive to distance changes in the line of sight. To derive real 3D object movements, expert knowledge for the data interpretation is necessary. Other methods are: using matching algorithms, like Iterative Closest Point (ICP) (Besl and McKay 1992; Chmelina et al. 2012), Least Squares 3D Surface Matching (LS3D) (Gruen and Akca 2005) or Gauss-Helmert LS3D (Ge and Wunderlich 2016) to derive transformation parameters (for sub regions) of the surveillance area.

In our new approach we want to derive deformation parameters from point clouds by using geometric features. Either all points or a preselected subset of "interesting" points are converted into a descriptor. Simplified, this means a numerical vector that intends to (uniquely) encode the individual point characteristics and its local spatial neighborhood. These descriptors, extracted from two point clouds, are matched to find correspondences and possible displacements. This procedure is equivalent to feature matching algorithms in computer vision, e.g. SIFT (Lowe 2004) or SURF (Bay et al. 2006).

In 2D as well as in 3D space, an endless number of features exist. In 3D, mostly the local structure in the spatial neighborhood around a point is described, e.g. the adjacent points inside a sphere with a given radius or a voxel with a defined edge length. This can be done with characteristics of the 3D covariance matrix (3D structure tensor), such as the ratios of the eigenvalues or eigenvectors (Weinmann et al. 2014). Another approach is using the local curvature around the point by a multi-dimensional histogram of values (Flint et al. 2007; Rusu et al. 2008; Scovanner et al. 2007).

Most applications using 3D feature matching are developed in the computer vision and robotics community, in conjunction with (artificial) indoor scenes. To transfer these features to be used in natural scenes with diffuse, random structures, some work is still necessary. We need to develop more unique features which can be reliably found in the point clouds of

both epochs. At the moment we are testing multiple feature types, their combinations, and the most suitable neighborhood radius and respective voxel sizes. So far we have been able to reliably segment different types of objects, such as stones from vegetation, as in our Aggenalm scenery (Figure 2). This is used as preliminary step for further processing, which can be concentrated only on selected parts of the data.

In the future, we will integrate radiometric properties into these feature vectors obtained by laser scanners (intensities), cameras (color), or a combination of both, like a scanning IATS as described.

Fused approach based on image and scan data

Based on experience of the previous mentioned methods, in particular on the research project "alpEWAS", we developed an approach to analyze fused image and scan data. The release of a new total station with integrated overview and telescope cameras and the aforementioned scanning ability of up to 1000 points per seconds further supported this idea. In this approach, movements will be uncovered by generating 3D displacement vectors of subsequent epochs using RGB+D images. The measurement device, a single modern total station, acquires images and point clouds of the monitoring area. The single images are projected onto a sphere, whose center point is defined by the instruments station. The angle value of one pixel defines the resolution of the final spherical panorama. If the instrument's resolution (in our case: 0.61 mgon) is used, the resulting panorama will be generated in full resolution. Smaller values lead to up-sampled panoramas, larger values result in lower resolution panoramas, which speed up the further processing but limit the final accuracy. To compensate vignetting effects, each image is brightened at the border region to generate a smooth blended panorama. A panorama stitching by image processing methods is not necessary, as the high accurate exterior orientation of each single image – determined by the total station – can be used directly. The image coordinates of the spherical panorama correspond directly to theodolite angular values. Needless to say, an appropriate image-theodolite system calibration is necessary for all these steps, e.g. as proposed by Walser (2004), Vogel (2006) or Wasmeier (2009).

In the following step, the scanned 3D points of the total station get projected into the previously generated spherical panorama. For each image pixel the respective obtained distance from the station is converted into a grey or color value, forming a depth image – the D-channel of the RGB panorama image. The projection of the point cloud first results in an irregular grid of 2D points. These points need to be interpolated into a regular grid with the same grid dimensions of one panorama pixel.

Figure 3 shows an RGB+D image taken at the Aggenalm test site. It is a spherical panorama consisting of 9x7 single images which are blended into each other. The x-axis is given in angular values, representing horizontal theodolite angles, the y-axis the respective vertical angle values. Together with the D-channel (partly superimposed in the center of Figure 3) a 3D polar coordinate can be determined for each pixel.

In the proposed monitoring approach, multiple measurement epochs (RGB+D images) are generated in permanent or periodical operation mode. If corresponding points are found in subsequent RGB+D images, 3D displacements can be directly determined. Such correspondences can be found by using any kind of image matching method, such as intensity-based, feature-based, relational or global/dense matchers. All of these methods detect 2D pixel displacements which can be transformed into the 3D space by the D-channel of both RGB+D images. If additional stable control points are measured by standard surveying methods, e.g. points signalized with prisms, a further geodetic deformation analysis can be calculated. Figure 4 summarizes the single processing steps in a sequence diagram.

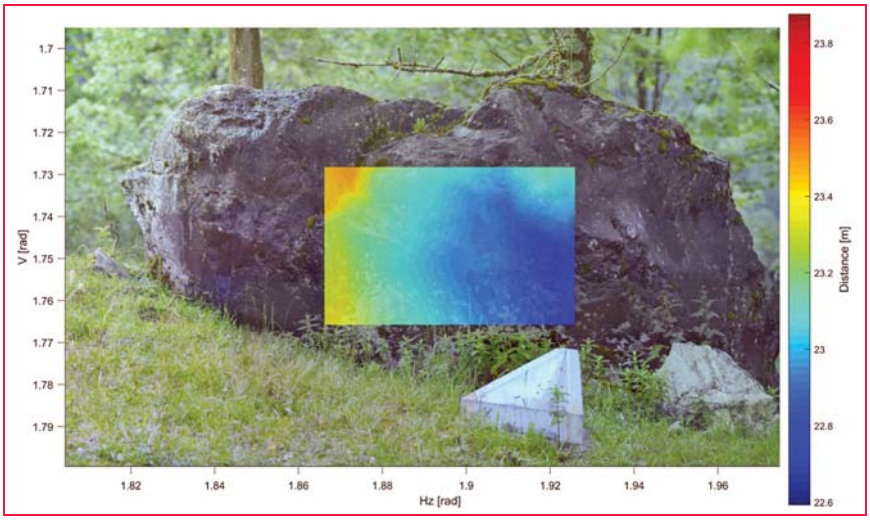

Figure 3: Spherical panorama composed of 9x7 telescope camera images using a Leica MS50. Column pixel coordinates correspond to horizontal angles, rows to vertical angles of the theodolite. A part of the scene is superimposed (faded) by the color coded D-channel, which represents the distance from the station to the respective pixels.

The main advantage of this approach is the fused analysis of image and scan data. Using RGB+D images combines the advantages of both acquisition methods (imaging and scanning) to detect displacements. In contrast to a pure comparison of point clouds, such as those determined by TLS, object movements perpendicular to the line of sight can be reliably uncovered as additional image information is used. Movements in line of sight, on the other hand, can also be detected. This would not be possible if only a single camera system was used. This method will be the first that makes use of the full potential of modern total stations by utilizing different sensor data in a combined approach. A more detailed description of the approach can be found in (Wagner 2016).

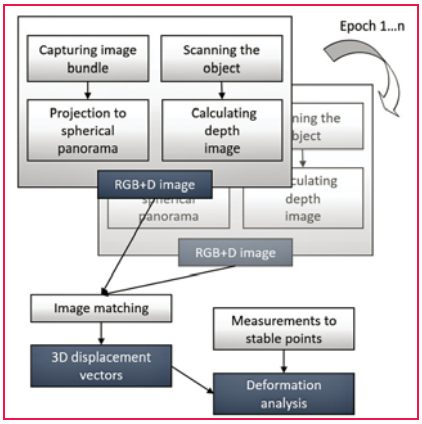

Figure 4: Sequence diagram of the new geo-monitoring approach based on RGB+D images (Wagner 2016).

Summary

In this paper we presented three different approaches to use natural targets for geo-monitoring. All of these methods have been tested, or are still under development at the Aggenalm landslide. The test site there is used as an outdoor laboratory for various geo-deformation measurement systems and prototypes. The data of all methods presented can be acquired by modern total stations, which combine standard surveying features with image analysis and scanning functions.

So far, only the last mentioned method delivers reliable outcomes. In the first mentioned image-based method, the reliability of the object recognition was too low. With the benefit of hindsight, other image analysis algorithms, like template or feature matching, would have been the better choice. The second approach is a very promising one – even though it does not yet provide the desired results. Different object types can already be segmented from each other, which can be preliminary work for other analysis steps. We are confident that we will be able to track natural objects by analyzing geometric features more reliable in the future. The last presented method: using a fused analysis of image and scan data, can be seen as a continued development of the first approach, while overcoming the disadvantages mentioned. The next logical step is to further incorporate the second (scan-based) approach. We plan to generate feature vectors consisting of scan and image elements and thereby extend/combine both approaches.

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The Gravimetric Quasigeoid Model UGQ2014 for Uganda

In this paper the Gravimetric Quasigeoid Model UGQ2014 for Uganda is computed using the KTH Method based on a combination of terrestrial and satellite gravity data

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For many developing countries such as Uganda, the potential of GNSS has not been fully exploited due to the absence of accurate regional gravimetric quasi-geoid models. This means that the ellipsoidal heights, which are geometrical heights cannot easily be transformed into the physically meaningful normal heights which are required for most of the surveying/engineering applications. For many of these countries geoid determination is difficult due to the insufficient quantity and quality of terrestrial gravity data. However, new advances in geoid computation techniques coupled with the availability of gravity data from GRACE and GOCE satellite missions have made it possible to determine accurate regional geoid models based on a combination of terrestrial and satellite gravity data.

The gravimetric quasigeoid can be computed either directly by using the modified Stokes formula or indirectly by computing the gravimetric geoid first and then determining the quasigeoid-to-geoid separation, which is then used to determine the quasigeoid. In this paper we use the later technique to the determine the quasigeoid over Uganda (UGQ2014) based on the Uganda Gravimetric Geoid Model 2014 (UGG2014) which was determined using the Least Squares Modification of Stokes formula with additive corrections (Ssengendo, et al., 2015a).

Principles of gravimetric geoid determination based on the KTH method

The Least Squares Modification of Stokes formula with additive corrections, commonly called the KTH method was developed at the Royal Institute of Technology (KTH) Division of Geodesy and has been presented in various studies and versions over the years; see e.g. Sjöberg, 2003a. For completeness only the basic formulas are presented in this paper. Compared to other methods, this method is superior because it is the only method that minimizes the expected global mean square error of the estimated geoid height. Hence, in contrast to most other methods of modifying Stokes' formula, which only strive at reducing the truncation error, the KTH method matches the errors of truncation, gravity anomaly and the Global Geopotential Model (GGM) in a least squares sense based on the Least Squares Estimator for the geoid height, which is given by Sjöberg (2003b) as

$$N^{L,M} = \frac{R}{4\pi\gamma}\iint_{\sigma_0} S^L(\psi)\Delta g\, d\sigma + c\sum_{n=0}^{M}\left(Q_n^L + s_n\right)\Delta g_n^{GGM} + \delta N_{comb}^T + \delta N_{dwc} + \delta N_{tot}^a + \delta N_{tot}^e \quad (1)$$

where σ_0 is a spherical cap, R is the mean Earth radius, γ is mean normal gravity on the reference ellipsoid, $S^L(\psi)$ is the modified Stokes' function, $c = R/2\gamma$, S_n are the modification parameters, M is the maximum degree of the GGM, L is the maximum degree of modification, Q_n^L are the Molodensky truncation coefficients, Δg is the unreduced surface gravity anomaly, Δg_n^{GGM} is the Laplace surface harmonic of the gravity anomaly determined by the GGM of degree n. This is the so-called combined estimator which means that the truncated Stokes' formula is applied to the unreduced surface gravity anomaly after which the final geoid height is determined by adding a number of additive corrections (Sjöberg, 2003b) highlighted below;

The combined topographic correction is computed as (Sjöberg 2001)

$$\delta N^{T}_{comb}(P) = -\frac{2\pi\mu}{\gamma}\left(H^2(P) + \frac{2}{3}\frac{H^3(P)}{R}\right) \quad (2)$$

where P is the computational point, H is the topographic height, μ is the product of the gravitational constant (G) and the standard topographic density (ρ), i.e. $\mu = G\rho$.

The downward continuation (DWC) correction can be written as (Sjöberg 2003b)

$$\delta N^{L}_{dwc} = \delta N^{B,L}_{dwc} + \delta N^{te,L}_{dwc} \quad (3)$$

where $\delta N^{B,L}_{dwc}$ and $\delta N^{te,L}_{dwc}$ are the Bouguer shell effect and terrain effect, respectively , given by

$$\delta N^{B,L}_{dwc} = \delta N^{B}_{dwc} + c\sum_{n=2}^{\infty}\left[\left(\frac{R}{r_P}\right)^{n+1} - 1\right]\left(s^{*}_{n} + Q^{L}_{n}\right)\Delta g_n \quad (3a)$$

with

$$\delta N^{B}_{dwc} \approx \frac{H(P)\Delta g(P)}{\gamma_0} + 3\frac{H(P)}{r_P}\zeta_P - \frac{H^2(P)}{2\gamma_0}\left(\frac{\partial \Delta g(P)}{\partial H}\right) \quad (3b)$$

and

$$\delta N^{te,L}_{dwc} \approx \frac{R}{4\pi\gamma_0}\iint_{\sigma_0} S^{L}(\psi)\left(H_P - H_Q\right)\left(\frac{\partial \Delta g}{\partial H}\right)_{Q} d\sigma_Q \quad (3c)$$

In the equations above, P and Q are the point on the Earth's surface and the running point on the sphere, respectively, $r_P = R + H(P)$, ζ_P is defined by Bruns' formula, i.e. $\zeta_P = T_P/\gamma$ where T_P is the disturbing potential for point P and γ is the normal gravity at the normal height of point P and Δg_n is the Laplace harmonic in the sum in Eq. (3a) taken from a GGM, which requires the upper limit of the sum to be set equal to or below its maximum order.

Following Sjöberg and Nahavandchi (2000), the combined atmospheric correction can be computed as

$$\delta N^{a}_{comb} = \frac{\delta V^{a}_{0}}{\gamma} - \frac{2\pi R\rho_0}{\gamma}\sum_{n=2}^{M}\left(\frac{2}{n-1} - s_n - Q^{L}_{n}\right)H_n(P) - \frac{2\pi R\rho_0}{\gamma}\sum_{n=M+1}^{\infty}\left(\frac{2}{n-1} - \frac{n+2}{2n+1}Q^{L}_{n}\right)H_n(P) \quad (4)$$

where δV^{a}_{0} is the zero-degree term of the atmospheric potential, ρ_0 is the atmospheric density at sea level, H_n is the Laplace surface harmonic of degree n for the topographic height and either

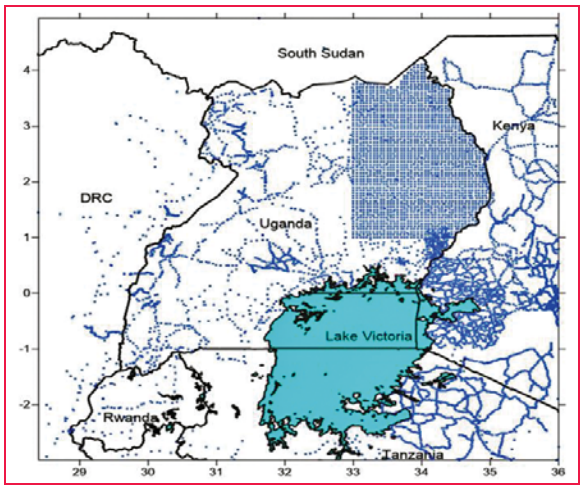

Figure 1: Distribution of gravity data over Uganda and parts of the neighbouring countries (BGI gravity database).

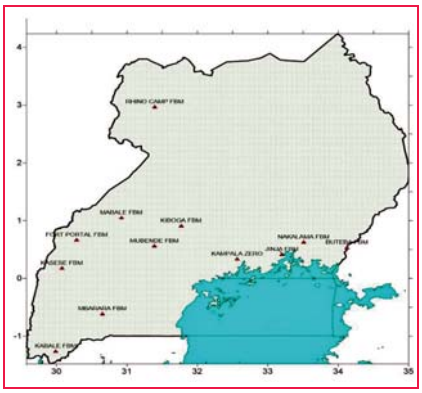

Figure 2: The GNSS/Levelling benchmarks

$s_n^* = s_n$ if $2 \le n \le M$ or $s_n^* = 0$ otherwise.

The ellipsoidal correction to order e^2 of the modified Stokes formula is given by Sjöberg (2004) as

$$\delta N_{total}^{e,L} = \frac{R}{2\gamma}\sum_{n=2}^{\infty}\left(\frac{2}{n-1} - s_n^* - Q_n^L\right)\left(k\Delta g_n + \frac{a}{R}\delta g_n^e\right) \quad (5)$$

where δg_n^e is the Laplace harmonics of the ellipsoidal correction to the gravity anomaly, which can be decomposed into a series as shown by Sjöberg (2004), $k = a/R–1$ is a scale factor and a is the semi-major axis of the reference ellipsoid.

Geoid modelling database

The validation and evaluation of the several datasets required for geoid modelling is discussed in detail in Ssengendo, 2015. For completeness, we only highlight the data used in brief.

Gravity Anomaly Data

Terrestrial gravity data was downloaded from the BGI gravity database (*http://bgi.omp.obs-mip.fr/data-products/Gravity-Databases/Land-Gravity-data*). As shown in Figure 1, the data covers the area which lies between $3^\circ S \le \varphi \le 5^\circ N$ in latitude and $28^\circ \le \lambda \le 36^\circ$ in longitude. 7839 gravity points were obtained with 812 points identified as outliers and then removed from the gravity database. Using the Bouguer gravity anomaly the surface gravity anomalies were converted into reduced gravity anomalies, which are assumed to be smoother than the original surface gravity anomalies. This technique was used to overcome the challenge of interpolating unreduced gravity anomalies since the KTH method works on the full gravity anomaly without any reduction (Sjöberg, 2003b). Then the reduced gravity anomalies were interpolated to a denser grid and finally the effect of the topographic masses were removed from the Bouguer anomaly grid resulting in to free-air anomalies. The final grid at a resolution of $1' x 1'$ was constructed using the method of Kriging with linear variograms.

Digital Elevation Model

The digital elevation model SRTM3 version 4.1 from the Consortium for Spatial Information of the Consultative Group of International Agricultural Research, Italy (*http://www.cgiar-csi.org/data/srtm-90m-digital-elevation-database-v4-1*) was used as it had the best quality in Uganda when compared to the ASTER DEM.

Global Geopotential Models

For the computation of UGG2014, we used the GOCE-only GGM GO_CONS_GCF_2_TIM_R5 up to degree 280 since it had the lowest standard error of all GGMs evaluated with GNSS/Levelling data.

GNSS/Levelling

GNSS observations using Trimble R7 GNSS receivers were carried out carried out on 12 Fundamental Benchmarks (FBM) of the Uganda vertical network, whose normal-orthometric heights were readily available from

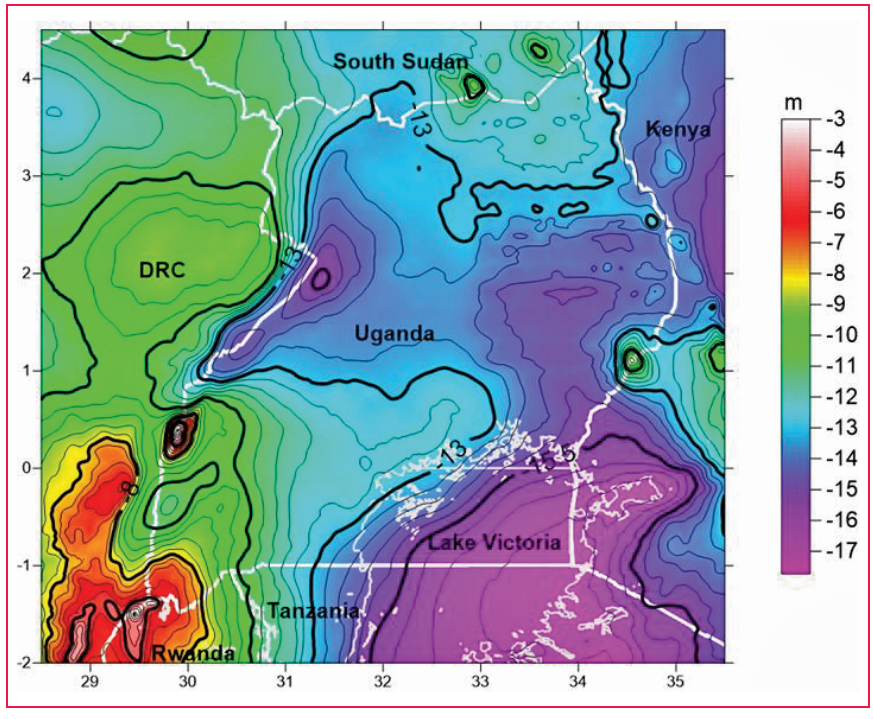

Figure 3: The Uganda Gravimetric Quasi-geoid model 2014 (Contour interval = 0.5 m)

Table 1: The GNSS/levelling residuals over 12 GNSS/levelling points before and after the 4-parameter fit (units: cm)

Model		Min	Max	Mean	Standard deviation	RMSE
UGQ2014	Before	-30.5	14.6	-8.6	12.8	**14.9**
	After	-17.5	14.4	0.0	8.1	**7.7**
UGG2014	Before	-14.6	36.8	9.3	13.2	**15.7**
	After	-15.6	13.6	0.0	9.1	**8.7**

the National Mapping Agency (see Figure 2). The ITRF08 coordinates of the 12 points were computed using the Bernese software version 5.2.

The Uganda Gravimetric Geoid Model 2014

Based on Eq. (1), UGG2014 was computed using the datasets highlighted above. Its internal accuracy based on error propagation was estimated as 11.5 cm whereas the external accuracy based on comparison with the 12 GNSS/Levelling points shown in Figure 2 was estimated as 15.7 cm and 8.7 cm before and after the 4-parameter fitting respectively (Ssengendo, 2015).

Determination UGQ2014 and its evaluation

The gravimetric quasigeoid model shown in Figure 3 was computed using Eq. (6) below

> For developing countries, the accuracy of UGQ2014 represents significant progress towards the goal of determining cm-level gravimetric geoid/quasigeoid models

where N is the geoid height extracted from UGG2014, $(\zeta - N)$ is the quasigeoid-geoid separation which is computed from Eqs (7a, 7b & 7c) given by Sjöberg and Bagherbandi (2012)

$$\zeta - N = \frac{T(r_P,\Omega)}{\gamma_Q(\varphi)} - \frac{T^*(r_g,\Omega)}{\gamma_0(\varphi)} + \frac{V^t_{bias}(r_P,\Omega)}{\bar{\gamma}(\Omega)} \quad (7a)$$

$$\text{with } T^*(r_g,\Omega) = \sum_{m=-n}^{n} T_{nm} Y_{nm}(\Omega) \quad (7b)$$

$$V^t_{bias}(r_P,\Omega) = 2\pi G\rho'_0 \sum_{n=0}^{n_{max}} \sum_{m=-n}^{n} \left(H^2_{nm} + \frac{2}{3R} H^3_{nm} \right) Y_{nm}(\Omega) \quad (7c)$$

Here T is the disturbing potential at an arbitrary point (r,Ω), R is the Earth's mean radius, Y_{nm} are the fully normalized spherical harmonic functions of degree n and order m, T_{nm} are the fully normalized coefficients of the disturbing potential, n_{max} is the upper summation index of spherical harmonics, γ_Q is the normal gravity at the telluroid, γ_0 is the normal gravity at the reference ellipsoid, r_P is the geocentric radius of the surface point. $T^*(r_g,\Omega)$ in Eq. (7b) is the analytically continued external type harmonic series at the geoid where the true potential is not harmonic. The 3-D position is defined in the system of spherical coordinates (r,Ω), where r is the spherical radius and $\Omega = (\varphi,\lambda)$ is the spherical direction with the spherical latitude φ and longitude λ. $V^t_{bias}/\bar{\gamma}$ is the topographic bias which represents the error in the analytical downward continuation of the external gravitational potential inside the topographic masses (Sjöberg, 2007) where ρ'_0 is the mean topographic mass density and the terms

$\left\{\sum_{m=-n}^{n} H^i_{nm} Y_{nm}(\Omega) : i = 1,2,3,\ldots\right\}$ define the spherical height functions $\left\{H^i_n : i = 1,2,3,\ldots\right\}$; i.e.

$$H^i_n(\Omega) = \frac{2n+1}{4\pi} \iint_{\varphi} H^i(\Omega') P_n(t) d\Omega' = \sum_{m=-n}^{n} H^i_{nm} Y_{nm}(\Omega) \quad (8)$$

where P_n is the Legendre polynomial of degree n with $t = \cos\psi$ i.e. the cosine of the spherical distance between spherical directions Ω and Ω'.

UGQ2014 was then independently evaluated using the 12 GNSS/levelling points shown in Figure 2. The results of the evaluation before and after 4-parameter fitting are reported in Table 1 along with the evaluation results for UGG2014.

Compared to UGG2014, UGQ2014 fits GNSS/levelling better by approximately 1 cm in terms of RMS both before and after the 4-parameter fitting. This is most likely a result of the fact that the quasigeoid is theoretically the proper zero reference surface for normal-orthometric heights, which are the heights used in Uganda.

Conclusions

The main purpose of this paper was to present the gravimetric quasigeoid model UGQ2014 for Uganda. The 14.9 cm and 7.7 cm Root Mean Square Errors (RMS) obtained by UGQ2014 before and after the 4-parameter fit respectively are very satisfactory given the quality and quantity of the terrestrial data used. If the standard errors for the ellipsoidal and normal-orthometric heights are 2.2 cm and 1.0 cm respectively, then the standard error of UGQ2014 can be estimated as 14.7 cm and 7.3 cm before and after the 4-parameter fit. We can see that the 4-parameter model has reduced the standard error of UGQ2014 by 7.2 cm or 48% by absorbing the systematic biases most likely arising from the current state of UVN.

For developing countries, the accuracy of UGQ2014 represents significant progress towards the goal of determining cm-level gravimetric geoid/quasigeoid models. First it highlights the robustness of the KTH Method in determining accurate regional geoid models based on a least squares combination of terrestrial and satellite gravity. Secondly and perhaps most important is the ability to determine cm-level accuracy even with insufficient quantity and quality of the terrestrial gravity data. Here the example of Uganda is instructive as with one gravity data point for every 65 km^2, the approximately 7 cm accuracy of UGQ2014 is truly unprecedented. As part of future work, we anticipate that improvements in terrestrial gravity coverage as part of increased mineral exploration in the country will provide more gravity data that can be used to improve the accuracy of the gravimetric quasigeoid model. In addition more GNSS/levelling observations are needed so as to provide a much better homogeneous data set that can be used for validating and evaluating global and regional gravimetric quasigeoid models.

Acknowledgments

An earlier version of this paper was presented at the FIG Working Week in Sofia, Bulgaria, 2015. I am therefore gratefully to my co-authors for allowing me to use some of the results in that paper i.e. Ssengendo, et al., 2015b.

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Amendment in surveying, mapping law in China

The top legislature is considering amending the Surveying and Mapping Law to improve the management and sharing of China's geological data, according to a statement. The amended draft was submitted to legislators for its first reading at the bimonthly session of the National People's Congress (NPC) Standing Committee.

The law was formulated in 1992 and amended for the first time ten years later.

According to a statement from the Ministry of Land and Resources, the current rules on surveying and mapping are out of date, as technological advances have changed the way in which people interact with and access data.

Problems have arisen as a result of this new situation, including insufficient application and sharing of surveying and mapping results, as well as security risks due to satellite navigation and positioning reference stations, which make the need to amend the law all the more pressing, according to the statement.

According to the revised draft, the source and destination of geological information must be better managed, adding that measures should be taken to better integrate the various sources of geological data and improve the way in which it is shared and used. *www.shanghaidaily.com*

Ordnance Survey creates new data layer of hedges

373, 919km of England's farmland hedges have been accurately mapped to create a new digital dataset, OS Landscape Features Layer, which will be used by the Rural Payments Agency (RPA). The new dataset will play an important role in the Rural Payments Agency's administration of the Common Agriculture Policy (CAP)

The CAP Regulations require effective administrative controls to be established, and for hedges declared as Basic Payment Scheme (BPS) Ecological Focus Areas (EFAs), this means creating a control layer of mapped hedges against which subsidy claims can be checked. The aim of the project was to automate the identification and mapping of hedges in a repeatable business process using imagery and height data products, and producing consistent results that are far more effective than costly manual data capture.

The new system enables hedges to be identified and classified from high resolution aerial imagery and height information where OS digital mapping already shows field boundaries. The new technology is now fully embedded into the Ordnance Survey process with seamless updates being made on a daily basis. *www.ordnancesurvey.co.uk*

UN Member States participate in 3rd Plenary of UN-GGIM: Europe

More than 100 delegates representing 31 countries gathered in Budapest, Hungary recently for the 3rd Plenary of UN-GGIM: Europe. In addition, Member States approved the 2017 to 2020 work plan and requests for observer status from the Global Spatial Data Infrastructure Association (GSDI) and specialist IT consultancy, ConsultingWhere. Delegates also approved the appointment of Janusz Dygaszewicz from the Central Statistical Office, Poland to the UN-GGIM: Europe Executive Committee.

Chair of UN-GGIM: Europe Executive Committee, Bengt Kjellson from Sweden said: "Our aim is to build on existing frameworks in Europe by avoiding duplication of effort and encouraging data interoperability, harmonisation and sharing to optimise the overall management of geospatial information. *http://un-ggim-europe.org*

EuroGeographics and Kadaster renew agreement

EuroGeographics has renewed its Service Level Agreement with The Netherlands' Cadastre, Land Registry and Mapping Agency (Kadaster) to provide secretariat services for UN-GGIM: Europe. In addition to ensuring that relevant organisations in the European UN Member States and European Institutions are well informed about its activities, EuroGeographics also organises the annual plenary as well as Executive Committee and Working Group Meetings. *www.un-ggim-europe.org*

Supergeo partnership with GPS Lands Indonesia

Supergeo Technologies Inc has announced the partnership with PT. GPS Lands Indosolutions in Indonesia. Being an authorized distributor of Trimble for years, GPS Lands Indosolutions has rich experiences in serving, training, and supporting customers to accomplish various surveying works. *http://www.supergeotek.com*

East View launches MapVault

East View Geospatial (EVG) has launched MapVault™, a web-based subscription service providing access to a global collection of raster mapping. The scope of the collection that EVG offers is a first for the field of mapping. Subscribers to MapVault gain immediate access to hundreds of maps from global scale series, ranging from aeronautical charts produced by the US Government to locally-produced topographic maps covering specific countries around the world, such as Colombia, Botswana, Syria and Russia. *www.eastview.com*

Siemens and Bentley Systems advance strategic alliance

Siemens and Bentley Systems have announced that they have formalized a strategic alliance agreement to drive new business value by accelerating digitalization to advance infrastructure project delivery and asset performance in complementary business areas. Siemens and Bentley Systems will initially invest at least Euro 50 million in developing joint solutions to enlarge their respective offerings for infrastructure and industry to the benefit of the end-customers. This work will uniquely leverage new cloud services for a connected data environment to converge respective

digital engineering models from both companies. *www.bentley.com*

dpSpatial 7.8 by Digpro

Digpro, the major innovator in the field of Geographic IT, has launched its latest version of dpSpatial. Version 7.8 contains about 80 general improvements in the base platform. With its base platform dpSpatial, Digpro reaches longer than similar platforms when it comes to flexibility, integration and transparency in the public sector, both in traditional map production and new service-based methods for data exchange. *www.digpro.com*

Police to combat crime using GIS

The Fiji Police Force recently launched their GIS tool which would allow Police to store and analyse critical crime data and would assist them in putting in place targeted strategies to combat crime. The GIS Project would assist Police in instant crime analysis, development techniques, active enforcement, monitoring the emerging pattern and accountability programme for the managers. The project will be piloted first at the Samabula Police Station and later implemented at other Police Station Divisions around the country. *http://fijisun.com.fj*

No local mapping data in South Korea

South Korea has refused to use local mapping data offered by Google and held security reasons responsible for such decision. The refusal came following the Alphabet Inc.'s unit's request to the nation to utilise its global maps service.

Google is known for handling its map services at centers outside South Korea and it wanted the nation to share its data with it. The verdict of refusal has, therefore, imposed restrictions on the use of the map services by people living in the nation. The nation's government said that it would permit Google to use its mapping data if it would promise not to disclose information about the military facilities across the nation via its satellite maps. It requested the company to blur those parts for security reasons if they really desired South Korea to use the mapping services. *www.gamenguide.com*

India moots registry to vet geospatial data

The government is developing a national data registry that will require all agencies— state, private and academic — that collect and store geospatial data to share it with the registry. The registry will also serve as a source of "authenticated" information — meaning officials at the Survey of India would vet it for accuracy and see whether it contains information that contravenes national security.

Officials of the Department of Science and Technology (DST), the nodal coordinating agency, said the purpose of such a registry was to create a "catalogue" that would "prevent duplication" of data sets and help users locate the right agencies to source information. The registry will be a 'meta-data' repository: it will not actually be a source of geospatial data but will only inform about the nature of the data a service provider has. Thus, everyone from restaurant-location-service providers to hospital-location aggregators will have to comply with the directive, and the government may bring in legislation. The DST is soliciting vendors capable of developing such a database. *http://www.thehindu.com*

BRICS States agreed to Create Joint System of earth remote sensing

BRICS states agreed to create a joint satellite constellation for Earth remote sensing, Director General of the Russian State Space Corporation Roscosmos Igor Komarov said. Roscosmos said that representatives of the space agencies of BRICS member states discussed elaborating a document on sharing data obtained by the orbital groups of Earth remote sensing satellites and signed a memorandum on cooperation in space exploration for peaceful purposes at the meeting in the Chinese city of Zhuhai. *https://sputniknews.com*

New GNSS weather data sets from TechDemoSat-1

New weather datasets, which could prove highly valuable for weather forecasting and for longer term climate monitoring, have just been made available from the Space GNSS Receiver-Remote Sensing Instrument (SGR-ReSI) instrument on board TechDemoSat-1, a small technology demonstration satellite launched by Surrey Satellite Technology Ltd (SSTL) in 2014.

With support from the European Space Agency, SSTL and the National Oceanography Centre (NOC) are continuing to work on the data received from TechDemoSat-1 and have been steadily improving the calibration of the measurements and researching new techniques and applications.

Looking to the future, the NASA CYGNSS mission due to launch later this year will fly 8 satellites carrying SSTL's SGR-ReSI instrument, with the particular focus to measure the winds within cyclones, hurricanes and typhoons. The SGR-ReSI instrument was developed by SSTL and is able to calculate TechDemoSat-1's position and speed in much the same way as does a car-based SatNav, by measuring ranges and triangulating its position from high altitude GNSS satellites orbiting 20,000km above the satellite itself. The SGR-ReSI also carries a high gain nadir (downward-pointing) antenna to utilise a technique called GNSS reflectometry where the GNSS signals scattered off the Earth's surface are collected and measured.

GPS reflections are not only collected by the SGR-ReSI over the ocean, but over land too where measurements to date show strong variations that could contain valuable geophysical information about the land surface. For instance, healthy vegetation will absorb more of the signal whilst damp soil can cause stronger reflections. *www.merrbys.org*

GPS device mandatory for mineral transport vehicles in Odisha

The Odisha government, India has made it mandatory for all the mineral transporting

vehicles to install GPS devices as part of its effort to further streamline the mining activities in the state, a senior official said.

"We have asked all the vehicle owners engaged in transportation of minerals to install GPS devices by December 28. This will help the administration track movement of mineral carrying vehicles from the starting point till the port or plant," Director of Mines, Deepak Mohanty said a meeting of state-level task-force chaired by Chief Secretary A P Padhi. Once GPS devices are fitted in the vehicles, he said, one can easily locate the trucks, carrying minerals, and their route. *http://indianexpress.com*

Russia may launch up to 4 Glonass Navigation Satellites next year

Russia's Roscosmos space agency may launch up to four Glonass navigation satellites in 2017, Deputy Director General for Automatic Space Complexes Mikhail Khailov said on Monday. According to him, the launches will be carried out if operating satellites are out of order. *http://www.satnews.com*

China launches pulsar navigation satellite

China has launched a navigation satellite which will conduct in-orbit experiments using pulsar detectors to demonstrate new technologies. The X-ray pulsar navigation satellite, weighing more than 200 kilogrammes, was launched from the Jiuquan Satellite Launch Center in the country's northwest.

It was carried by a Long March-11 rocket, the 239th flight mission by a Long March carrier rocket series. While in orbit, the satellite will undergo tests on its detector functions and space environment adaptability. The satellite and the rocket were designed by academies affiliated with the China Aerospace Science and Technology Corporation, state-run Xinhua news agency reported.

The X-ray pulsar navigation will help reduce the spacecraft's reliance on ground-based navigation methods and is expected to lead to autonomous spacecraft navigation in the future.

FAA releases National Airspace System Navigation Strategy

The United States Federal Aviation Administration (FAA) has released its Performance-Based Navigation (PBN) National Airspace System (NAS) Navigation Strategy 2016, the result of a concerted year-long effort by FAA and aviation industry stakeholders. It describes how the FAA intends to transition U.S. NAS operations over the near- (2016–2020), mid- (2021–2025) and far-term (2025–2030) from predominantly point-to-point navigation, reliant on hundreds of ground-based navigation aids, to PBN-centric operations relying on systems and services supporting Area Navigation (RNAV) and Required Navigation Performance (RNP).

Performance-based navigation specifies the aircraft area navigation performance in terms of accuracy, integrity, availability, continuity and functionality needed to conduct specific operations in a particular airspace.

While promoting the PBN benefits of GNSS such as the GPS and the Wide Area Augmentation System (WAAS), the PBN Strategy also recognizes the need to maintain resilient PBN capabilities that remain unaffected in the event of GNSS interference, and that can continue to support PBN operations or provide safe navigation alternatives.

Itelma Selects OT to deliver connectivity for eCall

OT (Oberthur Technologies), a leading global provider of embedded security software products and services announced that Itelma, the biggest Tier 1 automotive equipment supplier in Russia, has selected OT to connect cars to ERA-GLONASS, the Russian emergency call system, and to VimpelCom, one the of the leading operators in Russia, for commercial services such as breakdown calls or stolen car recovery, remote control and diagnostics, fleet management, etc. *http://www.businesswire.com*

Pulse Electronics Introduces Off-the-Shelf Antennas

Pulse Electronics introduces three, ready-to-use, standard, wireless printed circuit board antennas for laptops, tablets, mobile devices, and devices that operate in a similar environment. The SH0319D/E/W family of antennas provides wireless signal reception ranging from dual-bands to multi-bands covering GPS, GLONASS, WLAN/dual-band WIFI, and GSM900/1800. The antennas are design-ready and can be directly integrated into various electronic devices as an evaluation antenna for use or performance evaluation. *http://antennas.pulseelectronics.com*

u-blox powers new smart bus solution

u-blox has announced its technology is powering a new smart bus solution from Baoruh Electronic in Taiwan which combines LTE-based telematics and Automated Fare Collection (AFC) for intelligent fleet management. The new POS One smart bus solution uses the NEO-M8U positioning module from u-blox for enhanced positioning accuracy thanks to acceleration and gyroscope sensors incorporated in this module. A TOBY-L280 cellular module transmits vehicle telematics and on-board payment transactions over a high speed LTE connection to back systems. An ELLA-W131 module provides additional Wi-Fi and Bluetooth connectivity for ease of access to vehicle data logs and video recordings. *http://iotbusinessnews.com*

Garmin® Introduces the GPSMAP® 64sc

Garmin has announced the GPSMAP 64sc, updating the popular line of rugged, button-operated outdoor handhelds with an 8MP camera complete with geotagging and flash functionality. The GPSMAP 64 series brings a dual GPS and GLONASS receiver, preloaded geocaches and smartphone connectivity1 to a product line already popular with hunters, hikers and geocachers of all ages, and the 64sc unit adds another reliable unit to the lineup. *http://www.garmin.com/outdoors*

Galileo update

Arianespace launches four new Galileo satellites for ESA

An Arianespace-operated Ariane 5 rocket has launched four more satellites under the European Space Agency's (ESA) Galileo.

Launched from Europe's spaceport in French Guiana, the satellites have extended Europe's ability in satellite-based navigation.

A total of 14 satellites under the Galileo programme were initially launched using the Soyuz Fregat rocket. ESA Galileo programme and navigation-related activities director Paul Verhoef said: "Now that we can rely on the powerful Ariane 5, we can anticipate the quicker completion of Galileo deployment, permitting the system to enter full operation."

Two more Ariane 5 missions of the programme are also planned to be launched over the next two years.
www.aerospace-technology.com

European Commission, GSA issue third call for Galileo, EGNOS R&D contracts

The European Commission (EC) has opened the third round of competition for €33 million (US$35.15 million) in Horizon 2020 (H2020) contracts for development of European GNSS (EGNSS) applications exploiting use of Galileo and the European Geostationary Navigation Overlay Service (EGNOS).

The third call targets four topics aimed at supporting innovative applications, products, feasibility studies, and market tests that "can have a substantial effect on development of European innovation know-how and economy." The categories and funding amounts are:

- GALILEO-1-2017: EGNSS Transport applications, €14.5 million
- GALILEO-2-2017: EGNSS Mass market applications, €9 million
- GALILEO-3-2017: EGNSS Professional applications, €8 million
- GALILEO-4-2017: EGNSS Awareness raising and capacity building, €1.5 million.

The deadline for submitting applications in March 1, 2017.

According to the European GNSS Agency, which is managing the call for bids, to maximize the adoption of Galileo and EGNOS, the third Horizon 2020 call focuses on the development of user-oriented, downstream applications. Priority is also given to projects capable of stimulating the competitiveness of the European GNSS downstream industry.

Proposals for EGNSS transport applications covering the aviation, road, maritime and rail market segments should be built on exploitation of the EGNSS signals and operational advantages, implementation of EGNSS based pilot projects and end-to-end solutions, standards, certification, legal and societal acceptance; and exploitation of synergies with other positioning and navigation systems and techniques.

EGNSS mass-market applications should foster the adoption of EGNOS and Galileo in such areas as the Internet of Things, smart cities, emergency services, and commercial and "social location-based services" (LBS). Proposals should make the best use of European GNSS features that improve performances in urban environments; multi-constellation, fusion with other positioning techniques; authentication services of Galileo, and techniques to optimize power consumption.

SNIPPETS

At a Glance

- Bluesky Geospatial Aerial Photos Update Irish Tourist Maps
- The Falcon Group has completed an acquisition agreement with Vantage Vertical, a nationwide drone aerial imaging services firm.
- Kerala to roll out Joint Action Plan on Space technology
- OTOC buys surveying business for $5m
- SimActive offers Correlator3D service support for Cloud
- HP launches new DesignJet Z-series printers in India
- CyberCity 3D announces partnership with DigitalGlobe, signs Integrator License Agreement
- City in Georgia opens GIS platform to citizens
- Pitney Bowes makes geospatial API available on AWS marketplace
- HERE to provide map data for Hexagon Smart M.App developers
- ULA launches WorldView-4 satellite for DigitalGlobe
- IoT sensors market expected to grow at 42.08% CAGR by 2022
- Esri donates Cloud-based GIS solutions to more than 30 schools
- Bentley Systems acquire ComplyPro for further expansion
- FARO's updated PointSense v17.5 accelerate workflows inside Revit, AutoCAD
- PerúSAT-1 delivers first images

Bundled Survey Solution for UAVs

Eos Systems, the developer of PhotoModeler, and Klau Geomatics, the developer of the KG PPK system, are launching an integrated and bundled system for high-accuracy survey for unmanned aerial vehicles (UAVs) while using minimal or no ground control points. The Klau Geomatics PPK System provides precise camera positions for aerial photography. Coupled with PhotoModeler's photogrammetry software, this is a solution with a great level of accuracy and reliability for survey-grade mapping applications.

The Klau Geomatics PPK is a lightweight plug and play box that can be installed on any UAV by end users or as an OEM product for manufacturers. Integrating PPK into a photogrammetry program provides a strong platform for obtaining very accurate drone-based surveys with minimal or no ground control input, greatly reducing the time and cost for accessing a site to place GCPs.

5G networks in cities using Drones

By using aerial photographs taken by drones and photogrammetry software, researchers created detailed 3D models of urban environments. These models could be used in designing radio links or 5G wireless connections. Remote-controlled drones can be used to create an accurate 3D model of an urban area and design wireless networks, scientists say, an advance that may help set up 5G mobile connections in a cost effective manner. The development of mobile devices has set increasingly high requirements for wireless networks and the emission of radio frequencies.

Researchers from Aalto University and Tampere University of Technology in Finland, recently tested their research work how aerial photographs taken using a so-called drone could be used in designing radio links. By using both the aerial photographs taken by the drone and a photogrammetry software, they were able to create highly detailed 3D models of urban environments. These models can be used in designing radio links. *http://punemirror.indiatimes.com*

Topcon to Distribute Intel Falcon 8+ UAS in North America

Topcon Positioning Group will distribute Intel Corporation's Falcon 8+ System, a V-shaped, eight-rotor unmanned aerial system (UAS) in North American markets.

The Intel Falcon 8+ features triple-redundant AscTec Trinity autopilot capability and has full electronic system redundancy. It also includes the Intel Cockpit ground control and Powerpack smart battery system.

Unifly acquires 5m Euros financing for international growth

Terra Drone (a major Japanese drone operator and system integrator) confirms its trust in the VITO spin-off Unifly by investing a total of 5 million euro together with Qbic and PMV. Terra Drone provides 80% of the total capital.

Unifly - the European leading provider of Unmanned Traffic Management (UTM) and Drone Operations Management software - will use the investment to accelerate its growth and to build an international sales organisation. Unifly is uniquely positioned to capture a large market share and to become a global player.

UAV's – a large part of the Kaikoura solution

New technology is allowing spatial data professionals to make instant assessments of damage to the roads and valleys caused by the South Island earthquakes.

UAVs mounted with specialised data capture cameras are the new surveying and mapping tools that have become readily available since the Christchurch quakes.

Immediately after the Christchurch earthquakes, land surveyors - who specialise in precise measurement - were critical to the urgent monitoring of building stability movement, determining by centimetres, the effect and changes in ground levels and resultant flooding. Spatial data managed by surveyors, spatial professionals and the construction sector has been a critical in the Canterbury rebuild, helping to re-establish services. Spatial professionals in Christchurch have proven how important this is and are taking lessons learned to provide a coordinated and effective response in Kaikoura.

The Inland Kaikoura Route is a road that winds through farming country west of Kaikoura and includes Culverden, Rotherham, the Waiau plains and Mt Lyford. It has been an absolute priority from the outset to get the road open so a basic traffic link to the outside world for the stoic people of Kaikoura and its surrounds can be provided.

Surveyors used a 1.8m span octo-copter to take a series of photos which were then further processed to provide 3d models of the major Rotherham land slip. There are of course, many slip and damaged areas to be flown, mapped and assessed with modelling experts to the forefront of this work. The outcome is something we can all be proud of that these communities are slowly reopening and recovering. *www.surveyors.org.nz*

DroneDeploy launches the first app market for drones

Cloud-based drone platform DroneDeploy has announced the opening of its App Market, the first drone industry app store. The store launched with more than 15 apps directed at businesses using drones. It also provides access to the world's largest data-set of drone 2D maps and 3D models.

The company's new App Market will provide a one-stop shop for businesses and developers to obtain apps for all aspects of cloud-based drone data analysis. *http://siliconangle.com*

New aerial site-mapping drones to assist solar market

Solar EPC firm TerraSmart has launched a new aerial drone that is expected to bring added precision, speed and cost-saving measures to the PV construction sector.

TerraSmart's High Precision Aerial Site Mapping service drones (HPASM) will utilise the latest autonomous technology to generate topographical data with unprecedented accuracy. With this new fleet of drones that are designed to speed up site mapping, it can spend less time out in the field assessing a potential develop site's area. These drones — which can cover an area of 20 to 32 hectares in an hour — can map, process images and develop a detailed site topography for a 5MW project in only 48 hours. *http://www.pv-tech.org*

Microdrones partners with Delair-Tech

Delair-Tech, a global provider of professional fixed wing UAVs, and Microdrones, the manufacturer of industrial-grade quadcopters, have signed partnership agreement with plans to develop new solutions that will provide greater value for professional drone users. *www.microdrones.com*

Adani Enterprises in India to make UAVs

Diversified conglomerate Adani Group's flagship firm Adani Enterprises Ltd will make unmanned aerial vehicles (UAVs) in joint venture with Israeli firm Elbit Systems. The joint venture company named Adani-Elbit Advanced Systems India Ltd (AEASIL) will be headquartered in Ahmedabad. *http://www.thehindubusinessline.com*

AT&T and NASA collaborate on drone traffic management system

AT&T and the National Aeronautics and Space Administration (NASA) are researching traffic management solutions for Unmanned Aircraft Systems (UAS).

The goal is an Unmanned Aircraft System Traffic Management (UTM) solution that supports the safe and highly secure operation of drones in the national airspace.

A key element AT&T and NASA are researching is the potential impact of cybersecurity threats. The vast availability of drones – and their many current and potential uses — could increase their risk of cyberattacks. *http://about.att.com*

H3 Dynamics launches HYWINGS electric unmanned aircraft

H3 Dynamics in Singapore and Austin, Texas, is unveiling a hand-launchable unmanned aerial vehicle (UAV capable of 10-hour flight durations and distances of up to 500 kilometers: HYWINGS.

HYWINGS, with a total take off-weight of just seven kilograms, can cover larger areas of land faster, while removing the need for catapult launchers or runways typically required by larger, heavier, and more expensive systems. *www.intelligent-aerospace.com*

Pix4Dmapper now with fully-automated DTM extraction

Pix4D has announced the implementation of some of its most successful academic research for DTM extraction into Pix4Dmapper. Using DSMs generated from high-resolution images, Pix4Dmapper algorithms can now detect bare earth, as well as compute and remove above-ground objects precisely without pulling the terrain height up for interpolation. This new approach gives the accurate terrain model elevation, instead of just visually removing objects.

RESOURCESAT-2A Remote Sensing Satellite launched

In its thirty eighth flight (PSLV-C36), ISRO's Polar Satellite Launch Vehicle successfully launched the 1235 kg RESOURCESAT-2A Satellite today morning (December 07, 2016) from Satish Dhawan Space Centre SHAR, Sriharikota. This is the thirty seventh consecutively successful mission of PSLV.

After separation, the two solar arrays of RESOURCESAT-2A deployed automatically and ISRO's Telemetry, Tracking and Command Network (ISTRAC) at Bangalore took over the control of the satellite. In the coming days, the satellite will be brought to its final operational configuration following which it will begin to provide imagery from its three cameras. The data sent by RESOURCESAT-2A will be useful for agricultural applications like crop area and crop production estimation, drought monitoring, soil mapping, cropping system analysis and farm advisories generation.

Like its predecessors RESOURCESAT-1 and 2, RESOURCESAT-2A has a unique 3-Tier imaging system with Advanced Wide Field Sensor (AWiFS), Linear Imaging Self Scanner-3 (LISS-3) and Linear Imaging Self Scanner-4 (LISS-4) cameras. The AWiFS provides images with a sampling of 56 metres, a swath of 740 km and a revisit of 5 days whereas the LISS-3 provides 23.5 metre sampled images with 141 km swath and a repitivity of 24 days. LISS-4 provides 5.8 metre sampled images with 70 km swath and a revisit of 5 days. *http://www.isro.gov.in*

Register by Jan 15, 2017 to receive the early rate!

GNSS-
IS IT TIME FOR BACKUP?

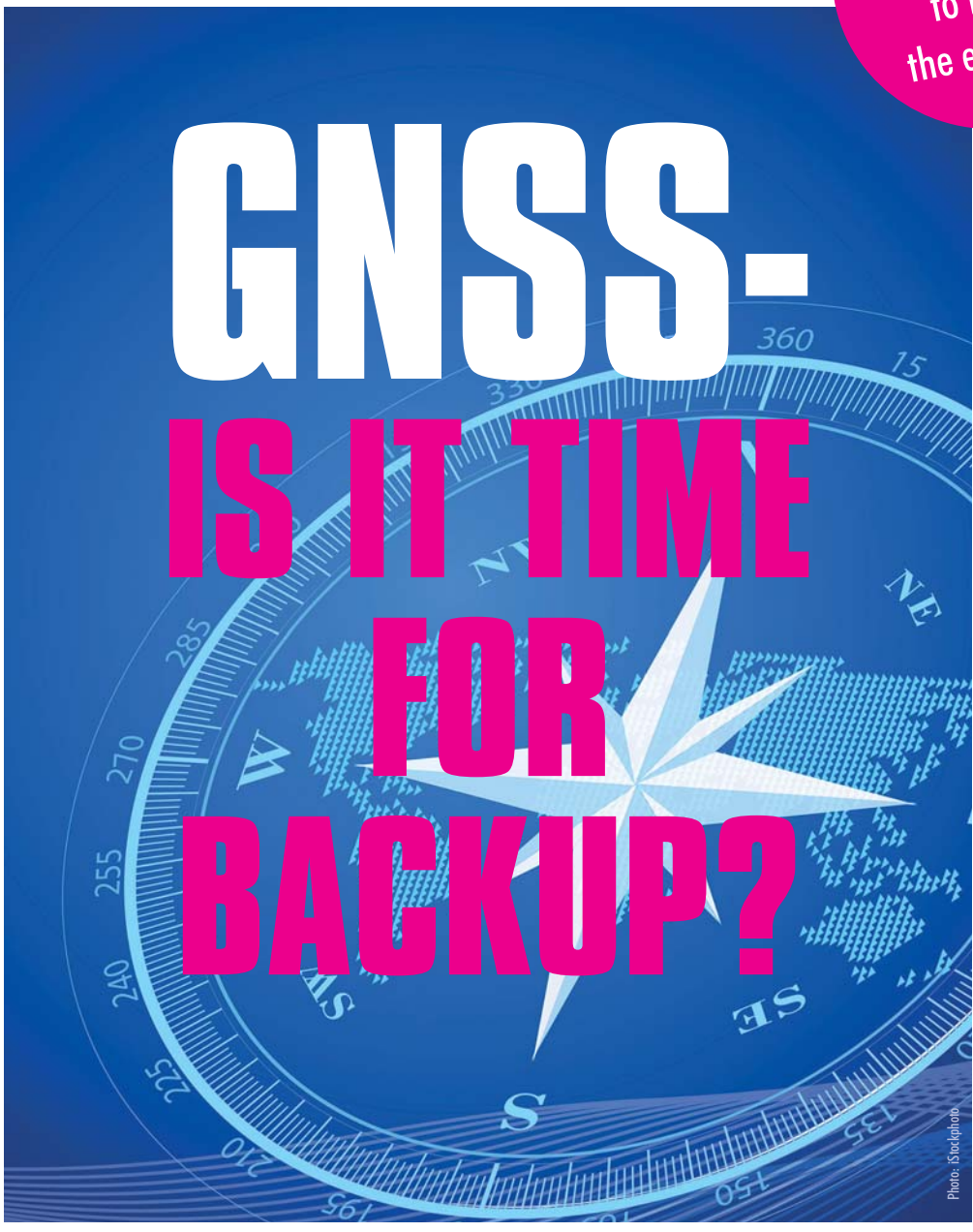

Photo: iStockphoto

Munich, March 14 – 16, 2017

MUNICH SATELLITE NAVIGATION SUMMIT 2017

www.munich-satellite-navigation-summit.org

SpaceX wins NASA contract to launch ocean-surveying satellite

SpaceX has won another contract from NASA to launch one of the agency's Earth science satellites in less than five years. The satellite in question is the Surface Water and Ocean Topography vehicle, or SWOT, and it's designed to scan the planet's oceans and provide the "first-ever global survey of Earth's surface water." The satellite will ride to space on one of SpaceX's Falcon 9 rockets, with a target launch date of April 2021 from Vandenberg Air Force Base in California.

It marks yet another critical science mission that SpaceX will be launching for NASA. The company launched the Jason-3 ocean-monitoring satellite for the space agency in January, and in 2017 SpaceX is supposed to launch NASA's Transiting Exoplanet Survey Satellite, or TESS, designed to look for small planets around bright stars outside our Solar System. *http://www.theverge.com*

China made Pakistan's first remote sensing satellite launch in 2018

China will construct and launch two remote sensing satellites one each for Venezuela and Pakistan in the coming two years. China Great Wall Industry Corp, the nation's only authorized firm for international space collaboration, will launch Venezuela's second remote sensing satellite next year and Pakistan's first remote sensing satellite in 2018, said Fu Zhiheng, vice-president of Great Wall Industry, China Daily reported Saturday. *http://www.brecorder.com*

RS products market expected to reach $13.8 billion by 2021

A research study provides an overview of the remote sensing industry and 2016 to 2021 national-level forecasts for nine application-oriented markets.

The global market for remote sensing products reached $8.4 billion in 2015. This market should reach nearly $8.9 billion in 2016 and $13.8 billion by 2021, a compound annual growth rate (CAGR) of 9.3% over the five-year period from 2016 to 2021. Space-based - conventional platforms as a segment should reach $3.3 billion in 2016 and $4.3 billion in 2021, a CAGR of 5.3% over the five-year period from 2016 to 2021. Airborne - unmanned platforms as a segment should reach $503.0 billion in 2016 and $2.3 billion in 2021, a CAGR of 36.1% over the five-year period from 2016 to 2021. *http://www.prnewswire.com*

Remote sensing to check illegal mining

As the Union ministry of mines in India looks to crack down on illegal mining in the country , major mines in Tamil Nadu have been mapped and digitised and included in the Centre's database. The process to integrate data from a TN-specific mining tenement registry is also underway. The Centre recently launched the Mining Surveillance System (MSS), a satellite-based monitoring system which seeks to curb instances of illegal mining activity through automatic remote sensing detection technology.

The system checks a region of 500 meters around the existing mining lease boundary for unusual activity, possibly an instance of illegal mining, and generates automatic triggers. Using a mobile app, which even citizens can use, officials can submit reports of their inspections.

A dashboard will help officials track the current status of mapping of the mining leases, reasons for triggers, the status of inspections, and penalties levied. However, the onus of taking the follow up steps and penalizing offenders rests with the state government. The process of integrating TN-specific data is also underway. The state is developing a Global Information System and satellite image enabled mining tenement registry, a comprehensive database of mining leases in various districts. *http://timesofindia.indiatimes.com*

Robotic riverbed survey vessel tracked with FOCUS 35 TS

The Ribble Rivers Trust recently commissioned a bathymetry survey of a notable section of the riverbed. A robotically controlled 1.2-meter twin-hull shallow draft vessel powered by a twin jet system was used to survey approximately a hectare of the river's bed. Aboard the vessel was a depth recording sonar and a tracking prism that enabled a Spectra Precision FOCUS 35 total station to lock onto and robotically follow and record the location of the vessel. Echo soundings from the sonar were transmitted back to a tablet PC ashore via long-range Bluetooth and time stamped, while the boat's position was continuously recorded by a FOCUS 35 total station and sent back to a tablet PC also using long-range Bluetooth and time stamped. The tablet PC ran, 4Site, a program that formatted and processed the data from the sonar and the total station into a DWG drawing. Each point was positioned in real-time on the screen of the tablet to permit the operator of the vessel to see gaps in the data in real-time and navigate the boat back to them to ensure complete coverage. A mesh of the survey area, a 200-meter section of the 50-meter wide river with depths to 3.5 meters, was created and combined with aerial Lidar information to produce a topographic survey that was provided to the Ribble Rivers Trust for its education outreach efforts as part of its Heritage Lottery Funded "Ribble Life Together" project. *www.spectraprecision.com*

UP Police launch Emergency Operation Center

Uttar Pradesh Police in India has opened its state-wide, centralized "Dial 100" Emergency Operation Center in the provincial capital, Lucknow. It houses India's largest police emergency response system, which is equipped with Hexagon Safety & Infrastructure's industry-leading Intergraph Computer-Aided Dispatch (I/CAD)software.

The safety solutions will enhance incident management and agency-wide reporting in India's most populous state, serving

220 million people across 75 districts. Relying on Hexagon's advanced call-handling and dispatching capabilities, the new 24/7 operation center will have up to 250 call takers and 150 dispatchers to manage 200,000 estimated calls per day via its emergency hotline services – landline, VoIP, SMS, email, social media and mobile application. *www.hexagonsafetyinfrastructure.com*

Wearable GNSS Receivers by Asteri Navigation

Asteri Navigation has introduced a new line of rugged, compact and fully integrated GNSS receivers during recently held 2016 Autodesk University in Las Vegas, USA. Designed for geospatial field data collection and inspection applications that require high accuracy positioning, it is light enough to be mounted to external sensors or worn on the body or arm.

Engineered to provide centimeter-level accuracy with Real-Time Kinematic (RTK) or Virtual Reference Station (CRS) correction when connected to an external antenna, the Asteri GNSS receivers support a generic NMEA 0183 GNSS data protocol. *www.AsteriNav.com*

Harxon offers new waterproof helical GNSS antenna

Harxon has released its next-generation triple-frequency Helix Antenna HX-CH7603A.

It is capable of GPS L1/L2, GLONASS L1/L2 and BDS B1/B2/B3. Though compact, it provides high peak gain (more than 3.5 dBi) and wide beam width to ensure the signal receiving performance of satellite at low elevation angles.

Trimble Catalyst turns smartphones into GNSS Receivers

Trimble has introduced a new software-defined GNSS receiver that works with select Android mobile handhelds, smartphones and tablets, called the Trimble Catalyst. When combined with a digital antenna and subscription to the Catalyst service, the receiver provides on-demand GNSS, geo-location capabilities to transform consumer devices into high-accuracy mobile data collection systems. With the evolution of smartphones and tablets as commonly used mobile information tools, more field workers and consumers now have access to positioning technologies for geospatial data use and collection.

Telit autonomous nav module uses internal sensors, GNSS

Telit has announced the commercial availability of the SL869-3DR, a GNSS module for global use that leverages information from internal gyros, accelerometers and a barometric pressure sensor to perform dead-reckoning navigation for application areas such as track and trace and in-vehicle systems.

The module delivers accurate position data either directly from its multi-constellation receiver or from a fully autonomous dead-reckoning system, requiring no connections to external devices or components other than an antenna for satellite signal reception and power.

Mayflower SAGE provides anti-jam capability for submarines

Mayflower Communications Company said its submarine anti-jam GPS enhancement (SAGE) supports the U.S. Navy's multifunction mast antenna System (OE-5388) upgrade to improve communications systems and navigation warfare (NAVWAR) requirements.

It is part of a contract that Space and Naval Warfare Systems Command awarded to Lockheed Martin Sippican and Granite Slate Manufacturing. SAGE, a variant of a small antenna system (SAS), was developed to support the Navy's GPS anti-jam requirements for submarines in GPS-contested or -denied NAVWAR environments.

SAGE, which is integrated into the OE-538B antenna by Lockheed Martin Sippican, features low size, weight, and power (SWaP) requirements; multiple ports; GPS radio frequency output; and L1 and L2 outputs with adjustable power levels

Clock system protects telecomms against GNSS data loss

Microsemi has announced its TimeSource "Enhanced Primary Reference Time Clock" to protect against GNSS vulnerabilities; presented as the first such system available, it has been designed to meet an ITU recommendation, ITU-T G.8272.1 to provide secure timing infrastructure to telecommunications and mobile operators.

The clock "generates time" by producing its own independent time scale aligned with GNSS, while its phase, time and frequency signal outputs remain autonomous. This provides users in the communications, power, public safety, data centre and government network markets with a secure infrastructure, reducing dependency on GNSS and enabling network operators to retake control of the timing source used for network synchronization. *www.microsemi.com*

NovAtel and Stanford sign autonomous vehicle study agreement

NovAtel has signed a contract with Stanford University for a study to determine how GNSS technology can deliver a positioning system that meets safety and accuracy requirements for autonomous land vehicles. The study, to be conducted at Stanford's GPS Research Laboratory, will build on similar aircraft research. In addition, the research will include concepts for high integrity carrier-phase algorithms, threat models, and safety monitors for improving autonomous vehicle transportation. NovAtel's efforts in autonomous vehicle development date to the Defense Advanced Research Projects Agency (DARPA) Grand Challenge in the California desert, and in urban settings, more than a decade ago. The DARPA winner, Stanford's Stanley vehicle, incorporated NovAtel's ProPak dual-frequency GNSS inertial navigation system (INS) that used a satellite-based augmentation system (SBAS) to improve positioning.

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http://www.esri.in/events

NRSC USER INTERACTION MEET 2017 (UIM 2017)
January 23-25
HICC, Hyderabad

February 2017

17th annual International LiDAR Mapping Forum (ILMF)
13-15 February
Denver, Colorado, USA
www.lidarmap.org

March 2017

2017 GIS /CAMA Technologies Conference,
6 - 9, March
Chattanooga, Tennessee
www.urisa.org

Munich Satellite Navigation Summit 2017
14 – 16 March
Munich, Germany
www.munich-satellite-navigation-summit.org

International Forum GEOSTROY
16-17 March 2017
Novosibirsk, Russia
http://www.geostroy-sib.ru/en/

April 2017

ISDE10 & Locate17
3 - 6 April
Sydney, Australia
www.digitalearthsymposium.com

UNMANNED WORLD
5 - 7 April
Doha, Qatar
www.unmanned-world.com

International Navigation Forum / Navitech'2017
25 - 28 April
Moscow, Russia
www.navitech-expo.ru/en/

GISTAM 2017
27 - 28 April
Porto, Portugal
http://gistam.org

May 2017

MMT 2017: The 10th International Symposium on Mobile Mapping Technology
6 - 8 May
Cairo, Egypt
http://mmt2017.aast.edu/index.php

XPONENTIAL
8 - 11 May
Dallas, USA
http://xponential.org

11th Annual Baska GNSS Conference
7 - 9 May
Baska, Croatia
www.rin.org.uk

The European Navigation Conference 2017
9 – 12 May
Lausanne, Switzerland
http://enc2017.eu

GeoBusiness 2017
23 - 24 May
London, UK
http://geobusinessshow.com

FIG Working Week 2017
29 May - 2 June
Helsinki, Finland
www.fig.net

June 2017

10th International ESA Conference on Guidance, Navigation & Control Systems (GNC)
29 May - 2 June
Salzburg, Austria
http://esaconferencebureau.com

TransNav 2017
21 - 23 June
Gdynia, Poland
www.transnav.eu

July 2017

IGS 2017: International GNSS Service Workshop
3 - 7 July
Paris, France
www.igs.org

IEEE Frequency Control Symposium and European Frequency and Time Forum
9 - 13 July
Besançon, France
www.eftf-ifcs2017.org

Esri User Conference
10 – 14 July
San Diego, USA
http://www.esri.com/events/user-conference/papers

September 2017

Interdrone 2017
6 - 8 September
Las Vegas, USA
www.interdrone.com

ION GNSS+ 2017
25 - 29 September
Portland, USA
www.ion.org

Intergeo 2017
26 - 28 September
Berlin, Germany
www.intergeo.de


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NT1065 "Nomada"

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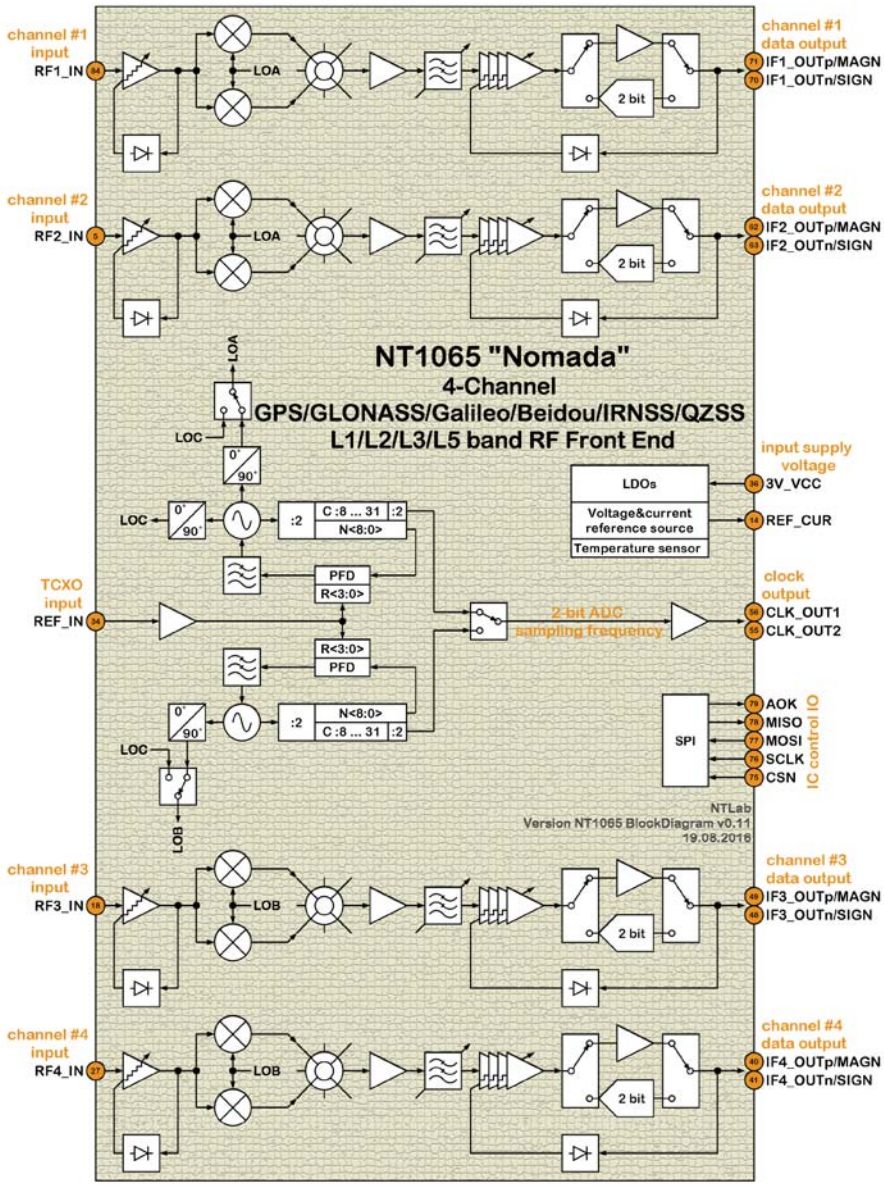
NT1065 "Nomada" is a 4-channel GNSS RF Front-End chip for professional navigation market: geodesy, driverless cars, drones and similar applications.

The feature list includes:

- Simultaneous reception of GPS/ GLONASS/Galileo/BeiDou/ IRNSS/QZSS signals
- Frequency bands: L1/L2/L3/L5/ E1/E5a/E5b/E6/B1- C/B1I(Q)/ B1-2I(Q)/B2/B3
- Full programmability of each of 4 channels (center frequency, frequency bandwidth, AGC options, mirror channel suppression, analog/2-bit digitized output, etc.)
- Simple and easy-to-use register map for chip configuration.

NT1065 is already in mass production. It also could be used by GNSS researchers to create sophisticated front-ends for their receivers. For such purposes, we offer wide selection of evaluation kits (including SDR receivers): with 4 and more channels, analog and digitized outputs, connectable to PC or FPGA platforms.

Fabricated by amsAG, Austria.



Datasheet is available at **www.ntlab.com**

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