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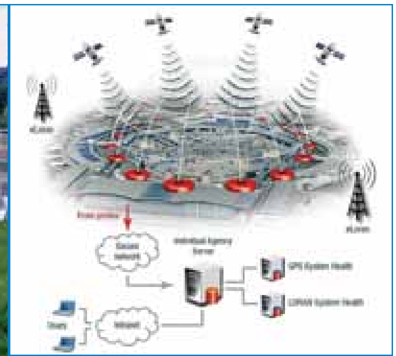
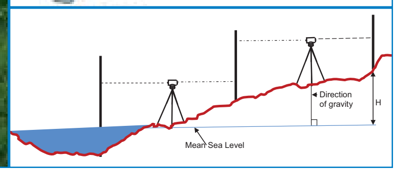

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Columns

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Kudos to 'Curiosity'

On August 6, 2012

Mankind accomplishes another feat,

When our curiosity to locate life

Beyond the Earth,

Finally, landed Curiosity - the NASAs Rover, on Mars.

This also sets stage for future endeavors

With some other nations joining the pursuit

To explore more and more

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Ultimately it's our curious instinct

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GAARDIAN: A system to detect GNSS jamming and Interference

Protecting the UK Infrastructure

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Divisional Manager
GNSS Applications and Solutions, Chronos Technology Ltd., UK

Charles W T Curry
Managing Director, Chronos Technology Ltd., UK

Jenna Tong
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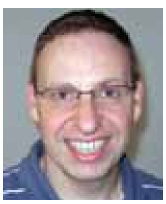

Robert Watson
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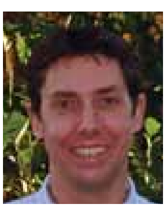

Paul Cruddace
Geodesy and Positioning Manager
Ordnance Survey

GNSS vulnerability currently one of the most talked about topic in the GNSS world. Publicity of events such as the “accidental” GPS jamming at the Newark Airport in the United States, the Royal Academy of Engineering report regarding the vulnerability of UK GNSS services, the recent investigations into the LightSquared “problem,” numerous conference presentations, and many articles in technical journals and news media — all address the well-known fact that space-based position, navigation, and timing (PNT) is vulnerable to localized RF interference at or near to the receiver operating frequency.

Some of this publicity relates to the UK’s developments in the area of detecting GNSS interference, specifically the GAARDIAN program (for GNSS Availability, Accuracy, Reliability anD Integrity Assessment for Timing and Navigation). This was a wide collaboration between government, academia, and industry to develop a robust system for analyzing interference phenomena associated with GPS and eLoran systems and the effects on their use in safety- and mission-critical applications.

The GAARDIAN program completed in 2011. This article gives an overview of the resulting capability to detect GNSS interference and jamming. It also provides details about a specific recent detection event that demonstrated the capability of the system and that, by involving UK Law enforcement agencies, proved the system can be operationally effective.

GAARDIAN's Guardians

GAARDIAN, a collaboration led by Chronos Technology Ltd., included the University of Bath, General Lighthouse Authorities of UK and Ireland, BT, Ordnance Survey, National Physical Laboratory, and Imperial College London. The project was part-funded by the UK’s national innovation agency, the Technology Strategy Board, and ran between October 2008 and March 2011.

The project set out to create interference detection and monitoring sensors (IDMs) that could be deployed in the vicinity of safety- and/or mission-critical PNT applications. These sensors or probes had a design brief to monitor the integrity, reliability, continuity, and accuracy of the locally received GPS and eLoran signals on a round-the-clock basis and report back to a central server, which acts as the user interface. Users were to be alerted in real time to any anomalous behaviour in either of the GPS and eLoran signals. This concept can also be considered a GNSS/PNT quality of service (QoS) monitoring and reporting system.

GAARDIAN probe as deployed around the UK

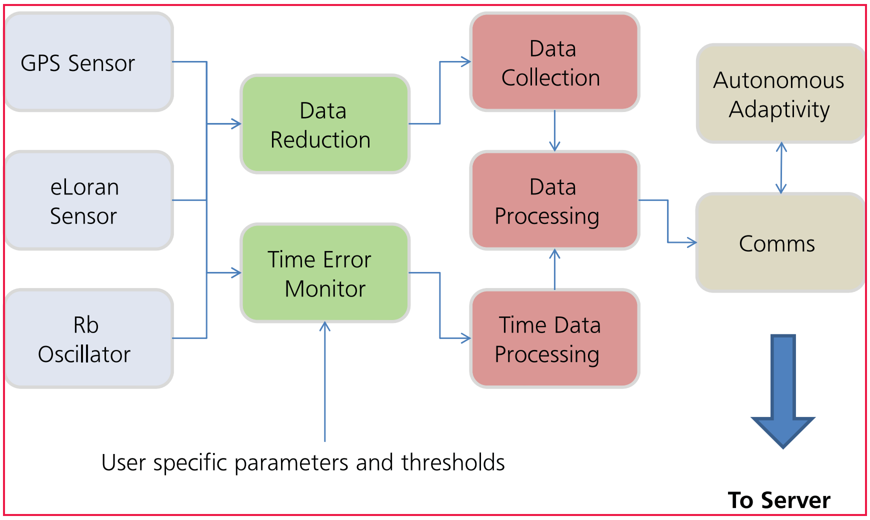

Figure 1: Simplified probe architecture

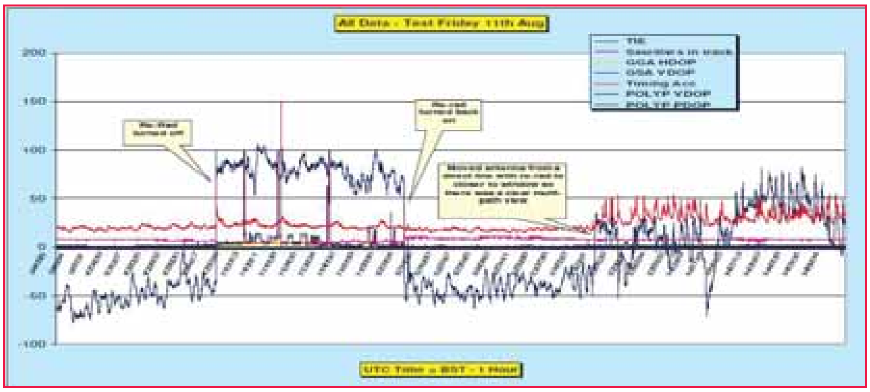

Figure 2: **Example TIE plot showing the responsiveness to GNSS anomaly**

System design

The GAARDIAN program has resulted in a 24x7 nationwide experimental IDM system, whose sensors continuously monitor PNT signals from both GPS and eLoran. GPS is the main GNSS technology monitored, but integration of other GNSS technologies is certainly possible. eLoran is an alternative PNT technology unaffected by interference to GPS and technically dissimilar in its dependencies, e.g., operating at different frequencies and using separate infrastructure from GNSS.

The design of the GAARDIAN architecture consists of three main elements: probe, server, and communication. The probe, shown in the accompanying photograph, acts as a semi-portable station that executes specialised functions to detect anomalous events and failures of GPS or eLoran in the vicinity of the probe. The station also processes data obtained by the probe to reduce the amount that needs to be transmitted to the central server. The server's role is to manage and process the data received from probes and external sources including the Ordnance Survey's OS Net network of permanent GNSS receivers.

The server offers the users real-time access to the output of the probes (including anomalous events) and dedicated system (GPS and eLoran) positioning/ timing performance. Furthermore, it provides the probes with information on failures that have a regional impact.

Both the probes and the server integrated specialist monitoring technologies from the partners, with the integration and normalization being carried out at and by Chronos' UK headquarters premises and staff, respectively.

The probe is designed to be adaptable to various user applications, and specific functionality can be enabled or disabled depending on user requirements. Every probe performs a minimum set of functions:

- interference detection
- failure identification
- data capture during anomalous events
- eLoran validation

The specific functionality of the probes and the server, summarised above are based on these activities. For example, assessment of conditions such as space segment failures can be performed to ensure an event is due to a localized problem and not systematic.

Figure 1 outlines the basic probe architecture in which the outputs from a GPS receiver, an eLoran receiver, and a small form factor rubidium atomic clock are analyzed. One form of the analysis performed is an investigation of the 1PPS output of the two PNT sources against a common reference.

A time interval error (TIE) measurement of these outputs is conducted continuously over multiple sample window sizes. This is converted to maximum time interval error (MTIE) and compared with a predefined limit. This enables short-, medium-, and long-term timing anomalies to be reported.

Not only does this feature enable the detection of multipath, interference, and system anomalies in the GPS signal, it also provides a readymade QoS service should eLoran become the accepted technological alternative PNT to GPS or for adopters of the future Galileo Publicly Regulated Service (PRS).

Maximum time interval error (MTIE) is the largest peak-to-peak TIE (i.e., wander) in any observation interval of length t, calculated as follows:

$$MTIE(n\tau_0) \cong \max_{1\le k\le N-n}\left[\max_{k\le i\le k+n} x_i - \min_{k\le i\le k+n} x_i\right], \quad n = 1,2,\ldots,N-1$$

Equation 1 Maximum time interval error

where n is the number of samples in the measurement window, τ_0 is the sample

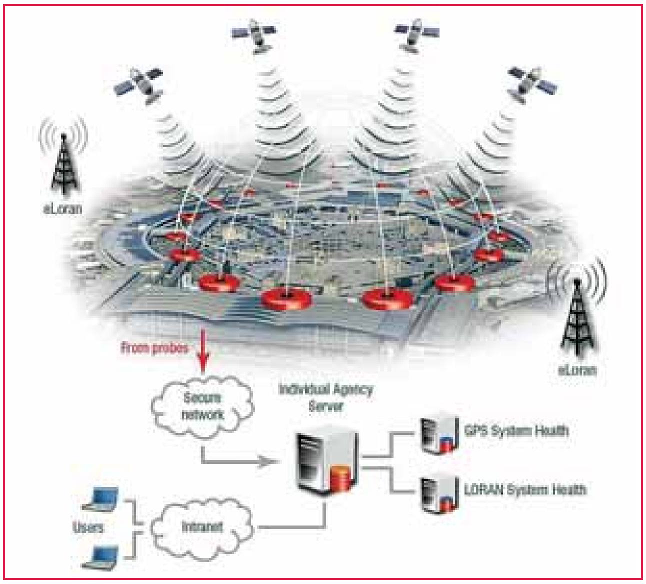

Figure 3: SENTINEL overview

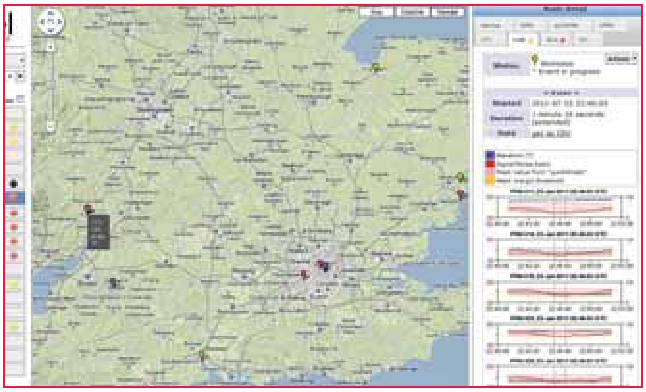

Figure 4: **GAARDIAN/SENTINEL server interface (location identifiers removed)**

interval, N is the number of samples in the data set. The index variable i is incremented to scan across the window and k, representing the starting point of the current data set, is incremented for sliding the measurement window.

This principle can be used to set thresholds of maximum allowable TIE, which when exceeded can be flagged as an alert. Figure 2 shows some early experimental data that compares a GPS 1PPS to a cesium standard, with a jump in the TIE when a system anomaly occurs. In the example data, the operation of a GPS repeater is causing the reaction.

In addition to this TIE measurement, the probe characterizes the GNSS RF multipath environment. This is accomplished via an algorithmic comparison of the measured GPS signal/noise ratio (SNR) for each satellite against a pre-calculated polynomial "Quickthresh" mask. This algorithm uses the SNR, azimuth, and elevation values to develop a mask for "normal" signal strength and extract some parameters related to multipath of the probe.

An "event" occurs when the SNR for a [user-configurable] number of satellites has dropped below expected tolerances, leading to the assumption that a multipath or jamming environment may exist. Other parameters are taken into account, such as standard deviation per satellite and the multipath conditions of the "normal" state.

This means that a probe can, if necessary, be deployed into a strong multipath environment. Over the course of the GAARDIAN program, the time required for the normal state determination was reduced to a level that enables the rapid deployment of a probe to a location of interest, a concept being used in the successor program, SENTINEL (Figure 3).

Probes are currently deployed at various locations around the UK and Ireland and continuously report on the integrity, continuity, accuracy, and reliability of the PNT signals in the vicinity. The

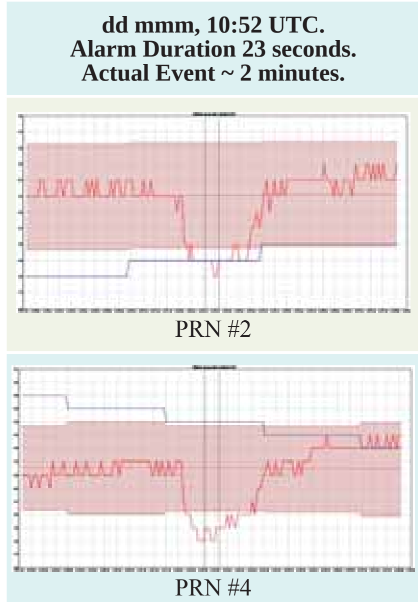

Figure 5: **Event Type 1**

data is communicated back to a central location, and continuously available via a common web browser, making the complex data accessible quickly and easily. Figure 4 shows the server's graphical user interface through which users are alerted and, in turn, can access data from individual probes and perform detailed event analysis.

Server side analysis tools include the ability to perform historical trend analysis of both the GPS and eLoran data from the probes. These tools enable operators and users to monitor long-term factors, such as the eLoran *additional secondary factor* (ASF) variations, and analyze long-term GPS QoS metrics and event patterns. This pattern analysis capability was used during a recent investigation by the GAARDIAN program team, which we will describe next.

Event investigation

GAARDIAN as a research tool has delivered a number of key firsts in the field of GPS interference detection, eLoran monitoring techniques, and GPS multipath characterization, Even though only an experimental rather than operational system, one of the partners, Ordnance Survey, requested


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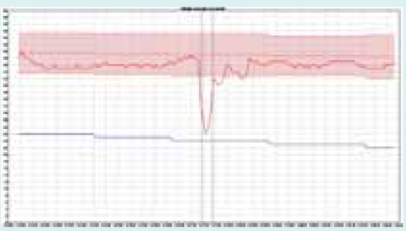
“Deep Short Sharp” Signature Signatures correlate with Loss of Lock on the OS Net Receiver co-located with the GAARDIAN probe

DSST Signature seen on Satellites PRN #2, 4, 10, 13, 20, 23. nn mmm 14:17 UTC. Alarm Duration 18 seconds



PRN #20: 24° Elevation

PRN #13: 76° Elevation

Figure 6: **Event type 2**

that a GAARDIAN probe be moved to a specific site of interest in the UK.

This article will not detail the location of this probe, but the reason for the deployment was that an Ordnance Survey OS Net reference station at the location was experiencing significant failures. The OS Net network, consisting of more than 100 continuously operating GNSS receivers, facilitates a core geodetic remit of Ordnance Survey as well as providing data and services for internal and commercial GNSS correction services across the whole of Great Britain. Therefore, failure of an OS reference station, particularly intermittent failure, of any of these reference stations has a significant effect on business continuity because of the resulting data loss. .

Deployment of the GAARDIAN probe to the site of the OS Net reference station represented the first operational deployment of the system in the UK. Installation and set-up work by Chronos Technology, meant that the same RF environment as seen by the reference station was also seen by the probe. Although the probe detected immediate loss-of-signal events, the program team allowed the probe to gather three weeks’ worth of data before full analysis was undertaken.

Human or natural?

The analysis showed two clear and distinct types of event; Figure 5 shows an example of the first event type, dubbed internally as “Short Shallow Fat” or SSF. The figure diagram shows carrier/noise values against time, and the event is clearly visible. This event was found to be sidereal in nature and therefore discounted as the cause of the problem. The root cause of this first type of event is currently under investigation and not part of this article.

Figure 6 shows the second type of event detected by the GAARDIAN probe. Its signature was christened internally as “Deep Short Sharp” or DSS. Again, the event can be clearly seen in the data and was found to have an average duration in the order of only a few seconds. This was the event that correlated each time with the loss of lock experienced by the OS Net reference receiver. The DSS event affected signals from all satellites in view at the time of the event.

Detailed analysis concentrated on the DSS profile, particularly the frequency of occurrence, looking for trend patterns. This analysis showed that the event exhibited regularity in terms of days of the week upon which it occurred. The event also changed activity during a public holiday (e.g. an expected Monday event happened on a Tuesday as Monday was a public holiday). In addition to other indicators that cannot be detailed here, this pattern led the team to suspect it was not caused by a natural event, but rather by manmade means.

Enforcement

To progress this analysis further and to bring the OS Net reference site back to full and reliable operation clearly called for some “on the ground” investigation and mitigation. During the GAARDIAN program, strong links were forged with elements of UK law enforcement and culminated in the SENTINEL program. This activity included gaining the UK Association of Chief Police Officers ITS Working Group (ACPO ITS) as a full partner.

Discussions with ACPO ITS and other law enforcement agencies (LEAs) allowed the GAARDIAN team to compile a confidential report on the events described here, which led to the deployment of LEA assets to the vicinity of the site in question.

Small, handheld detection devices were used to aid in localizing any interference source, as GAARDIAN itself cannot provide a location or bearing of the interference source. (This latter capability *is* part of the SENTINEL program.)

This article cannot provide specific details of the LEA operation nor describe how the GAARDIAN team further contributed, for reasons of operational security and possible legal proceedings. We can say, however, that the LEA ground operation did identify a source of the interference, which was identified as one of the vehicle based GPS jamming devices seen frequently on the Internet and as described in the Royal Academy of Engineering report on GNSS vulnerabilities.

As a result of this event analysis, therefore, the initial assessment that the problem was manmade was proven correct. Any further action by the appropriate UK authorities is to be determined by the UK LEAs, and the GAARDIAN team will not be involved.

Conclusion

This overview and case study has shown that the GAARDIAN system, although an experimental network, is fully capable of detecting deliberate and accidental GPS

CTL3500 handheld interference detector

interference & jamming. And, as the case described here demonstrates, it is capable of being the primary detection sensor used in an operational law enforcement environment. Detection of interference events lasting just a few seconds has shown to be possible. We should also note that occasional variants of the DSS profile described in the article exhibited a “tail,” i.e., a shallow recovery back to a normal signal/noise state. This was subsequently identified as a waiting period by the vehicle emitting the jamming signal at nearby traffic lights.

GAARDIAN thus fulfils the role called for by the original design concept. Further work would be needed to integrate the server and probe functionality within a customers’ existing monitoring infrastructure, or perhaps to form the core of a monitoring system that needed to be implemented from the ground up. A number of avenues are currently being explored in this respect.

As collateral benefits of the GAARDIAN project in addition to achieving the core goals of GPS interference detection, additional capabilities have been realized, such as long-term eLoran ASF monitoring and calibration, differential eLoran calculations, and the introduction of a multiple technology PNT QoS monitoring system..

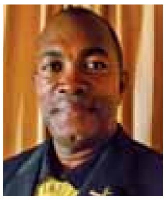
The technology mentioned in this article is also being improved upon for the SENTINEL program, which incorporates additional capabilities for determining the location of an interference source and providing a measure of trust in a PNT system. Cooperation between the GAARDIAN team and UK LEAs, based on analysis of GAARDIAN data, enabled a quick and effective identification of the source of radio interference. GAARDIAN data was an invaluable aid to decision making on the ground, which not only proved successful but also avoided the need for potentially protracted and costly law enforcement investigation.

Manufacturers

The handheld interference detector used in the GAARDIAN program was the CTL3500 interference monitor from Chronos Technology Ltd., Lydbrook, Gloucestershire, United Kingdom. The GPS receiver system used within the GAARDIAN probe is a CTL430 also from Chronos Technology Ltd, and the eLoran receiver used in both the GAARDIAN and SENTINEL projects is a UN-150 eLoran Timing Receiver from URSANAV Inc.

The Jamaica VRS and Cadastral Surveying

This paper provides a history of the Jamaica Geodetic infrastructure and the changes that have taken place with this network over the last few decades. We present here the first part of the paper. The concluding part will be published in September 2012 issue



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Virtual Reference System (VRS) comprises a network of three (3), or more, continuously operating Global Navigation Satellite System (GNSS) receivers, sited at points of known coordinates up to 70 Km apart and connected via data links. A control centre, with computer processing capability as well as a mobile phone data link, such as Global System for Mobile communication (GSM), is established for communication between the control centre and the users' rover receivers.

All receivers are linked via land line telephones to the control centre. Data from these receivers are fed into the control centre via the telephone links and used at the control centre to compute corrections for the two major sources of errors that affect GNSS measurements - and are easily mathematically modelled - ionospheric and tropospheric errors. Other errors/biases including satellite and receiver clock errors are removed by double and triple difference options, while those falling in neither category e.g., cycle slip and multipath errors, are minimized through the use of proper observational techniques.

Any user with a GNSS receiver in the roving mode and connected, whether by wire or Bluetooth to a GSM ready cellular telephone, may dial into the control centre and send a standard National Marine Electronics Association (NMEA) position string which includes its coordinates as determined by the receiver autonomously, provided a signal is available. The control centre computes corrections for the rover as if the base station were at the rover's position. This is what is regarded as the Virtual Reference Station.

The configuration effectively eliminates the need for users to establish their own base station, as in the case of Real Time Kinematic (RTK), and translates into significant cost savings for those investing in GNSS technology. Of course users will have to pay providers for their cellular calls to the control centre. So far, there has been no indication of user fees to be charged by the National Land Agency of Jamaica, to the users of the VRS.

The corrections transmitted to the rover from the control centre are good enough to yield centimeter accuracy for the coordinates of the rover station. This level of accuracy would be quite acceptable for most applications including Cadastral, Engineering Topographic, Hydrographic and Mining Surveying.

Virtual Reference Systems may be mounted on an existing local geodetic control infrastructure where the reference stations occupy known control points. Alternatively, they may form a completely new network of points or indeed a combination of both. Since the safety and security of the equipment is of paramount importance, the locations of existing control points would not in all cases, be suitable for VRS Stations. In any event, the VRS network would be tied to the local geodetic control so that the control network can act as an integrity monitor for ground truthing the VRS coordinates. However, concerns have been raised as to whether the Jamaican control network in its current form can adequately support

It is expected that the implementation of the Virtual Reference System will revolutionize the surveying and construction sectors as it will lower the cost of positioning

a VRS in this regard. The integrity monitoring feature of a National Control in support of a VRS, is a vital aspect of the use of VRS in Cadastral Surveying.

Table 1 EDM and Triangulation Distances compared

Line	Tellurometer	Triangulation	Diff	Ratio	PPM
P13-P19	14,796.027	14,796.030	0.003	1/4,900,000	0.20
P14-P15	10,479.009	10,479.125	0.116	1/86,000	11.07
P27-P28	18,615.106	18,615.588	0.482	1/38,000	25.89
P24-P32	15,727.141	15,727.369	0.228	1/74,000	14.50
P33-P40	25,483.036	25,483.612	0.576	1/45,000	22.29
P36-P37	14,366.034	14,366.491	0.457	1/31,000	31.81
P37-P44	40,389.934	40,390.173	0.239	1/166,000	5.92
P40-P41	24,176.761	24,176.882	0.121	1/198,000	5.00

Table 2 Astronomical Azimuths

	Azimuth	p.e.	No. of Pointings	Diff.
Mount Denham – Cockpit	289° 57’ 11.87”	±0.22	40	+6.63”
Coopers Hill – Nutfield	04° 34’ 04.70”	±0.07	17	+10.03”
Nutfield - Coopers Hill	184° 34’ 41.00”	±0.26	15	+13.92”

Jamaica geodetic control

The Jamaica Geodetic Control Infrastructure was originally established in three tiers, Primary, Secondary and Tertiary. The Primary network originally comprising of thirty-eight points was observed by Royal Engineers between November 1937 and April 1939. An additional six stations were subsequently incorporated by the Government Survey Department Surveyors to complete the network in 1944. The points form a mesh network of triangles spanning the length (230 km) and breadth (80 km) of the island. Typical side lengths range between 13km and 42 km. Given the non-existence of Electromagnetic Distance Measurement (EDM) devices at that time, only one distance was measured and all the angles in each triangle were measured. The azimuth of one side was obtained through stellar observations.

The datum point was established by connecting a point (Flagstaff at Fort Charles, Port Royal) to the United States of America (USA) Navy Department’s 1873 network of points where astronomical longitudes were observed between the United States mainland through a number of the West Indian Islands to Central America and South America. Observations for astronomical latitudes were made at the same time at each station where longitude was established. This gave rise to a Pure or Classical form of Triangulation (Figure 1). on a non-geocentric datum.

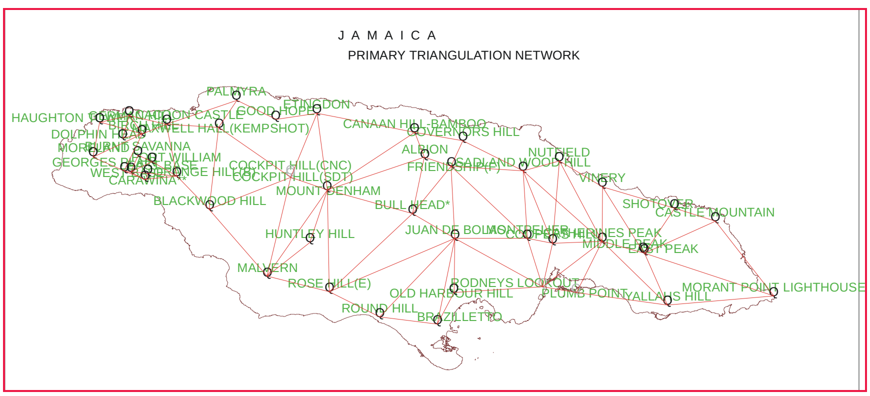

Figure 1 : Jamaica Primary Triangulation Network

A line of levels was run between a control station called Plumb Point and a mark on the officer’s bath (swimming pool) at Port Royal. The mark was reported by the British Admiralty to be 1.0668m (3.50 ft.) above mean low water as determined by the British Admiralty in 1886. The heights of all other primary triangulation stations were determined from reciprocal vertical angle measurements and related to the height of the Plumb Point Station.

When Electronic Distance Measurement (EDM) became available, a campaign was launched to upgrade the network. Between 1961 and 1963, a Tellurometer was used to measure all the lines on the periphery of the primary triangulation network. A number of other lines were measured also. A comparison was made between the E.D.M distances (in feet) and those calculated from the triangulation. Table 1, provides some comparisons.

The difference are all positive and exhibits a progressive deterioration in the scale of network as one goes from west –P13 (near the base) to east – P37 i.e. 1/4,900,000 to 1/31,000. This trend strangely reverses in areas in the east (P37-P41) where there are weak

Table 3 Coordinate Values for Mount Denham, RE and IAGS

	Lat (N)	Long (W)
Mount Denham (RE)	18° 13' 23.15"	77° 32' 08.72"
Mount Denham (IAGS)	18° 13' 43.64"	77° 32' 08.28"
Diff.	+ 20.49"	-0.44"

triangle misclosures, so that the ratios 'improves' to 1/198,000 (Robinson 1975)

In 1959 the Inter American Geodetic Surveys (I.A.G.S.) observed a first order azimuth for the line Mt. Denham to Cockpit. In 1968 Mr. Keith .A. Lee (Local Surveyor) of the Survey Department determined the azimuth of the line Coopers Hill to Nutfield reciprocally. The results and differences when compared with the R.E.'s azimuths for same lines are shown in Table 2.

These differences in azimuth were considered large and followed a systematic pattern of these azimuths being greater than those calculated from the triangulation by the R.E.'s. Mr. K. Lee checked the R.E.'s computations for the azimuth Maxwell Hall to Etingdon and discovered an error of -10.39". Mr. Lee's check resulted in a computed azimuth of 81° 16' 46.64" as against the original computed azimuth of 81° 16' 36.24". The application of this difference brought all four azimuths in closer agreement but still exhibiting an inconsistency of 7.29" between the lines Mt. Denham to Cockpit and Nutfield to Coopers Hill.(Mugnier, Cliff 2003)

Further reductions by application of the Laplace Azimuth equation to the astronomical azimuths produced a +1.1" difference between the I.A.G.S. azimuth and the R.E. azimuth (corrected by K.A. Lee), for the line Mount Denham to Cockpit. This difference was far more acceptable for Primary Control standards.

The error of -10.39" in the orientation of the triangulation network caused an anti-clockwise rotation of the network about the fixed point (Flagstaff at Port Royal), which resulted in a positional vector error for a point, say at Negril Lighthouse - 200km west, of 10m. This error varies directly with the radial distance of points from the Flagstaff. All modern maps of Jamaica produced prior to 1968 were based on this network and exhibits this system systematic error in the position of points. (Robinson, 1975).

> Unique and precise coordinates will be provided for each point that is coordinated with this system as it will be configured to function in the JAD2001 datum

A check on the coordinates of the datum point (Flagstaff) was achieved in 1959 when a first order astronomical fix was observed at Mount Denham by the I.A.G.S. The comparison with the R.E.'s coordinates (calculated through the network), is given in Table 3.

Re-adjustment

In 1963, the then Survey Department requested the Directorate of Overseas Surveys to carry out a complete re-adjustment of the triangulation and E.D.M. traverse network. The reasons were: -

- to homogenise all coordinates for points in the network
- to take advantage of the E.D.M. traverse around the island to provide a new scale for the network.
- to take advantage of the correct azimuth of the line, Maxwell Hall to Ettingdon
- to include other observed azimuths to strengthen the orientation of the network.
- to include additional observations (angular and linear) to strength the network.

The primary triangulation network for the new (1969) adjustment consisted of observations taken by the Royal Engineers and additional measurements done by the Survey Department. At the same time it was decided to change spheroid and carry out all computations on the CLARKE 1866 spheroid instead of the then CLARKE 1880 spheroid. These decisions were agreed on by the Jamaica Survey Department and the Directorate of Overseas Surveys. The adjustment was computed by the variation of geographical coordinates and was completed in 1969. Hence the datum name JAD69 on which Latitudes and Longitudes/Northings and Eastings were published.

The network remained in this form for another three decades until the National Land Agency decided to transition to a geocentric datum consistent with WGS84 named JAD2001. This datum was realised through the adoption of points established in the WGS84 datum, at the two (2) international airports by the United States of America National Geodetic Survey as part of a seventy-two (72) hour campaign carried out to establish accurate control at airports to support the improvement to takeoff/ landing infrastructure and ultimately the airports' category rating. Existing triangulation control points (JAD69) were then coordinated from these points, using GNSS, as the Agency moved to densify the network by establishing new points in the JAD2001 datum. It is anticipated that the existing network of JAD69 points will be transformed into this new system using, for example grid file distortion modelling (Collier & Bowden 1999) or by readjusting the network, holding JAD2001 coordinates of JAD69 points fixed, to achieve a complete renovation of the Geodetic Infrastructure.

In the absence of a rigorous renovation of the national network through a dense observation campaign, with a complete adjustment on the WGS84/JAD2001 Datum, it is hoped that the result of the approach that the Survey and Mapping

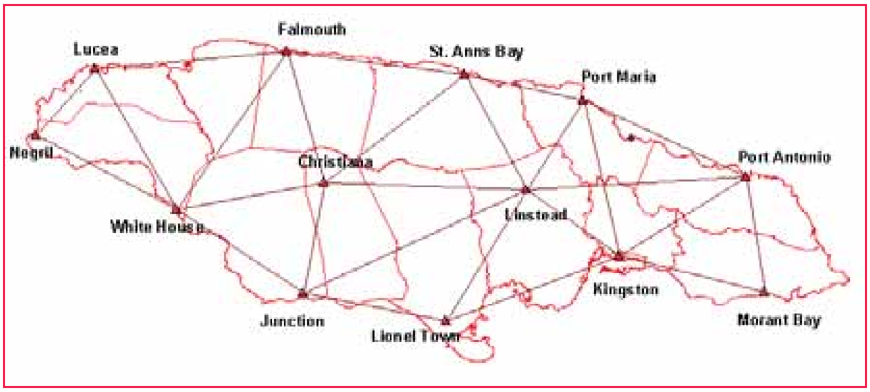

Figure 2: Virtual Reference Stations across Jamaica

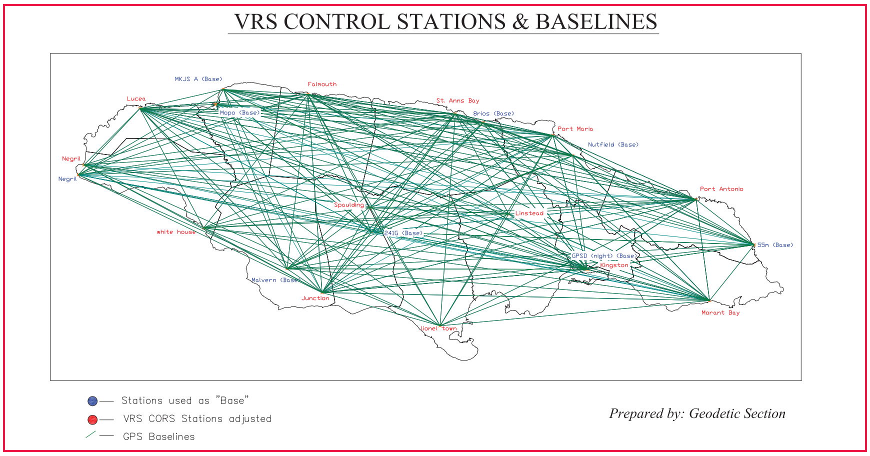

Figure 3: Virtual Reference Stations Network

Division is taking, as articulated above, will render the geodetic infrastructure of a sufficient accuracy to provide users of VRS a sound integrity monitor for their surveys.

Jamaica VRS network

The government of Jamaica under a contract to Spatial Innovision Limited, the regional dealers for Trimble products, has installed a Virtual Reference System constituted by thirteen continuously operating reference stations (CORS) across the island (see Figure 3). The system allows for the real-time augmentation of the information acquired by a single active receiver in the field. The thirteen stations are placed across the island so as to enable full island coverage. This will allow for the use of VRS in any location where no less than three reference station receivers within a seventy kilometre range of that location, will provide a position fix to an active receiver in real-time. The control centre, which is located at the National Land Agency (NLA) transmits differential corrections through a General Packet Radio Service (GPRS) cellular enabled network which is received in real-time allowing for on-site, real-time results. It is anticipated that this infrastructure will be a major boost to the efficiency of the modern land surveyor.

It is expected that the implementation of the Virtual Reference System will revolutionize the surveying and construction sectors as it will lower the cost of positioning. Unique and precise coordinates will be provided for each point that is coordinated with this system as it will be configured to function in the JAD2001 datum.

In October 2009, staff from the Lands and Surveys Division of the National Land Agency together with staff and students from the Division of Land Surveying and Geographic Information Sciences, University of

Figure 4: Occupation of a GNSS Calibration Network Station

Technology and staff from Spatial Innovision Limited, combined resources to coordinate the positions of the thirteen (13) VRS antennas that is to constitute the network.

In this campaign, one (1) of the airport control and eleven (11) other existing points for which JAD2001 coordinates were previously determined during the NLA's densification program, were occupied; six (6) for eight (8) hours and the other six (6) for twenty-four (24) hours. In a constrained adjustment of the network in which the airport control and one (1) other point was held fixed, the residuals at the other points ranged from -0.026m to +0.042m in Northings, -0.044m to +0.051m in Eastings and -0.555 to +0.269 in Height. The less than acceptable spread in the height residuals can be easily explained on the account of the status of our height control given earlier. While using VRS therefore, surveyors expect to achieve in the order of ±0.05 m in Northings and Eastings when checking or integrity testing the VRS before and after using the system for Cadastral Surveys. For the VRS to be of any value in Topographical and Engineering Surveys, substantial work needs to be done to improve our height control infrastructure.

To be continued in next issue

GNSS: Agenda and approach

Excerpts from the report on the United Nations International Meeting on Applications of Global Navigation Satellite Systems, Vienna, 12 - 16 December 2011

The United Nations Programme on Space Applications, the Office for Outer Space Affairs held the United Nations International Meeting on Applications of Global Navigation Satellite Systems at the United Nations Office at Vienna, Vienna International Centre, in Vienna from 12 to 16 December 2011. The Meeting was co-sponsored by the United States of America through International Committee on GNSS (ICG).

The five-day International Meeting on the applications of GNSS was aimed to contribute to international cooperation by providing opportunity to exchange updated information on the use of GNSS technology and its applications. The specific objectives of this International Meeting were: (i) to examine the trends that are apparent in the worldwide development of GNSS and how they will affect the growing population of civil users of satellite-positioning technologies; (ii) to review on-going and planned initiatives as well as case studies that could contribute to the wider use of GNSS technology and its applications, including the possibility of one or more national, regional and international pilot projects, in which interested institutions could incorporate the use of GNSS technology; (iii) identify a functional partnership that could be established in order to promote innovative GNSS-enabled applications, as well as recommend how such a partnership could be established through voluntary actions that could include Governments, international organizations, research and development institutions, academia and other relevant stakeholders; (iv) define recommendations and findings to be forwarded for consideration by ICG and its working groups.

At the opening of the Meeting, introductory and welcoming statements were made by the Director of the Office for Outer Space Affairs and the representative of the United States, as the co-chair of the Action Team on GNSS. The keynote presentation, entitled "ICG and its programme on GNSS applications" was made by a representative of the Office for Outer Space Affairs, in which the work carried out by the Office in supporting activities to promote the use of GNSS-based applications was described.

> The combination of GNSS constellation, and augmentation satellites will provide far superior satellite geometry and signal availability than with one GNSS alone

A total of 41 presentations were made by invited speakers from both developing and developed nations. A total of 75 specialists in satellite navigation systems were invited to attend the International Meeting. The following 36 Member States were represented at the International Meeting: Algeria, Austria, Brunei Darussalam, Burundi, China, Colombia, Costa Rica, Croatia, Ecuador, Egypt, France, Germany, India, Indonesia, Israel, Italy, Japan, Latvia, Madagascar, Morocco, Nigeria, Pakistan, Republic of Moldova, Romania, Russian Federation, Serbia, Spain, Swaziland, Thailand, the Philippines, Tunisia, Turkey, United Arab Emirates, United States of America, and Uzbekistan. The Office for Outer Space Affairs, the European Space Agency (ESA), International Association of Institutes of Navigation (IAIN), International GNSS Service (IGS), International Telecommunication Union (ITU) and Space Generation Advisory Council (SGAC) were also represented.

The presentations made at the Meeting and the abstracts of the papers, as well as the Meeting programme and background materials, are available from the website of the Office for Outer Space Affairs (*www.unoosa.org*).

Participants were divided into four working groups on the basis of their areas of expertise and interest: future of the ICG; GNSS applications and space weather effects on GNSS; regional reference frames and systems; and GNSS education curriculum and ICG information centres.

Working group on future of the ICG

At the Seventh Meeting of the Providers' Forum held in conjunction with the Sixth Meeting of the ICG, it was agreed that the future role and work of the ICG and its Providers' Forum should be reviewed. The decision to begin discussions on the future development of ICG, as a new agenda item at the Providers' Forum meeting, emphasized that ICG shall play an important role in future GNSS developments and their implications for civil use and performance. ICG Member States focused on the issues related to ICG's effective functioning and current format as a body established to promote cooperation on matters of mutual interest related to civil satellite-based positioning, navigation, timing, and value-added services, as well as the compatibility and interoperability of GNSS22. The meeting of the working group on the future of the ICG was chaired by the United States of America, as the co-chair of the Action Team on GNSS. In considering the structure, role and objectives of the ICG and its Providers' Forum in general, the working group prepared an informal note on a number of possible options and modalities that could strengthen the effectiveness of the ICG in the future.

Working group on GNSS applications and space weather effects on GNSS

The working group identified GNSS as the global public goods for worldwide enhancement of the quality of life, particularly with GNSS utilizations such as (i) applications for individual handsets and mobile phones, (ii) road transport, (iii) aviation, (iv) maritime transport, (v) precision agriculture and environment protection, and (vi) civil protection and surveillance.

Placing emphasis on applications development, the working group strongly recommended protection of GNSS spectrum and noted that use of GNSS for sustainable development in application areas, such as navigation, surveying, and mapping, can yield significant societal benefits.

In the context of future developments of GNSS and its applications, the working group identified the achievement of interoperability between different GNSS, and provision of sustained and balanced quality of positioning, navigation, and timing GNSS services as the key elements in order to achieve maximum civil user benefit. It was noted that the combination of GNSS constellation, and augmentation satellites will provide far superior satellite geometry and signal availability than with one GNSS alone, and it will make a big difference to both present and future applications. In this regard, multi-GNSS demonstration campaigns were encouraged.

The working group noted that space weather refers to the environmental conditions in the Earth's magnetosphere, ionosphere and thermosphere due to the Sun and the solar wind that can influence the functioning and reliability of spaceborne and ground-based systems and services or endanger property or human health.

The working group also noted that space weather accounts for the most substantial errors experienced by GNSS systems and their users. Predictions of space weather are important to the GNSS community. Scientific efforts applied to monitoring and predicting space weather and resources available and under development to aid GNSS users in dealing with all possible adverse effects of space weather need to be increased. In this regard the International Space Weather Initiative (ISWI) was emphasized.

> The establishment of GNSS positioning services, is an urgent need for many countries in the world

The working group specifically addressed and highlighted the multi-GNSS demonstration campaign undertaken in the region of Asia and the Pacific, taking into account the fact that this region is an unique area where multi-GNSS constellations and new modernized signals will be able to be utilized sooner than in other regions in the world due to the contributions from regional constellations such as the second stage of Beidou/COMPASS of China, IRNSS of India, and QZSS of Japan, in addition to global GNSS constellations as GPS, GLONASS, and Galileo.

The working group recognized a number of important multi-GNSS benefits: (i) multi-GNSS use can provide not only the increment of the number of navigation satellites but also additional signals and frequencies, (ii) multi-GNSS use is a method to reduce the vulnerability and increase the reliability and robustness of GNSS services. Additionally, the incremental increase of the number of visible satellites using the same frequency can support Receiver Autonomous Integrity Monitoring (RAIM) technologies.

Working group on regional reference frames and systems

The working group recognized that reference networks, comprised of permanent stations, operating GNSS receivers on a continuous basis, provide the fundamental infrastructure required to meet the needs of geodesy, geosciences, navigation, surveying, mapping, and other applications.

The working group encouraged national and regional authorities to support initiatives of regional reference frames and systems such as an International Association of Geodesy Reference Frame Sub-Commission for Europe (EUREF), the European Position Determination System (EUPOS), the Geocentric Reference System for the Americas (SIRGAS), African Geodetic Reference Frame (AFREF), and Asia-Pacific Reference Frame (APREF). A consolidated list of reference frames and systems, that are used by national authorities, agencies, or regional organizations, and their prospective plans for future development should be made available on the ICG Information Portal.

The working group encouraged the use of multi-constellation GNSS signals in reference networks.

The regional reference frames should use, if possible, the same frame (best or latest version) realization for ensuring the trans border data exchange compatibility and interoperability. The best solution is to achieve consensus with neighbouring countries on one reference frame realization.

The utilization of GNSS Real-Time Kinematic (RTK) technique had encouraged users to apply GNSS reference receivers to support the growing number of applications of high accuracy positioning for engineering, precision agriculture, etc. In this regard the working group called for the set up of more permanent stations, or consider the existing dense GNSS Continuously Operating Reference Station (CORS) network infrastructure in order to improve the velocity field of reference frame and provide more adequate information for static and kinematic applications.

Depending on the expected accuracy and type of the required measuring method (static or RTK), the definition of the frame as a static reference frame or as a frame realization with applied velocities should be defined. For the determination of velocity of reference frame repeated static measurements are required. The best method to monitor this is to install GNSS CORS.

The working group felt that the establishment of GNSS positioning services, e.g. RTK networks, is an urgent need for many countries in the world. The working group recommended the provision of a document to the public that describes the procedure to set up a national GNSS positioning service. Geodynamic activities in specific regions need to be considered and may cause different recommendations for stable regions and regions prawn to large tectonic movements.

GNSS education curriculum and ICG information centres

The working group noted the available capacity building opportunities and the status of operation of the UN-affiliated Regional Centres for Space Science and Technology Education, located in Brazil and Mexico for Latin America and the Caribbean, in India for Asia and the Pacific, and in Morocco and Nigeria for Africa. The working group had before it the updated education curricula for (i) remote sensing and GIS, (ii) satellite meteorology and global climate, (iii) satellite communications, and (iv) space and atmospheric science.

Since 2008, all United Nations-affiliated Regional Centres for Space Science and Technology Education are acting as ICG Information Centres.

The working group continued the development of the GNSS Education Curriculum by taking into account GNSS course outlines as used at the university level in a number of developing and industrialized countries. The incorporation of elements of GNSS science and technology into university-level education curricula served a dual purpose. It could enable countries to take advantage of the benefits inherent in the new technologies, which, in many cases, are spin-offs from space science and technology. Utilize the educational system, introduce the concepts of high technology in a non-esoteric fashion and help create national capacities in science and technology in general. Currently there are strong attempts world wide to introduce GNSS

> An increasingly important role of GNSS science, technology, and education calls for the establishment of an International Centre for GNSS Science, Technology, and Education

in terms of science, technology, and applications as a stand alone discipline in the university level teaching curricula.

The working group took note of the fact that the GNSS Education Curriculum under development differs from most of those available in literature and on the World Wide Web. In this regard the GNSS Education Curriculum is a unique result that emanated from the deliberations of the series of regional workshops on GNSS applications since 2006. The working group also agreed to develop as part of the GNSS Education Curriculum a module for hands-on GNSS exercises based on data and equipment used for space weather monitoring.

Based on the working groups recommendations, the International Meeting concluded that an increasingly important role of GNSS science, technology, and education calls for the establishment of an International Centre for GNSS Science, Technology, and Education. This conclusion was emphasised by the ten years of achievement of the United Nations on GNSS.

The International Meeting recommended that the United Nations should lead, with the active support of China and relevant scientific organizations, an international effort to establish an International Centre for GNSS Science, Technology, and Education in an existing national educational and research institution. Beihang University24 of China, offered to host this Centre.

The Centre might grow into a network of centres, focusing on GNSS science, technology, and education, around the world – all dedicated to advancement of GNSS research, applications, and education.

The Centre would provide capacity building and technical guidance to nations that wish to engage in GNSS science, technology, and education. Capacity building consists of three main components (i) Training on GNSS, (ii) Training on data processing and analysis and (iii) Education/training in GNSS science, technology, and applications. GNSS work is roughly divided into two spheres: (a) operating GNSS receivers; and (b) scientific, technical, and educational activities for GNSS. 52. Science, technology, applications, and education are the domain of advanced institutions and universities. The Centre must be part of such an advanced institution or university. Moreover, a proven record of capacity building in space science and technology is an essential prerequisite for the host institution of this Centre.

The Centre must be an institution with a proven record in organizing regional and international GNSS activities. These activities include GNSS schools, workshops, application campaigns, installation of GNSS technology in different regions of the world, training of instrument host staff and students, and regional and international outreach programmes.

The Centre will cooperate with the United Nations affiliated Regional Centres for Space Science and Technology Education, located in India, Mexico/Brazil, Morocco, and Nigeria, the International Centre for Space Weather Science and Education, located in Japan, and other centres of excellence in space science, technology, and education.

The Centre will report annually to the ICG Working Group on Information Dissemination and Capacity Building lead by the United Nations Office for Outer Space Affairs. The Centre will also act as the information centre for ICG.

Geoid modelling

In this work, polynomial models using least squares method was developed from the combination of orthometric heights, from geodetic levelling, with ellipsoidal heights, from Differential Global Positioning System, for Port-Harcourt Area in Nigeria

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The geoid can be determined using different method such as gravimetric, astro-geodetic, GPS/ Levelling and "satlevel". 'Satlevel' is a new method of geoid determination, in which the ellipsoidal height is used with orthometric height to model the geoid. Geoid modelling is a process of developing mathematical algorithms to represent the geoid. This is the reference surface for orthometric height. Geoid is one of the geodetic surfaces.

Geodetic surfaces

All activities in surveying are carried on three basic surfaces referred to as geodetic surfaces. These surfaces are: the topographic surface, the geoid and the ellipsoid

The topographical surface

The Topographical Surface generally called the earth's surface is the actual surface of the land and sea. This is where all measurements and observations are being carried out. It is an irregular surface and therefore geodetic computation cannot be carried out on this surface. The surface that is closely related to the topographical surface is the geoid.

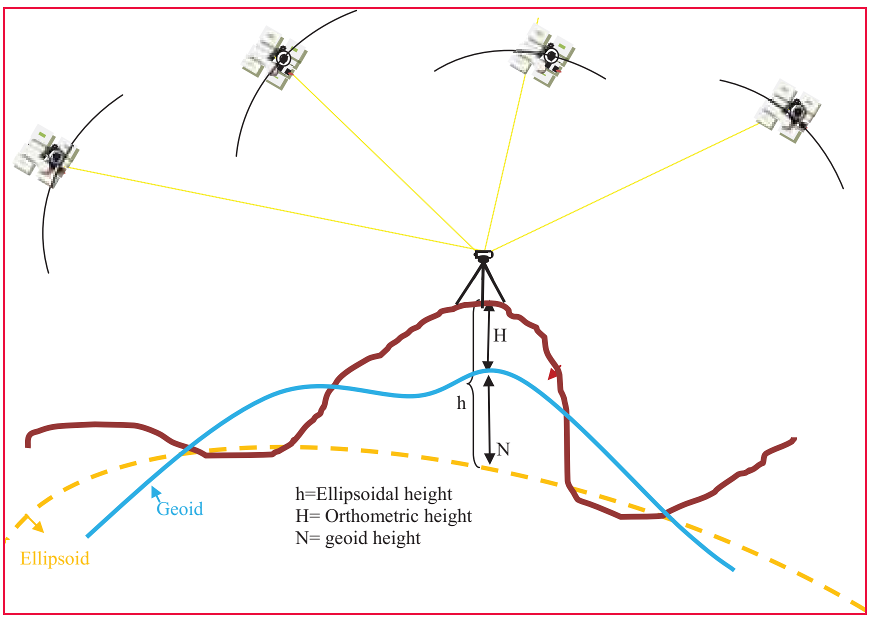

Figure 1: The Geodetic Surfaces and the GPS Satellites

Geoid

Geoid comes from the word "geo" literarily means earth-shaped. The geoid is an empirical approximation of the figure of the earth (minus topographic relief). It is corresponding to the Mean Sea Level (MSL) over the oceans. It has a definite physical interpretation, in the sense that it can be fixed by measurements over the ocean with the use of Mean Sea Level.

Mean Sea Level (MSL)

The surface to which heights of points are referred is called a vertical datum. Traditionally, surveyors and mapmakers have tried to simplify the task by using the average (or mean) of sea level as the definition of zero elevation, because the sea surface is available worldwide.

The surveyor in the field, levels the instrument with the aid of spirit level, which aligns the plumbline perpendicular to the geoid. Therefore, it is a very good approximation to say that the spirit level is always parallel to the geoid, even if a little way above or below it. MSL can be used to approximate the geoid which can be fitted to a more regular surface called the ellipsoid.

The ellipsoid

The ellipsoid may be defined as a surface whose plane sections are all ellipses. One particular ellipsoid of revolution, also called the "**normal earth**", is the one having the same angular velocity and the same mass as the actual earth, the potential U_0 on the ellipsoid surface equal to the potential (W_0) on the geoid, and the centre coincident with the centre of mass of the earth (Xiong *et al*, 2001. The ellipsoid serves as reference to which the coordinates of satellite systems such as the Global Navigation Satellite System are referred.

One of the components of geodetic coordinates is the ellipsoidal height, i.e. the height measured with reference to the ellipsoid; while orthometric height is measured with reference to the geoid. The fastest method of obtaining ellipsoidal height is from satellite methods using Global Navigation Satellite Systems.

Global Navigation Satellite System

Is the general term referred to the families of satellite based positioning systems like the Global Positioning System (GPS), Glonass, Compass, Indian Regional Navigation Satellites System and Quasi-Zenith Satellite System.

Surveys with all these satellites system result in 3D coordinates with reference to a range of reference ellipsoids. GPS provides coordinates using the WGS 84 reference ellipsoid. Ellipsoidal height is not always used because; it does not provide elevation above the MSL which refers to the earth gravity equipotential surface i.e. the geoid, the referenced surface for orthometric heights. There are many reasons which may be accounted for the use of orthometric height.

Spirit levelling is the dominant technique for providing elevation above MSL (Orthometric height) (Bomford,1980; Fajemirokun, 1980; Featherstone, 1998; Vanicek, 2001; Fotopoulus, 2003 and Uzodinma, 2005). The equipment is inexpensive and the method is highly accurate. However, it is labour intensive over long distances and the field procedures are tedious and prone to human and other errors. In some areas such as Niger Delta region of Nigeria, it is often impossible to perform spirit levelling due to weather, terrain conditions and swamps. Ellipsoidal height is simpler and easier to obtain with GPS than orthometric height. Combined, the two quantities give the geoid-ellipsoid separation as can seen in the basic equation 1.1.

$$N = h - H \qquad (1.1)$$

Where:

N = geoid-ellipsoid separation (geoid height)

h = Ellipsoidal height

H = Orthometric height

One of the common problems with height systems in Nigeria is the lack of a uniform reference datum. the MSL is often adopted as the basis for reckoning heights. However, defining the mean sea level and carrying it to the hinterland have always been problematic resulting in poor or uncoordinated height systems (Olaleye *et al,* 2010).

Another problem is the failure of some of the existing models to accurately model the Nigerian environment because they are developed to suit a particular area or region hence there is need for a model to meet the challenges.

The aim of this research is to develop an empirical geoid model for predicting the undulation values for transforming ellipsoidal heights to orthometric heights and vice versa. Using today's available technology and techniques, ellipsoidal heights can be obtained from different systems, such as: Very Long Baseline Interferometry (VLBI), Satellite Laser Ranging (SLR), and other navigation based systems such as: Doppler Orbitography by Radio-positioning Integrated on Satellite (DORIS), GPS and GLONASS and satellite altimetry.

Ellipsoidal height is one of the 3D components of GPS. Apart from ellipsoidal height, the other information required to implement equation 1.1 is the orthometric height, which has relationship with Mean Sea Level as earlier discussed. This can be practically obtained using geodetic levelling for data acquisition.

Study area

The model was tested using the data acquired in Port Harcourt area of Nigeria.

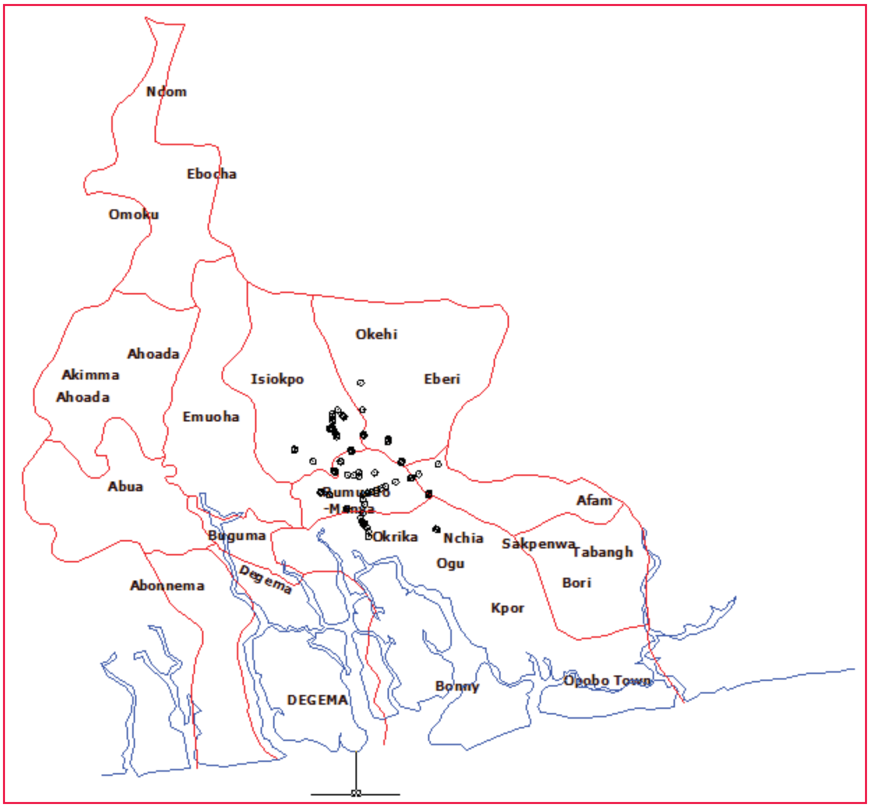

Figure 2: Local government map of rivers state of Nigeria showing distribution of points used for the study

The study area, Port Harcourt lies between latitude: 4°45' and 5°02'N and between longitude: 6°52E and 7°09'E.

Since sufficient data were available to implement Equation 1.1, it is possible to derive a mathematical model such that, with GPS observation, we should be able to compute the geoidal undulation using any regression method, provided it satisfies certain statistical criteria regarding the data and determining the best fit to the observations (Younger; 1985). In this case, the least squares approach was used to find the best curve, that is, the one which is on average closest to all points, since blunders in the observations were removed.

As a way of checking for arithmetic errors or blunders, the values of the coefficients were substituted into the original model and both equations must check. Problems were experienced with regard to the number of decimal places carried causing rounding errors. The new models combined the accuracy of orthometric height and ease of ellipsoidal height in geoid determination to develop the 'Satlevel' model.

'Satlevel' method of geoid determination

Satlevel method of geoid determination involves the use of both ellipsoidal and orthometric heights to develop a mathematical algorithm to determine the geoid. The methodology involves acquisition of data relating to ellipsoidal and orthometric heights, formulating the problems to develop the model and analysis of results.

Field Operations

The field operations were carried out for the purposes of acquiring the ellipsoidal heights and orthometric heights for a number of well distributed points in the study area. Both spirit levelling and GPS field exercises were carried out.

Spirit levelling

Every survey job must be planned to attain certain accuracy. In this research, first order accuracy was planned and achieved in geodetic levelling. (Davis *et al*, 1981; SURCON, 2003).

GPS observation

Methodology of Differential Global Positioning System (DGPS) as given by Trimble (2007) was adopted. DGPS observations were made at the most suitable locations along the levelling routes using a dual frequency GPS receiver (Trimble 4700). The results of the field operation were processed and used for the mathematical modelling.

Mathematical model

Physical evidence of the views of the surface of the earth supports the hypothesis that the totality of geoidal undulation at a geographic location is composed of two parts, namely:

1) the constant part throughout the study area $N_m = X_0$ (independent of position) and
2) the changing part $N_c = f(\varphi, \lambda)$ which depends on changes in geographic location within the study area.

$$N = N_m + N_c \qquad (2.1)$$

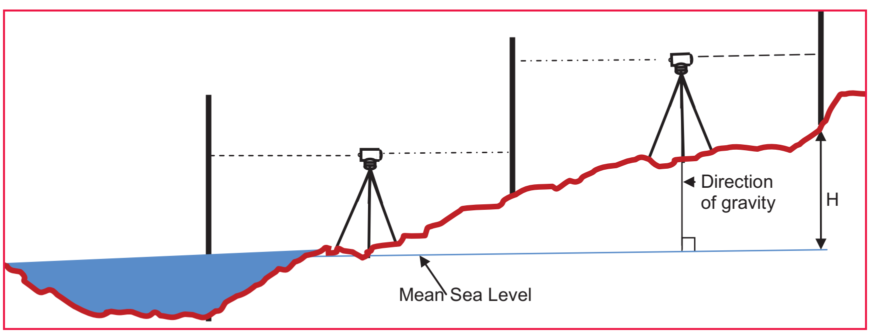

Figure 3: Levelling procedure for acquiring data for orthometric height

The statistical significance of these relationships is considered in developing the model. The model assumed that the geoidal undulation is a function of geographical location. The model was derived

$$\begin{aligned} N_i = N_m + &\left[2h - 3a^2e^2 \sin\phi\cos^4\phi - 3ae^2\sin\phi\cos^5\phi\right]x_1 + \\ &\left[3ae^2\sin^2\phi\cos\phi\sin\lambda + 3a\cos\phi\cos\lambda - h\cos\phi\sin\lambda\right]x_2 + \\ &\left[3a^2e^2\sin^2\phi\cos\phi\cos\lambda - 3a^2e^2\sin^2\phi\sin\lambda + 2h\right]x_3 + \\ &\left[3ae^2\sin^2\phi - 3a\sin^2\phi + 2h\right]x_4 + \\ &\left[3ae^4\cos^2\phi + 3ae^2\cos\phi - 3ae^2 - 3a + 2h\right]x_5 \end{aligned} \qquad (2.2)$$

Where:

x_1, x_2, x_3, x_4 and x_5 are the unknown parameters.

All other terms as earlier defined.The set of base functions for Equation 2.2 were determined and the unknown parameters were estimated using least squares adjustment since sufficient observation point were available.

Results and analysis

Result

The results of data acquisition of orthometric height (H) from geodetic levelling and that of GPS ellipsoidal heights (h) are presented as shown in figure 1. On the Y-axis are the values of undulations while X-axis contained the numbers given to each of the 76 points used for the study. Dh and DH are the ellipsoidal and orthometric heights differences between successive points respectivelly. DIFF is the height differences between Dh and DH Other terms as defined previuosly.

Assessing the parametric model performance

The following tests were used to assess the performance of parametric

Classical empirical approach

The residuals were computed. The mean square error obtained was 0.134mm

Model validation

Data for five points were randomly selected as checks for model validation. The mean square error computed to be 0.159mm


"Much more than a GNSS receiver.
Best in class support. Outstanding reliability."

Significance test of the model parameters

Null hypothesis

$H_0: x_1, x_2, x_3, x_4, x_5 = 0$ (3.1a)

Alternative hypothesis

$H_1: x_1, x_2, x_3, x_4, x_5 \neq 0$ (3.1b)

To test the hypothesis that there is no significant contributions to the variability of geoidal undulation by the explanatory variables.

Decision Rule: H_o may be rejected at significance level $\alpha < 0.05$ if $F > F_{3,71,\alpha=0.05} = 8$ obtained using Microsoft excel.

Decision: H_o was rejected; since the computed F (13) was greater than the F from the table (8). Meaning that, the explanatory variables made significant contributions to the variability of geoidal undulation.

Coefficient of determination

A statistical measure of the goodness of the parametric model fit for a discrete set of points is denoted by R^2. The coefficient of determination for the model was computed as 0.982. Therefore, the variation not accounted for by the model is just 2%.

'Orthometric Height on Fly'

The model was used to develop a computer program to compute orthometric height from GPS coordinates.

Conclusions

In this study, levelled heights were established and the benchmarks were coordinated and collocated with both GPS and geodetic levelling in the Port Harcourt Metropolis. Optimal predictive geoid models 'Satlevel' for deriving orthometric height from ellipsoidal heights on the WGS 84 reference ellipsoid were developed. Analyses were carried out which showed that there is no significant differences between the values obtained with the derived modelled and the observed values. 'Orthometric Height on Fly' was developed for converting GPS ellipsoidal height to orthometric height.

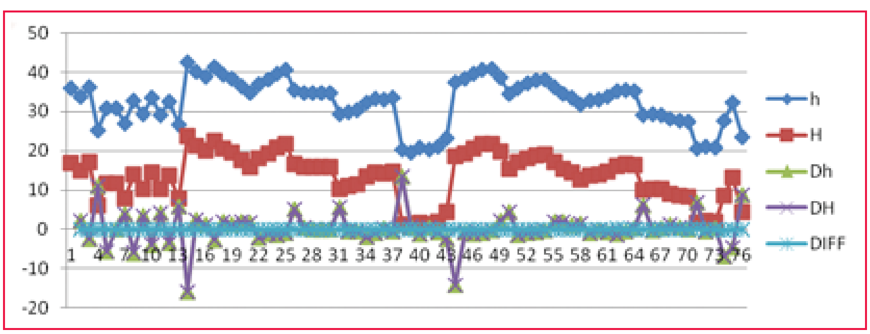

Figure 4: The relationship between the ellipsoidal and orthometric heights

Recommendations

It is also recommended that the area of the data be extended as funds become available so that improvement can be made on the models. It will be necessary to carry differential levelling to other parts of Rivers state and indeed, other parts of Nigeria to serve the need of Surveyors and Engineers.

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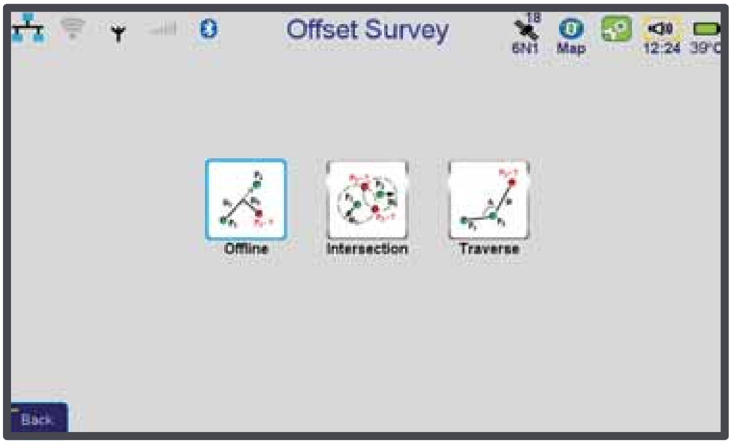
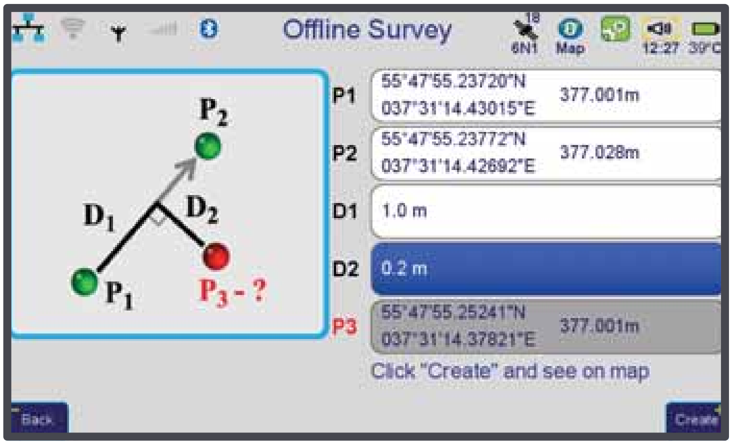
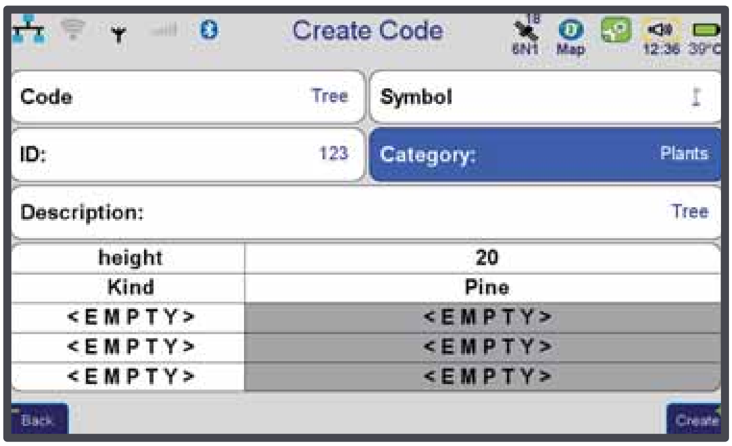


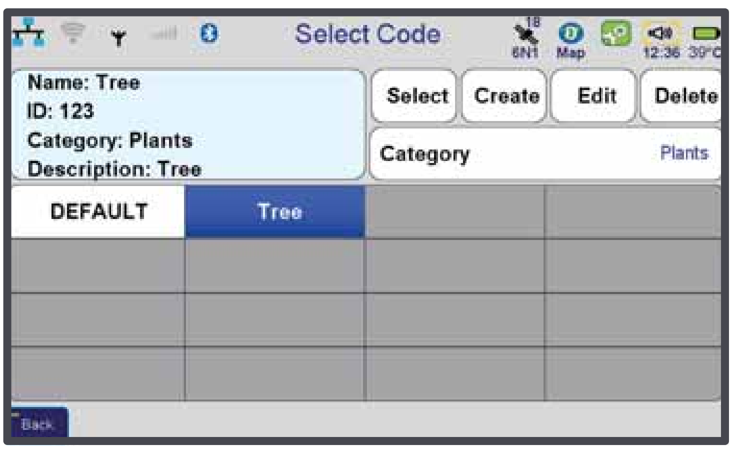
• Offset surveys can be reached from this screen.



• This screen guides you how to perform Offline survey and see the results on the map.



• This simple screen allows you to predefine codes and attributes and access them with a single click during survey.



• This is how code attributes can be selected. You click just a predefined code like “TREE” and all its predefined attributes will carry over.

Using Visual Stakeout

Visual Stakeout purpose

- Visual Stakeout (VSO) is a convenience extension of the regular stakeout procedure. VSO makes it easier to find the target point in the field displaying the point on a special augmented reality screen which can be accessed during a regular stakeout process.

Running Visual Stakeout

Push 1

Start regular stakeout of some previously measured point

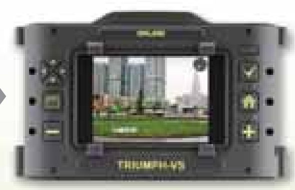
Push 2

On the main stakeout Action Screen push “Fn” button to bring up secondary action screen

Push 3

Use arrow buttons to cycle through the secondary action screen representations until the camera picture shows up

4



Note that the only way to return from the secondary action screen to the main one is pushing “Fn” again. Home button doesn’t work in secondary action screen

Visual stakeout functioning

- While at VSO screen the camera picture will always be displayed. There will also always be a virtual bubble level in the top-right corner of the screen and a green crosshair at the centre of the screen. Virtual bubble level should act just like a real one placed on top if the device, helping to hold the device horizontally. Crosshair only shows the camera optical axis. Generally VSO precision is better when the target point is close to the crosshair.

- When there is a point target point selected for the regular stakeout mode, VSO screen will try to display it over the camera picture. If the point is out of the camera's field of view, wide arrow would appear at the edge of the screen pointing the closest turning direction to bring the target point to the field of view.

- If the target point is in the front camera's field of view, it will be marked with a small green circle and a flag of variable color. The green circle is displayed right at the target point and the flag should look like a real physical flag placed at this point. Note the green circle has a constant size, the flag is always scaled so that it looks like a 1.6-meter height one. E.g. it becomes larger as you approach the point.

- Near the target point the planar distance to it is displayed. The distance is displayed in meters if it's smaller than 1 km and in kilometers otherwise.

- The flag color represents current position solution type: it can be green, yellow or red, indicating RTK Fixed, RTK Float and Stand-alone solutions.

- When you come close enough to the target point the device will automatically switch view to the bottom camera.

- Displayed information remains the same as for the top camera except for the flag. The 1.6-meter height flag is replaced with a 30-cm circle for the bottom camera. The circle should look like a physically painted 30-cm circle around the target point. The circle color has the same meaning as the flag color to the top camera VSO.

- Note that the distance displayed is still a planar one. E.g. holding the device in a meter or two right over the pint will result in a zero distance.

Notes

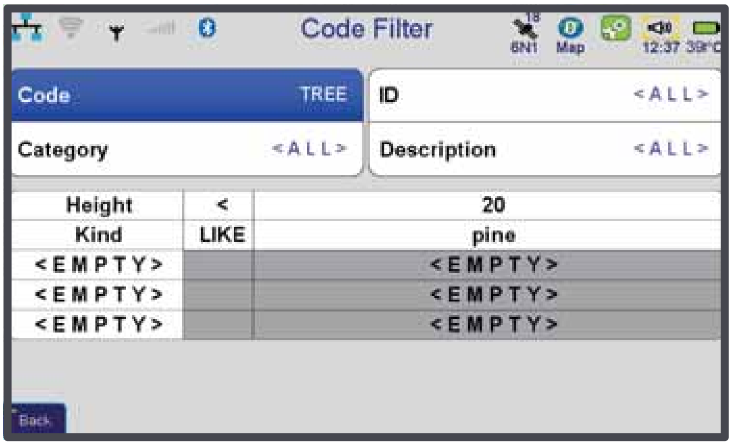
1 The VSO precision is better when you came closer to the target point and it's also better when the point is close to the crosshair. This means that the best way to get the most precise target point picture is to place the device so that the bottom camera's marking circle is right in the center of the screen and the virtual bubble level has its bubble right in the center.
Still the regular stakeout precision is a bit better. So it's recommended to use VSO as an easy and convenient way to get close to the target point, and than switch to the regular stakeout mode to perform precise measurement.

2 The VSO precision is highly depends on the levels and compass measurements. Be sure these are always accurately calibrated.

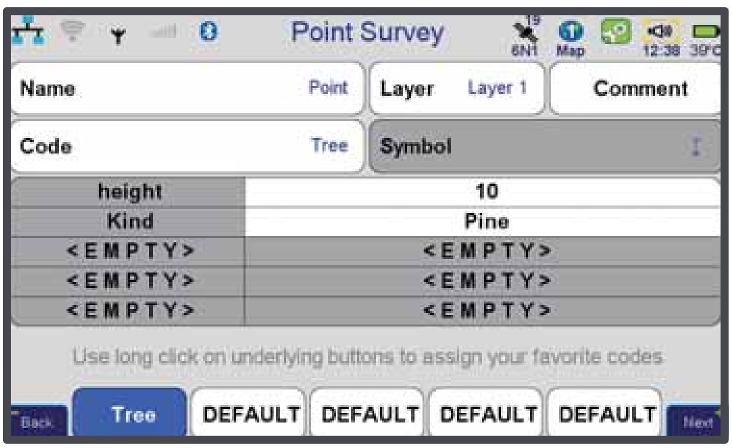
3 VSO is designed to work with the target points at the ground, not in the air. The marking flag and circle would only be painted reasonably if the target point was previously measured with a correct "Measured height" parameter.

Here are some examples

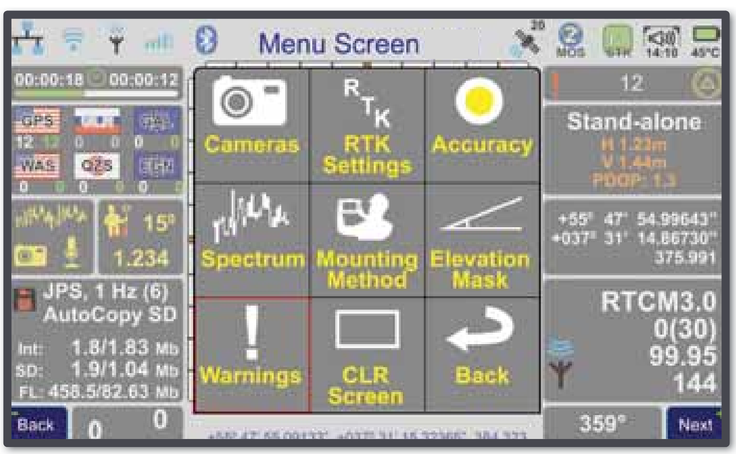
• Code Filter allows you to shorten the points list and identify points that you want to see.



• This is how Code Filters are selected. You can filter on Code, ID, Category, Description and variable attributes.



• A single click from the Action Screen brings you to this screen that allows you to easily assign attributes of points.



• Action Screen shows the status of all functions. Each action can be activated by a single click.

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INS-GPS-GLONASS navigation fusion scheme for high dynamics guided projectiles

This paper presents a comprehensive study on the combining of GPS and GLONASS for receivers and the advantages of either system in case of restricted visibility of satellites and degraded performance of geometric Dilution of Precision

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The Satellite Navigation solution is the most preferable, effective and economic aid to various Low and Medium Grade Inertial Sensors in order to get better Navigation accuracy for medium and long duration of navigation solutions. The navigation data from INS and Sat. Receiver at different intervals is synchronized and fused together by using Kalman Filter algorithm so as to obtain precise Navigation solution as long as Sat. Receiver tracks healthy and sufficient number of Satellites constellation. The major limiting factor with the mostly used/popular GPS system performance is the availability of Satellites and the geometry of Satellites in view at any particular point in space and time. In order to alleviate this restriction for single constellation (i.e. GPS), it stands to reason that more observations to be introduced to provide increased levels of positioning continuity and higher levels of data redundancy. The recent enhancement of GLONASS satellite system suggests combined use with GPS, in order to increase the satellites availability as well as Navigation Solution continuity and accuracy. Taking the advantage of combined GPS-GLONASS systems, the new Hybrid Navigation scheme has been developed to fuse the data from INS, GPS and GLONASS systems by using the raw measurements (Pseudo ranges and Delta Pseudo-ranges) of GG Receiver and which are Synchronized to INS clock (Real-Time algorithms are adopted). The INS system is implemented in the strap down configuration and the Extended Kalman filter is used to fuse the Inertial and GPS-GLONASS Raw measurements data in tightly coupled architecture.

Integration of GPS-GLONASS systems

The GPS and GLONASS satellites transmit ranging signal and the ephemeris data at two different frequencies in the L-band. To our interest, L1 transmitting frequencies for both the systems are shown below. We can also state the transmitted C/A code signal on L1 frequencies from GPS and GLONASS satellites by following equations:

$$s_{gps}(t) = A.c_{gps}(t).D_{gps}(t).\cos(2.\pi.f_{L1gps}).t$$

$$s_{glo}(t) = A.c_{glo}(t).D_{glo}(t).M(t).\cos(2\pi.f_{L1,glo} \pm N.0.5625 \times 10^{6})t$$

where:
A = amplitude of transmitted signal
N = frequency channels of GLONASS (-7 to +6)
$C_{gps}(t)$= 10 bit C/A code of a GPS
$C_{glo}(t)$= 9 bit ML code of GLONASS
$D_{gps}(t)$= 50 Hz Ephemeris data of GPS
$D_{glo}(t)$=50 Hz Ephemeris data of GLONASS
M(t)=100 Hz Meander sequence of GLONASS
$f_{L1,gps}$ = L1 frequency of GPS

(1575.42MHz)

$f_{L1,glo}$ = L1 frequency of GLONASS (1598.0625-1605.375 MHz)

The power transmitted by the GPS and GLONASS satellites are almost similar, where the minimum received power level at the earth's surface is approximately -130 dBm for the C/A code signal. This implies that the signal is merged in thermal noise and is detected using de-spreading the signal.

A combined GPS-GLONASS receiver can dramatically improve the reliability, visibility and productivity of positioning. However, the basic design differences of these system results in significant complexity in terms of modeling and ambiguity resolution for integrated GPS and GLONASS positioning system. Two major differences between GPS and GLONASS that affect the combined positioning are given below.

System time

GLONASS system Time is closely coupled to Moscow time UTC SU (ICD-GLONASS –2000). GLONASS system time is permanently monitored and adjusted in a way that the difference to UTC-SU does not exceed 100ns. It is closely coupled to UTC, but with a constant offset of three hours along with some leap seconds. Since there exist two different master clocks there is difference, which need to be accounted. GLONASS user is informed about the difference to UTC with parameter τ_c, as a part of GLONASS ephemeris .In order to combine GLONASS and GPS the different system time scales must be taken into consideration such that we obtain a unique time for all observation. Transformation from GLONASS time to GPS time can be done with the help of following equation.

$$t_{GPS} = t_{Glonass} + \tau_c + \tau_u + \tau_g + \tau_r$$

where t: Reading of the satellite clock at emission time of the signal

τ_c: GLONASS time scale correction to UTC (SU), given for the calendar Day number within the 4-year period beginning with the leap year

τ_u: $t_{UTC} - t_{UTC(SU)}$

τ_g: $t_{GPS} - t_{UTC}$

τ_r: Receiver clock bias between GPS and GLONASS observations

Since the data from the local timing centers are not compared and combined to UTC in real-time, the difference between UTC(USNO) and UTC(SU), therefore the difference between GPS and GLONASS system time neither is directly (a-priori) available in real-time. This is the crucial problem to be solved when combining GPS - GLONASS data in navigation or in other near Real-Time Operation.

Co-ordinate frames

In GLONASS only solutions, satellite positions in PZ-90 are obtained from the ephemeris data, thus the user position is in PZ-90. In GPS only positioning solutions, the satellite positions are given in WGS84 and thus the user position is in WGS84. Since GPS navigation has become the standard in Western countries and WGS84 therefore is more widely spread and better known than PZ-90, it is considered best to transform GLONASS satellite positions from PZ-90 to WGS84, thus obtaining the user position also in WGS84. There are several transform available, figure below shows one of the most commonly used transform.

The combination of GLONASS and GPS nearly doubles the number of available satellites. This will increase the effectiveness of some applications, e.g., Real-time Kinematics' (RTK) and troposphere estimates. The usage of two autonomous systems should also improve the reliability. As we saw above that in order to combine GLONASS and GPS

- a *unique time scale* for all observations and satellite ephemerides and
- a *unique reference system* for all satellite and receiver positions are required.

Combined positioning

In GPS or GLONASS system, as you know there are four unknowns and more than four observables available. The measurement can be mathematically represented as,

$$\delta\rho_i = \sqrt{(x_i - x_u)^2 + (y_i - y_u)^2 + (z_i - z_u)^2} + b_u$$

where,

ρ is measured range by TOA,

(x_i, y_i, z_i) are satellite co-ordinates,

(x_u, y_u, z_u) are user co-ordinates,

b_u is user clock bias w.r.t. respective system time.

Linearzing this equation through differentiation, we get,

$$\delta\rho_i = \frac{(x_i - x_u)\delta x_u + (y_i - y_u)\delta y_u + (z_i - z_u)\delta z_u}{\sqrt{(x_i - x_u)^2 + (y_i - y_u)^2 + (z_i - z_u)^2}} + \delta b_u$$

For n number of satellites we can write it in a matrix form as,

We can denote the above equation by

$$\delta\rho = \alpha\ \delta x$$

The user position solution and clock bias can be found using iterative least squares method by the following equation.

$$\delta x = [\alpha^T \alpha]^{-1} \alpha^T \delta\rho$$

We know that with increased number of measurements the user position accuracy improves. In order to have more number of measurements we can use satellites from both GPS and GLONASS constellation. It also improves the reliability and integrity of the solution. However, the GPS and GLONASS clocks are not exactly synchronized. So, when computing the combined position solution, we need to solve for this additional unknown. We require a minimum of total 5 satellites from GPS-GLONASS (GG) to get a position fix. A similar least squares approach as defined above can be used for integrated GPS and GLONASS position computation. The Direction Cosines Matrix gets modified as,

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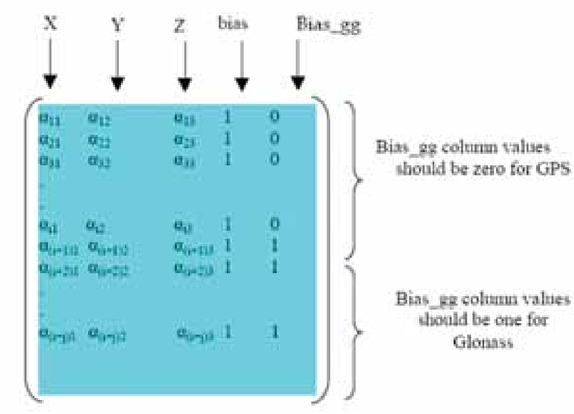

α_{11} to α_{i1} rows are for GPS, and the remaining are that of GLONASS.

High dynamics signal tracking

Two tracking loops are needed to track Navigation Satellites signal. One tracking loop is for Carrier Doppler removal and another is Code tracking loop for phase error elimination. Doppler frequency from carrier tracking loop can be aided to the code tracking loop. The loop consists of prediction integrators, a discriminator and a loop filter. Prediction integrator reduces the noise by integrating the correlation value for a given time. As the integration time increases, the noise performance improves, but the dynamics performance becomes weak. Beyond certain high dynamics the single mode FLL is the preferred carrier tracking loop to track the Satellites signal than FLL assisted PLL Loop. Single mode leads to a marginal tradeoff between accuracy and tracking of the signal beyond certain high dynamics. In our receiver design third order FLL loop has been adopted in order to successfully track the GPS-GLONASS Satellites signal for High Dynamics Projectiles applications.

Tightly coupled INS-GPS-GLONASS fusion scheme

A system diagram representing the integrated INS-GG navigation scheme is shown in *figure 1*. The diagram contains the major elements like INS sensors, GG Receiver and 19-states Extended Kalman Filter in tightly coupled configuration. The complexity of the tightly coupled filter is that the raw measurements are added to the INS-GG filter. At least four more states are be added to the Filter to estimate GG receiver clock bias and clock drift rate w.r.t GPS and GLONASS frames of measurement. The INS process and models (as shown in *Table.1*) measurements from inertial sensors and reconstruct the equation of motions in the ECEF frame for the Vehicle.

The tightly coupled filter requires line of sight information to the satellites as well as potential information on GG signal strength or elevation angle to improve the measurement noise estimates while incorporating the GPS and GLONASS updates. Apart from characterizing the measurement errors to design the measurements matrix *R (for Pr & DPr)* the KF does Estimates Clock Bias and Clock Drift errors of Receiver clock in order to correct the Clock Bias and Clock Drift Models (as shown in *Table 2)* so as to compute true Range and Delta-Range. Before processing the pseudo-range measurement update, an estimate of range to the satellite from the INS i.e. is computed with INS position estimate and the Line-of-Sight vectors to the satellites as shown below:

$$\bar{\rho} = \left\| R_{SV}^{ECEF} - R_{INS}^{ECEF} - 1^{ECEF} \right\| = \sqrt{\Delta x^2 + \Delta y^2 + \Delta z^2},$$

$$e^{ECEF} = \begin{pmatrix} \Delta x/\bar{\rho} \\ \Delta y/\bar{\rho} \\ \Delta z/\bar{\rho} \end{pmatrix} = D_W^E e^W,$$

where, R_{sv} is the satellite position, and *e* is the satellite Line-of-Sight unit vector. The Kalman filter measurement is now defined in terms of the pseudo-range estimate and the GG measured pseudo-range.

The delta-range measurements are formulated by first differencing the pseudo-range estimated at the epoch from the current.

$$\Delta\bar{\boldsymbol{\rho}}(k+1) = \Delta\bar{\boldsymbol{\rho}}(k+1) - \bar{\rho}(k)$$

The delta-range measurement update is then defined by:

$\boldsymbol{y} = (\Delta\bar{\rho} - \Delta\rho_{GG})/\Delta t,$ with Δt the time from the last epoch to the current.

Navigation Kalman Filter implementation

Defined states for Navigation Kalman filter are as follows:

$$\boldsymbol{\delta x = (2\delta b, 2\delta d, \delta R^e, \delta v^e, \delta \Psi_e, \delta\omega^b, \delta a^b,)^t}$$

where,
δR^e, δv^e and $\delta\Psi_e$ are the INS error states for Position, Velocity and Tilt, $\delta\omega^b$ and δa^b are the gyro drift and accelerometer bias error states and 2δb, 2δd are the GG receiver Clock bias and clock drift errors w.r.t to GPS and GLONASS measurements.

Table. 1

	INS Error Modeling
Gyro Error Model	$\begin{bmatrix} \delta\omega_x \\ \delta\omega_y \\ \delta\omega_z \end{bmatrix} = \begin{bmatrix} S_x & M_{xy} & M_{xz} \\ M_{yx} & S_y & M_{yz} \\ M_{zx} & M_{zy} & S_z \end{bmatrix} \omega^b + \begin{bmatrix} G_{xx} & G_{xy} & G_{xx} \\ G_{xx} & G_{xx} & G_{xx} \\ G_{xx} & G_{xy} & G_{xx} \end{bmatrix} + \begin{bmatrix} G^2_x a_x a_z \\ G^2_x a_x a_z \\ G^2_x a_x a_z \end{bmatrix} + \begin{bmatrix} \varepsilon_x \\ \varepsilon_y \\ \varepsilon_z \end{bmatrix} + \begin{bmatrix} n_x \\ n_y \\ n_z \end{bmatrix}$ S_i = Scale Factor Error ε_i = gyro bias drift M_{ij} = Misalignment Error n_i =random walk errors G_{ij} = g-sensitive error G_i^2 = g^2-sensitive error
Accelero--meter Error Model	$\begin{bmatrix} \delta a_x \\ \delta a_y \\ \delta a_z \end{bmatrix} = \begin{bmatrix} K_x & L_{xy} & L_{xz} \\ L_{yx} & K_y & L_{yz} \\ L_{zx} & L_{zy} & K_z \end{bmatrix} a^b + \begin{bmatrix} \nabla_x \\ \nabla_y \\ \nabla_z \end{bmatrix}$ K_i = Scale Factor Error L_{ij} = Misalignment Error ∇_i = Acc-Bias error
	INS Error Equations
Attitude Error Eqn.	$\delta(d\overline{\Psi_e}/dt) = \delta\overline{\Psi_e} \times \overline{\Omega^e} - \overline{C^e_b}\varepsilon_i$
Velocity error Eqn.	$\delta(d\overline{v}/dt)^e = -C^{e*}_b\delta\overline{a^e} + \times(\delta\overline{\Psi_e})C^e_b{}^*\overline{a^{b*}} - \overline{2\Omega^e} \times \overline{v^e} + \delta g^e$
Position Error Eqn.	$\delta(d\overline{R^e}/dt) = \overline{\delta v^e}$

$$y = \bar{\rho} - \rho_{GG}$$

The State Transition Matrix (Φ) is a truncated Taylor series expansion of the analytic Fundamental matrix is represented as:

$$\Phi = e^{At} = I + At + (A^2t^2)/2 + (A^3t^3)/6 + h.o.t$$

$$\Phi = \begin{array}{c} \begin{array}{ccccccccc} ggb & ggd & gb & gd & R^e & v^e & \Psi_e & \omega^b & a^b \end{array} \\ \left(\begin{array}{ccccccccc} 1 & t & 1 & t & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & I & tI & (t/2)X & (t^2/6)XC^b_e & (-t^2/2)C^b_e \\ 0 & 0 & 0 & 0 & 0 & I & X & (t/2)X & t^4/8C^b_e \\ 0 & 0 & 0 & 0 & 0 & 0 & I & tC^b_e & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & I & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & I \end{array} \right)_{19\times19} \end{array}$$

Observation process

The measurement matrix z_k is processed by the filter to yield the best estimates of the error state x_k.

$$z_{(k|k-1)} = H_k x_{(k|k-1)}$$

the observation matrix H_k relates the components of the of the true state vector to the measurements.

The observation matrix's for pseudo-range is as follows:

$$H_\rho = \left[\begin{array}{cccccccccc} 1 & 0 & 1 & 0 - e_x^L & - e_y^L & - e_z^L & 0 & 0 & & \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{array} \right]_{1\times19}$$

The observation matrix for Delta-range is as follows:

$$H_{\delta\rho} = \left[\begin{array}{cccccccccc} 0 & t & 0 & t & 0 & 0 & 0 - e_x^L & - e_y^L & & \\ - e_z^L & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{array} \right]_{1\times19}$$

In the observation matrixes the first two elements represent the GPS clock bias and clock drift observations. The next two elements are the GLONASS clock bias and clock drift observations. The Measurement noise values for *Pr & Dpr* are 2 m and 0.02 m/s respectively.

Voting for multiple GG navigation solutions and receiver data validation for KF

The fusion Filter is driven by number of Navigation solutions available with GG receiver. Therefore it becomes obvious to take best decision in Real time to get optimized Hybrid Navigation solution so as to guide the Vehicle in the desired basket of accuracy.

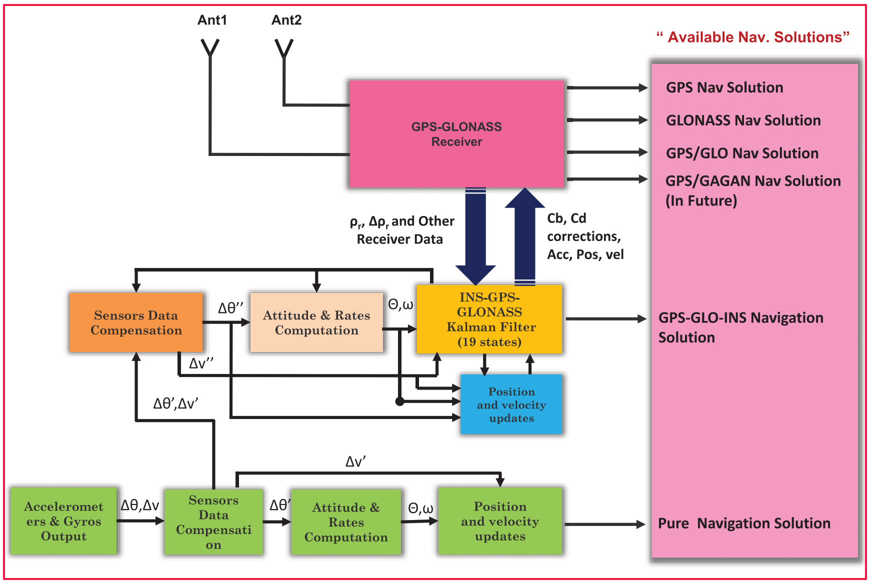

Figure 1: Tightly Coupled INS-GPS-GLO Navigation Scheme

Table: 2

	GG Error Modeling
Pseudo-range measurements	$\rho = c\Delta T + b - b_s + d_i + d_t$
Delta-range measurements	$\delta\rho = c\Delta T - c\Delta T_{old} + b_d\Delta t$ where, **Δt** = measurement update interval **ΔT**$=(t_r - t_t)$=signal time delay t_r=time of reception t_t=time of transmission **c**=speed of light **b** = receiver clock bias error $\mathbf{b_s}$ = bias due to SV clock error $\mathbf{d_i}$ = ionospheric delay $\mathbf{d_t}$ = tropospheric delay $\mathbf{b_d}$ = bias due to GG Rx clock drift
Receiver clock bias model	$d(\delta b)/dt = w_{\delta b}$, where $w_{\delta b}$ is white noise process

As shown in the *fig2*, for the available multiple GG navigation solutions, the voting is done to select the best available solution among all and w.r.t that the Data validation is carried out for valid channels before its transferred to the KF (as shown in *fig 3*). The KF processes the valid data form Inertial Sensors as well as from GG Receiver and generates second level of errors compensation for all designed states as shown in *fig 1*.

We can conclude that the redundancy of GG Navigation solution ensures high level

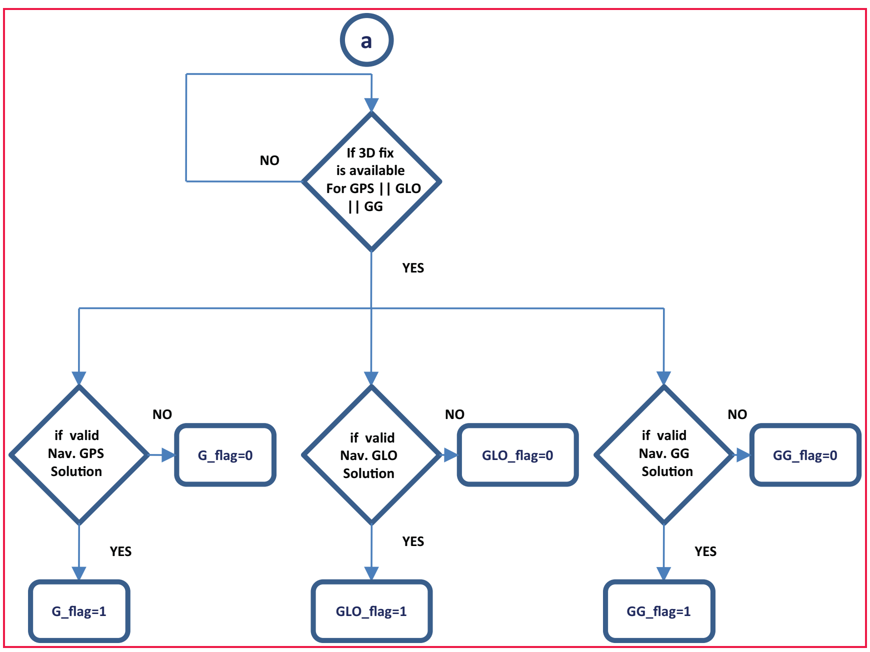

Figure 2: Voting for GG Navigation Solution

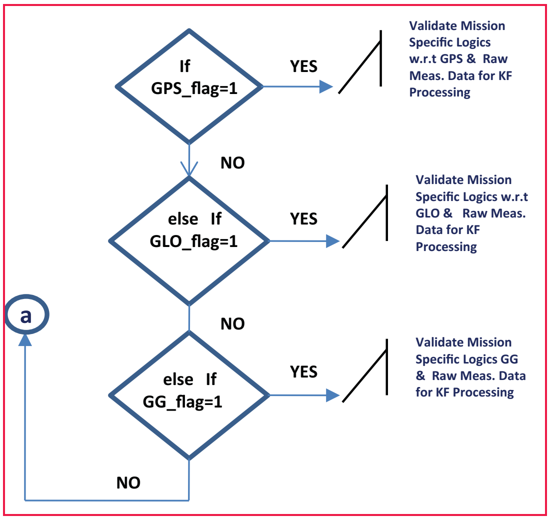

Figure 3: GG Data Validation for KF Processing

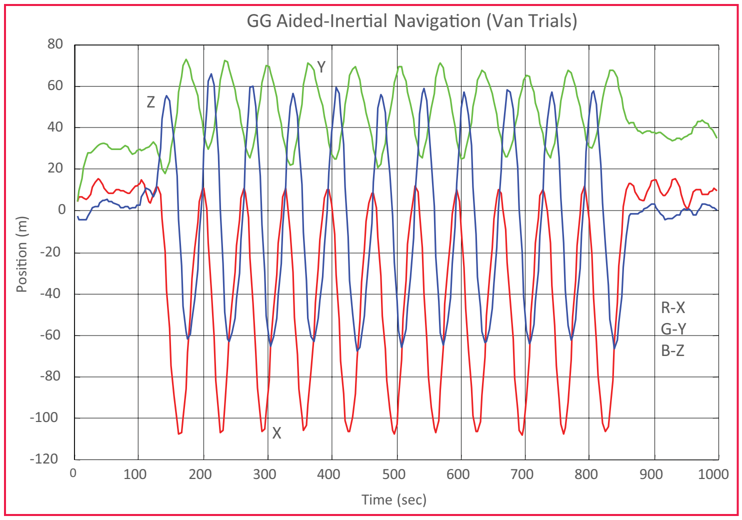

Figure 4: GG aided Inertial Nav. Relative Positions for Van Trials

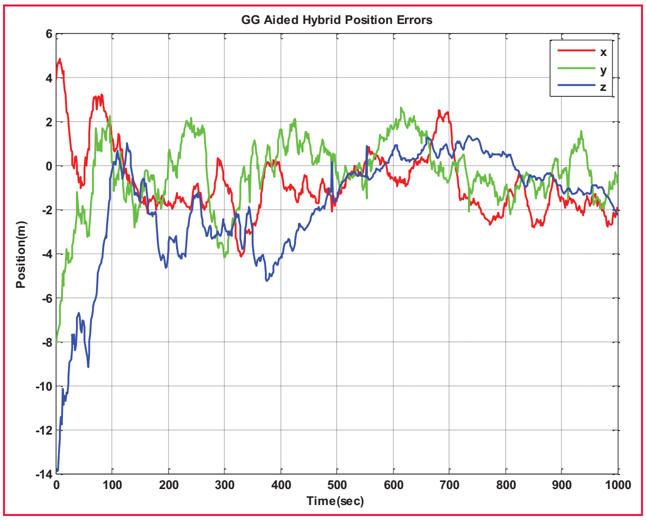

Figure 5: GPS-GLONASS aided Inertial Navigation System Position Errors

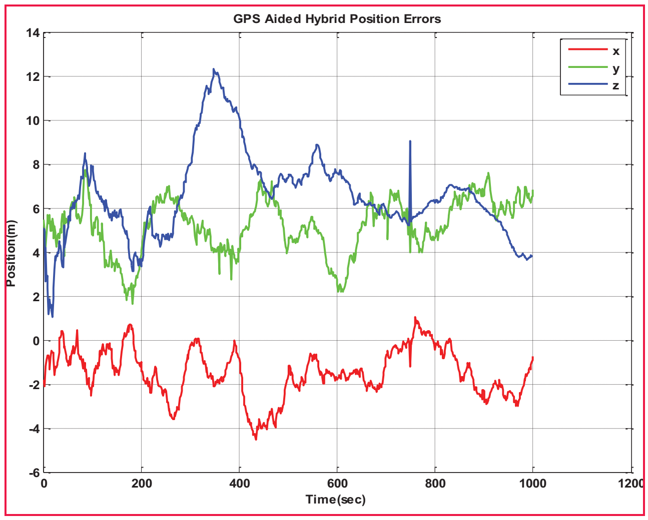

Figure 6: GPS aided Inertial Navigation System Position Errors

of reliability to the GG aided inertially guided vehicles in the entire range of flight.

INS-GPS-GLONASS Scheme Performance

The performance of the GPS-GLONASS aided Inertial Navigation systems are evaluated for Real Time in the Lab as well as for the simulated Flight trajectories of various High Dynamics Projectiles. This study has been carried out using different class of Inertial Sensors ranging from Medium Grade to High Grade accuracy. The Navigation filter was tuned for different application by adjusting noise spectral densities in order to achieve acceptable filter performance for Low and High Dynamics applications.

Figure 4 & 6 shows the Medium Grade Dynamically Tuned Gyros based INS-GG System performance (for static and Low Dynamics). As analyzed, where the INS is aided by single (GPS/GLO) constellation, the position error of Hybrid Navigation is driven down to less than 15m (1-σ) after about 50 sec, whereas the position error of combined aided GPS-GLONASS constellations is better than 7m (1-σ) after 50 sec as shown in figure 5. It has been observed that for weak GPS constellation the concurrent healthy GLONASS measurements provides better accuracy, high redundancy and more reliable combined GG solution. This also results in improved GDOP and Hybrid Navigation Performance. Further the Real Time Simulation studies are carried to analyze the performance of this scheme for High Velocity Projectile applications. The scheme has been simulated for medium range guided Projectile and post simulation results were analyzed as shown in *fig 7* & *fig 8*. The Projectile travelled with forward velocity 800m/s and beyond covers the short (< 100 Km) to medium down range (< 250 Km) in the flight time of 371 sec. As it's analyzed, the Vehicle in the entire Thrust Phase and beyond is guided through either by GPS or GG aided Navigation by correcting all the propagated Navigation errors in all phases, which resulted in achieving the desired accuracy for Hybrid Navigation (< 25 m, 1-σ) of the Vehicle as shown in *fig 8*.

Summary

In degraded signal environments the accuracy and availability of the GPS


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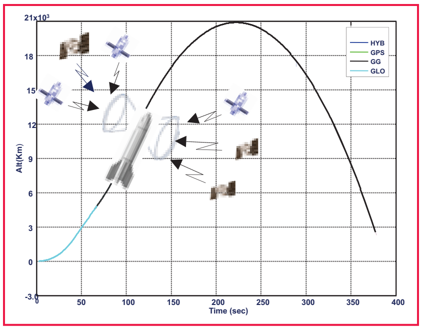

Figure 7: Trajectory Profile for High Dynamics Projectile

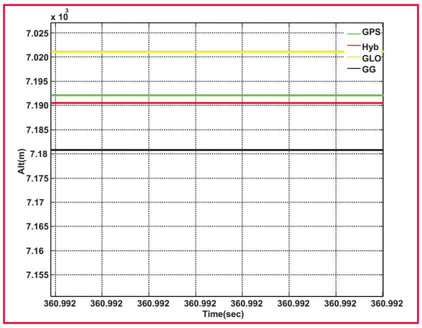

Figure 8: In flight performance of Integrated INS-GPS-GLO system

are affected for Kinematic applications. To address this issue, combined GPS-GLONASS systems are studied for various Low and High Dynamics applications using tightly coupled GG aided INS solutions to overcome the problem of using single constellation when we desire to achieve reliable high terminal accuracy for Inertial Guided Vehicles. In tightly coupled integration scheme the raw receiver measurements are directly used to update the Kalman Filter. Some of the benefits are : more direct exploitation of fundamental measurement data, more direct aiding of the receiver tracking loop by the filter and INS, better resiliency to poor satellite geometry, high vehicle dynamics and data dropouts etc. Work to further improve the tightly coupled TTFF (Time to First Fix) GG aided Low Grade INS performance for short range is currently underway. In addition, studies which will asses Hybrid Navigation performance under Ultra Tightly Coupled TTFF GG-INS scheme are also planned.

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eHarta tryst with Romania

Community powered project, a success beyond borders

Codrina Maria Ilie
Board Member
geo-spatial.org

Historical maps represent a valuable cultural and scientific heritage. Maps are much more than just physical representations of a territory at a certain time. Personal beliefs, political interests and cultural views are also a part of the message sent by maps through time.

eHarta is a collection of thousands of georeferenced historical maps, published and documented with the help of the community. It is a collaborative initiative to digitally preserve and freely share old cartographic documents. The datasets are published by geo-spatial.org – a collaborative online platform aiming to facilitate the sharing of geospatial knowledge and the discovery and publishing of free geographic datasets and maps for the Romanian community. The project has many similarities with this kind of projects, such as the project initiated by the National Library of Scotland in collaboration with Klokan Technologies GmbH, but some remarkable differences as well. The most important features of the project are described below:

- eHarta aims to offer free online access to thousands of old map sheets and atlases. All the maps are made available for download as georeferenced independent files and accessible through a number of web services that fit a broad range of users (e.g. Zoomify tiles or KML files for ordinary users; standard geospatial services like WMS/WMTS for users with advanced GIS skills).
- eHarta has no financial resources available. It completely depends on community contributions (e.g. metadata creation, data processing, etc.), institutional donations (e.g. Internet bandwidth, free access to map archives, access to high performance scanners and other digital preservation instruments) and free and open source software usage.

> eHarta aims to offer free online access to thousands of old map sheets and atlases

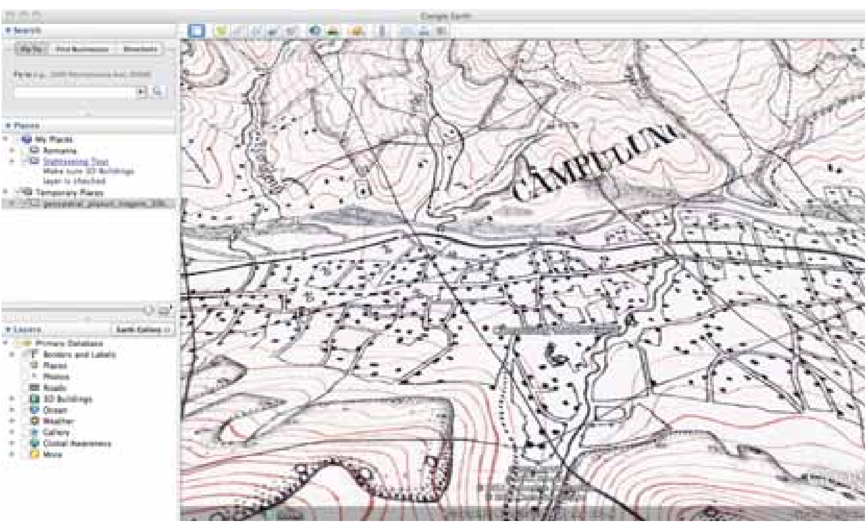

Figure 1. Example: map access through Google Earth.

Community involvement

Community powered projects are no longer a novelty. Online initiatives like Wikipedia or OpenStreetMap proved that it is possible to achieve incredible results, both in quality and quantity, only with volunteers, open data/knowledge model and an adequate set of web tools. eHarta employs the same principles and methods like other online collaborative projects:

- Friendly web interfaces for old map related operations (e.g. metadata creation, add control points for georeference, image enhancements, etc.);
- Feedback channels
- Open data license for the final products
- Public recognition of each member contribution
- User content control mechanisms

eHarta has no financial resources available. It completely depends on community contributions, institutional donations and free and open source software usage

For the eHarta project the geo-spatial.org members were invited to contribute with their time, knowledge, and experience. In just two months after the project's launch more than 200 accounts were registered. We consider the number to be quite significant when talking about a niche community like the Romanian historical cartography passionate individuals. More importantly, thousands of map sheets were processed in just two to three days after digital scans were made available. eHarta project started with the publication of the 1:20.000 Romanian map series under the 'Lambert-Cholesky' projection system. The maps were created after World War I, for military purposes (especially artillery). More than 1,800 map sheets from this collection were identified in archives belonging to the Faculty of Geography – University of Bucharest, Faculty of Geography - University Babes Bolyai, Institute for Cultural Memory and the National Museum of Romanian History. The maps were scanned at 300 dpi and saved as uncompressed TIFF files. Zoomify versions were later derived for metadata creation and identification of control points for georeferencing. Several web user interfaces were created to facilitate the community's involvement. The final step of this first eHarta project was to publish the maps as raw files and standard web service (Figure 1).

Architecture

eHarta online system was designed following a distributed architecture, entirely based on free and open source software. The content is managed by Textpattern, a powerful and flexible open source content management (CMS) application. For supplementary, specific functionality, custom modules were built. Other free applications are providing server-side functionality: MySQL (relational database management system), PHP, Python, Java (server-side scripting languages), Apache (webserver), Tomcat (servlet container), phpMyAdmin, phpPgAdmin (web clients for database management).

For geospatial data management, top open source applications were also integrated in the website: PostGIS (vector geospatial data storage), GeoNetwork (geospatial data catalog and metadata editor), GeoServer (standard geospatial server for serving data via WMS), GeoWebCache (Java based WMTS/TMS server, with pluggable caching mechanisms and rendering backends), OpenLayers and GeoExt (client webmapping application), GDAL (data processing). The information flow between the various server side applications and the front-end graphical interface is determined by the interaction with the portal users and their requests (Figure 2).

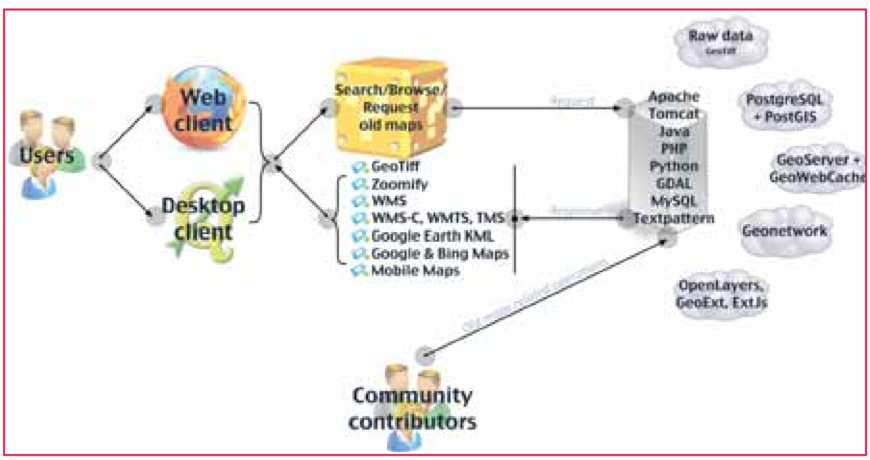

Figure 2: eHarta system architecture.

Public recognition

eHarta collaborative project won the 'Better Data Award' at 'Open Data Challenge'. The prize was awarded at the Digital Agenda Assembly, being held in Brussels on 16th and 17th June 2011, by the European Commission Vice-President Neelie Kroes. Organized by the Open Knowledge Foundation and the Open Forum Academy under the auspices of the Share-PSI initiative, the Open Data Challenge invited designers, developers, journalists, researchers and the general public to come up with useful, valuable or interesting uses for open public data. It attracted 430 entries from across the EU. Entries were invited in four categories for prize money totaling €20,000. The categories were fully blown apps, ideas, visualisations and liberated public sector datasets. The winners were selected by open data experts, including the inventor of the World Wide Web Sir Tim Berners-Lee.

Future opportunities of development

The success of the eHarta project was beyond expectations, if we are to consider the number of contributors and the appreciation received from third parties, beyond Romanian borders. The attention led to more than one perspective in the future development of the project. We were offered the umbrella of an international renown, openhistoricalmap.org, or the possibility of integrating our map collections in the oldmapsonline.org project. Another interesting possibility is the extension at a regional dimension of the eHarta project itself. There have been concrete offers of datasets from Hungary, Poland, Czech Republic, Ukraine and France to integrate within our project. *(http://earth.unibuc.ro/articole/eHarta?lang=en)*

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Avoid tweet at London Olympics

LONDON Sports fans attending the London Olympics were told to avoid non-urgent text messages and tweets during events because overloading of data networks was affecting television coverage. Commentators on men's cycling road race were unable to tell viewers how far the leaders were ahead of the chasing pack because data could not get through from the GPS satellite navigation system travelling with the cyclists.

An explosion in the use of mobile phones to access the Internet and take and send photos and video has made London 2012 the first true "social media Games", but also put pressure on the networks. The host broadcaster, the BBC, is enabling fans to see many events live on their smartphones. *http://www.reuters.com*

GPS can now measure ice melt

Researchers have found a way to use GPS to measure short-term changes in the rate of ice loss on Greenland - and reveal a surprising link between the ice and the atmosphere above it. The study, published in the early online edition of the Proceedings of the National Academy of Sciences, hints at the potential for GPS to detect many consequences of climate change, including ice loss, the uplift of bedrock, changes in air pressure - and perhaps even sea level rise. *http://researchnews.osu.edu*

Telekom Malaysia partnership to enhance local GPS

A collaboration between MSC [Multimedia Supercorridor] Malaysia status IT solutions firm Milan Utama and national telco Telekom Malaysia (TM) will enhance content for a Malaysian GPS navigation solution.

TM executive vice president, SME, Azizi A Hadi said one of the objectives of the partnership is to enhance the content of Lokatoo, a local GPS navigation solution. "Through this partnership, Yellow Pages business listings and TM WiFi sites will also be embedded into the GPS navigation system; a synergy that will provide a richer content of directory information for Lokatoo users and bring a whole new meaning to navigating."

Currently, the Lokatoo GPS navigation system is developed specifically to cater to automakers and will be available for mass consumer segment by the end of 2012. *http://www.mis-asia.com*

Four GPS centres to come up in Rajasthan, India

With a view to monitor and study earthquakes, over 250 GPS centers would be set up in the country including four in Rajasthan. These centers will be funded by the Ministry of Earth Sciences, New Delhi. Though most of these centres will be set up in the Himalayan region but having identified earthquake-sensitive zones in Jaisalmer, Bikaner, Ganganagar and Kota, four centres will be set up in Rajasthan too. *http://articles.timesofindia.indiatimes.com*

RMIT in Japanese space hook-up

Australia's RMIT University has secured an agreement to develop global navigation satellite systems with the Japan Aerospace Exploration Agency (JAXA). The collaboration, recursively dubbed the Multi-GNSS (Global Navigation Satellite System) Joint Experiment in the Asia-Oceania Multi-GNSS Demonstration Campaign, consists of a series of evaluation activities over five years. These evaluation trials will include the JAXA Quasi-Zenith Satellite System (QZSS) which is a network of multiple satellites in orbits with zenith paths over Japan. Under the agreement, JAXA will loan two GNSS receivers to RMIT to conduct the Multi-GNSS Joint Experiments. *http://www.theregister.co.uk*

Russia Offers India Joint GLONASS Development

Russia has offered India joint participation in development of its GLONASS satellite navigation system on an equal basis, Deputy Prime Minister Dmitry Rogozin. "We have offered our Indian counterparts not only use of the Glonass system but also participation in upgrading it. We practically see it as a joint effort. I think our Indian counterparts will be interested in it," said Rogozin, who has special responsibility for Russia's military-industrial complex. *http://en.ria.ru/mlitary_news*

Police suspect Glonass contractor of misappropriating $17M

Police raided a Russian space firm suspected of misspending 565 million rubles ($17 million) of state money on developing the country's Glonass satellite navigation system, according to the Interior Ministry. Investigators established that managers at Russian Space Systems, a contractor used by the Federal Space Agency, signed research contracts with unqualified commercial companies, only to siphon off the money later. *http://www.themoscowtimes.com*

GLONASS designer honored with Royal Institute of Navigation Award

The Royal Institute of Navigation has awarded the Duke Of Edinburgh's Navigation Award for Technical Achievement to Professor Nicolai Testoedov, who received it on behalf of Yuri Urlichich, the chief designer of GLONASS, "in recognition of the achievement of a complete operational constellation of satellites in December 2011, thus providing a full global positioning and timing service."

Country will soon have its own navigation satellite: ISRO chief

India, which is using navigation satellites of other countries now, will soon have its own navigation satellite system, said K. Radhakrishnan, chairman of Indian Space Research Organisation and the Space Commission. He said that the first of the seven satellites of the Indian Regional Navigation Satellite System would be launched in 2013. He said that ISRO would launch Astrosat, an Indian multi wavelength astronomy satellite, in 2014. He added that Chandrayaan I had helped discover water molecules on the Moon and ISRO would work in this area in the coming years too. *http://www.thehindu.com*

SLA launches 7th SiReNT station

Singapore Land Authority (SLA) launched its 7th SiReNT Continuously Operating Reference Station (CORS) recently. This latest reference station, SNSC, is GNSS capable and provides GPS + GLONASS corrections. This CORS is located at the National Sailing Centre along East Coast Park. This CORS is fully independent, using solar & battery power with 3G/GPRS for communications. SNSC is also the first SiReNT ground based CORS. With the introduction of SNSC, the SiReNT infrastructure now consist of 5 GPS + 2 GPS/GLONASS CORS. For SiReNT users, the introduction of a 7th CORS means the ability to apply differential corrections for equipment that are GPS+GLONASS capable. These equipments are preferred to traditional GPS only equipment in urban canyon environments, which are common in Singapore' landscape. *www.sla.gov.sg*

Europe clears first airline satellite navigation operation

Europe is rolling out operational service of its satellite-based aircraft navigation system EGNOS, an official with Britain's largest air traffic control agency said. An 18-passenger aircraft serving the island of Alderney, located off the French coast of Normandy, is the first to be outfitted and certified to use the European Geostationary Navigation Overlay Service, or EGNOS. The system, which makes use of GPS signals to guide aircraft to the runway, is particularly useful when visibility is limited. *http://www.reuters.com*

NICT and Fujitsu develop indoor guidance technology for the blind

Japan's National Institute of Information and Communications Technology (NICT) and Fujitsu have announced their joint development of an indoor support system for the blind that uses ultra wide band (UWB) technology and a smartphone. The system is able to provide real-time positioning data, even indoors where GPS cannot be used, and provide audio instructions on the distance and direction to a destination to help guide the blind. This guidance support system for the blind reduces inconveniences facing the blind and is expected to pave the way to major R&D advances in other guidance support systems. *http://www.nict.go.jp/en/index.html*

Navilock presents new generation of u-blox based GLONASS receivers

Navilock has announced a new family of GLONASS receiver products including the NL-662U USB based receiver equipped with a u-blox GLONASS chipset. The receiver products have internal patch antenna in various configurations to serve different installation requirements. Four housing variants with USB or serial MD6/TTL interfaces are available for installation on vehicles or boats. *www.navilock.com*

Using cell phone while driving could get reported

Researchers at Anna University of Technology in Tamil Nadu, India have developed a technology that not only jams cell phone calls while a vehicle is in motion, but can report a driver's attempt to use their mobile communication devices to the authorities. The technology, based on RFIDs, is aimed at preventing truck drivers and other road users from using their cell phones while driving and could also be integrated with police traffic monitoring. *http://fleetowner.com*

Indoor GPS system uses smartphone and earth's magnetic field

Finnish researchers from the University of Oulu (who founded their own company named IndoorAtlas) may have a solution with an indoor positioning system that uses the Earth's magnetic field to figure out exactly where you are. The research is already being adapted into a product that your smartphone can use to create indoor maps and IPS-powered apps. The idea behind the technology is to use your smartphone's magnetometer, which powers your phone's digital compass, to identify your location no matter where you are.

Compasses can be useless in an urban setting because all the metallic structures that throw the Earth's smooth magnetic field out of whack. IPS, however, doesn't use your digital compass to derive which way is north. Instead, it uses the phone's magnetometer to map these magnetic disturbances to produce a digital representation of a building's floor plan. *http://www.pcadvisor.co.uk*

App to know where you are

Buti Mohammad Al Delail, 21, a recent graduate of Computer Engineering at the university in Sharjah has developed an indoor navigation application that could kick-start the future of indoor mapping. Only outdoor maps are presently accessible through Google.

Buti's 'Context Aware Visual indoor Augmented Reality' application (CAViAR App), which is compatible with and downloadable from Apple's iTunes platform, uses state-of-the-art Augmented Reality (AR) technologies to provide the user with the blueprint of his/her location, 3D view of the vicinity and navigation based on image detection. *http://www.khaleejtimes.com*

Where will you be this time tomorrow?

UK researchers have developed an algorithm that can predict your future geographic location using data gathered from your friends' smartphones. In the study of two hundred people, the algorithm predicted the location of some users 24 hours later within 100 metres, others as close as 20 metres.

Mirco Musolesi, lead researcher and computer science lecturer at the University of Birmingham, said the algorithm is exploiting the synchronized rhythm of the city. "I know this kind of thing looks kind of Big Brother," said Musolesi. There is a problem for privacy, it is a big problem for these kind of services in general." Still, if users' phone information could be protected, the algorithm has a potential future in targeted advertising, said Musolesi. *http://www.thestar.com*

Police of Finland Make Neighborhoods Safer

The Police of Finland - Poliisi - wants to make neighborhoods safer by engaging the citizens of Finland in a mobile and online social conversation. Poliisi will be testing beta app Grafetee as a public safety tool in the following months, and engage with non-mobile users via Grafetee-supported interactive map on *lahivinkki.com.*

It allows users to update their status with images and text, and to alert the police in real time about things happening in their area, without having to actually make a call. With just a tap, citizens of Finland will be able to report a crime or a dangerous situation, or inform officials of any situation needing immediate attention. Likewise, the police can alert citizens and request support as needed. *www.prweb.com*

Flickr adds Nokia Maps for Photo Geotagging

Photo site Flickr has partnered with Nokia for an all-new online maps function. Up-to-date maps now provide greater levels of detail and allow closer zooming than before, thanks to Nokia's map style and satellite images, as well as continued Open Street Map (OSM) integration for areas where commercial maps didn't have full coverage. *www.pcmag.com*

XcelMobility launches Mach 5 LBS feature

XcelMobility Inc has introduced its Mach 5 LBS as a featured product and optional component of its Mach 5 browser accelerator product line. The Company has opened talks aimed at cellular carriers, OEM manufacturers and retail distributors for initial entry into the Asian marketplace within the next few months. *www.xcelmobility.com.*

Smartphone-interfacing solutions for compatible automotive navigation

The North and Latin American automotive navigation markets are on the cusp of a shift to connected navigation systems that offer real-time traffic information and local searching options. Navigation systems, whether by original equipment (OE) fitment, aftermarket, or portable navigation device (PND), are feeling the heat of competition from smartphone-based navigation applications. Low-cost smartphone replication technologies are helping navigation markets breach the perimeter of the mass market. *www.frost.com*

Lexus selects TomTom navigation

TomTom will supply one of the navigation solutions available in Europe on the upgraded Lexus CT 200h. The MoveOn navigation system offers TomTom HD Traffic and is seamlessly integrated in the dashboard of the Lexus CT 200h. It will be introduced in several European markets this year. *www.tomtom.com*

DigitalGlobe and GeoEye merge

DigitalGlobe and GeoEye have announced that the boards of directors of both companies have unanimously approved a definitive merger agreement under which the companies will combine in a stock and cash transaction valued at approximately $900 million. The combination of DigitalGlobe and GeoEye will create a global leader in earth imagery and geospatial analysis with a more diversified revenue base, a superior financial foundation and significant growth potential.

The transaction structure will allow both DigitalGlobe and GeoEye shareowners to participate in the substantial value creation opportunity resulting from this combination. The combined company will be named DigitalGlobe and continue to trade on the NYSE under the symbol DGI. By bringing the two companies together, this combination will enable the U.S. government to meet the requirements of the EnhancedView program at substantial savings to the U.S. taxpayer. In addition to the compelling savings, the U.S. government and other customers will benefit from an optimized constellation and better integrated imagery collection, processing and analytics. www.DigitalGlobe.com, www.geoeye.com

India to boost space assets to meet demand

India is boot-strapping its space-based assets to meet the growing demand for enhanced services in communications, broadcasting remote-sensing and navigation, "To meet the rising demand for multiple space-based services spanning communication, navigation and earth observation, we are enhancing our capacity in terms of rockets, satellites and ground-based systems," Indian Space Research Organisation ISROchairman K. Radhakrishnan said recently. "We are doubling our rocket launches soon to deploy as many heavier communication and earth-observation satellites for meeting the growing demand of service providers, state-run organisations and security agencies," he added. *http://www.newstrackindia.com*

Cameroon to protect forests with satellite monitoring

Cameroon has joined a Congo Basin initiative that uses satellite imagery to monitor changes in forest cover in an effort to curb deforestation and help Central African countries access carbon finance. Democratic Republic of Congo (DRC) and Central African Republic (CAR) signed an agreement with the French government and Astrium Services ahead of U.N. climate talks in South Africa late last year. The Agence Française de Développement (French Development Agency) is financing the provision of SPOT satellite imagery to Central African countries to support their participation in the U.N.-backed REDD (Reducing Emissions from Deforestation and Forest Degradation) programme. *http://www.trust.org*

First Vietnam-made satellite launched into orbit

The unmanned Japanese spacecraft HTV-3 left the Tanegashima Space Centre on July 21, bringing five small satellites, including Vietnam's F-1, into orbit. F-1 is first of its kind designed and manufactured in Vietnam by the Space Research Division (FSpace) of FPT Technology University, measures 10x10x10cm and weighs one kilogram. It can take 640x480 pictures and send them to earth at a speed of 1,200b/s. The satellite will be used to help monitor maritime transport and forest fire prevention efforts. *http://english.vov.vn/Home*

Belarus' first satellite enters orbit

Belarusian authorities have announced that a remote sensing satellite the country launched had entered its designed orbit. The Belarusian satellite, which was launched together with four other space vehicles of Canada, Germany and Russia, has transmitted data to the satellite flight control center based in Minsk, capital of Belarus, according to head of the satellite flight control center Vladimir Yushkevich. *http://news.xinhuanet.com*

Satellite usage surveys planned

The Japanese government is supporting two surveys on possible uses in Myanmar for an earth observation satellite that is scheduled to be launched in December, the Ministry of Transport said. The ASNARO satellite, provided by the Japanese government, weighs almost 500 kilograms and will have an estimated lifespan of three years. *www.mmtimes.com*

AeroGRID signs agreement with BKG for aerial imagery of Germany

AeroGRID has announced a new licensing agreement with BKG (Bundesamt für Kartographie und Geodäsie), the German government's federal provider of orthophotos and mapping. The agreement enables AeroGRID to distribute high resolution 20cm orthophoto data of all Germany via WMS and also sell the imagery offline. *www.aerogrid.net*

exactView-1 satellite launched

Surrey Satellite Technology Ltd (SSTL) has announced the successful separation from the Soyuz launcher and subsequent operation of mission-critical systems onboard the exactView-1 satellite, which was built by the Company under contract to prime contractor COM DEV Canada for exactEarth. exactView-1 separated from the Soyuz launch vehicle's Fregat upper stage in low Earth orbit approximately 2 1/2 hours after launch.

SSTL will continue the commissioning of the satellite in orbit. Once all platform systems are operational, engineers from COM-DEV Canada will work alongside the SSTL ground operations team to commission its highly advanced Automatic Identification System payload. *www.sstl.co.uk*

Esri Joins World Ocean Council

Esri has joined the ocean business alliance World Ocean Council (WOC) and will support its international initiatives for sustainable development and conservation of the ocean. Esri chief scientist Dawn Wright will share her geospatial expertise with WOC's Coastal and Marine Spatial Planning (CMSP) and Ocean Science working groups. WOC members are oil and gas, seafloor mining, shipping, fisheries, aquaculture, tourism, and offshore renewables companies. *esri.com/news*

GIS installing new number plates in all buildings

New number plates have been installed on 90% of buildings in Qatar as part of the unified number project undertaken by the Centre for Geographical Information System (GIS). The project is conducted in two phases: First external number plaques are to be installed on all buildings, whether residential, commercial, services or towers. In the second phase, sub-numbers will be given for the units within the buildings whether they were apartments, offices or shops, which would be normally linked to the external number. This second phase is estimated to take two years and would be launched shortly. All new plaques have RFID data chips hidden in them. These include all the related numbers and data of the building and directly linked with the GIS data base. These chips can be read through PDA appliances. These employ information safety standards to avoid any misuse. *http://www.gulf-times.com*

Delhi-Jaipur Expressway route mapping complete

Route identification for 265 km Delhi-Jaipur Expressway has been completed, the Road Transport and Highways Minister, Mr C. P. Joshi, has said. "We want an expressway on the PPP (Public-Private Partnership) model". The starting point in the national capital for the expressway, for which the detailed project report has been finalized, would be the Indira Gandhi International Airport. He said that alongside the expressway, with controlled access, will be a few nodes where real estate hubs would be developed. *http://www.thehindubusinessline.com*

New initiative to help 10 central African countries in monitoring: FAO

A new regional initiative will help 10 central African countries to set up advanced national forest monitoring systems, according to FAO. The 10 countries are part of the Congo Basin and include Burundi, Cameroon, Central African Republic, Chad, the Democratic Republic of the Congo, the Republic of the Congo, Equatorial Guinea, Gabon, Rwanda and São Tomé and Principe. The forestry project will be managed jointly by the Central Africa Forests Commission (COMIFAC) and FAO in close collaboration with the Brazilian National Institute for Space Research (INPE). The Congo Basin Forests Fund, launched by the Governments of Norway and the United Kingdom through the African Development Bank, is funding the initiative with €6.1 million. *http://www.fnbnews.com*

Jamaica to develop NSDI

The Government is working to build a national spatial data infrastructure (NSDI) for Jamaica, announced Robert Pickersgill, Minister of Water, Land, Environment and Climate Change. "This is necessary to facilitate sectoral growth, and for us to keep up with technological advancements and of course, provide for the geospatial data needs of the government and our people". He informed that work is currently underway on a metadata policy, which will make it mandatory for all creators of geospatial data to collect and maintain metadata, adding that all creators and users of geospatial data need to collect and manage metadata. *http://www.jis.gov.jm*

Find "1", Get "1", Use "1"

What's "1"? It's the new set of digital cartographic frameworks from The National Atlas of the United States of America®. Prepared at one million-scale (where an inch on a map is nearly 16 miles) this authoritative and integrated national dataset has twice the detail of previous versions. Users can now easily find "one" using popular search engines or portals like Data.Gov; get it as documented data or Web map services from nationalatlas.gov and other sources; and use "one" in their geospatial analyses, maps, or map mashups. This new release serves as the foundation for small-scale maps and datasets on the Nation's people, heritage, and resources. *http://nationalatlas.gov*

Namibia: Ministry Launches Vital Aerial Photo-Imaging Exercise

The Ministry of Lands and Resettlement launched a N$19-million project that entails the gathering of aerial and orthophoto images of the country. The project will cover central Namibia between 20 degree south latitude and 24 degree 10 minutes south latitude, covering an area of 320 000 square kilometers. The project will deliver full-colour digital, imagery including panchromatic and infra-red, with applications such as map revision, land-use planning, archeology, movie production, environmental studies, surveillance and environmental site assessments. *http://allafrica.com*

Kuwait to monitor encroachment of state properties via g-tech

The Ministry of Finance, Kuwait, signed an agreement with an international consultancy company, Jiscon, to set up a GIS database for the state. Under the agreement, a GIS database will be developed which will store all important maps and documents. Such kind of database will help relevant authorities to pin point any kind of infringement on state properties, degree of such breaches and cost of removing and restoration of illegally build structures. *http://www.kuna.net.kw*

Sri Lanka eyes PHL land admin and management reforms

Officials of the Democratic Socialist Republic of Sri Lanka recently visited the Philippines to study the country's

land administration and management system, including the property valuation and taxation, intending to learn from the Philippines' successful experience under the Second Land Administration and Management Project (LAMP2) of the Department of Environment and Natural Resources (DENR), and the Department of Finance (DOF).

In 2011, the UN Special Unit for South-South Cooperation recognized the LAMP project as an "example of successful solution to support rural and agricultural development, and that the experience of the Philippines offers a comprehensive solution to improving land tenure regulation and land rights". LAMP2 is a long-term commitment of the government to address poverty alleviation and promote economic growth through secure land tenure and equitable property valuation. *dof.gov.ph, http://www.gov.ph*

BAE Systems merges multiple geospatial technologies

BAE Systems developed SOCET GXP® v4.0 which merges the full spectrum of mapping and analysis capabilities into a single package. Commercial, defense, and government customers worldwide can now use the same tool to create and share a wide range of products, from complete 3-D city models to GeoPDF intelligence reports. *http://www.marketwatch.com*

Bangalore: City's property ID model

In a major boost to the Bruhat Bangalore Mahanagara Palike, the Union government of India has decided to mandatorily implement the Bangalore model of GIS based on the Unique Property Identification Number (UPID) in all the municipal corporations across the country.

The officials at the Union Ministry of Urban Development were so impressed with the UPID that they wanted it to be linked with Jawaharlal Nehru National Urban Renewal Mission (JnNURM) scheme. It is pushing a proposal wherein it will be mandatory for states or cities to implement the GIS-based UPID to avail funds under the scheme. *http://www.deccanherald.com*

Galileo update

Galileo interoperability with GPS

ESA's first two Galileo navigation satellites in space have achieved their latest milestone, transmitting dummy signals in a modulation scheme designed to allow full interoperability with the US GPS once operational services start.

"This is an advanced modulation technique that offers robust protection against signal interference and the misleading signal reflections known as 'multipath'," said Marco Falcone, Head of Galileo System Services.

"Significantly, this is also the European version of the Multiplexed Binary Offset Code signal standard agreed with the United States for the interoperability of Galileo and GPS.

"So this transmission helps demonstrate how the two systems will work together in future with no risk of signal interference." *http://www.esa.int*

EU boosts GPS accuracy with web-based service

European Commission vice president Antonio Tajani has unveiled a new service intended to make satellite data more reliable. The European Data Access Service (EDAS) will make data from the European Geostationary Navigation Overlay Service (EGNOS) available on the Internet. As a result, people will be able to access this GPS data from hand-held devices, Tajani said, improving the accuracy of things like high-precision fertiliser spraying, automatic road-tolling, fleet management, inland waterway navigation, dangerous goods transportation or accurate area measurement. *http://www.pcmag.com*

ESA... GIOVE-B going soon

ESA's GIOVE-B experimental navigation satellite is gradually raising its orbit as it prepares for well-earned retirement at the end of its four-year mission paving the way for Europe's Galileo constellation. Recently, an initial thruster firing raised GIOVE-B's orbit by about 30km. This will be followed by others soon so that by mid-August the satellite will be in a graveyard orbit some 600km above its original 23,222km orbit. *http://www.satnews.com*

ESA extends its navigation lab in readiness for galileo testing

With the next Galileo launch approaching, ESA has extended its Radio Navigation Laboratory to meet the testing needs of Galileo. Located at ESA's ESTEC technical centre in Noordwijk, the Netherlands, the laboratory has almost doubled in size, and includes a specialised facility, the PRS Laboratory, suitable for evaluating the single most precise and secure type of Galileo signal, the Public Regulated Service (PRS).

Transmitted on two encrypted signals, PRS offers the highest accuracy Galileo service, with access reserved for governmental organisation such as the police, fire brigade or civil protection. *http://www.spacedaily.com*

New System test algorithms combining GNSS and inertial MEMS

Spirent Communications has launched new simulation software that combines inertial MEMS sensor with multi-GNSS (GPS, GLONASS, etc.) testing. SimSENSOR includes trajectories that embed representative human motion gestures, such as arm movements. In additon MEMS noise models and errors such as bias and drift are also available under user control. The software can test fusion algorithms that take inputs from a large variety of sensors, including accelerometers, gyroscope, magnetometer, digital compass and barometric height sensors.

Ultimate construction data preparation software by Leica

Leica Geosystems has added the latest office software to its recently launched new Leica iCON portfolio. It is a complete data preparation, editing and reporting software package is the link between the office and the Leica iCON hardware and software solutions for many construction applications. *http://www.leica-geosystems.com/icon*

Trimble to supply GNSS receivers to Japan

Trimble has announced that it will supply more than 500 Trimble NetR9 GNSS reference station receivers to the Geospatial Information Authority of Japan (GSI), part of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), to modernise its nationwide GeoNet GNSS-based network. *www.trimble.com*

Leica GeoMoS 5.3 integrated as a secure windows service

Leica GeoMoS has been updated to version 5.3. In order to enable a permanent monitoring process, the latest version provides the best possible integration into a modern and high secure IT infrastructure as a windows service. For large monitoring installations using GNSS sensors and multiple total stations with hundreds of prisms, new functionalities have been introduced that make the configuration easier and the monitoring process faster. *www.leica-geosystems.com*

NVS Technologies AG Selected by Panasonic

Panasonic has announced the launch of a Toughbook® CF-31 model with a built-in GPS/ GLONASS NV08C-CSM receiver by NVS Technologies AG, the first rugged notebook on the Russian and CIS market. "The Built-in GPS/ GLONASS navigation receiver does not increase the weight and dimensions of the laptop. The model CF-31 with the GLONASS navigation system is primarily intended for government agencies, law enforcement and military services, which carry their operations in the harsh weather conditions, as well as for industries where the use of the protected equipment is essential - oil and gas, energy, transportation, exploration, forestry and fisheries sectors.", as quoted by Panasonic. *www.nvs-gnss.com*

Stamp-sized GPS-INS unit to debut

The world's first GPS-aided inertial navigation system on a surface-mount chip the size of a postage stamp is being unveiled by a U.S. company. VectorNav Technologies said its VN-200 combines an advanced GPS module with the latest in MEMS inertial and pressure sensor technology. Its onboard microprocessor runs an aerospace-grade Kalman filter algorithm at a rate of as much as 200 Hz and provides accuracies better than 0.25 degrees in pitch and roll and 0.75 degrees in heading, the company said. *http://www.upi.com*

GMV collaboration with South African national space agency

GMV is leading a major satellite navigation project in collaboration with the South African National Space Agency (SANSA). The project, SBAS Awareness and Training for South Africa (SATSA), will increase the technological navigation capacity in the South African region ultimately improving location identification and tracking capabilities for Safety-of-Life Services especially during emergency or disaster situations. SATSA is set to run for 18 months during which GMV will install testing platforms in South Africa for conducting practical tests. www.usa.gmv.com.

Carlson Survey 2013 Just Released

Carlson Survey 2013 provides upgrades to core features like the coordinate database, Field-to-Finish coding and As Built Reports as well as new commands, including one to twist points to a 3D view. Its 2013 version provides support for AutoCAD® 2013 and also works on AutoCAD versions 2004 and newer. All Carlson 2013 office software comes with IntelliCAD® 7.2 built-in, which offers greater performance and stability, plus support for MrSid and JPG 2000 images.

New GNSS receiver by Altus Positioning Systems

Altus Positioning Systems has launched its new APS-U GNSS receiver. It is scalable from a single stand-alone GNSS receiver to full options with heading, wireless links, precise point positioning and RTK capability. The unit has an additional processor for on-board configuration and custom applications separate from the GNSS engine. It has an extensive suite of interfaces for data output, timing, event marks and a second antenna port for GNSS heading. *www.altus-ps.com*

Hemisphere GPS awarded new patents

Hemisphere GPS continues to expand its intellectual property portfolio with newly awarded patents. These patents represent the latest advancements in adaptive machine control and GNSS solutions. The Adaptive Machine Control System and Method patent describes the sophisticated adaptive control methods used to guide vehicles and provide accurate and efficient coverage. The system is comprised of a machine controller, GNSS guidance system, and software and is most commonly used in precision farming. The patent supports current products and new developments within Hemisphere GPS' precision farming product line including Outback Guidance® branded products. *www.HemisphereGPS.com/Patents*

New Version of NMEA 0183 Released

The National Marine Electronics Association (NMEA) has released a significantly updated version of NMEA 0183, its well-known standard that enables the interfacing of marine electronics. Version 4.10 will improve boating safety and navigation through updates and expansions of various electronic communications "sentences" pertaining to a number of navigation and communications devices, including Galileo satellite receivers and Automatic Identification Systems (AIS). *http://www.maritime-executive.com*

New GNSS SBAS receiver by Geneq

Geneq Inc. has announced the SXBlue II GNSS, a GNSS receiver that uses both GPS and GLONASS with SBAS (WAAS/EGNOS/MSAS/GAGAN) to attain 30cm/1 ft (RMS) accuracy in real-time using free SBAS corrections. In addition to the built-in long-range Bluetooth transceiver, the SXBlue II GNSS also has a standard DE-9 RS-232 port and a USB Type B port whose outputs are fully programmable up to 10Hz standard, and a 20Hz option. Other optional features are L1 RTK for <2cm real-time accuracy and base station RTCM output. There is no need for post-processing or other sources of differential corrections as the SXBlue II GNSS uses WAAS (North America), EGNOS (Europe), MSAS (Japan) and GAGAN (India) satellite corrections. Users receive real-time, 30cm/1 foot positioning all day long. *http://www.sxbluegps.com*

CHC introduces the X900+ Advanced GNSS Receiver

CHC has launched X900+ GNSS receiver bringing the future proof GNSS tracking technology to surveyors without the conventional cost associated with GNSS solutions. It combines advanced 120-channel GNSS technology (GPS, GLONASS, Galileo and Compass) and state-of-the-art RTK reliability and accuracy for either traditional base + rover configuration and RTK networks thanks to its flexible GPRS and UHF communication systems. *www.chcnav.com*

Mali Hydro Agriculture Mapping Project Relies on ProMark GNSS Technology

CIRA, a major West African consulting engineering firm, working on behalf of the Office du Niger, a quasi governmental Mali company charged with managing more than 100,000 hectares of irrigated delta land, has completed surveying an additional 25,000 hectares for hydro agriculture development. In the course of two months during the dry season, two CIRA survey teams, each equipped with three Ashtech ProMark 500s, a base station and two rovers connected via UHF, completed the entire survey collecting four points in x,y and z per hectare to produce the digital model. *www.trimble.com*

Trimble positions software for Mapping and GIS Applications

Trimble® Positions™ Mobile extension is a new streamlined choice for integrating Trimble's GNSS professional field solutions and data verification into the Esri ArcGIS for Windows Mobile environment. It was first introduced as a development kit to Trimble's GIS developer community in late 2011. Today, the software suite has expanded to provide a streamlined option for users who wish to work directly with Esri's ArcGIS for Windows Mobile technology. *www.trimble.com/positions*

First open source initiative for CARIS

CARIS has released its first open source API - CARIS OSCAR-js, a JavaScript Map API, allows you to create and embed custom web maps on your website. The API was created to help shape CARIS Spatial Fusion Enterprise and includes tools for navigation, measurement, and download, as well as providing a means for developers to create their own custom tools and extensions. It extends the very popular OpenLayers library and utilizes jQueryUI and YUI to help create a feature rich mapping experience. The API is designed around the creation of map themes. *www.caris.com*

Location-based services gaining traction in South Africa

Recent TNS research found that there is a growing appetite for LBS among mobile subscribers worldwide, including South Africa. Jacques Swanepoel, MD of Cellfind, says that the technology is gaining traction for navigation, personal safety and entertainment applications. LBS are set to break into the mainstream of South Africa's mobile market, with more than half of consumers expressing interest in using these services in the near future. This reflects a growing understanding of the benefits of LBS in South Africa. *www.cellfind.co.za.*

MARK YOUR CALENDAR

September 2012

ION GNSS 2012
September 17-21, 2012
Nashville, Tennessee, USA
www.ion.org

October 2012

IAIN 14th Congress & Melaha 2012 Conference
1 – 3 October
Cairo, Egypt
www.ainegypt.org

GISSA Ukubuzana 2012
2 - 4 October
Gauteng, South Africa
www.gissa.org.za

UPINLBS 2012 Conference and Exhibition
3 – 4 October
Helsinki, Finland
http://217.152.180.26/upinlbs/

INTERGEO 2012
9-11 October
Hanover, Germany
www.intergeo.de/en

XXXII INCA International Congress
11 – 13 October
Dehradun, India
sajeevnair_inca32@yahoo.com

19th ITS World Congress
22 – 26 October
Vienna, Austria
http://2012.itsworldcongress.com/content/congress

19th United Nations Regional Cartographic Conference for Asia and the Pacific
29 October - 1 November
Bangkok, Thailand
http://unstats.un.org/unsd/geoinfo/RCC/unrccap19.html

The International symposium on GPS/GNSS 2012
31 October - 2 November
Xi'an, China
www.gpsgnss2012.com

November 2012

Trimble Dimensions User Conference
November 5-7
Las Vegas, USA
http://www.trimbledimensions.com/

2012 International Conference on Indoor Positioning and Indoor Navigation (IPIN)
13-15 November
Sydney, Australia
www.surveying.unsw.edu.au/ipin2012

spatial@gov® Conference and Exhibition 2012
20 – 22 November
Canberra, Australia
www.cebit.com.au/spatial

8th Fig Regional Conference
26 - 29 November
Montevideo, Uruguay
www.fig.net/uruguay

The 33rd Asian Conference on Remote Sensing
26 - 30, November
Pattaya, Thailand
http://acrs2012.gistda.or.th

December 2012

European LiDAR Mapping Forum
4 - 5 December
Salzburg, Austria
www.lidarmap.org

NAVITEC 2012
5 - 7 December
Noordwijk, Netherlands
www.congrexprojects.com/12c13/introduction

4th Asia Oceania Regional Workshop on GNSS
9-10 December
Kuala Lumpur, Malaysia
www.multignss.asia

January 2013

ION International Technical Meeting
27 – 29 January
San Diego, California, United States
http://ion.org/meetings/

February 2013

Second High Level Forum on Global Geospatial Information Management
4-6 February
Doha, Qatar
http://ggim.un.org/

The International LiDAR Mapping Forum
11-13 February
Colorado, USA
www.lidarmap.org

The Munich Satellite Navigation Summit 2013
26 – 28 February
Munich Germany
www.munich-satellite-navigation-summit.org

April 2013

Pacific PNT
22-25 April 2013
Honolulu, Hawaii
www.ion.org

35th International Symposium on Remote Sensing of Environment
22 - 26 April
Beijing, China
http://www.isrse35.org

June 2013

TransNav 2013
19 - 21 June
Gdynia, Poland
http://transnav2013.am.gdynia.pl

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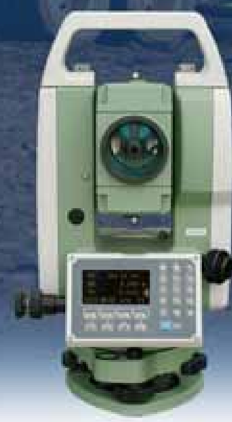

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