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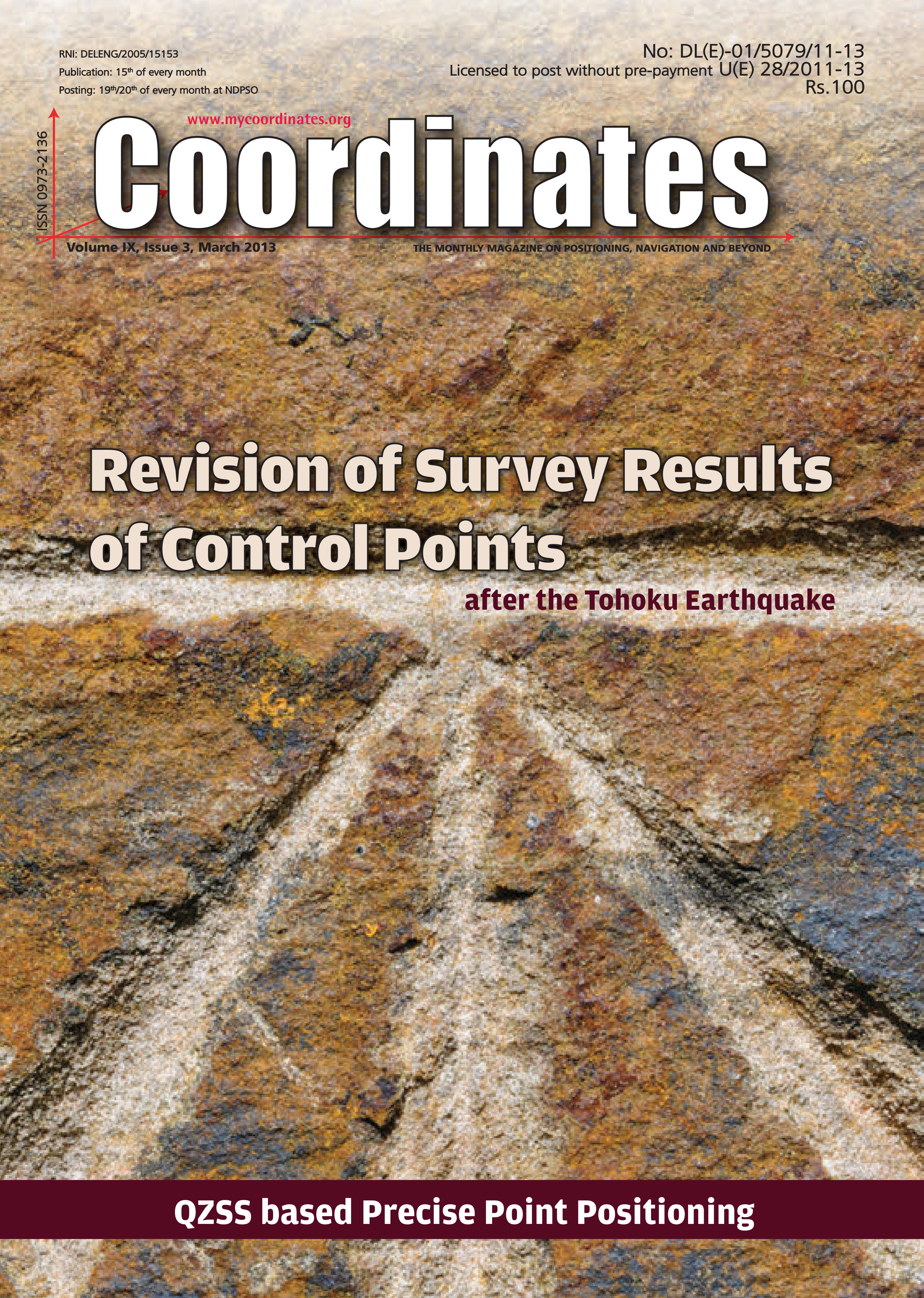

Revision of Survey Results of Control Points

after the Tohoku Earthquake

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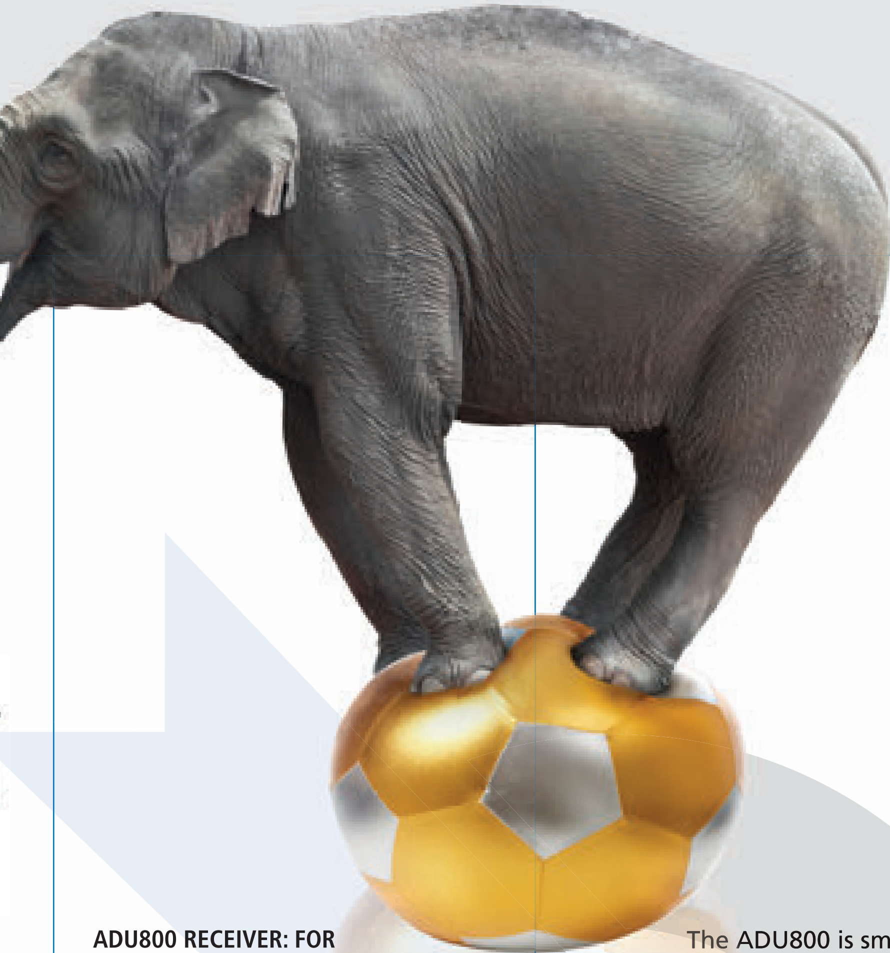

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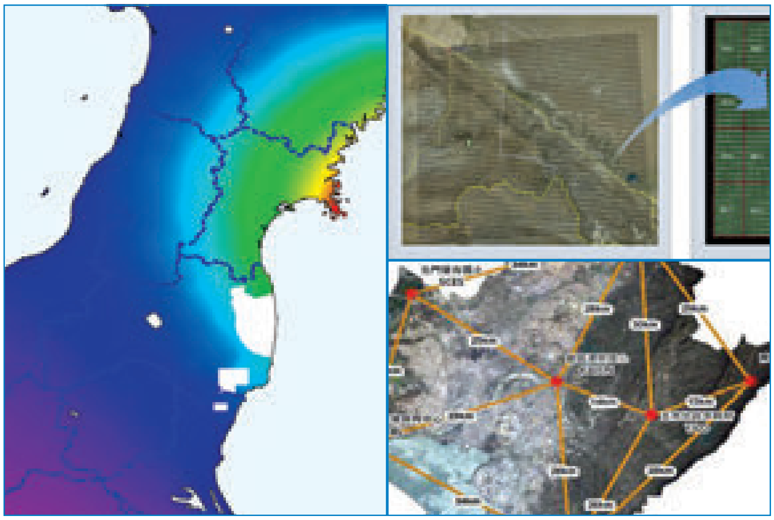

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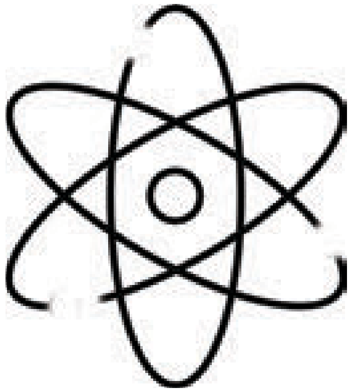

Thinking energy

March 11, 2011.

The earthquake, tsunami and the nuclear devastation.

18,500 deaths, 400,000 houses destroyed.

Thousands still live in temporary houses.

The 'fight back' spirit of Japan deserves salutation.

However, the 'energy intensive economies'

Need to explore and promote

The alternatives of nuclear energy.

Japan can innovate and lead.

Bal Krishna, Editor
bal@mycoordinates.org

Revision of Survey Results of control points

In this paper, GSI's activity on revision of Survey Results of control points after the Tohoku Earthquake is presented

Atsushi YAMAGIWA
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Geospatial Information Authority of Japan (GSI) is the governing institute on geodetic survey and mapping. It manages about 130,000 geodetic reference points in Japan and their survey results are consistent with the International Terrestrial Reference Frame. The recent development of GNSS technology led to more than 1,200 GNSS-based control stations with operation system called GEONET as new geodetic reference points.

The 2011 earthquake that took place off the Pacific coast of Tohoku (hereafter 'Tohoku Earthquake') was such a major seismic event (Mw=9.0) that occurred at 05:46:23UT and triggered a huge tsunami, causing severe damage along the coast of Tohoku or Kanto district. With this, large-scale crustal deformation was detected by GEONET. The station 'Oshika', located close to the epicenter, was moved about 5.3m to the east-southeast direction and subsided about 1.2m for instance (Figure 1). After the main shock, post-seismic deformation has been continued widely along the Pacific coast area of eastern Japan and local scale crustal deformations have been observed due to some aftershocks (Suito et al., [2011a, 2011b]).

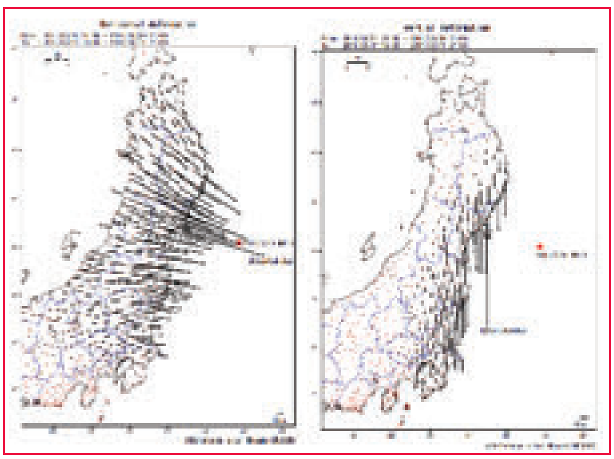

Figure 1: Crustal movements caused by the Tohoku Earthquake (Left: horizontal deformation, Right: vertical deformation)

To carry out the public surveys, the precision of the relative position between nearby control points is crucial in terms of maintaining consistency.
GSI stopped the publication of the Survey Results of the GEONET stations, triangulation stations and bench marks in the affected area on March 14, 2011, and started to discuss on their revision.

In this paper, GSI's activity on revision of Survey Results of control points after the Tohoku Earthquake is presented.

Calculation of Survey Results of GEONET Stations

Conventionally, new Survey Results were calculated based on existing results. However, since crustal deformation occurred across a large area due to the Tohoku Earthquake, we decided to calculate the coordinates of GEONET stations that correspond to International Terrestrial Reference Frame 2008 (ITRF2008), based on the observation results at the VLBI (Very Long Baseline Interferometry) station (TSUKUB32) located in GSI, Tsukuba, Japan. These calculated coordinates were then adopted as the new Survey Results for the area where update of Survey Results were required.

Required accuracy and revision date for the Survey Results of GEONET stations

In accordance with the tolerances indicated in the General Standard of Operation Specifications for Public Surveys in Japan, the accuracy required for calculating Survey Results of GEONET stations should be to a point-to-point relative accuracy of 2ppm.

Since positional data were necessary for the restoration/reconstruction of the disaster-stricken area, and also be utilized in the resurvey of triangulation stations and public control points, urgent revision of Survey Results of GEONET stations was required. Meanwhile, to decrease the effect of post-seismic deformation, future deformation was estimated based on the observation data of GEONET stations using the approximation formula with a logarithm function by Marone et al., [1991] as follows:

$$y(t) = c + a\ln\left(1 + {t}/{\tau_{\log}}\right)$$

where c and a are the constants, $\tau_{\log}$ is the time constant and t is the time elapsed from the earthquake.

The appropriate time of re-publication of revised Survey Results was then discussed based on the predicted deformation (Fig. 2). As a result, we decided that the new Survey Results of GEONET stations should be published by the end of May 2011.

Calculation of Survey Results based on VLBI and GEONET

Coordinate of TSUKUB32

The coordinate of TSUKUB32 on ITRF2008 was estimated on the analysis of VLBI observation data of international

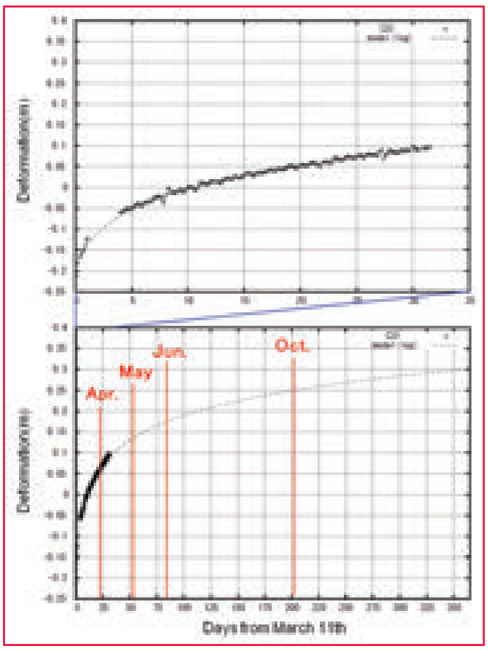

Figure 2: (Top diagram) Progression of post-seismic deformation observed at the GEONET Station 'Yamada' (950167) and (Bottom diagram) predicted deformation

VLBI session 'IVS-R1482', which was conducted on May 10, 2011, to adopt the latest coordinates for the revision of the Survey Results. We constrained the ITRF 2008 coordinates of five overseas stations, which were not affected by the earthquake, and the coordinates of TSUKUB32 were calculated.

Survey Results calculation method

The calculation method for Survey Results with observation results of the VLBI and GEONET is as follows:

(1) First, the post-seismic deformation was calculated from the difference in averages of prompt GEONET solutions using IGS's Rapid Orbit (R3 solutions) at Station No. 92110 (located in GSI, Tsukuba) between May 8-12 and May 22-26, 2011. Next, we calculated the coordinate of TSUKUB32 at 12:00 UTC on May 24 by adding the post-seismic deformation to the coordinate calculated from VLBI observation at 5:00 UTC, May 10.

(2) The coordinates (ITRF2005) at 12:00 UTC on May 24 were calculated by averaging the R3 solution data in May 23-25. Then, we transformed the reference frame from ITRF2005 to ITRF2008.

(3) Lastly, we combined (1) and (2) with the collocation result in 2007 (Miura et al. [2009]) and shifted the R3 solutions so that they were consistent with the coordinate of IGS station 'TSKB' (located in GSI, Tsukuba) based on VLBI. The shifted R3 solutions were used as new Survey Results of GEONET stations that are located in the area for which the publication of Survey Results had been stopped.

Adjustment calculations on boundary area

Discrepancies across the boundaries of areas with updated Survey Results and those with no updates had been caused by accumulated crustal strain, since the last update of survey results. Thus, we calculated correction values for the revised Survey Results so that the amount of discrepancy across the boundaries became 2ppm or smaller.

Re-publication of Survey Results of GEONET stations

On May 31, the updated Survey Results of 438 GEONET stations were released, and it became available to carry out public surveys using GEONET stations in the affected area and its vicinity.

Amendment of coordinate/ elevation of origins of Japanese horizontal/ vertical control network

Due to the Tohoku Earthquake, the positions of the Origins of the Japanese Horizontal and Vertical Control Network in Tokyo had also shifted. This resulteding in the legally prescribed coordinate and elevation being far off the actual positions after the earthquake. Tthe coordinate and elevation of those origins were amended to ensure the accuracy of surveys.

Amendment of coordinate of the origin of the Japanese horizontal control network

To again calculate the coordinate of the Origin of the Japanese Horizontal Control Network, GNSS observations were conducted between June 21 and 25, 2011 at the VLBI marker for TSUKUB32 and at the Origin of the Japanese Horizontal Control Network.

Table 1: Amended coordinates of the Origin of the Japanese Horizontal Control Network

Longitude Latitude	X (m)
	Y (m)
	Z (m)
139°44′28″.8869 35°39′29″.1572	-3959340.203
	3352854.274
	3697471.413

Table 2: Azimuth from the Origin of the Japanese Horizontal Control Network to the VLBI marker at GSI, Tsukuba

Azimuth	32°20′46″.209

The coordinates of the Origin of the Japanese Horizontal Control Network calculated again through these observations and the azimuth from the Origin of the Japanese Horizontal Control Network to the VLBI marker for TSUKUB32 are shown in Tables 1 and 2 respectively.

Amendment of Elevation of the Origin of the Japanese Vertical Control Network

GSI has kept regular leveling once per year from Aburatsubo tide station to the Origin of the Japanese Vertical Control Network to monitor vertical changes at the origin. Sea levels recorded at the Aburatsubo tide station before and after the Tohoku Earthquake showed that no significant tidal change associated with the earthquake was observed. Additionally, no significant change in ellipsoidal height was observed between pre-earthquake (January 2011) GPS observation results and post-earthquake (July 2011) results at Aburatsubo in terms of uncertainty of GPS observations. Therefore, new elevation of the Origin of the Japanese Vertical Control Network was calculated through the following procedures (1) and (2) and then verified by procedure (3).

(1) When the elevation of the Origin of the Japanese Vertical Control Network was fixed based on leveling results from the region between the Aburatsubo tide station and the Origin of the Japanese Vertical Control Network in January 2011 prior to the earthquake, the height of the reference point at the Aburatsubo tide station was determined to be 2.4173m.

(2) By fixing the elevation of the reference point at the Abratsubo tide station obtained in (1), the new elevation of the Origin of the Japanese Vertical Control Network calculated based on leveling results of July 2011 was determined to be 24.3904m.

(3) For verification, the elevation of the Origin of the Japanese Vertical Control Network was calculated based on the results of leveling between the VLBI marker for TSKUB32 and the Origin of the Japanese Vertical Control Network with the result of 24.4007m.

With regard to standard deviation of the network adjustment of the leveling, since the estimated error of +/-0.0026m may be contained in the results shown in (1) and (2), the newly amended elevation of the Origin of the Japanese Vertical Control Network should be 24.3900m after rounding off the ten-thousandth place.

Revision of Survey Results of triangulation stations

To ensure accuracy of the revised Survey Results of triangulation station, it is desired that surveys are conducted on-site at triangulation stations. However, in terms of time and cost it is not always practical to conduct surveys at each and every triangulation station due to the fact that publication of Survey Results for more than 40,000 triangulation stations was stopped. Since the observed crustal deformation due to the Tohoku Earthquake was relatively similar in a wide area, precise geodetic surveys were to be conducted only at a selected number of triangulation stations - similar to practices followed after the Tokachi-oki Earthquake in 2003 (Doi et al., [2005]) - and triangulation stations not targeted for resurvey were to have their Survey Results recalculated using correction parameters.

Triangulation station resurveys

Within the area for which publication of Survey Results was stopped, precise

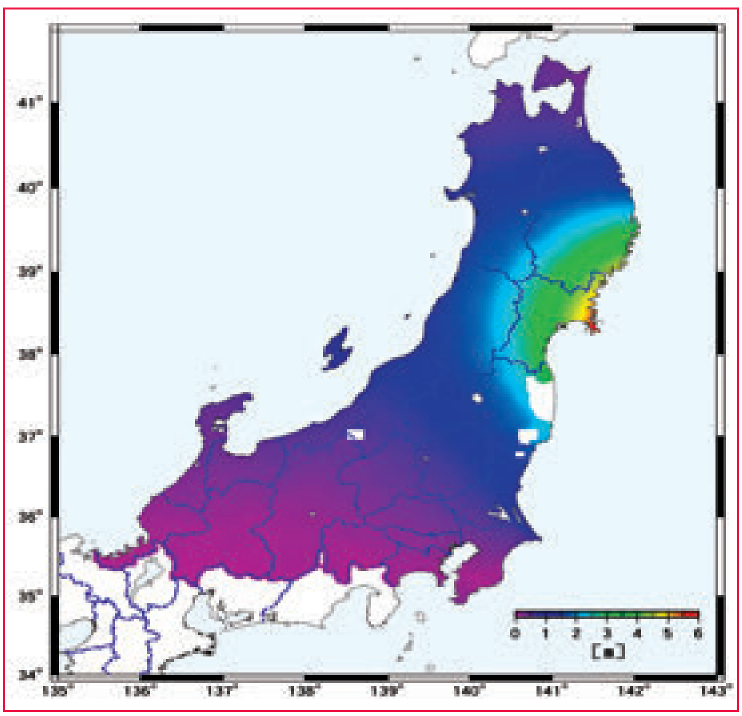

Figure 3: Correction parameters developed for coordinates

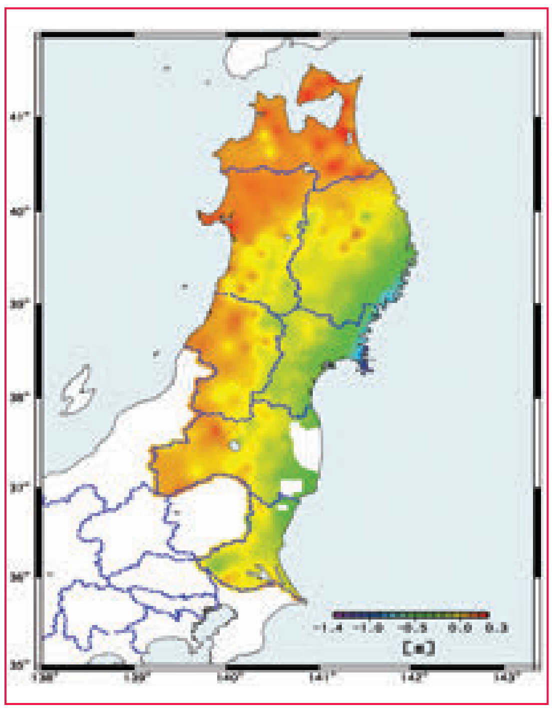

Figure 4: Correction parameters developed for elevations

geodetic surveys were conducted at 595 selected points and 1,272 points in the area where aftershocks and induced earthquakes occurred.

Recalculation of Survey Results of Triangulation Stations

For the remaining triangulation stations, a new set of correction parameters were developed and Survey Results of the triangulation stations were recalculated using PatchJGD, the software for correcting geodetic coordinates (Tobita, 2009). The number of the stations recalculated by the software was 41,392.

Correction Parameters

To recalculate the Survey Results of triangulation stations, correction parameters for coordinates (horizontal) and elevations were developed using both previous and revised Survey Results of GEONET stations and the triangulation stations for precise geodetic surveys. The correction parameters were constructed by estimating variations at each grid with a resolution of 45 seconds in longitude and 30 seconds in latitude from displacements of GEONET stations and triangulation stations using the Kriging method. It should be noted that there were some excluded area where relatively large aftershocks or induced earthquakes made complicated deformations as observed by GEONET and Synthetic Aperture Radar (SAR) interferometry. Additionally, the area around the Fukushima No.1 nuclear power plant was also excluded. The revision of Survey Results for triangulation stations not slated for resurvey was carried out based on these correction parameters (Figure 3 and Figure 4).

Revision of Survey Results of Bench Marks

The target accuracy of the correction parameters for elevations used for the revision of Survey Results of triangulation stations was 10cm to 20cm and those parameters cannot be applied in the revision of Survey Results of bench marks that requires elevation accuracy of 0.1mm to 1mm. Therefore, the revision of Survey Results of bench marks was, in essence, to be carried out through resurvey. Network adjustment with multiple reference points was calculated under the condition that the coordinates of the Origin of the Japanese Vertical Control Network and another bench mark at the northern margin of the revision area which was less affected by the Tohoku Earthquake were fixed.

Revised Survey Results of bench marks obtained by network adjustment calculations based on these two reference points were released on October 31, 2011 with those of triangulation points.

Conclusion

Following the Tohoku Earthquake, notable crustal deformation occurred over a wide area of eastern Japan, which led to the halt in the publication of Survey Results of GEONET stations, triangulation stations and Survey Results of bench marks in the affected area.

In order to contribute to swift restoration/reconstruction of the disaster-stricken area, and to ensure stable provision of Survey Results for many years to come, the amount of future deformation was estimated by taking post-seismic deformation monitored by GEONET stations into account. After discussions with regard to an appropriate time for re-publication, revised Survey Results of GEONET stations were released on May 31, 2011.

Precise geodetic surveys were conducted at some of triangulation stations, and Survey Results for the remaining triangulation stations were revised through calculations based on the correction parameters.

The revision of the Survey Results of bench marks was, in essence, achieved through resurvey. Leveling was conducted and network adjustment was calculated based on the revised elevation for the Origin of the Japanese Vertical Control Network.

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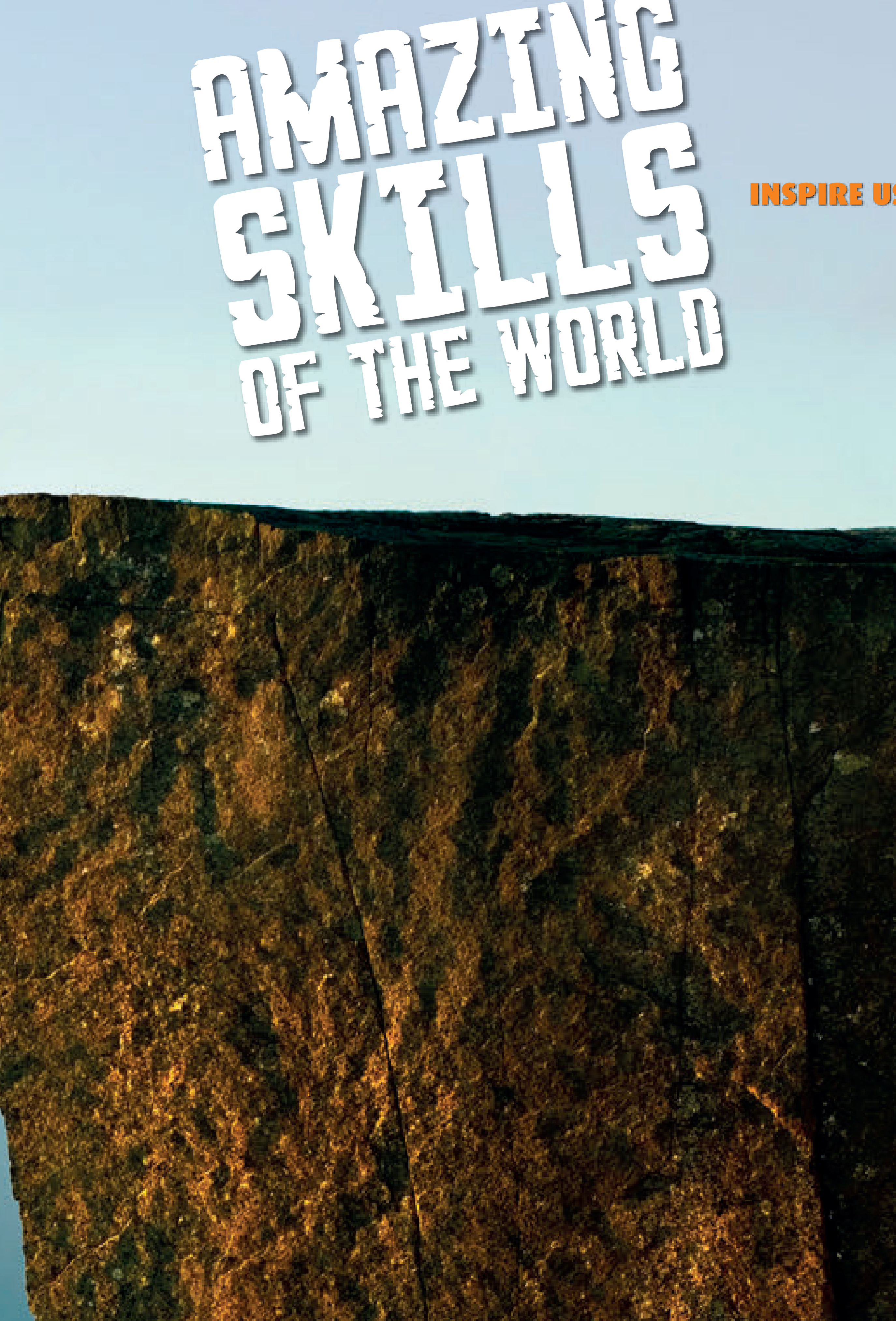
NORWEGIAN EXTREME ARTIST, ESKIL RONNINGSBAKKEN, DURING A BALANCING ACT AT PULPIT ROCK, 1982 FEET ABOVE THE LYSEFJORD, NORWAY, 2006.



When size, performance and robustness matter

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An approach to effective land registration

Case study in Baharly, Ahal Velayat, Turkmenistan

Hyunil Yoo
Korea Cadastral Survey Corporation, Seoul, Republic of Korea

Handon Joo
Korea Cadastral Survey Corporation, Seoul, Republic of Korea

With the advent of satellite imagery resolution, the satellite photogrammetry has become a new area of practice to handle mass data and been utilized in many areas with its low cost and short production time. In particular, it is more likely to be utilized in geospatial industry than cadastral areas, such as topographic mapping, land use analysis and monitoring, land use planning, and disaster research etc. This is because, in terms of positional accuracy, satellite photogrammetry does not meet with criteria required by cadastral jurisdictions where there are basically strict standards due to land ownership security. What is more, a crucial issue is that the identification of the parcel boundary only relies on clearly visible boundary features or corners from the satellite imagery unless otherwise significant follow-up ground surveys are performed to check out every actual legal boundary points. Consequently, it could bring in inconsistency with already existing legal boundaries.

On the contrary, in the case where a wide range of areas are not entirely registered yet or are required to be newly or renewly registered for land information management rather than

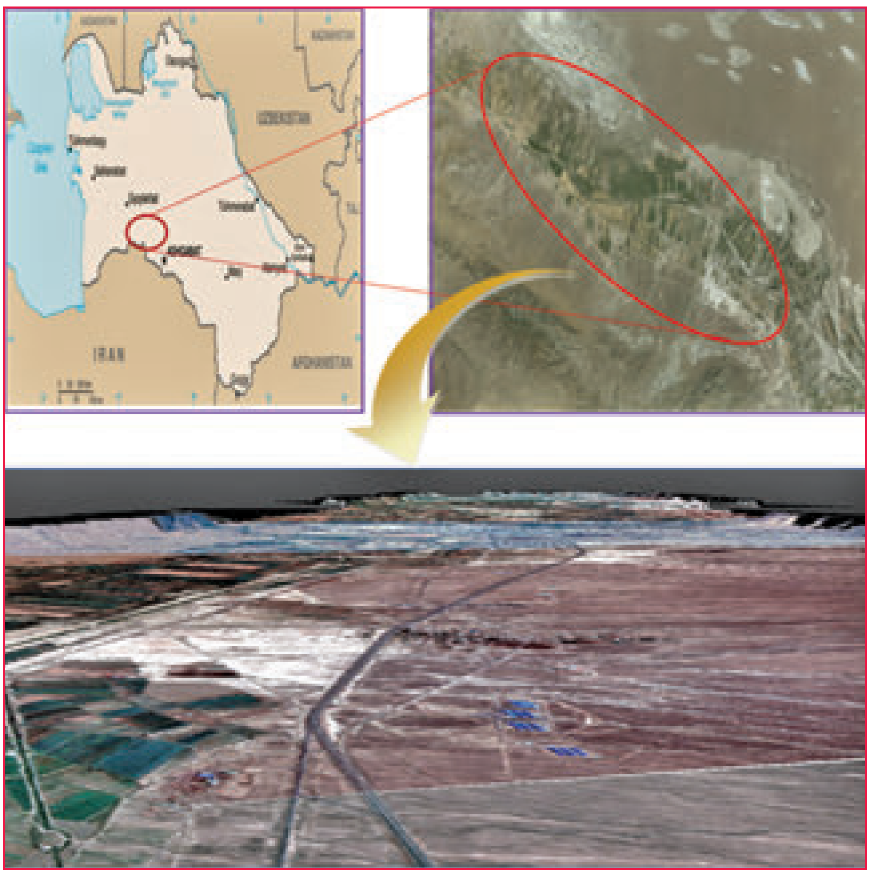

Figure 1: Pilot project area and 3D view of terrain

determining private land ownership. Land registration through the satellite photogrammetric technique could be an alternative solution in cost-effective and the time-saving way.

In Turkmenistan, most of the lands are owned and managed by the government, and a certain amount of lands are distributed to each household for cultivation. Agricultural farming is still major industry, so that most of the territories are basically composed of farming and resident areas near where agricultural farming is feasible. The Service of Land Resource(SLR) under the Ministry of Agriculture has strived to handle land information as a reference data for taxation and national decision-making in effective way. The SLR has filled out and mainly focused on annual report covering land information based on site investigation and Land Use Maps(LUM) which is the primary map for land management in Turkmenistan. However, there appears to be a discrepancey between true ground features and already exisiting boundaries from the LUM due to poor quality of the map and analog method for production, and slow updating. Thus, the government has atempted a land registration renovation to synchronize the true ground feature into the map and land information management computerization for better land administration. At that time, satellite photogrammetric method was regared as an altnernative solution considering the time and cost. Thus, a joint project for renewal of land registration and establishment of systematic land information managemetnt system was launched by the Ministry of Agriculture and Korea Cadastral Survey Corporation with the technical support of satellite photogrammetric method.

In this paper, methodology of pratical work for land registration through satellite photogrammetric method is represented. Land information management system application is introduced in maintaining and managing registered land information. After qualitive and quantitive assessment is carried out to compare positional accracy of check points obtained by GPS-RTK method and satellite photogrammetirc method, feasiblility of land registration renewal without groud survey is discussed.

Overview

Current status

A total of Turkmenistan's area is 491,210sqkm, and 70% of territories are covered with deserts and waste lands. The area available for farming is assumed around 20% of total territories, but farming and resident areas actually registered and used can be estimated around less than 5% of total territories. Most of farming and resident areas along with the fertile ground are built up and owned by the government. The government has granted a certain amount of lands to people in order to promote farming cultivation, effective taxation system, and enhance agricultural productivity.

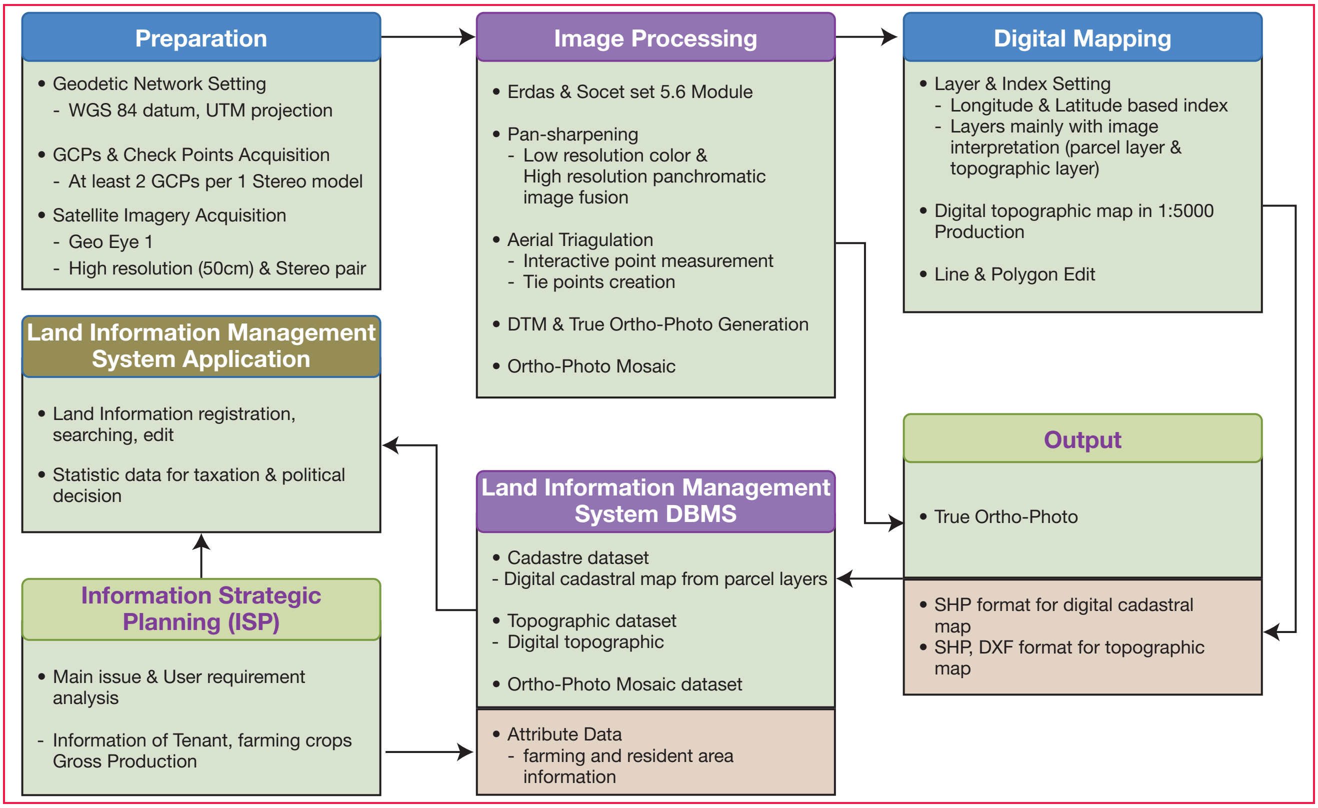

Figure 2: Flow chart of practical work

Main national land matters are dealt with The Service on Land Resource (SLR) under the Ministry of Agriculture: Land distribution, registration, management. The SLR has produced and mainly focused on annual report covering the land information with respect to type of farming, land category, crop classification, tenant, and soil information, and so on. This annual report is regarded as essential data when statistical data is computed for taxation, and national decision is made such as location of irrigation canal or roads. In this process, the Land Use Map (LUM), which is a primary map, plays an important role as significant reference data while the annual report is filled out.

However, the main issue is that the LMU is a paper-based and generated through analog production method, so quality is relatively poor. Besides, it is not easy to update varying land information promptly due to analog production process. Therefore, it has caused a discrepancy between true ground feature and map feature. For this reason, awareness of demand for renewal of land registration and land management system computerization has emerged.

Pilot project

The title of this pilot project is "Project for the Modernization of Cadastral system in Turkmenistan". The total period of this project is 18 month starting from 12th, Dec, 2011 and shall be completed by 23th, June, 2012. The scope of this project is to establish adaptive geodetic network structure, and produce digital cadastral maps in 1:5000 to be put into a land information management system using the satellite photogrammetric method. The final goal is to assist users to register, maintain, and manage land information which is subject to change through the system.

Project site is located in the baharly, Ahal velayat out of five velayats, and the size of areas is covered by 600 sqkm. The majority of land is composed of a farming area, resident area, and pasture lands. As shown 3D view of terrain in the Figure 1, most parts of the pilot project site are flat and plain, so positional distortion is able to be minimized while satellite photogrammetric technique is utilized. Besides, parcel of farming areas are basically big size as to demarcate the boundary lines without difficulty. Considering the size and type of areas, and purpose of this project, satellite photogrammetric method was chosen as an alternative solution in cost-effective and the time-saving way.

Methodology of practical work

A total process of practical work is basically categorized into 4 stages: Preparation, Image processing, Digital mapping, and Land information management system application as shown in the Figure 2.

Preparation

Geodetic network system establishment

Turkmenistan has stuck to the coordinates system and projection method inherited from the former Soviet Union. Control points have been managed by the Ministry of Defense and regarded as a military secret, so that public sections have limited


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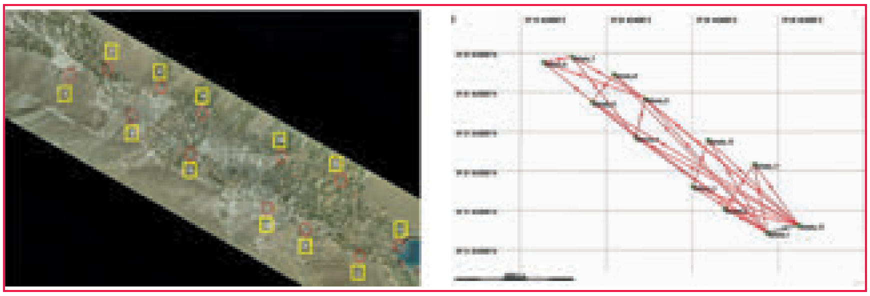

Figure 3: GCPs surveying network

Table 1: Satellite imagery specification

Product type	Geo Stereo	Output Projection Type	Universal Traverse Mercator(UTM)
Spectral type	Bundled(Pan+MSI)	Projection parameter	UTM 40 North
File Structure	NIR/R/G/B-Sperate MSI Files	Datum	WGS 84
File Format	GeoTIFF	Maximum Cloud Cover	15 percent
Radiometric Resolution	11 Bits/Pixel	Ground Sample Distance	0.5 meter
Source Type	New Acquisition	Collection Vehicle	GEOEYE-1
Min/Max Elevation Angle	90/60	Collection Date	September, 2011

access to its information. Due to practical difficulties in access to control point information, the new establishment of coordinates system was attempted. When it comes to establishing the new geodetic network system in the pilot project area, the WGS84 datum and UTM projection method was adopted because transformation into local coordinate was not indispensable once again right after GPS surveying result using the same WGS84 datum and UTM projection method was obtained. Surface elevation was obtained as the ellipsoid height along with GPS surveying, and transformed to the Orthometric height based upon the EGM 08.

Ground Control Points (GCPs) Acquisition

GPS surveying was carried out with Topcon Hipper II. Geoeye imagery has a good relative accuracy: thus only a small number of GCPs were needed to refine the ephemeris data. Therefore, the number of GCPs was determined 12 points considering the size of imagery and model, and GPS surveying network as shown in the Figure 3. Distances between GCPs were retained by 10-15km for the better quality of Aerial Triagulation (AT). Almost all of the GCPs were located on the corners or edge of artificial features, if not possible, some points were observed using the signal for aerial survey. In the post processing, the value of GPS surveying was generated in the WGS 84 coordinates and UTM projection method. Above all, 2 GCP coordinate were picked up with 8 hours surveying, and then calculated in connection with 6 stations of International GNSS Service Network (IGS): KIT3, THEN, POL2, DRAG, RAMO, and ARTU. After that, observed 2 points were set up as base stations, and the other 10 GCPs were made up as a session and observed with respect to base stations. Besides, around 200 check points in some parts were picked up using Stop-And-Go techniques in order to assess the result of digital mapping.

Table 2: Residual of GCPs result

Point No.	GPS surveying result Coordinate		Imagery coordinate		Residual	
	x	y	x	y	d(x)	d(y)
GCP#1	3.66127897710e+005	4.23345042830e+006	3.66128000690e+005	4.23345001080e+006	0.0398049	-0.40766
#2	3.38850846970e+005	4.23707501460e+006	3.38851115077e+005	4.23707468090e+006	0.202088	-0.373368
#3	3.33363880640e+005	4.24035038800e+006	3.33363835328e+005	4.24035033441e+006	-0.0141145	0.00519983
#4	3.45816813110e+005	4.24520320830e+006	3.45818358011e+005	4.24820077550e+006	0.228007	0.527316
#5	3.36373076000e+005	4.23570033100e+006	3.36372868152e+005	4.23570860100e+006	-0.109683	0.299646
#6	3.28114883300e+005	4.23089447700e+006	3.28314420060e+005	4.23089468300e+006	-0.460241	0.18124
#7	3.32873547700e+005	4.26074298800e+006	3.32873440060e+005	4.26074333046e+006	-0.104036	0.351128
#8	3.40087642700e+005	4.23813030100e+006	3.40017833450e+005	4.23812077700e+006	0.209749	0.288365
#9	3.45387283200e+005	4.25427602800e+006	3.45387290850e+005	4.25427877300e+006	0.0000103	-0.154795
#10	3.56019964900e+005	4.24789237480e+006	-0.298074 3.56010966030e+005	4.24789220810e+006	-0.298074	-0.0787455
Count					10	10
Mean					0.16742329	0266146113
Minimum					0.0398049	0.00519983
Maximum					-0.460241	0.527316

Satellite Imagery Acquisition

A fragment of raw stereo imagery from the Geoeye-1, a commercial satellite launched in 2008, over the barharly, Ahal velayat was taken September 2011. Two different types of imagery were provided: a low-resolution multispectral imagery (NIR/R/G/B) with 40cm GSD and a high resolution panchromatic imagery with 1.6m. Satellite imagery was taken in the 1 direction horizontally, divided into 6 models and covered by the pilot project areas (65km * 15km). Rational Polvnimial Coffecient(RPC) that provides geometry information of imagery was given when satellite imagery was taken. Imagery coordinate system and projection method were the same as GPS surveying result in the form of WGS84 datum and UTM projection method.

Image Processing

Image processing was implemented using modern development in Digital Photogrammetric Workstation (DPWs) and the ERDAS IMAGINE 10 and SOCET SET 5.6 module.

Firstly, Pan-Sharpening was implemented throughout the ERDAS IMAGINE 10. In this process, a high resolution panchromatic imagery was combined with a relatively low resolution color multi spectral imagery to create high-resolution fused color imagery. This fused imagery provides a solution to identify the category of farms with clear color imagery.

After the Pan sharpening procedure, Aerial Triangulation (AT) was undertaken using the SOCET SET 5.6. As Rational Polynomial Coefficient (RPC) was roughly made of geometric correction, only particular adjustment was needed to carry out at the AT stage. In order to secure more positional accuracy, absolute orientation and interactive orientation were undertaken at the same stage using GCPs and tie points. Total 10 out of 12 GCPs was used to synchronized GCPs coordinate into imagery coordinate using interactive point measurement module, at least 2 GCPs was put into each model out of 6 models. Furthermore, around 250 tie points were automatically created, sometimes manually adjusted when there were unmatched tie points. These tie points were to make each model more tied each other and evenly distribute positional accuracy to the every model. Besides, check points obtained by Stop-And-Go techniques were inserted evenly at this stage in order to check residual error. The overall result of Aerial Triangulation (RMS) was satisfied at general accuracy. The Root Mean Square (RMS) was in easting(x)=0.2237, northing(y)=0.3497, elevation(z)=0.31307, and total RMS was computed as 0.5908.

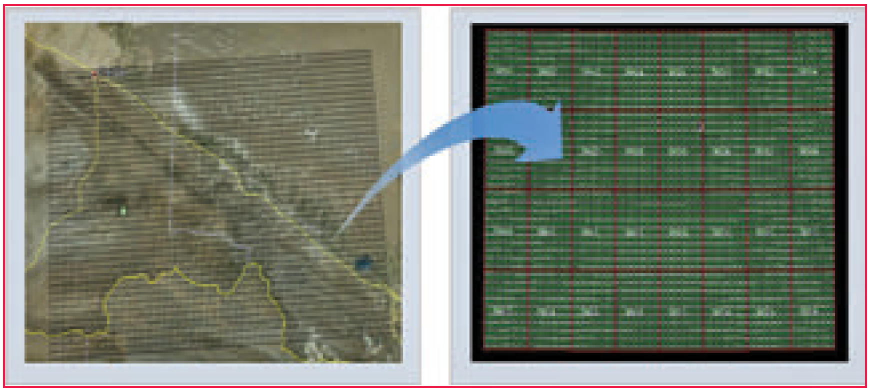

Figure 4: Map index

Digital Terrain Model (DTM) and True Orthophoto were generated to be loaded with land information management system. Firstly, the DTM was created to provide for surface information at the True Orthophoto generation stage because image-object reprojection was required to compensate for relief displacement. In this procedure, distances between easting(x) and northing(y) were set up as a 1m, and final format was a grid throughout adaptive strategy. After DTM production, True Orthophoto was generated for each model. At this time, the surface discontinuity caused by buildings was taken into

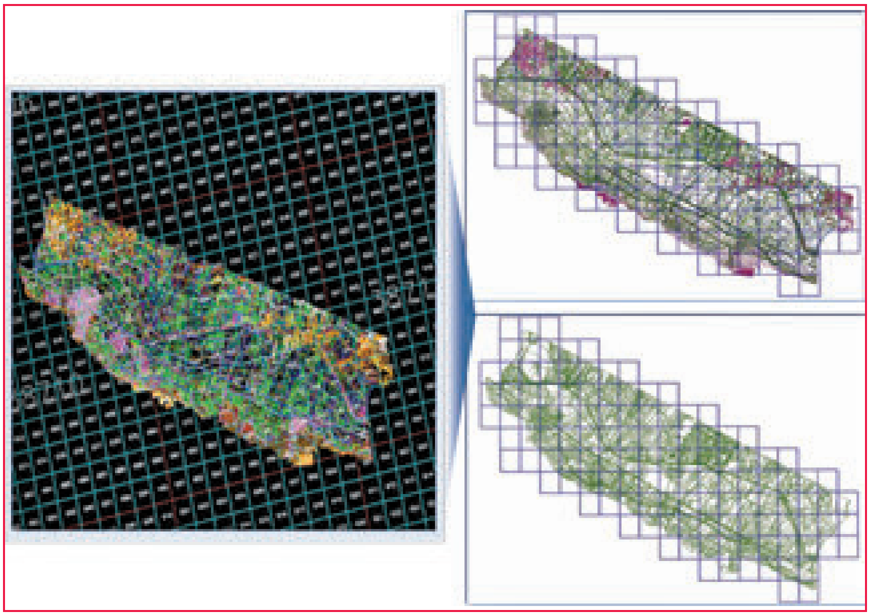

Figure 5: Digital mapping result, cadastral map, topographic map

account in the Ortho-rectification. This is because DTM was not able to delineate buildings. Hence, artificial features and buildings were collected as a feature data, and then some parts of displacement were rectified manually. Finally, each True Orthophoto models were merged throughout imagery mosaic module before it was embedded with the land information management system DB server.

Mapping

Digital mapping was implemented using VR ONE 5.6, and the result was converted to DXF format and edited using the AUTOCAD 2O1O. The type of map was produced in the form of topography, and scale was 1:5000. In order to enhance the quality of map, digital mapping was undertaken in company with the stereo pairs instead of the True Orthophoto. Before digital mapping, index map and layers were set up. Firstly, sections between left upper corner E58° (Longitude), N39° (Latitude) and right lower corner E60°, N38° divided by 1° and then divided by 15' once more as shown in the Figure 4. Among 32 sections resulting from division, each section was classified into 100 equal sections. A total 4 out of 32 sections were chosen to be utilized with respect to digital mapping.

In regards to layers, Layers were made based on topographic mapping; in the particular parcel layers were subdivided in order to extract digital cadastral map for the land registration. In this process, firstly satellite imagery was analyzed, and then layers that can be observed and described from the imagery were classified. After that, through discussion with the Ministry of Agriculture, layers supposed to be frequently used were determined and divided into 3 categories: Primary, sub-primary, sub-sub-primary structure. The primary structure was a total of 10 and composed of Roads, Building, Hydrograph, Boundary, Contour, Artificial feature, Border, Symbol, Text, and Index. Among these categories, basically most layers of Roads, Buildings, Hydrograph, Boundary, and Artificial features were incorporated into parcel layers.

The method of mapping was followed as applied in Turkmenistan. In particular, there was no discussion with concerned land users because most of the lands are owned by the government. For this reason, if there was issue, discussion was comprised between Korea Cadastral Survey Corporation and Land Resource Service. With regards to result of digital mapping, a total of 10,498 parcels were generated, and buildings were 21,408. As shown in the Figure 5, the left picture shows the digital mapping result, the upper right picture represents digital cadastral map extracted from digital mapping result, and the lower right picture shows topographic map in the form of SHP. After mapping process, parcel layers were edited to enclose lines, and were transformed into SHP format as a digital cadastral map before it was inserted into land information management system.

Land Information Management System Application

The land information management system was designed to register and manage digital cadastral map and land information resulting from parcel layers. This system can establish infrastructure as to provide reference data regarding taxation and national decision-making while the annual report is drafted. Before designing the system, Information strategic planning(ISP) was firstly implemented by anlyzing requirements and main tasks with concerned group working at the SLR. Consequently, information of rent, farming crops, gross production, residence derived from category of the annual report were main requirements in order to deal with resident and farming area information.

Vector (topographic map, cadastral map) and attribute data (land information) were assigned to the DBMS. The method of system operation was that vector and attribute data were firstly loaded with the DB sever, and then they were managed and applied by users through operational laptop. DBMS was built up through Oracle 11g r1. The vector and attribute data were stored in the DBMS through ArcSDE and operated by users through Arc Desktop. The form of DXF for the vector data was transformed into SHP format and loaded with system because the system is based on Arc GIS, and Spatial Unit ID had to be automatically allocated to building and parcel.

When it comes to designing table of attribute data, arrtibutes extracted from category of the annual report and necessary functions analyed at the ISP stage were considered. Funciotns of user management and code management were designed for the basic configuration. Parcel and buildings were desinged to be newly registered and edited using the

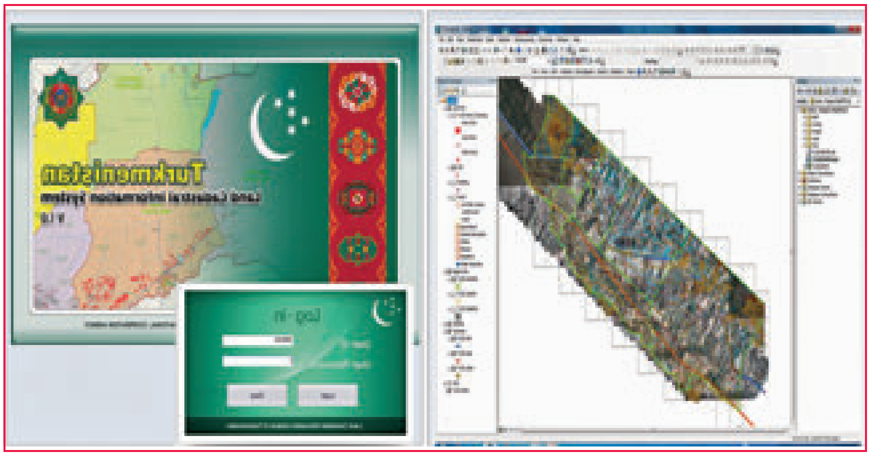

Figure 6: Turkmenistan Land information management system

edit function; thus, shape and attribute of parcel were able to be edited and rectified using the edit function. Control points, SHP file, DXF file, and True Orthophoto were designed to be registerd using registration function. Serach and statistic function were designed in oder to calculate numeric data and identify parcel quickly.

With regards to layers, parcel layers based on digital cadastral map as well as topographic layers were made up. ParcelInfo Feature Dataset concering digital cadastral map consists of parcel layers, building layres, control point and farming area layers. RegionInfo Feature Dataset consists of the state border layer, municipalaty border layer, block border layers, and is not able to be edited by users. TopoMap Feature Dataset consists of main rivers and roads. CAD Feature Dataset includes the original outcome in the form of DXF from digital mapping.

Qualitive & quantitive assessment

The positional accuracy of digital mapping was assessed and analyzed by comparing the check points coordinates obatined by the digital mapping and GPS-RTK. These check points were picked up in the 2 parts of the pilot project area where resident areas are largely composed of. The number of check points were around 250, and most of them were collected on the edge or corner of buildings. Around 70% of RMSe(x), and RMSe(y) were less than 1m, 20% were between 1m and 2m. On the whole, most of the points recorded excellent results only with satellite photogrammetric technique even though additional follow-up ground survey were not implemented. It can be assumed that the result was excellent considering satellite imagery resolution. These figures might be a problem in the case where cadastral map has to be produced to secure private land ownership. However, it turns out that land registration using satellite imagery could be an alternativ solution where land infomation management is more important than determining private land ownership like Turkmenistan, in particular considering the effectiveness of time and cost.

Conclusion

In Turkmenistan, the government owns and manage a whole nation's land, and distribute a certain amount of land to each public in order to encourage agricultural farming and enhance productivity. As a result, land administration has focused on dealing with land information to generate reference data for taxation and national decision-making instead of securing and determining private land ownership.

Since a high positional accuracy is not crucial factor, the pilot project for land registraion and management using satellite photogrammetric technique that has relatively lower positional accuracy has been attempted. Hence, digital cadastral map was generated from digital mapping using satellite imagery, and land information management system was established based on vector and attribute data. This infrastructure enables users to manage and register land information through DBMS, and to gnerate reference data for taxation and national decision-making effectively.

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QZSS LEX message data for precise point positioning

The LEX PPP data with the IGS Ultra rapid data products have been compared to analyze the accuracy of LEX data

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Errors associated with GPS observations make it impossible to use a single receiver for geodetic, geodynamic and vehicle automation applications requiring centimeter or millimeter level accuracy. Real Time Precise Point Positioning (RT PPP) has become a powerful tool that can provide positioning accuracy comparable to the network solution (Ge et al., 2007) without the need of GPS base station network. International GNSS service (IGS) has been providing data necessary for PPP via internet in real time. Quasi-Zenith Satellite System (QZSS) is a Japanese GPS augmentation system that also provides real time PPP correction through an experimental signal (LEX) from June 2011. LEX signal provides real time GPS satellite ephemeris and clock correction. The accuracy of these corrections data will directly affect the positioning accuracy (Zumberge et al., 1997). Through this paper we compared the LEX PPP data with the IGS Ultra rapid data products to analyze the accuracy of LEX data.

Quasi-Zenith Satellite System (QZSS)

Quasi-Zenith Satellite System (QZSS) is a regional time transfer and GPS augmentation system covering the Asia pacific region mainly focusing on Japan. The first of the three QZS satellite that is needed to complete the consolation was launched on September 11, 2010. The path of the satellites has been designed with highly elliptical orbit to ensure that its orbit is at an elevation of more than 70° over Japan for a minimum of eight hours per day. This high elevation increases the availability of GPS satellites in urban cities in Japan. The system is designed to broadcast GPS L1C/A signal, L1C signal, L2C signal, L5 signal and two new signals L1-SAIF and LEX. L1-SAIF provides Wide Differential GPS (WDGPS) data which is only applicable for Japan. LEX is a new experimental signal broadcasting Precise Point Positioning (PPP) data. Table 1 contains signal specifications of QZS satellite. Eamonn P. (Glennon 2011) through his study has shown that QZSS signal design specification is very similar to that of GPS, which means that the effort needed to add QZSS capability to standard GPS receivers can be done with ease. The process should be easier for receivers tracking SABAS signals.

Table1: QZSS Signal specification (JAXA 2012)

Signal	Frequency	Description
L1-C/A	1575.42MHz	GPS interoperable signals Compatibility and interoperability with existing and future modernized GPS signals
L1C		
L2C	1227.6MHz	
L5	1176.45MHz	
L1-SAIF	1575.42MHz	Compatibility with GPS-SBAS WDGPS
LEX	1278.75MHz	Experimental Signal with higher data rate message (2Kbps) Compatibility with Galileo E6 signal

QZSS LEX message

QZSS LEX signal is transmitted in 1278.75MHz as a new experimental signal through QZSS satellites. The signal is made up of different experimental messages and each one is made up of 2,000 bits: a 49-bit header, a 1695-bit data section and a 256-bit Reed-Solomon code. Transmission of the message takes one second. LEX signal doesn't only contain PPP correction data, it also carries messages for other experiments and application demonstration in the private sector. For the PPP application only LEX

Table 2: Message type 10, 11 broadcast interval, update interval and valid time (JAXA 2012)

Message data	Nominal broadcast interval	Nominal update interval	Nominal valid time
Signal health	1 second	1 second	-
Ephemeris	12 seconds	3 minutes	6 minutes
SV clock	12 seconds	3 minutes	6 minutes
Ionospheric correction	12 seconds	30 minutes	-

Table 3: Definition of message type source (JAXA 2012)

Message type		Content	Notes
0-9		Spare (System use)	
10-19	10	Single health (35 satellites) Ephemeris & SV clock (3 satellites)	For JAXA experiment
	11	Signal health (35 satellites) Ephemeris & SV clock (2 satellites) Ionospheric correction	
	12~19	Spare	
20		For experiment by Geographical Survey Institute	
21~155		For experiment	For experimental user except JAXA, GSI and users of application demonstration in private sector
156-25		For application demonstration in private sector	For experimental users of application demonstration in private sector by means of performance enhancement signal

Message ID 10 and 11 are used. The 1,695-bit data section of message ID 10 includes the signal health and Ephemeris & SV clock data. Message ID 11 includes the signal health, Ephemeris & SV clock and ionosphere delay correction data. Table 2 contains the broadcast interval, update interval and the valid time of the data for Message 10 and 11. (JAXA 2012)

LEX signal decoding

LEX Message is Reed Solomon (255,223) encoded which enables to correct 32bit of error in the LEX Message. Each LEX Message signal is made up of a total of 2,000 bits; 49-bit header, 1695-bit data and 256-bit Reed-Solomon code. Figure 1 shows the flow chart of data extraction.

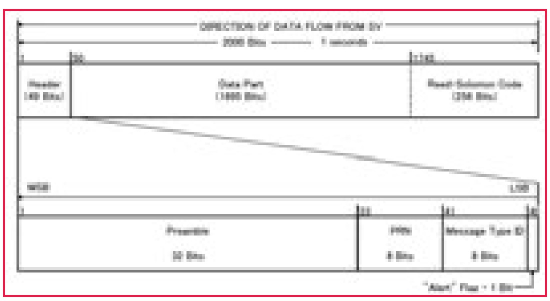

Figure 2. LEX Message structure (JAXA 2012)

Each Message is identified with a Message ID, the Message IDs are given in Table 3 as defined by JAXA (JAXA 2012). The research work only focuses on satellite ephemeris and clock correction data, thus only message ID-10 and ID-11 containing ephemeris, SV clocks and ionospheric correction were extracted.

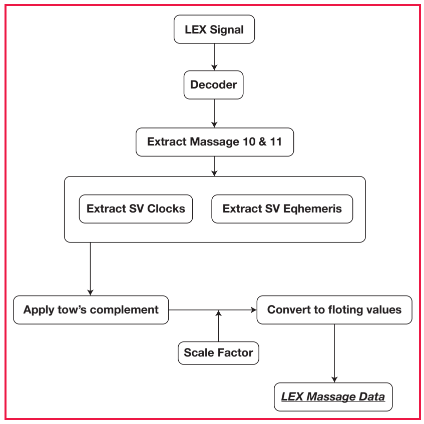

Figure 1. LEX data extraction flow chart

To extract the message ID-10 and message ID-11, individual 1744 bits has to be identified. According to Figure 2 data, bit packets were separated to three parts header, data part and the Reed-Solomon code. The preamble was checked for error caused during extracting the Message. The PRN was checked to see the broadcasting SV number. Message ID-10 contained ephemeris and clocks of three satellites and the message ID-11 contains ephemeris and clocks of two satellites and the ionospheric correction data.

IGS products

The International GNSS Services, (IGS) global system of satellite tracking stations, Data Centers, and Analysis Centers provides high-quality GPS data and data products on line in near real time to meet the objectives of a wide range of scientific and engineering applications and studies (IGS n.d.). IGS products contain satellite ephemeris and clock corrections with various temporal resolutions and

Table 4: IGS data products

Product	Accuracy	Latency	Update interval
Broadcast	orbits ~100 cm	real time	daily
	Clock ~5nsRMS ~2.5 ns SDev		
Ultra-Rapid (predicted half)	orbits ~5 cm	real time	15 min
	Orbit ~3 ns RMS clock ~1.5 ns SDev		
Final	orbits ~2.5 cm	12 - 18 days	15 min
	Clock ~75 ps RMS ~20 ps SDev		Stn.: 5 min

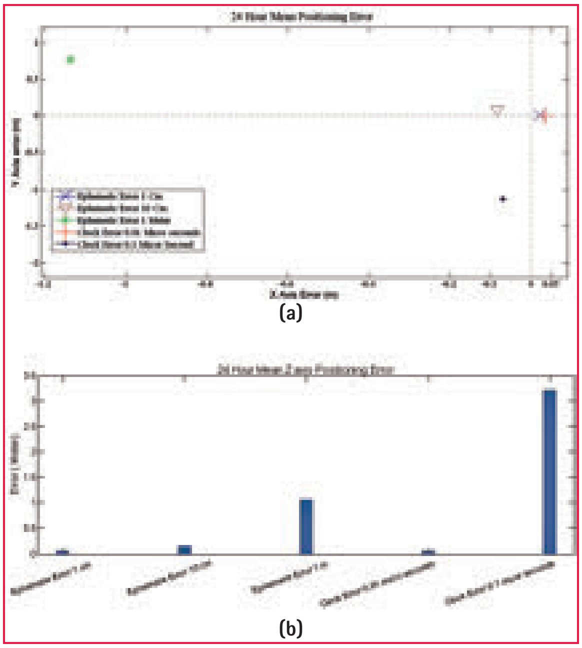

Figure 3: PPP positioning sensitivity analysis, comparing the effect on PPP positioning calculation with changing ephemeris and clock errors; (a) shows the 2D positioning error, (b) elevation error

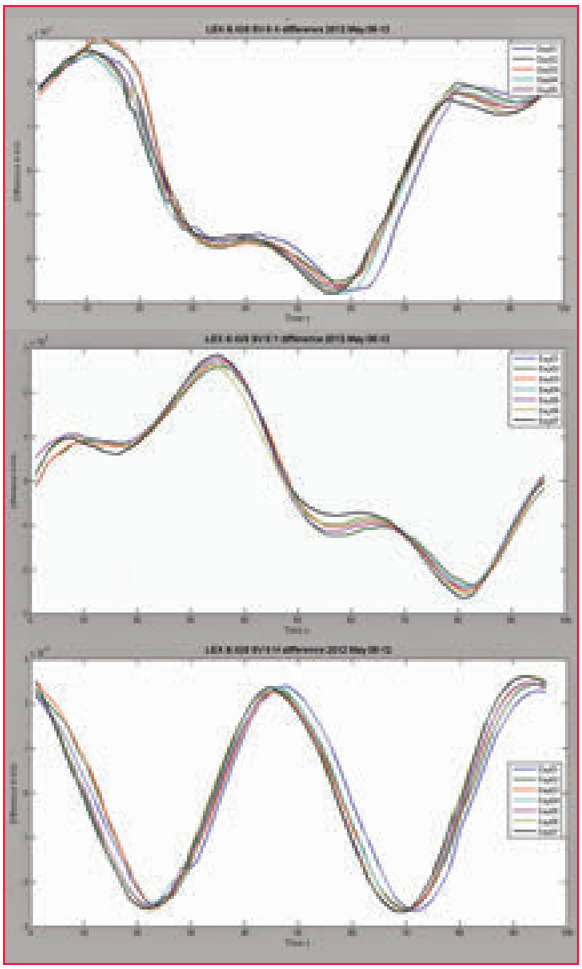

Figure 4. LEX Ephemeris error during second week of May 2012

Table 5. LEX data correlation with IGS data

Satellite	Correlation factor			
	X direction	Y direction	Z direction	Clock
16	0.98	0.98	0.98	0.21
02	0.83	0.92	0.89	0.04
12	0.96	0.98	0.95	0.02
28	0.98	0.98	0.98	0.15

accuracy. Final products are the most accurate with ~2.5cm ephemeris accuracy and ~75 ps RMS clock accuracy, but there is 12 - 18 days of latency. (IGS n.d.). As shown in Table 4, real time products have less accuracy compared to the final product. Jake Griffith and Jim Ray (Griffiths and Ray 2009) and (Urschl et al. 2005) have shown that the IGS data are accurate.

PPP sensitivity analysis

To analyze how the accuracy of ephemeris data and clock correction data affect the PPP positioning, a sensitivity analysis was carried out using IGS Final Products data. Different scales of error values were introduced to the IGS Final Products data and position was recalculated with the changed data using 24 hours of observation. The mean positioning error values are shown in Figure 3. One centimeter error in ephemeris and 0.01 micro second of error had little impact on the positioning and nearly equal amount of error. But when it moves to 0.1 micro second of error in the clock correction, there is around 1m error in positioning in the Y axis, where as 10 cm in ephemeris only produced an error of 10 cm in position. Thus PPP is more sensitive to the clock correction data accuracy compared to the accuracy of the ephemeris data. Figure 3 (b) shows the error in the Z axis, which shows the error in clock correction has a high impact on the Z axis positioning. Thus accuracy of the clock correction will have more impact on PPP positioning accuracy compared to the improvement in the ephemeris.

LEX data analysis

LEX data showed high correlation in ephemeris, with the correlation coefficient around 0.98 in all X, Y and Z axis. High correlation in the ephemeris data doesn't imply that the LEX data is accurate as IGS data; it says the data has the same characteristics and the same change in gradient in the data, thus the LEX data has accurate orbital path variation. However, clock error correction, correlation was below 0.3 showing that the LEX clocks correction data was not accurate. Accuracy of clock correction data is very important compared to satellite ephemeris data for real time PPP calculation as shown in the PPP sensitivity analysis. Table 5 shows correlation values for four selected satellites.

To further analyze the LEX data, satellite ephemeris errors were calculated taking IGS final product data as the benchmark, as IGS final product data have been proven centimeter level accuracy in the orbital data (Griffiths and Ray 2009). The errors were computed in 15 minutes intervals for a period of one week. It was found that the error in LEX ephemerides are partially systematic and, can be corrected to some extent by using modeling. But it's not expected for the model to improve

Table 6. LEX weekly error correlation for SV 6

Day	Error Correlation coefficient		
	x- axis	y -axis	z –axis
Day 2	0.986	0.996	0.9867
Day 3	0.987	0.994	0.9817
Day 4	0.982	0.991	0.9815
Day 5	0.975	0.989	0.9691
Day 6	0.951	0.983	0.951

the ephemeris to centimeter level as it is difficult to model the changes in atmospheric drag, effect of solar radiation and effect of external bodies that can affect the stability of SV. The LEX ephemeris error varied from time to time from minimum of zero error to nearly 2.5 m of maximum error. Figure 4 shows the five-day error values in LEX signal for satellite SV 6. The error varies from +2.5 to -2.5. It also shows high correlation to the satellite orbital path of the satellite in each plane. All the satellites showed similar behavior for the entire week.

To find any relationship between daily errors, further analysis was done. Table 6 below shows the correlation coefficients of Day 1 (6th May 2012) in X, Y and Z axis LEX data error, with the rest of the week LEX data error for satellite SV 6. There is high correlation in all three axis throughout the week. The error is systematic and the high correlation proves that the error correction of the first day of the week can be applied to the rest of the week to improve the accuracy.

Clock correction

Initial analysis of the LEX data showed that the LEX clock correction was a constant value which confirms the low correlation value of the LEX clock data with the IGS Final products data. Changes to the LEX clock correction was applied as a sudden step by changing the value by 1 microsecond to change the value as shown in Figure 6 diagram (b) and (h). Thus, the expected accuracy of the LEX clock correction is one microsecond. As for the IGS clock correction, there is a continuous change in the correction which is systematic and has an almost constant gradient. There are some points where the clock correction has sudden changes of the normal gradient. Figure 7 shows IGS clock correction data for the first three days of the week and the sixth day of the week for SV6. IGS Clock correction is decreasing with a constant gradient throughout the week. Analysis of all the satellites for a period of 7 days showed the clock correction gradually increasing or decreasing with time. This gradient can be predicted using the 1st order polynomial.

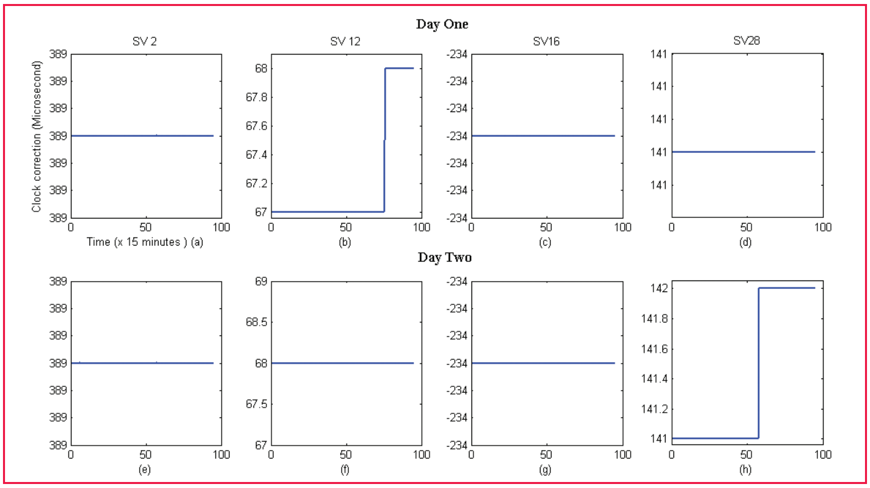

Figure 6: LEX SV Clock correction comparison on day one and day two

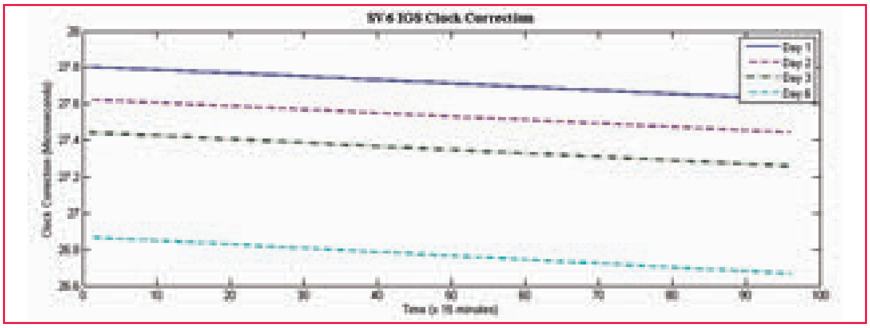

Figure 7: IGS SV 6 Clock Correction data for four days

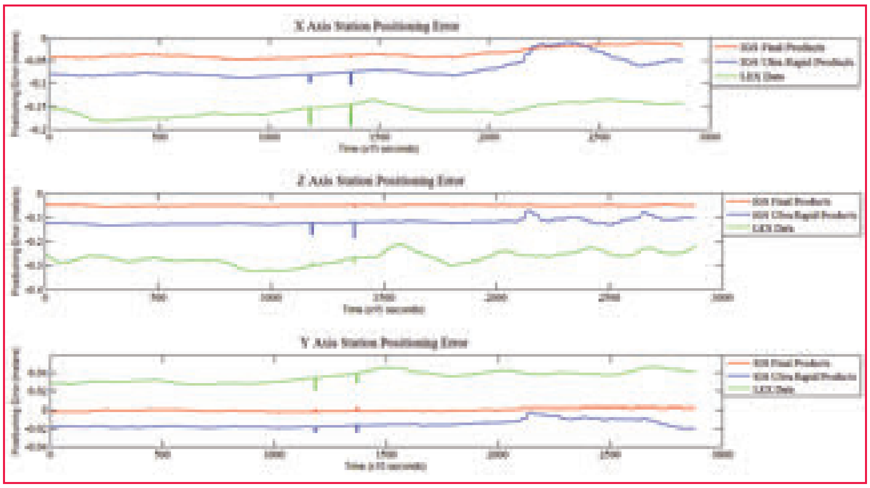

Figure 8: Positioning accuracy comparison of IGS Final Product, IGS Ultra Rapid Products and LEX PPP data sources.

Position accuracy

To evaluate the positioning accuracy of different PPP data, 24-hour of dual frequency observation from a well-

Table 7: Day 5 IGS Ultra Rapid and LEX Corrected positioning error results

Position	Root Mean Square Error		Standard Deviation	
	IGS Ultra Rapid	LEX	IGS Ultra Rapid	LEX
Nothing	0.035	0.024	0.011	0.005
Easting	0.041	0.166	0.011	0.013
Elevation	0.050	0.342	0.024	0.023
2D	0.108	0.336		

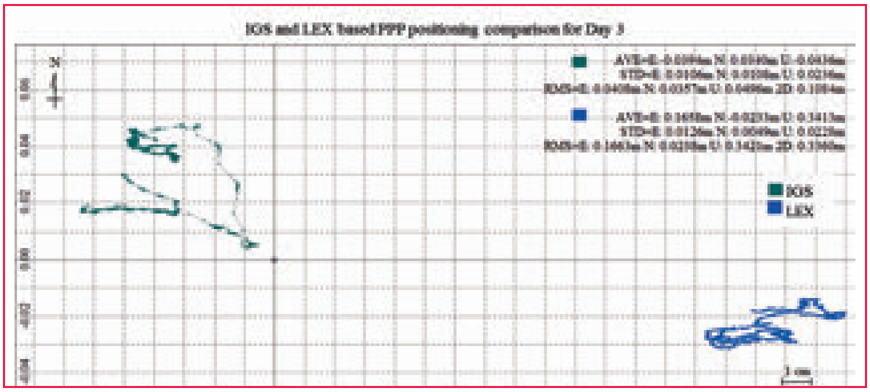

Figure 9: IGS & LEX based positioning results from real time data

established station was used. Real time LEX, IGS Ultra Rapid and post processed IGS Final products were used in this experiment. Figure 8 shows IGS final products were able to provide centimeter level accuracy with high precision. IGS Ultra Rapid data was able to keep the accuracy below 10 cm. On the other hand QZSS LEX based positioning accuracy was around 20 cm with relatively low precision compared to IGS-based PPP positioning.

Figure 9 illustrates the 24 hours of positioning calculation using LEX and IGSUR data in 2D Cartesian plane. It shows 2D root mean square error of 0.108 m and 0.336 m and IGUR and LEX respectively, thus IGSUR data is able to provide around 10 cm of accuracy improvement compared to LEX in the 2D plane, for the height error IGSUR has a much higher accuracy with error of 5 cm compared to 30 cm error in the LEX data.

Conclusion

It's demonstrated through the research that IGS Ultra Rapid SV ephemeris and clock corrections are accurate compared to LEX data, thus for best real time positioning, the IGS Ultra Rapid data is the best solution currently available. On the other hand however, QZSS based PPP is not restricted by the limitation of GSM network such as coverage and weak signal as in the case of IGS data. Thus, QZSS PPP brings more possibility, such as real time PPP positioning in remote area such as mountains and even in the ocean. It will also help reduce data transfer between the base stations and GPS based monitoring sensors such as sea buoy, enabling the monitoring station to calculate its position accurately and transfer data when it is necessary. The result also shows the LEX data has ± 2.5 m errors in ephemeris data and its systematic repeating throughout the week can be improved to some extent. The satellite clock correction data provided by QZSS LEX data has only one microsecond accuracy. This is the major factor for low accuracy of QZSS PPP positioning. It's suggested that QZSS LEX based positioning can be improved by using dense network of GPS base stations to improving the GPS satellites ephemeris and clock correction models as well as incorporating with the IGS data products.

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Lift&Tilt

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6 Parallel RTK Engines

and

Visual Stakeout

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The next GNSS

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Mitigating the systematic errors of e-GPS leveling

The test results show that the proposed method can mitigate the systematic errors of orthometric height $\hat{H}$ from e-GPS leveling efficiently. We present here the first part of the paper

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e-GPS (Electronic Global Positioning System), used in Taiwan, is a kind of real-time kinematic satellite positioning technology as VRS-RTK (Virtual Reference Station Real Time Kinematic).

Because of basing on different vertical datum, any point on the surface of the Earth, its ellipsoidal height h and orthometric height H are different. The height difference between h and H is called undulation N. Suppose it can be ignored that the vertical deflection on ground is very small, then any point on the ground, the relationship among h, H and N, can be represented it with a simple mathematical equation: $h = H + N$ (Hu, et al., 2004; Kavzoglu and Saka, 2005; Kuhar et al., 2001; Stopar et al., 2006). Therefore, for a point p, if the values of h from e-GPS and N from regional geoid model are known, then H value of point p can be calculated by the following equation: $H = h - N$. This is the basic principle of e-GPS leveling.

For a certain region, if the regional geoid model has been constructed, the undulation of any point $\hat{N}$ can be estimated by means of interpolation method. If, the accuracy of the estimated value $\hat{N}$ meets the required accuracy, the orthometric height H of any point can be calculated quickly by means of e-GPS leveling.

> If, the accuracy of the estimated value $\hat{N}$ meets the required accuracy, the orthometric height H of any point can be calculated quickly by means of e-GPS leveling

In the past, many experts and scholars have been engaged in research for geometric fitting construction of the regional geoid model theme. They used the following geometric fitting methods: conicoid fitting method (Hu et al., 2004; Lin, 2007), neural network method (Hu, et al., 2004; Kavzoglu and Saka, 2005; Kuhar, et al., 2001; Lin, 2007; Stopar et al., 2006), support vector machine (Zaletnyik, et al., 2008) and so on. In their studies, the author(s) applied different geometric fitting methods to construct a regional geoid model, under different regional conditions, and got good results.

In general, due to the complexity of distribution of the geoid, use of geometric fitting to determine the regional geoid model, the selected model always exists model errors or systematic errors. Therefore, how to mitigate or eliminate the model errors or systematic errors of the regional geoid model has also become one of the research topics. The proposed methods to mitigate or eliminate the systematic errors of the regional geoid model are: the geoid model errors treated as additional parameters using the least squares method (Hu and Sun, 2009), the geoid model errors treated as parameters using least squares collocation method (Hu and Sun, 2009), a quadratic surface fitting an BP neural network method (Hu, et al., 2004; Hu and Sun, 2009).

If, on the other hand, the geoid model of a region is available. And the ellipsoidal height h of each benchmark of this region can be measured by e-GPS. Then, each benchmark has two kinds of orthometric height, an announced orthometric height

H from governments, and estimated orthometric height $\hat{H}$ ($\hat{H} = h - \hat{N}$) from e-GPS leveling. The difference between the two values is $\Delta H = H - \hat{H}$. Supposed that there are n benchmarks in this region, then, there are n values of ΔH. Those statistics, such as mean square error, standard deviation, mean, etc. (Ghilani, 2010) from n values of ΔH can be used to evaluate the performance of e-GPS leveling.

Through data analysis of test results, it is found that the ΔH standard deviation of all benchmarks is greater than the expected value in the test area, but also the mean of ΔH is not equal to 0.000m. So, it is suspected that $\hat{H}$ from e-GPS leveling may contain systematic errors. Sources of systematic errors may come from the regional geoid model, various height accuracies between different values of h from e-GPS and static GPS, etc. Therefore, three methods, conicoid fitting method (CFM), BP (back-propagation) neural network and BP neural network method (BP&BP), and BP neural network and conicoid fitting method (BP&CFM), are proposed in this paper, in order to mitigate or eliminate the systematic errors of the e-GPS leveling. This paper is divided into four sections, as an introduction for the first section, section two is the description of proposed methods to improve e-GPS leveling accuracy, for test results and discussion in section three, fourth section for the conclusion of this paper.

Proposed methods to improve e-GPS leveling accuracy

Related Terms Definitions

For ease of describing the proposed methods and test results, the related terms, statistical values, etc. are defined as follows.

Assume the announced orthometric height of a benchmark is H (treated as a true value), and its estimated orthometric height from e-GPS leveling is $\hat{H}$. The difference between H and $\hat{H}$ is defined as:

$$\Delta H_i = H_i - \hat{H}_i, i = 1, 2, \cdots, n \quad (1)$$

where $i = 1, 2, \cdots, n$, denotes the serial number of benchmarks; n indicates the total number of benchmarks.

Therefore, for an test region, with n benchmarks, after e-GPS leveling, the maximum, minimum, mean, mean square error, and standard deviation (Ghilani, 2010) of n benchmarks' ΔH can be calculated accordingly. Equation (2), (3), and (4), define the mean, standard deviation and mean square error of ΔH respectively.

$$\text{mean} = \overline{\Delta H} = \frac{\sum_{i=1}^{n} \Delta H_i}{n} \quad (2)$$

$$\sigma = \pm\sqrt{\frac{\sum_{i=1}^{n}\left[\left(\Delta H_i - \overline{\Delta H}\right)\times\left(\Delta H_i - \overline{\Delta H}\right)\right]}{n-1}} \quad (3)$$

$$m = \pm\sqrt{\frac{\sum_{i=1}^{n}\left[\left(\Delta H_i\right)\times\left(\Delta H_i\right)\right]}{n}} \quad (4)$$

Assuming the relationship between ΔH and plane coordinates (x, y) of n benchmarks can be expressed by the following equation:

$$\Delta H_i = f(x_i, y_i) + v_i, i = 1, 2, \cdots, n \quad (5)$$

where v_i denotes the residual of benchmark I; $f(x_i, y_i)$ is a function which establishes the relationship between a benchmark's ΔH and its plane coordinates. The geometric fitting methods, such as conicoid fitting method, BP neural network method, etc., can be used to determine function $f(x_i, y_i)$.

The following data $P = \{P_1, P_2, \cdots, P_n\}$ from n benchmarks are used to determine the function $f(x_i, y_i)$.

$$P_i = (x_i, y_i, \Delta H_i), \ i = 1, 2, \cdots, n \quad (6)$$

Assume that there are n benchmarks in a test region. These n benchmarks will be divided into three categories, reference points, check points, and validation points respectively. Data from reference points, with n_1 (about 3/4 of total n benchmarks) points, will be used to determine the coefficients of the polynomial function or to train the neural network and estimate the $\delta\hat{H}$ of every reference point's ΔH. With n_2 ($n_2 = n - n_1$, about 1/4 of total n benchmarks) points, data from check points, will be used to evaluate the fitting accuracy of the determined polynomial function or the trained neural network and estimate the $\delta\hat{H}$ of every check point's ΔH. Finally, data from validation points, with n points, will be used to estimate the $\delta\hat{H}$ of every validation point's ΔH.

If the estimated $\delta\hat{H}$ (denoting the systematic errors of $\hat{H}$ from e-GPS leveling) values of n benchmarks are available, the corrected orthometric height $\tilde{H}$ and corrected orthometric height difference $\Delta\tilde{H}$ after the first time systematic errors correction, can be calculated by equations (7) and (8) respectively.

$$\tilde{H}_i = \hat{H}_i + \delta\hat{H}_i, i = 1, 2, \cdots, n \quad (7)$$

$$\Delta\tilde{H}_i = H_i - \tilde{H}_i, i = 1, 2, \cdots, n \quad (8)$$

If find that there are still some systematic errors, then further assume that the following equation can express the relationship between $\Delta\tilde{H}$ of n benchmarks and their plane coordinates (x, y).

$$\Delta\tilde{H}_i = g(x_i, y_i) + \tilde{v}_i, i = 1, 2, \cdots, n \quad (9)$$

where $\tilde{v}_i$ denotes the residual of benchmark i; $g(x_i, y_i)$ is a function which establishes the relationship between benchmark's $\Delta\tilde{H}$ and its plane coordinates (x, y).

The following data $Q = \{Q_1, Q_2, \cdots, Q_n\}$ from n benchmarks are used to determine the function $g(x_i, y_i)$.

$$Q_i = (x_i, y_i, \Delta\tilde{H}_i) \quad i = 1, 2, \cdots, n \quad (10)$$

Again, assume that there are n benchmarks in a test region. These n benchmarks will be divided into three categories, reference points, check points, and validation points respectively. Data from reference points, with n_1 (about 3/4 of total n benchmarks) points, will be used to determine the coefficients of the polynomial function or to train the neural network and estimate the $\delta\hat{H}$ of every reference point's $\Delta\tilde{H}$. With n_2 ($n_2 = n - n_1$, about 1/4 of total n

benchmarks) points, data from check points, will be used to evaluate the fitting accuracy of the determined polynomial function or trained neural network and estimate the $\delta\hat{H}$ of every check point's $\Delta\tilde{H}$. Finally, data from validation points, with n points, will be used to estimate the $\delta\hat{H}$ of every validation point's $\Delta\tilde{H}$.

If the estimated $\delta\hat{\hat{H}}$ (denoting the systematic errors of $\tilde{H}$) values of n benchmarks are available, the corrected orthometric height $\tilde{\tilde{H}}$ and corrected orthometric height difference $\Delta\tilde{\tilde{H}}$ after the second time systematic errors correction, can be calculated by equations (11) and (12) respectively.

$$\tilde{\tilde{H}}_i = \tilde{H}_i + \delta\hat{\hat{H}}_i, i = 1,2,\cdots,n \quad (11)$$

$$\Delta\tilde{\tilde{H}}_i = H_i - \tilde{\tilde{H}}_i, i = 1,2,\cdots,n \quad (12)$$

The varied statistical values, such as mean square error, standard deviation, etc., of $\Delta\tilde{H}$, $\Delta\tilde{\tilde{H}}$, $\delta\hat{H}$, $\delta\hat{\hat{H}}$ can be computed in the light of calculation of varied statistical values of ΔH. In addition, for simplicity, σ_{ref}, σ_{chk}, σ_{val} represent the standard deviations of reference points, check points, and validation points respectively.

Conicoid fitting method (CFM)

The conicoid fitting method (CFM, also known as polynomial fitting) is usually used to construct a regional geoid model (Hu et al., 2004; Hu and Sun, 2009; Lin, 2007). However, CFM will be used to estimate $\delta\hat{H}$. The following polynomial represents the function $f(x_i, y_i)$ of equation (5):

$$f(x_i, y_i) = a_1 + a_2 x_i + a_3 y_i + a_4 x_i y_i + a_5 x_i^2 + a_6 y_i^2 + \cdots \quad (13)$$

Where $a_1, a_2, a_3, \cdots$ denotes the undetermined coefficients of a polynomial. Three types of CFM will be tested in this paper, i.e. 4-parameter CFM (a polynomial with undetermined coefficients $a_1, \cdots, a_4$), 6-parameter CFM (a polynomial with undetermined coefficients $a_1, \cdots, a_6$), and 10-parameter CFM (a polynomial with undetermined coefficients $a_1, \cdots, a_{10}$). When the total number of benchmarks is greater than the number of undetermined coefficients, the undetermined coefficients of a polynomial can be estimated using the least squares method. And, then enter the plane coordinates (x, y) of benchmarks within the region to equation (13), those values, such as $\delta\hat{H}$, $\tilde{H}$, and $\Delta\tilde{H}$, after the first time systematic error correction of e-GPS leveling, can be estimated using the following CFM procedures.

BP Neural Network and BP Neural Network Method (BP&BP)

Back-propagation (BP) neural network (i.e., the multilayer feed-forward neural network), is one of the neural network algorithms. The structure of BP neural network is divided into input layer, hidden layer and an output layer.

BP neural networks are often used to construct a regional geoid model (Hu et al., 2004; Hu and Sun, 2009; Kavzoglu and Saka, 2005; Kuhar et al., 2001; Lin, 2007; Lin, 2012; Stopar et al., 2006). However, this paper will use the BP neural network and BP neural network method (BP&BP) to estimate the values of $\delta\hat{H}$ and $\delta\hat{\hat{H}}$ of e-GPS leveling respectively.

First of all, a $2 \times p_1 \times 1$ BP neural network (2 represents the input layer has two elements, plane coordinates (x, y) of each point; p_1 denotes the number of neurons in the hidden layer; 1 represents the output layer has 1 element, ΔH value of each point), is trained to determine the function $f(x_i, y_i)$ of equation (5), using n benchmarks data $P = \{P_1, P_2, \cdots, P_n\}$. And then enter the plane coordinates (x, y) of points within the region, to calculate $\delta\hat{H}$, $\tilde{H}$, and $\Delta\tilde{H}$ values of all benchmarks, after the first time systematic errors correction of e-GPS leveling.

Next, a $2 \times p_2 \times 1$ BP neural network (2 represents the input layer has two elements, plane coordinates (x, y) of each point; p_2 denotes the number of neurons in the hidden layer; 1 represents the output layer has 1 element, $\Delta\tilde{H}$ value of each point), is trained to determine the function $g(x_i, y_i)$ of equation (9), using n benchmarks data $Q = \{Q_1, Q_2, \cdots, Q_n\}$. And then enter the plane coordinates (x, y) of points within the region, to calculate $\delta\hat{\hat{H}}$, $\tilde{\tilde{H}}$, and $\Delta\tilde{\tilde{H}}$ values of all benchmarks, after the second time systematic errors correction of e-GPS leveling.

BP Neural Network and Conicoid Fitting Method (BP&CFM)

If n benchmarks data $P = \{P_1, P_2, \cdots, P_n\}$ are available, first find the mean $\Delta\overline{H}$ of all points' ΔH, using equation (2). And, then calculate the dH value of each point using the following equation.

$$dH_i = \Delta H_i - \Delta\overline{H}, i = 1,2,\cdots,n \quad (14)$$

If the following equation can express the relationship between the dH values of n benchmarks and their plane coordinates (x, y).

$$dH_i = h(x_i, y_i) + \tilde{\tilde{v}}_i, i = 1,2,\cdots,n \quad (15)$$

Where $\tilde{\tilde{v}}_i$ indicates the residual of benchmark i.

There are two steps to be followed using BP&CFM. First of all, train a $2 \times p_1 \times 1$ BP neural network (2 represents the input layer has two elements, plane coordinates (x, y)of each point; p_1 denotes the number of neurons in the hidden layer; 1 represents the output layer has 1 element, dH value of each point), using n benchmarks data $(x_i, y_i; dH_i), i = 1,2,\cdots,n$, to determine the function $h(x_i, y_i)$ of equation (15). And then enter the plane coordinates (x, y) of points within the region, to calculate the estimation $\delta d\hat{H}$ of all points' dH. Finally, calculate $\delta\hat{H}$ (using equation (16)), $\tilde{H}$, and $\Delta\tilde{H}$ of all benchmarks.

$$\delta\hat{H}_i = \Delta\overline{H} + \delta d\hat{H}_i, i = 1,2,\cdots,n \quad (16)$$

Next, determine the CFM's 6 polynomial coefficients of function $g(x_i, y_i)$ of equation (9), using the least squares method, with all data $Q = \{Q_1, Q_2, \cdots, Q_n\}$. And then enter the plane coordinates (x, y) of points within the region, to calculate $\delta\hat{\hat{H}}$, $\tilde{\tilde{H}}$, and $\Delta\tilde{\tilde{H}}$ values of all benchmarks.

To be continued in next issue.

Surveying profession in Nigeria

Stimulating interest and encouraging youth participation for future sustainability

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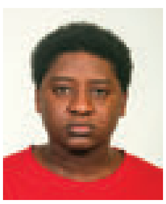

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The 21st century society is a knowledge driven one and many countries are investing massively on education in-order to enhance their global competitiveness and general well-being. Based on reports from Education at a Glance (OECD,2011), a recently published report by the Organization for Economic Co-operation and Development (OECD), the countries that invest the most in education have the most educated people. Similarly, the countries with the most highly educated citizens are also some of the wealthiest in the world. This direct relationship between education and development seems to be a motivating factor for significant investment in education. However, the OECD report also shows that while education has improved across the board, it has not improved evenly, with some countries/continents enjoying much greater rates of educational attainment than others.

One of the continents obviously lagging behind in educational attainment is Africa and one of the professions being affected by the slow educational development in the continent is the Surveying profession. Nigeria, the most populous country in Africa (Internet world stat, 2011) with a population of over 150 million people has witnessed a steady decline (relatively) in the quantity and quality of surveying professionals over the years. Not many youths are eager to enroll for surveying as a first choice course in tertiary educational institutions and a lot of surveying professionals in the country are not fulfilled (Fajemirokun et al. 2009). Many are even willing to switch profession at the slightest opportunity.

According to Fajemirokun et al. (2009), data contained in table 1 above shows the existence of problems regarding candidates' enrollment into the Surveying programme. Majority of the University Matriculation Examination (UME) candidates qualified for enrollment through supplementary admission-a process which usually selects from candidates crossing from other departments because they could not be admitted for their first choice courses. The candidates therefore settle for a second choice programme, often times halfheartedly.

To reverse this trend, it is necessary to carefully investigate the factors responsible for this alarming trend and proffer practical solutions.

Factors responsible for the decline in the number (quantity) of surveying professionals and prospective surveying students

What is in a name?

An average Nigerian youth with high school education is conscious of the prestige and respect that comes with certain professions. Professions like medicine, law, engineering, information technology, military services etc are popular among them. The dream of every child is to be addressed as a Dr. Barrister, Engineer, General etc in future. This is largely due to the respect accorded these professions by members of the society. The portrayal of these professions by the mass media as noble professions encourages many parents to convince their kids to enroll for such professions upon graduation from high school. These stereotypes unfortunately do not really extend to the survey profession in Nigeria. Many people have the erroneous impression that surveying is all about tedious land measurements. Images of technicians conducting survey works using traditional equipments like the theodolite and chains, under the scorching heat of the sun does not appeal to many (Nwilo and Osanwuta, 2004). Oblivious of the significant roles played by modern day


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Table 1: Students Enrolment Statistics in department of Surveying and Geoinformatics, University of Lagos Between 1998 and 2009 [Adapted from Fajemirokun et al. 2009]

S/N	Academic Session	No. of UME Applicants	Merit	Supplementary
1	1998/1999	*na	26	105
2	1999/2000	64	28	27
3	2000/2001	*na	11	65
4	2001/2002	*na	14	147
5	2002/2003	*na	28	27
6	2003/2004	42	23	*na
7	2004/2005	-	-	-
8	2005/2006	52	39	17
9	2006/2007	36	13	45
10	2007/2008	36	19	23
11	2008/2009	59	26	2

*na-Not Available

surveyors and allied professionals in developed countries in advanced fields like space technology, Remote sensing, GIS etc, the Nigerian youth and their parents often relegate the surveying profession to the back-stage when considering professions to be majored-in at higher educational institutions. While technological advancements have redefined and expanded the roles of surveyors in the 21^{st} century (Nwilo et al. 2000), many in Africa still relate surveying and surveyors only with physically demanding Land measurement tasks. Impressed by the glamour and prestige that come with professions like medicine, law, engineering etc, an average Nigerian youth would prefer to be referred to as a doctors, barrister, or engineer rather than being referred to as a Surveyor; the name sounds out-dated to them.

Poor job prospects

Another group of factors responsible for the decline in the number of people interested in practicing the surveying profession in Nigeria are low salary, poor job prospect and high rate of unemployment. The monthly salaries of fresh graduate surveyors working in private firms in Lagos, Nigeria's commercial capital, vary between N15,000 (USD94) to N60,000 (USD375) per month. The figure is even lower in less prosperous parts of the country. Those working in banks, oil companies, telecommunication companies, and manufacturing companies are better off. Considering the high cost of living, young surveyors are barley able to survive on this package. Consequently, there is little dedication to duty and eagerness to abandon the profession for better paying jobs. Similarly, career prospects for young surveyors do not appear too bright when compared with other professions. While other professionals such as civil engineers, architects and quantity surveyors have properly defined career prospects in other government ministries like transport, housing, and mine and power, surveyors are usually restricted to the federal ministry of works which has provision for full developed career prospects (Nwilo and Osanwuta, 2004). This situation prompts many young surveyors to abandon the profession at early stages of their careers. Some even return to school to enroll for a degree in Civil Engineering. The surveying discipline generally has a poor image of a non lucrative profession. This uninspiring situation makes it difficult for young people in the country to select surveying as a profession of choice when enrolling for undergraduate study in Tertiary educational institutions.

Conflicting representation of surveying

The absence of a unified status for the surveying profession also accounts for the lack of interest in the profession by youths. Globally, civil engineering, electrical engineering, mechanical engineering etc are all recognized as engineering professions. A civil engineer in Nigeria will also be recognized as a civil engineer in far away Australia. The same cannot be said of the surveying profession. While some universities view surveying as an Engineering profession, others view it as an Environmental science. Some even still treat the profession as a sub-set of Civil Engineering and surveying professionals do not earn the same income and respect as their counterparts in similar professions. For instance, a survey engineer in Nigeria might be regarded as an Environmental scientist elsewhere due to difference in curriculum and credit hours. Apparently, there is a lack of any clear international recognition of a 21st century definition of the profession of "surveying" and thus a failure to promote, at a global level, a clear, coherent "surveying" message to both clients and to the broader public. Indeed, there is evidence that some skills that are recognized and valued as being part of the surveying profession in some countries are not considered in the same light in others (Hannah et al, 2009). Furthermore, it appears various governments in the country do not accord the surveying profession the important position it ought to occupy and the priority it deserves in view of the indispensability of its services to sustainable development (Fajemirokun et al, 2002).All these combine to make many young people skeptical about venturing into the surveying profession.

Professional rigors and hazards

The use of outdated equipments for surveying practices means young surveyors have to spend several hours and even days on-site for data collection. Since field works are an integral part of the profession, fresh school leavers are usually reluctant to venture into this major. They prefer jobs that involve more office work and minimal field work. Specifically, female school-leavers are wary of hazards related to field work in remote parts of the country (Ruther, 2003). There are reported cases of boundary/land disputes where surveyors get caught in fights between feuding land owners. Some of these disputes are so serious that

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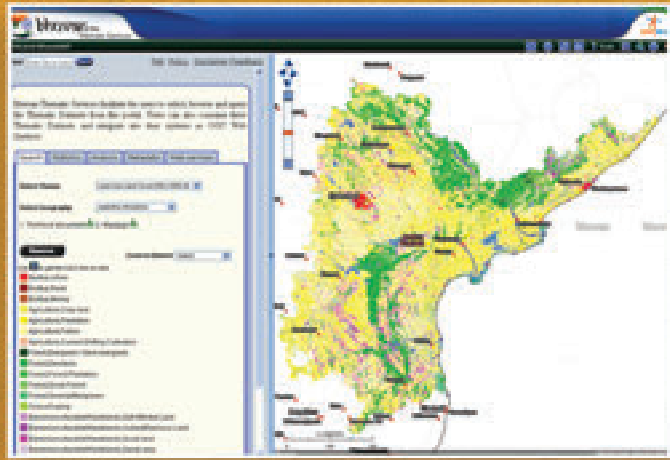

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dangerous weapons are used by warring factions thereby endangering the lives of surveyors and their expensive equipments too. Considering the unimpressive remuneration package and attendant rigours cum risks that come with it, young surveyors are tempted to switch profession and fresh school leavers are not motivated to pursue a degree in surveying at universities. This causes the number of surveying professionals to dwindle.

Brain drain

According to Ruther (2003), one of the central problems impeding the building of capacity in Africa is the 'pull of the first world'. Out of the few students that are determined to pursue a career in surveying, the cream of this group are usually offered scholarships by developed countries. Finding the lure of better academic and research facilities, fat remuneration package, and improved standard of living in these countries irresistible, pupil surveyors are tempted to stay back even after the expiration of their scholarship tenure. This ultimately affects the number of young surveyors capable of developing the profession locally.

Factors responsible for the decline in the quality of young surveying professionals and prospective surveying students

Dearth of qualified personnel

As mentioned above, the negative impact of the brain drain syndrome is profound. Many first class surveying graduates seek greener pastures outside the country, and even continent. They are reluctant to take up positions in local universities as researchers cum lecturers. Their geniuses are appreciated and adequately utilized in various research labs and universities in developed countries. As a result, the local universities are often left with average lecturers who might not necessarily possess the talent and finesse of their first class colleagues lost to the developed world. These average lecturers in-turn generally produce average students who end up giving average performances at the work place. Needless to say the fiercely competitive 21st century labour market has little tolerance for average performers.

Obsolete curriculum and inadequacy of modern equipment

Technological advancements in recent times have tremendously impacted the survey and mapping profession. Conventional survey techniques and instruments have been replaced by digital models (Bouloucos and Kufoniyi, 2000). Angular surveys have been augmented by electronic distance measurement, and more recently by satellite positioning. Photogrammetry has become an analytical discipline and Earth observation by satellites has made remote sensing an indispensable tool (Konecny, 2002). Unfortunately though, the African continent is yet to fully utilize the numerous benefits offered by modern day survey. A large number of professionals, lecturers, technologists and technicians in various organizations involved in geospatial information activities were trained in the obsolete methods of map production (Kufoniyi et al. 2002). Most of the personnel available for teaching are well grounded in the traditional survey techniques, but need to be retrained

Table 2: List of Universities in Sub-Saharan Africa [Adapted from Ruther (2003)]

Country	No. of Departments	Names of Universities
Nigeria	11	i. University of Nigeria, Enugu Campus ii. University of Lagos, Lagos. iii. Ahmadu Bello University, Zaria iv. Federal University of Technology, Yola. v. Federal University of Technology, Minna. vi. University of Uyo, Uyo. vii. Rivers State University of Science & Technology, PH. viii. Enugu State University of Science & Technology, Enugu. ix. Abubakar Tafawa Balewa, University, Bauchi. x. Imo State University, Owerri. xi. Anambra State University, Uli.
South Africa	1	University of Pretoria, Pretoria
Botswana	1	University of Botswana, Gaborone
Zimbabwe	2	i. University of Zimbabwe, Harare ii. State University of Midlands
Zambia	1	University of Zambia, Lusaka
Tanzania	1	University College for Land and Architectural Studies
Kenya	2	i. University of Kenya, Nairobi ii. Jomo Kenyatta University of Technology, Thika
Uganda	1	Makerere University, Kampala
Democratic Republic of Congo	1	University of Kinshasa, Kinshasa
Sudan	1	University of Khartoun, Khartoun
Ghana	1	University of Kumasi

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in the new emerging geoinformation techniques (Fajemirokun et al. 2002). With rare opportunities to go for pertinent refresher courses, they are unfamiliar with most modern survey techniques and equipments and are unable to teach same to students. They are compelled to rely on existing curricular, which are outdated. Consequently, students trained by these personnel are generally proficient in old survey techniques like theodolite-survey and inept at modern day techniques like GPS-Survey.

Paucity of funds

The importance of funds to the rapid development of the profession cannot be over-emphasized. Though Nigeria has a relatively large number of surveying departments when compared with other African countries, it nonetheless suffers a similar fate with them in-terms of inadequate funding. Researchers in the past have highlighted the fact that poor funding of surveying institutions is critically affecting surveying and geoinformatics education in Africa (Fajemirokun et al, 2002). Tertiary institutions are under funded and little progress can be achieved in the absence of much needed funds. Funds are needed to attract and retain quality researchers/teachers in academia; needed to procure state of the art surveying equipments; needed to train and constantly retrain educators in-order to properly position them for the challenges of the 21st century. Without funds, not much can be achieved in the quest for a viable and sustainable geospatial industry in Nigeria.

Charting a way forward

Lots of papers have been written in the past, detailing the necessary steps to be taken in-order to salvage the profession from apparent danger. Many of the proffered solutions are capital intensive and require huge government intervention. Unfortunately, the needed intervention has been slow in coming. In addition to the existing well-documented solutions, it is necessary to explore other initiatives that do not necessarily require direct government support or huge financial committments. Though simplistic on face value, these initiatives have the potential to significantly benefit the profession, if sustained.

> Impressed by the glamour and prestige that come with professions like medicine, law, engineering etc, an average Nigerian youth would prefer to be referred to as a doctors, barrister, or engineer rather than being referred to as a Surveyor; the name sounds out-dated to them

Change of name and curriculum

In line with global trend, it is necessary to change the name of the course in tertiary institutions from Surveying to Geomatic engineering/sciences. Geomatics is a globally admired brand name and adopting it will most likely stimulate the interest of youths in the profession. According to Ruther (2003), the change from Surveying to Geomatics has had some positive effect on the demographics of the student population in South Africa. Geomatics has a different image and is not perceived as being associated with extensive periods of fieldwork; as a result, larger numbers of female students are now registered there.

In addition to name change, it is also necessary to revise the curriculum and incorporate courses on pertinent modern fields like geoinformation, global positioning systems, Remote sensing etc. The introduction of these sophisticated programmes in the curriculum will further stimulate the interest of young students. This technique is working at the University of Lagos and it will most likely work in other surveying departments in the country if adopted.

Mentoring and volunteering

In different parts of the developed world, there are numerous Nigerian Surveyors working and excelling in the industry and academia. They utilize state of the art facilities and keep abreast of latest developments in the profession by attending conferences. These multitudes have experienced the beauty of the profession firsthand and are well placed to mentor young and upcoming surveyors on the prospects of the profession. As role models, they can convince High/ Secondary school leavers to enroll for a Geomatic degree in tertiary institutions. They can motivate current undergraduate students by facilitating internships and exchange programmes with foreign organizations. Collectively, they can provide invaluable information to their colleagues in Nigeria by sensitizing them on the various untapped opportunities in the developed world. There are lots of geospatial opportunities out there but having timely access to information on these opportunities is usually a challenge for home-based young surveyors.

Furthermore, these expatriate surveyors should be encouraged to periodically volunteer their expertise as educators in various institutions across the country. In addition, concerted efforts should be made to reach out to and seek the support of the following group of people:

1. Professionals from any country who want to share their expertise with counterparts in Nigeria.
2. Senior business leaders and retired executives from any country in the world who wish to support Surveying and geospatial development in Nigeria.
3. Surveying experts in Nigeria who wish to volunteer and share local knowledge with proteges.

Private funding initiatives

Instead of relying solely on government funds, efforts should be made to generate revenue from other sources. One major area that can be looked into is fund raising events. By liaising with their alumni associations, local universities can organize big fund-raising events. Such events usually provide an avenue for the alumni to reach out to their wide range of contacts in a bid to raise funds for the geomatic department. Similarly, International geospatial bodies like the Federation of International Surveyors (FIG) and the International Society of Phogrammetry and Remote Sensing (ISPRS) should be encouraged to host their international congresses here. Hosting events like this has the potential to generate lots of funds for the cash-strapped industry. For instance, the 2014 FIG congress scheduled to hold in Malaysia is expected to generate approximately £8.7 million for the Malaysian economy (Tourism Malaysia, 2010).

> In line with global trend, it is necessary to change the name of the course in tertiary institutions from Surveying to Geomatic engineering/sciences.

Use of modern equipment

The advent of modern techniques and equipment like Global positioning systems, geographic Information systems, satellite photogrammetry, remote sensing, GPS receivers, total station, CAD and GIS software etc has revolutionalized the surveying profession. To be globally competitive, young surveyors in the country have to be conversant with these tools. Though expensive, many of these tools can be acquired through the intervention of the Alumni and Nigerian expatriate surveyors. Through their network, they can liaise with various organizations and encourage them to donate some of these equipments. They can equally work out bargains that will enable them purchase some of the more expensive equipments at discounted prices and possibly make installment payments.

Using modern equipments will drastically reduce the time spent on site for data collection as well as make the whole survey process from start-to-completion very easy and fascinating. Without rigours and avoidable time consumption usually associated with the use of out-dated equipments, the negative perception of young people regarding the survey profession will change and they will be motivated to venture into it.

Academic collaboration and E-Learning

The dearth of well trained personnel in local institutions can be combated by collaborating with various institutions in developed countries. An obvious benefit of collaboration is the opportunity to be trained by experts in these countries via staff exchange programmes. With their assistance, outdated curriculums can be regularly updated. Also, refresher courses can be organized for academic staff members in-order to update their knowledge in line with the modernized curriculum.

In the past, collaboration initiatives were stifled by lack of funds needed to sponsor staff members to Geomatic departments in developed countries. However, real time online networking facilities like the *webinar* can now be used to conduct trainings without sending staff members abroad. A webinar is a web-based interactive seminar that enables a trainer to deliver lectures to anyone in any part of the world, in real time. Like real world situation, trainees can see the trainer, ask questions and receive answers immediately, and even record the event for future reference. By using facilities like this, staff training and retraining will be regularly conducted at a very low cost.

> Using modern equipment will drastically reduce the time spent on site for data collection as well as make the whole survey process from start-to-completion very easy and fascinating

Conclusion

Challenges facing Nigeria's education sector in general, and the geomatic profession in particular cannot be possibly exhausted in a single paper. Previous research efforts have discussed many of these problems and offered possible solutions, though some of the proffered solutions are impracticable. This paper has highlighted some of the most significant problems and suggested solutions that have not really been explored in the past. Though simplistic on face-value, these solutions are capable of revamping the profession if adopted collectively and spiritedly.

Here, more emphasis is placed on surveying in the academia over surveying in the industry. It is only logical that the situation in the industry is a reflection of what obtains in the academia. If the problems in the academia are fixed, more people will be motivated to enroll for surveying programmes in tertiary institutions , more competent graduates will be produced by these institutions, and the surveying profession will ultimately thrive both in the academic community and the industry.

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Remote sensing technology for govt property valuation

A MoU was signed by the Valuation and Property Service Department (JPPH) and Malaysian Remote Sensing Agency (ARSM), JPPH director general Datuk Abd Hamid Abu Bakar said the collaboration was done based on the success of a pilot project in the federal territory in accelerating and improving the efficiency and effectiveness of the valuation process. He said the pilot project was successful and had an impact in accelerating and improving the efficiency and effectiveness in the proses of property evaluation. *www.thesundaily.my*

Singapore moves to develop satellite and space technology industry

Singapore is making a major push to develop its satellite and space technology industry. Minister in the Prime Minister's Office and Second Minister for Trade and Industry S Iswaran announced the setting up of an inter-agency office to oversee the development of Singapore's local space industry. The Economic Development Board (EDB), together with participating ministries and agencies, have formed the Office for Space Technology and Industry or OSTIn. They include the Agency for Science Technology and Research (A*STAR), Ministry of Defence (MINDEF), Ministry of Education (MOE), Ministry of Foreign Affairs (MFA), Ministry of Trade and Industry (MTI) and the National Research Foundation (NRF). *www.channelnewsasia.com/*

Vietnam to launch $70 million satellite

The satellite VNREDSat - 1A will be launched into space by Ariane Space's Vega rocket from the Guiana Space Centre, European Space Agency (ESA), in Guyana, South America. It is designed by French satellite maker Astrium. It is an optical observation satellite. The 120 kg satellite can helps the management agencies to make early warnings to people about disaster. The VNREDSat-1A satellite project has an investment of more than $70 million, from the French government's ODA loans and reciprocal capital of Vietnam. *http://english.vietnamnet.vn/*

Astrium seeks for non-European Partner for its next EOS

Astrium is seeking for a partner to develop its new geostationary Earth observation satellite, the GO-3S. It is reaching out to countries outside of Europe to help finance this venture. The company has indicated that Singapore could be one of the possible countries interested in the GO-3S. *www.satellitetoday.com/*

Image Sensors Market worth $10.75 Billion - 2018

According to a new market research report "Image Sensors Market Analysis & Forecast (2013 - 2018): By Applications (Healthcare (Endoscopy, Radiology, Ophthalmology), Surveillance, Automobile, Consumer, Defense, Industrial)); Technology (CCD, CMOS, Contact IS, Infrared,

PSLV-C20 with 7 satellites including Indo-French SARAL launched

ISRO's Polar Satellite Launch Vehicle, PSLV-C20, successfully launched the joint Indo-French Satellite, SARAL, on February 25, 2013 in its twenty third flight from Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. Six other satellites, namely, UNIBRITE (NLS 8.1) and BRITE (NLS 8.2) from Austria, SAPPHIRE and NEOSSAT from Canada, AAUSAT-3 (NLS 8.3) from Denmark; and STRaND-1 from the United Kingdom, have also been launched into their planned orbits along with SARAL.

Satellite with Argos and Altika (SARAL) is an oceanographic satellite jointly developed by ISRO and the French Space Agency CNES. The satellite is built by ISRO, whereas CNES contributed the ARGOS and ALTIKA payloads. Data from SARAL will be useful for researchers besides having many practical applications like marine meteorology and sea state forecasting, climate monitoring, continental ice studies, environmental monitoring, protection of biodiversity and improvement in maritime security. *www.isro.gov.in*

X-Ray) And Geography" ,published by MarketsandMarkets, the value of image sensor market was $8.00 billion in 2012 and is expected to reach $10.75 billion in 2018, at an estimated CAGR of 3.84% from 2013 to 2018. In terms of volume, the total number of image sensors shipped is estimated to be 1.6 billion in 2013 and is expected to reach 3 billion by 2018. *www.marketsandmarkets.com/*

Forest cover is 7%, survey dispels fears

Kenya's forest cover is higher than previously thought after the Kenya Forestry Service conducted a mapping using remote sensing. Forestry and Wildlife Minister Noah Wekesa indicated that an accurate figure of the forest cover is 6.6 per cent, not less than two percent as had been previously estimated. This means the country is more likely to reach 10 per cent forest cover required by the Constitution. Using GIS and Remote Sensing Laboratory, Kenya Forestry Service and Kenya Forestry Research Institute conducted a survey countrywide. *www.standardmedia.co.ke/*

Russia, Cuba to work together on space exploration

The Russian government will sign an agreement with Cuba on cooperation in space exploration for peaceful purposes, the Russian Cabinet of Ministers said in a report posted on its website. The agreement between the Russian and Cuban governments is aimed at developing mutually profitable cooperation between the two countries in the sphere of space telecommunication technologies, satellite navigation, remote sensing of Earth, space medicine and biology, and the training of the Cuban staff. *http://rbth.ru/news/*

Fujitsu to get oldsters out the house and thoroughly caned

Fujitsu exhibited a prototype of its GPS-enabled walking stick at Mobile World Congress recently in Barcelona. The futuristic stick is aimed at getting older people out of the house, but would be equally at home slung over the arm of an Apple hipster while their iPod Nikes are in the wash.

The user can configure their route on a PC before downloading it to the stick via Bluetooth. As you tap along the street, a display on the top of the stick shows you when to turn - removing the need to muck about with smartphone maps while you're trying to pay attention to your surroundings. *www.theregister.co.uk*

TCS and Cellfind partnership

TeleCommunication Systems (TCS) and Johannesburg-based Cellfind, South Africa's leading location-based mobile services provider, has announced a partnership agreement where Cellfind's offerings will now include the LBS infrastructure solution provided by TCS. *www.gpsbusinessnews.com/*

Google launches indoor maps feature in Singapore

Google has launched its indoor maps feature in Singapore, making the city state the second country in Asia to have it. Android phone users will be able to use the online mapping system to help themselves find their way inside shopping malls and large buildings. *www.dnaindia.com/*

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I, Sanjay Malaviya, hereby declare that the particulars given above are true to the best of my knowledge and belief.

March 1, 2013 Signature of publisher

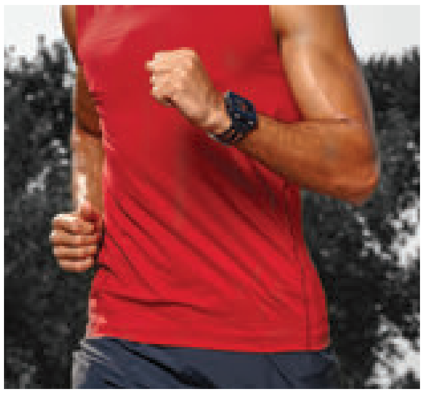
Smart satnav drives around the blue highway blues

Endlessly frustrated by congested roads, computer scientists at California State University, in Fullerton have developed a satellite navigation system, GeoTNavi, which hooks into historical traffic data and current vehicle movements to find the shortest commute and avoid the traffic jams. They point out that "sat-nav" systems have built-in updateable maps, while some are linked to web-based mapping services.

There also exist services that monitor traffic flow and alert drivers to potential trouble often based on calls from drivers to local radio news and road authorities depending on where you are in the world, while some systems have automated reporting from a select group of sat-nav users. There is a third source of information based on historical traffic movement databases. The team has now brought these various pieces of traffic information - maps, historical data and real-time driving conditions - together in a prototype system that could see an end to traffic jams. *www.eurekalert.org/*

GPS Fitness Watch Market to Grow 50% in 2013

The GPS fitness watch market is set to reach $1.07 billion in 2013, according to ABI Research's latest quarterly "GPS & GNSS" Market Data which forecasts fitness watches split by price tier. *www.abiresearch.com/*



LBS revenues in Europe to reach € 825 million by 2017

According to a new research report by Berg Insight, mobile location-based service (LBS) revenues in Europe are forecasted to grow from € 325 million in 2012 at a compound annual growth rate of 20.5% to reach € 825 million in 2017. The North American LBS market is forecasted to grow at a CAGR of 9.2% from US$ 835 million in 2012 to reach US$ 1,295 million in 2017. *www.berginsight.com/News.aspx*

MapMyIndia launches GPS and navigation app for BlackBerry Z10

MapMyIndia has launched its own GPS and navigation service on the Z10. The app has quite a few features such as the ability to mark places as "Home" so that you can quickly get a route to take you home. The app from the BlackBerry App World is for free, but it is only available on Indian handsets. *http://tech2.in.com/*

Galileo update

EGNOS + Galileo = safer skies

Europe's two satellite navigation systems could combine in future for heightened performance, an airborne test has confirmed. A helicopter flight took place above an Alpine valley, the one place on Earth where Galileo services are already routinely available.

Results of last autumn's flight test show that adding Galileo signals to the European Geostationary Navigation Overlay Service – EGNOS – that currently augments the accuracy and reliability of US GPS signals over Europe should boost its accuracy significantly. Operational horizontal and vertical distance 'protection levels' for safety were cut by approximately half by combining use of GPS and Galileo within EGNOS.

In addition, new integrity algorithms installed within the user receiver turned out to reliably detect and exclude reflected or otherwise faulty signals. The first test of real Galileo navigation fixes is scheduled for later this year from the four satellites already in orbit, with more satellites set to join them by the end of the year. As the constellation takes shape, satnav researchers and industrial developers can already try out Galileo services with prototype receivers at the giant outdoor laboratory that is the German Galileo Test and Development Environment, or GATE. *www.esa.int/*

Interim Report of the EU/US Cooperation on Satellite navigation released

The U.S.-EU Agreement on GPS-Galileo Cooperation signed in 2004 established the principles for the cooperation activities between the United States of America and the European Union in the field of satellite navigation.

The Agreement foresaw a working group to promote cooperation on the design and development of the next generation of civil satellite-based navigation and timing systems. This work became the focus of Working Group C (WG-C).

The subject Interim Report documents EU/U.S. accomplishments in developing the concept of ARAIM *(Advanced Receiver Autonomous Integrity Monitoring)* as a future basis for a multi-constellation support for global air navigation. The document captures the main findings of the studies conducted so far by joint teams on both sides of the Atlantic.

The report was prepared collaboratively thanks to the contributions from EU and US institutions, specialized agencies, research institutes and universities

The purpose of releasing this Interim Report is to inform the GNSS community about the progress made in this area thanks to the cooperative work of the U.S. and the EU, to call for comments on the findings, as well as to build a broad consensus towards the future standardization of ARAIM at international level. *http://ec.europa.eu/*

Economic Survey 2013 of India: Emphasis on Mines mapping

A detailed assessment of the country's mineral resources is required before mines are put up for bidding with the aim of revenue maximisation, said the Economic Survey. "In order to meet the objective of revenue maximisation in an open, transparent and competitive manner, this should be preceded by detailed geological mapping of the mineral wealth of the country," said the Economic Survey 2012-13, tabled in Parliament. *http://articles.economictimes.indiatimes.com/*

CSU, Butuan city govt to update comprehensive land use plan

The city government and Caraga State University (CSU) in Philipines, signed a memorandum of agreement (MOA) for the conduct of the Comprehensive Land Administration and Information Management of the city of Butuan using GIS. The output will be needed in updating the Comprehansive Land Use Plan (CLUP) of the city. *www.pia.gov.ph/news/*

Remote sensing database to upgrade planning in Kashmir

Underlining the harmonization of collection and reflection of real-time database essentially important for effective planning and better decision making, Chief Minister Omar Abdullah of J&K highlighted the importance of Spatial Data Infrastructure (SDI) this regard in a State like Jammu and Kashmir presenting mosaic of geographical diversity, remoteness of areas and hilly terrains. He recently launched the State Spatial Data Infrastructure (SSDI) project. *www.groundreport.com/*

UN agencies promotes use of GIS in disaster preparedness

The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) is working together with the United Nations Institute for Training and Research (UNITAR) in helping public sector organisations in the Asia Pacific region leverage geospatial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information, GIS and satellite derived imagery in disaster risk reduction, preparedness and emergency response. Under the Memorandum of Agreement, both UN agencies will focus their joint collaboration efforts on the priority areas of capacity development in space applications and ensuring optimal provision and dissemination of UNITAR's Operational Satellite Applications Programme (UNOSAT) products and services. *www.unescap.org*

India clears Rs 12k crore plan for police modernization

Sensing the urgency to strengthen police infrastructure across the country to meet day-to-day law and order challenges, the government of India has approved continuation of special schemes to modernize police forces in states worth over Rs 12,000 crore and earmarked nearly 20% additional funds for its ongoing 'Mega City Policing' plan for Mumbai, Delhi, Bangalore, Hyderabad, Chennai, Kolkata and Ahmedabad.

Nearly Rs 432 crore of this will go exclusively to seven metropolitan cities under the 'Mega City Policing' (MCP) plan. The fund will be used by these cities to procure modern equipment like GPS/GIS for 'Dial 100' systems and patrol cars, CCTV systems, vehicle scanners, vehicle number plate identification systems, cyber patrol and communication monitoring systems and integrated GIS based automated vehicle tracking and management systems. *http://articles.timesofindia.indiatimes.com/*

DSME selects Intergraph® SmartPlant® Enterprise

Daewoo Shipbuilding & Marine Engineering Company Limited (DSME) has selected Intergraph® SmartPlant® Enterprise solutions for operations and maintenance data handover of the INPEX Ichthys LNG Project in Australia.

The integrated suite of SmartPlant Enterprise solutions will ensure consistency between design tools and enable DSME to provide accurate, high-quality engineering data to INPEX. SmartPlant Enterprise will also help to facilitate the data handover process for smoother operations and maintenance when the vessel is delivered to the operator. *www.intergraph.com*

Spanish railways upgrades – Thanks to Deimos!

Taking a cue from how ESA controls satellites, Spanish railways now have their own high-tech upgrade to keep travellers abreast of when the next train is going to pull into the station. Drawing on sophisticated software that keeps satellites on track, the system was developed by a group of Elecnor Deimos engineers who had worked extensively on ESA projects. The outcome of this technology transfer is that up-to-date train schedules are now displayed at over 400 Spanish stations. "This came about as a result of the team's work with ESA's largest satellite, Envisat," said Carlos Fernández de la Peña, Director of Systems and Networks at Deimos. For Envisat, they created a software system designed to cope with the vast complexity of planning the satellite's operations: "It had to be robust, reliable and work 24/7. There is no room for error when it comes to satellites." *http://www.esa.int/*

Cultural heritage maps and a "Heritage Passport" of Mali

In response to the conflict taking place in the northern regions of Mali since April 2012, UNESCO, in collaboration with the National Directorate of Cultural Heritage in Mali and the International Centre for Earthen Architecture (CRAterre), has produced two publications on the cultural heritage of Timbuktu, Gao and Kidal. The first is an illustrated map with detailed texts. The second is a brochure entitled "*Passeport pour le patrimoine*" (Heritage Passport). *www.unesco.org*

Rolta bags USD 11 mn contracts from Northern Powergrid

Rolta UK has bagged two orders by Northen Powergrid worth nearly Euro 7 million (approx USD 11 million). The first is to implement a fully integrated asset management system with comprehensive geospatial functionality. The second is to provide data management and quality assurance service relating to asset records. *www.myiris.com/newsCentre/*

Cadcorp launches location intelligence product for the insurance sector

Cadcorp, has announced the availability of Web Map Layers for Insurance. The product brings together the location of both assets and hazards into a single GIS, and provides location intelligence in support of multiple business activities in insurance, notably sales, underwriting, customer service, and claims investigation. *www.cadcorp.com/*

Global Energy Mapper v 14.1 by Blue Marble

Blue Marble Geographics has released Global Energy Mapper 14.1, making available a variety of enhancements for energy professionals. This update to the company's desktop GIS software offers many new and improved features and functions including a significant improvement in the ability to process massive amounts of LiDAR point cloud data, jumping from tens of millions of points to hundreds of millions. *www.bluemarblegeo.com*

Database to provide tailored geographic data & modeling solutions

Have you ever wondered what the total length of all the rivers in Cambodia is? Or, how many people live within 5km of a road in Bangladesh? Or, how about the number of impoverished people in Zambia?

This kind of detailed information is essential for researchers and scientists around the world working in all food production systems. To support those seeking such geographic and spatial information, the CGIAR Research Program on Aquatic Agricultural Systems and WorldFish will launch an online database portal that will store ecological and socio-economic data, providing up-to-date spatial information and data on all kinds of important factors such as river systems, climate, distributions of fisheries, poverty levels, food security, and nutrition. The GIS database will provide custom information for scientists and researchers from WorldFish and the CGIAR Research Program on Aquatic Agricultural Systems (AAS), and the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

All software used by the project will be Open Source, and it is hoped that the scripts for populating the database and performing the queries will be written in SQL. The database will be managed under a subversion control system to ensure complete reproducibility. *http://aas.cgiar.org/*

Esri India introduces Cloud Based GIS Platform

Esri India has launched ArcGIS Online (AGOL), a cloud based GIS platform. It provides intuitive tools to create and publish maps and applications on demand for visualizing and sharing geospatial information. It provides open GIS capabilities to any user allowing access to any application, anywhere, anytime on any device. It facilitates sharing and use of geospatial content within groups of an organization, as well as between organizations and the public, providing a pervasive platform for services. *www.esriindia.com*

Karnataka to establish GIS for online mining applications

To facilitate the online processing of mining applications, the Department of Mines and Geology and the Government of Karnataka is going to establish a GIS based geo database system. According to the Department of Mines and Geology, the main objective of the project is to delineate the mineral belts on various potential zones in the state by adopting remote sensing techniques marking the free hold areas for the benefit of all stakeholders involved. *www.ciol.com/*

Proposal for open source alternative to GPS

Philipp Ronnenberg, a masters student in design interactions at the Royal College of Art in London, recently showed off the first prototype sensors for his alternate "Open Positioning System," which are designed to pick up regular seismic waves given off by large machinery in nearby power plants and factories. Once a sensor detects at least three different nearby seismic wave sources, Ronnenberg theorizes it should be able to determine its location.

So far, he's built a prototype sensor using the Arduino open source hardware microcontroller, which he says "can detect and collect different frequencies." The project is currently in its infancy and Ronnenberg is seeking input from other interested beta testers on the Open Positioning System website. *www.theverge.com/*

First Glonass monitoring station in Brazil

The first overseas Glonass ground station for differential correction and monitoring to improve the navigation system's accuracy is due to be launched in Brazil, the Federal Space Agency announced. In Russia, such stations ensure accurate positioning in the northern hemisphere. Further stations must be built to improve the accuracy of Glonass in the western hemisphere. *http://www.themoscowtimes.com/*

Google, GPS cannot track illegal mining: Goa govt

Google satellite imaging and GPS are flawed when it comes to monitoring illegal mining and encroachment of forest land by mining companies, the Goa government has told the Supreme Court of India. "The reliance on Google imagery to allege encroachment is absolutely erroneous and technically unsound," Principal Secretary (Mines) Rajani Kant Varma said in his affidavit before the apex court. The Supreme Court is hearing a public interest litigation on rampant illegal mining in the state filed by an NGO and activist-lawyer Prashant Bhushan. The Goa government now claims that there was a technical discrepancy in the Google maps software "with respect to altitude correction" and that hand-held GPS surveys were "not accurate to precisely identify encroachment as these GPS have an inbuilt error". *http://articles.timesofindia.indiatimes.com/*

GLONASS pilot project in India

"We are testing the GLONASS technologies for an effective solution of the transport problems in India's megapolises. We are shortly going to launch pilot projects in collaboration with Indian companies including Tata Consulting Service. These projects will be launched in megapolitan cities of Delhi, Mumbai and Bangalore. The introduction of the GLONASS technologies technologies in the public sector, like equipping the police personnel and vehicles with such systems is being seen as one of the prospective directions . Installation of GLONASS technologies in public transport is also being considered ." according to Mr. Aleksandr Bondarenko, Head of the representative office of the company "NIS GLONASS" in India. *http://indian.ruvr.ru/2013_02_01/GLONASS-project-India/*

A system that improves the precision of GPS in cities by 90 percent

Researchers at Universidad Carlos III de Madrid (UC3M) have developed a new system which improves the ability of a GPS to determine a vehicle's position as compared to that of conventional GPS devices by up to 90 percent, and which can be installed in any vehicle at a very low cost.

The system, which is based on sensorial fusion, was jointly designed and developed by the Applied Artificial Intelligence Group (GIAA – Grupo de Inteligencia Aplicada Artificial) and the Systems Intelligence Laboratory (LSI – Laboratorio de Sistemas Inteligentes) at UC3M. The prototype incorporates a conventional GPS signal with those of other sensors (accelerometers and gyroscopes) in order to reduce the margin of error in establishing a location. *www.uc3m.es/*

GPS Innovation Alliance launched

Citing the ever increasing importance of the GPS to the global economy and infrastructure, a group of GPS advocates have announced the formation of the GPS Innovation Alliance, an organization dedicated to furthering GPS innovation, creativity and entrepreneurship.

Members of the Alliance are drawn from a wide variety of fields and businesses reliant on GPS. These include manufacturing, aviation, agriculture, construction, transportation, first responders and surveying and mapping. Still others are organizations representing consumers who depend on GPS for boating and other outdoor activities, and in their automobiles, smartphones and tablets. It is Headquartered in Washington, D.C. USA.

Introduction of GNSS/EGNOS1 in Africa

ASECNA (Agence pour la Sécurité de la Navigation Aérienne en Afrique et à Madagascar) in consortium with Egis, Pildo Labs and ESSP have been designated by the ACP Group (African, Caribbean and Pacific Group of States) to implement the SAFIR Project, funded by the European Commission through the 10th EDF Intra-ACP envelope, with the objective of building capacity within African ACP countries for the future deployment of GNSS/EGNOS in the region. The SAFIR (Satellite navigation services for AFrican Region) project will last two years and will cover the set-up, staffing and operations of an EGNOS-Africa Joint Programme Office (JPO) with a proper regional participation of the various beneficiary countries. The missions of the future JPO will be to define the baseline and oversee the subsequent implementation phase for the specification and procurement of the development and deployment of GNSS/EGNOS in Africa.

NovAtel offers MEMS IMU for GNSS SPAN Integration

NovAtel Inc., has added a new commercially exportable MEMS IMU (micro electromechanical inertial measurement unit) to its line of SPAN GNSS/INS products. It is supplied by Analog Devices (Norwood, Massachusetts) and is exclusive to NovAtel. It can be paired with an OEM6 receiver card to provide continuously available position, velocity, and attitude (roll, pitch, yaw) in a small, single-unit form factor.

The new OEM-ADIS-16488 sensor is designed to be coupled with NovAtel's OEM6 receivers via a MEMS Interface Card (MIC). Measuring 71x46x11 millimeters, the MIC is designed to NovAtel's smallest receiver form factor, for pairing with an OEM615 SPAN-enabled receiver. The sensor uses 10–30 VDC power inputs, provides a 200 Hertz data rate, and is not subject to International Traffic in Arms Regulations (ITAR).

Rockwell Collins gets $3.2 mn GPS contract

Rockwell Collins received a $3.2 million technology investment agreement from the Department of Defense, USA to continue the next phase of the low-cost military GPS programme. *www.aviationtoday.com*

$120 million to Lockheed for new GPS satellites

The U.S. Air Force has awarded Lockheed Martin Space Systems with $120 million for two contracts to build the next four GPS satellites in the new GPS III program. All assembly, integration and testing of the four satellites will be done at Lockheed Martin's Jefferson County facility. *www.denverpost.com*

Esri ArcGIS supported by Leica Zeno GIS Office and MobileMatriX

Leica Zeno Office v3.1 and Leica MobileMatriX v5.1 has software updates for the Zeno GIS series. It now supports the new Leica CS25 GNSS, Esri ArcGIS 10.0/10.1 and post-processing accuracy improvements. The latest releases support the latest ArcGIS versions (ArcGIS 10 and ArcGIS 10.1). The direct integration allows organizations to access authoritative data to support enterprise analytics and GIS. *www.leica-geosystems.com/*

Trimble acquires Penmap Software

Trimble has acquired a suite of software solutions from Penmap.com Ltd. of Bradford, UK. Penmap.com's solutions include both office and field data collection software specifically designed for the cadastral and surveying markets. *www.trimble.com*

Broadcom latest GNSS chipset features low power Geofence Mode

The BCM47521, a single-die receiver IC, fabricated in low-power 40 nm CMOS technology, is currently in production and will be shipping in handsets by Q2 2013. In order to reduce the power consumption, the on-chip geofencing system allows the host CPU to be put into a sleep state until the handset crosses a predefined boundary, which triggers the BCM47521 to wake the host CPU. The BCM47521 chip also provides multi-constellation support. *www.gpsbusinessnews.com*

Symmetricom enhances SSU 2000 platform with GLONASS

Symmetricom, Inc. has announced two new capabilities for its SSU 2000 Synchronization Supply Unit: a GLONASS timing reference that uses signals from the satellite navigation system operated by the Russian Aerospace Defense Forces, and Synchronous Ethernet (SyncE), an ITU-T synchronization standard that delivers frequency synchronization over the Ethernet physical layer. This enhanced version of the SSU 2000 will be the first in a series of forthcoming Symmetricom products that include GLONASS capabilities.

Spectra Precision GNSS Receivers and Total Stations for Turkish University

The Hittite University School of Corum Department of Mapping and Cadastre has purchased two Spectra Precision Epoch 50 GNSS receivers and eight Spectra Precision Focus 8 total stations for academic study and research.

New bathymetry dataset offers easier access

Geoscience Australia has released a new multibeam bathymetry dataset that provides improved understanding about the topography and nature of the seafloor of offshore Australia, an area which for the most part remains poorly mapped. The 50m Multibeam Dataset of Australia 2012 is a tiled compilation of the entire multibeam dataset held by Geoscience Australia including all data lying within the outer edge of the offshore area of Australia, as well as some data in international waters, as at August 2012.

Bathymetry is the measurement or mapping of seafloor topography. One of the most accurate ways of collecting bathymetry data is through the use of multibeam echosounders which are acoustic ship-borne instruments designed to map the ocean floor.

Hemisphere GPS is now Hemisphere GNSS

Hemisphere GPS, Precision Products Business Unit, has been acquired by the Canadian subsidiary of Beijing UniStrong Science & Technology Co. Ltd. The Canadian entity will operate under the name of Hemisphere GNSS Inc. and our US entity and business headquarters located in Scottsdale, Arizona is named Hemisphere GNSS USA, Inc. Office addresses, website and contact details will all remain unchanged. The "Hemisphere GPS" brand will continue to be used in communications, product branding and advertising. *www.hemispheregps.com*

2013 GIS in Local Government Benchmark Study

Australia's Surveying and Spatial Sciences Institute (SSSI) has teamed with Esri Australia to conduct a national survey of local government use of Geographic Information Systems (GIS). The study will engage councils across Australia to understand how they are making use of intelligent mapping technology. The 2013 GIS in Local Government Benchmark Study will fill a lack of industry research into how the technology is being implemented. The industry has been aware that the role of GIS technology in local government is increasing and hopes to quantify both the use and potential in the report. The survey also aims to help local governments gauge where their current GIS technology capacity sits compared to their peers.

90 CHC GNSS Receivers for Chinese National Survey and Mapping Bureau

CHC Navigation has been awarded a contract to supply 90 units of X91 GNSS receivers to the Chinese National Survey and Mapping Bureau, for the completion of the Chinese Sea Islands and Reef Surveying & Mapping project.

Bentley Pointools' used to Uncover Prehistoric Artwork on Stonehenge

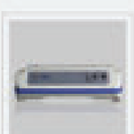
Bentley Systems, Incorporated announced that *Bentley Pointools* technology was used to visualize and analyze the most detailed laser scan survey ever conducted of historic Stonehenge – one of the world's oldest built environments. The laser scan with point spacing of 0.5 millimeters resulted in an enormous data resource of 850 gigabytes. The task of further examining this ancient infrastructure to discover more about it was awarded to ArcHeritage, part of the York Archaeological Trust in the United Kingdom as part of a project commissioned by English Heritage. *www.worldfishcenter.org/*

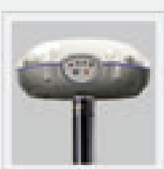
Mapping capabilities in the Swiss Alps of senseFly's eBee drone

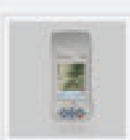
senseFly successfully demonstrated the 3D mapping capabilities of its fully autonomous mini drone under extreme conditions. Recently, the eBee conducted a mapping mission in the mountains above Zermatt at altitudes of up to 3000 meters. Several flights were conducted to map small hamlets and valleys at temperatures below -10 degrees Celsius (14°F). The entire mapping of a small valley, including the takeoff, flight, landing and resulting geo-referenced orthomosaic and 3D elevation map, is documented in a video available online.

Microsoft Introduces 210mm Lens for UltraCam Eagle

The Microsoft UltraCam business unit launched the 210mm lens for the UltraCam Eagle digital aerial camera system. It was the first multi-cone digital photogrammetric camera to offer an exchangeable lens system with 80mm (standard) and 210mm (tele) lenses. After extensive flight testing with exceptional results, the 210mm lens is now being released. The 210mm lens captures the same high dynamic, excellent quality, detailed imagery as other UltraCam systems, with the added benefit of flying at high altitudes, e.g., 5 cm imagery at a 2,000 m altitude.







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- ***SUPPORT***
  Worldwide network of local service centers and dealers

ESA selects Spirent Hybrid Location Technology Solution

European Space Agency (ESA) has selected Spirent's Hybrid Location Technology Solution (HLTS) to expand the location testing capabilities in their R&D labs. As the first test solution of its kind, Spirent's HLTS brings together all elements of hybrid positioning technology synchronously. It enables ESA to test positioning performance with a combination of Assisted Global Navigation Satellite System (A-GNSS), Micro Electro-Mechanical Systems (MEMS) sensor and cellular positioning technologies.

All-In-One Device for Mobile Communications and Surveying Data Collection

Trimble has announced an all-in-one device for mobile communications and surveying data collection—the Trimble® Slate Controller. It combines the convenience and ease-of-use of a smartphone with the rugged durability. Optimized for Trimble Access™ field software and the Trimble R4 GNSS receiver, it fully supports a surveyor's everyday workflows.

Offering voice, SMS text, and 3.75G cellular data transfer capabilities on GSM cellular networks worldwide, the Trimble Slate Controller is a rugged device that enables enhanced connectivity in the field. Its wireless communication capabilities keep surveyors in the field connected to the office. An integrated 8-megapixel camera offers enhanced job documentation and point attribution by providing geotagged, high-quality digital photos. *www.trimble.com*

Nokia mapping and nav apps for all Windows Phone 8 users

Nokia has opened up availability of Here Maps, Here Drive Beta, and Here Transit to all Windows Phone 8 devices in the US, Canada, UK, France, Germany, Italy, Mexico, and Spain. *www.theverge.com/*

MARK YOUR CALENDAR

April 2013

UAV training course
April the 9th 2013
Munich, Germany
www.rtg.bv.tum.de/index.php/fortbildungsseminar

The Eighth National GIS Symposium in Saudi Arabia
15-17 April
Dammam, Saudi Arabia
www.saudigis.org/

7th Annual GNSS Vulnerabilities and Solutions Conference
18 - 20 April
Baska, Krk Island, Croatia
www.rin.org.uk

UN/Croatia Workshop on GNSS Applications
21 - 25 April
Baska, Krk Island, Croatia
www.unoosa.org/oosa/SAP/gnss/index.html

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

European Navigation Conference ENC 2013
23 -25 April
Vienna, Austria
www.enc2013.org

The 7th International Satellite Navigation Forum
24 – 27 April
Moscow, Russia
http://www.expocentr.ru/en/events/glon

May 2013

Intergeo East 2013
2 – 4 May
Istanbul, Turkey
http://www.intergeo-east.com/

The 8th International Symposium on Mobile Mapping Technology
1-3 May
National Cheng Kung University, Tainan
http://conf.ncku.edu.tw/mmt2013/

FIG Working Week 2013
6–10 May
Abuja, Nigeria
www.fig.net/fig2013/

The 4th China Satellite Navigation Conference
15-17 May
Wuhan, China
www.beidou.gov.cn

June 2013

Hexagon 2013
3- 6 June
Las Vegas, USA
http://www.hexagonmetrology.us

The Munich Satellite Navigation Summit 2013
18 – 20 June
Munich Germany
www.munich-satellite-navigation-summit.org

12th SEASC - Geospatial Cooperation towards a sustainable future
18 - 20 June
Manila, Philippines
www.seasc2013.org.ph

MundoGEO#connect
June 18-20, 2013
Sao Paulo, Brazil
http://mundogeoconnect.com/2013/en/

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

RIEGL LIDAR 2013 International User Conference
25 – 27 June
Vienna, Austria
www.riegllidar.com

July 2013

GI Forum 2013
2 – 5 July
Salzburg, Austria
www.gi-forum.org

Survey Summit
6 – 9 July
San Diego, USA
www.esri.com/events/survey-summit/index.html

Esri International User Conference
8 – 12 July
San Diego, USA
www.esri.com

International Geoscience and Remote Sensing Symposium (IGARSS 2013)
22-26 July
Melbourne, Australia
www.igarss2013.org

August 2013

8th International Symposium on Digital Earth 2013 (ISDE 2013)
26-29 August
Kuching, Sarawak, Malaysia
http://isde2013.utm.my/

September 2013

ION GNSS 2013
16 – 20 September
Nashville, Tennessee, USA
www.ion.org

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