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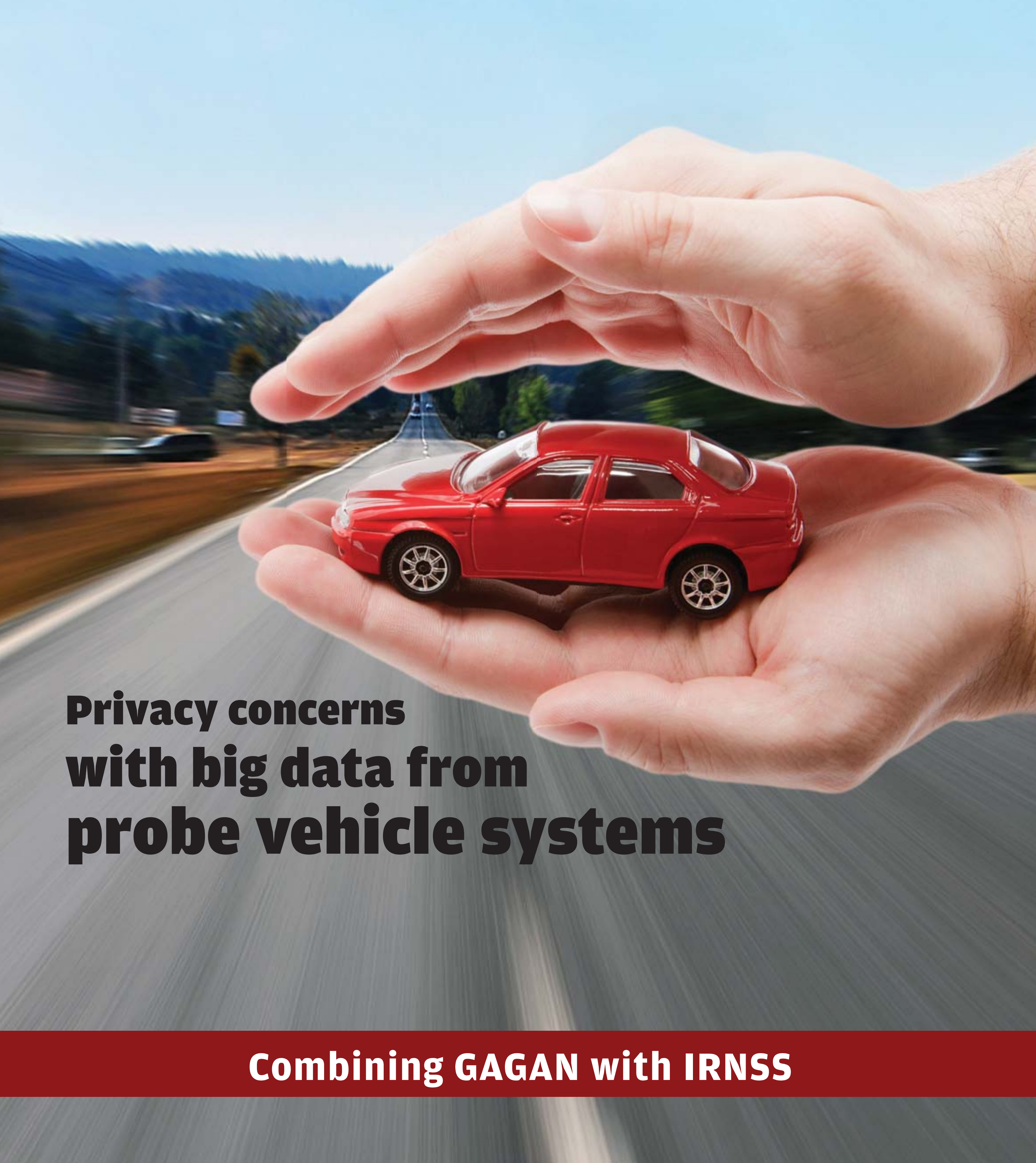
THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND



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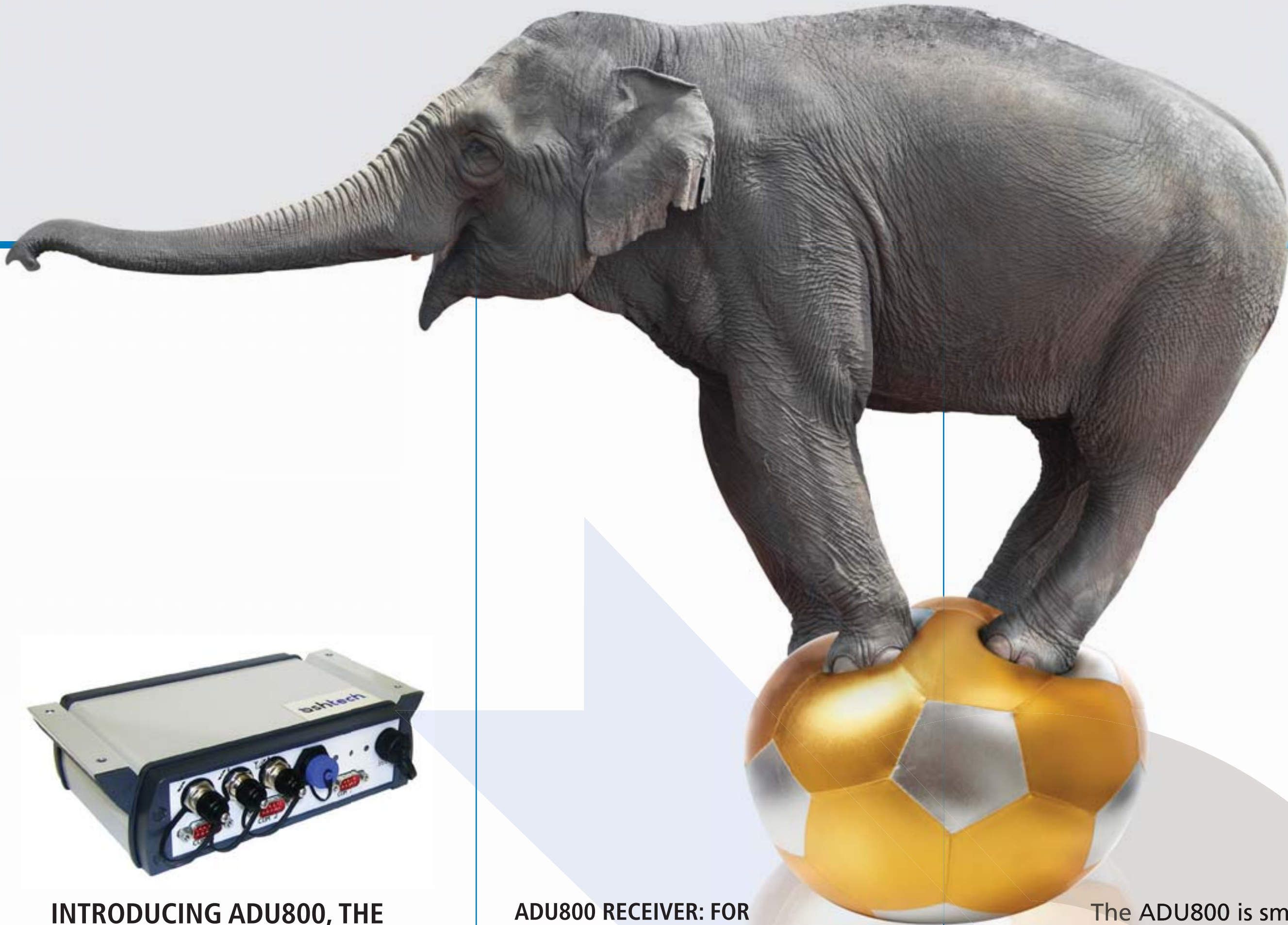

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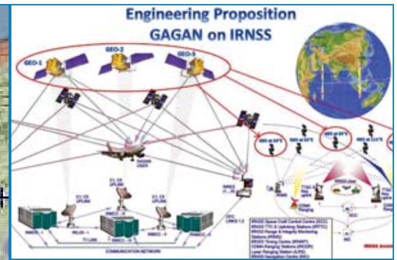

In this issue

Coordinates Volume 9, Issue 4, April 2013

Articles

Columns

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Right (to) Spatial Information

The Survey of India complains

Against Google's Mapathon 2013

Brings again the spatial data issues to the forefront

Whether Google has violated 'the law of the land' is under investigation,

And 'security concerns' are too grave to ignore,

Still, the mapping agencies need to innovate

Their responses to such challenges

Which they are likely to face more often

Given the trends of crowdsourcing.

The tendency of mapping agencies 'not to loose grip' is understandable

However, such issues should not be allowed

To overshadow

'The right (to) spatial information'

To common citizen

That is basic, fundamental and genuine.

Bal Krishna, Editor
bal@mycoordinates.org

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Privacy concerns with big data from probe vehicle systems

This paper discusses about the privacy concerns with probe vehicle systems, and proposes the classification of affordable anonymity for probe vehicle systems in order to allow the diversity of anonymity

Masaaki SATO, PhD
Visiting Research Fellow, KEIO-NUS CUTE Center, National University of Singapore, Singapore

In the age where the basis of Internet infrastructure for digital communication is developing, one of the most important issues that we need to address urgently is the building of a global service infrastructure in our society based on our activities and mobility.

The cutting edge network technologies are continuing to evolve at a remarkable speed, in a compelling environment in which we carry out various activities transparently and not limited to fixed locations. In such mobility aware environment, infrastructure and service based on mobility have become a necessity for transparent and optimal activities. With such mobile activity focus - collecting, sharing, and representing valuable probe information from vehicular activities using the Internet is becoming a hot topic in the research field and deployments beyond many countries.

Probe vehicle systems [1] [2] are designed to collect and share valuable information from vehicles (these are called probe data) via certain information infrastructure. By constructing the probe vehicle system on the open communication platform such as the Internet, the system can be kept independent from the under lying layer, and be able to provide various services. Organically consolidated probe data that make social instructive information, such as traffic congestion, accident, and environmental information, is deserving of societal expectation. The probe vehicle system has become a new trend for service deployment of ITS (Intelligent Transport Systems) to enhance car telematics. Furthermore, shifts in devices that do not require to be fixed to equipment inside vehicles, such as PND (Portable Navigation Device) or smart-phones as probe vehicle system have become a new focus on 'BIG DATA from Vehicle' sharing infrastructure. Using smart-phones as probe vehicle system enhances the possibility to create a mobility aware service platform which not limited only to vehicles, but to any activity related with mobility, relying on massive innovation not limit itself only to the ITS.

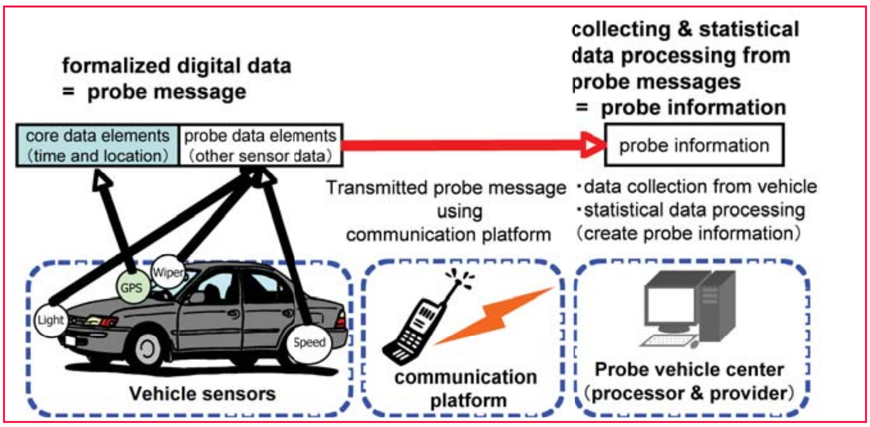

Figure 1. Concept and definition of Probe Vehicle Systems

General pictures of probe vehicle systems

A vehicle has more than one hundred sensors. Useful information can serve as a secure foundation for society, if information from those sensors can be collected. The probe vehicle system collects the vehicle sensor data via a communication infrastructure. The probe vehicle system has been researched upon, studied and examined in many countries. Besides, the general architecture, common data format and interfaces were standardized as ISO 22837:2009[3] in ISO/TC204/WG16.

The following list is denoted in the definition regarding the main components of probe vehicle system. The relationship between the factors is illustrated in Figure 1.

- **Vehicle sensor:**
  It is a device on a vehicle that senses conditions inside and/or outside the vehicle or that detects actions that the driver takes, such as turning on/off headlights or windshield wipers, applying the brakes, etc.
- **Probe data:**
  Vehicle sensor information that is processed, formatted, and transmitted to a land-based center for processing to create a good understanding of the driving environment. These probe data includes probe data elements and probe messages.
- **Probe data element:**
  An item of data included in a probe message, typically from onboard sensors. Systems in the vehicle may do some processing on the sensor reading to convert it into a suitable form for transmission.
- **Core data element:**
  Core data elements are basic descriptive elements intended to appear in every probe message. Core data element consists of a time stamp and a location stamp describing the time and place at which the vehicle sensor reading was made.
- **Probe message:**
  It is the result of transforming and formatting one or more probe data elements into a form suitable to be delivered to the onboard communication device for transmission to a land-based center. It is emphasized that a probe message should not contain any information that identifies the particular vehicle from which it originated or any of the vehicle's occupants, directly or indirectly.
- **Processed proba data:**
  The result of fusing and analyzing data from probe data messages in combination with other data.

Motivation – probe vehicle systems and privacy

In the International Standard ISO 22387, a probe vehicle system does not include any personal data within the probe data by definition. The probe vehicle system consists of vehicles that collect and transmit probe data and land-based centers that carry out probe processing. Probe processing builds an accurate understanding of the overall roadway and driving environment by fusing and analyzing probe data sent from multiple vehicles and data from other data sources. Namely, the probe vehicle system processes the data statistically to generate useful information. Therefore, a probe vehicle system doesn't require the vehicle and the data subject identification. In other words, probe data/ probe message requires 'anonymity'.

However, personal information might be handled in many different ways in the probe vehicle system [4]. For example, consider a probe vehicle system that does not include any personal data within the probe message, but uses personal information to authenticate the data subject when collecting probe data. In this case, even if their personal information is not contained in the collected data, the data subject cannot furnish vehicle data with complete peace of mind unless there is a system to protect their personal information. In addition, a probe message surely contains 'Location' and 'time' of transmitted vehicles. It may become personal information where the vehicle 'existed'. A vehicle has a close relation to the data subject and an excursion of the vehicle shows the activity history of the owner. Furthermore, there is a possibility of identifying a particular vehicle on the basis of the characteristic of probe data and where it has been collected. Identifying a vehicle means the possibility of disclosure of data subject's personal information and privacy.

Moreover, there are some novel applications using probe data with smart-phone or some nomadic devices have been intergraded into many aspects of our lives in not just the ITS area, such as ecological services and concierge services. These applications can help bring recognition to the probe vehicle systems, and have the economic effect of expanding markets of sensor data like probe information. There is much to be done for sharing valid data with some different probe vehicle systems to enhance the applications even through the typical probe vehicle systems. Coordinating services with some kinds of probe data collected by smart-phones or other nomadic devices could cause problems about the collision of type, reliability, and granularity of probe data among existing systems.

Privacy concerns

ISO/TC204/WG16 published international standard about personal data protection in probe vehicle system as 'ISO 24100 Intelligent transport systems - Basic principles for personal data protection in probe vehicle information services' in 2009 [5]. ISO 24100 is stipulated that even if data cannot identify an individual directly, if it can do so indirectly it should be regarded as personal data to be specified in this standard as a target of protection, as is mentioned in the OECD guidelines [6] for personal data protection. In order to protect the privacy, a vehicle should not be identified by the collected data. However, an authentication of the data subject is necessary to protect a probe vehicle system from a menace.

For privacy protection, one solution is to use a kind of random code. When a vehicle sends probe data with the given code, the probe data center knows that the data is valid, because the data came with a code signed by them. The data subject's privacy is protected using the random code, and therefore cannot be 'traced'. However, there is one problem in this approach, i.e., the data subject can never be traced by the probe vehicle system even if it is required (e.g., by the authority).This requirement is called 'Traceability'. As a method to satisfy 'Traceability', there is a proposed Anonymous Authentication scheme such as various anonymous credential schemes based on cryptography. However, this scheme is applied to all transactions, such that the probe data are completely unlinked. This state is called 'Unlinkability'. 'Unlinkability' is good state for the data subject's privacy, but the probe vehicle system still has a problem. For a measurement of the link travel time, the consecutive vehicle data are necessary to the probe vehicle system. In addition, complete anonymity requires a high cost that is not practical to the probe vehicle system. Therefore, in order to achieve the requirements of both the data subject's privacy and the probe vehicle system, there is a need to define the 'affordable' anonymity for probe vehicle systems.

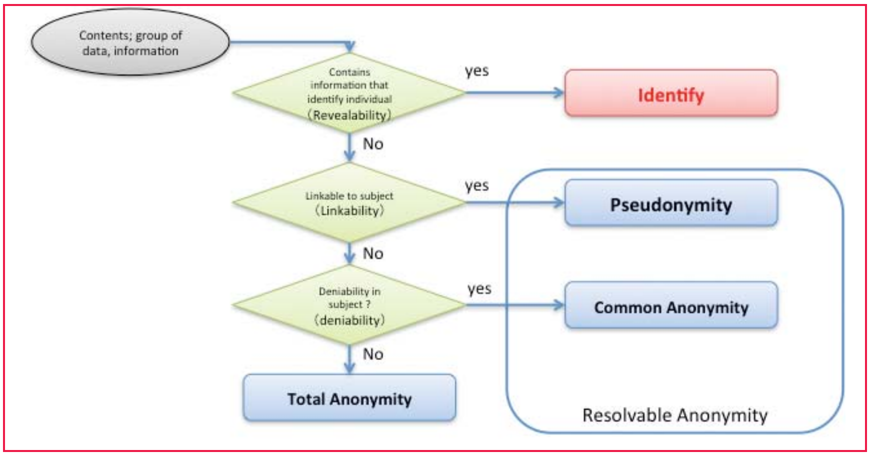

Figure 2. Flowchart of the classification of anonymity for probe vehicle systems

Concept of anonymity in probe vehicle systems

Fundamentally, almost all probe vehicle systems process the data statistically to generate useful information. That means the probe vehicle system doesn't need the vehicle and the data subject identification. On these assumptions, the anonymity of probe vehicle system can define as follows:

- Anonymity can be defined that the data subject cannot be identified.
- If it contains information which can identify the data subject directly is not anonymity.
- In the case that contains the information that can identify the data subject indirectly depends on the knowledge of the observer.

Besides, the information that can identify the data subject indirectly (e.g., user ID, device ID, provisional communication ID…) can be defined as follows:

- Indirect identifiable information of the data subject is a 'pseudonym' unless what is widely known.
- A 'pseudonym' can be defined as having anonymity to the public when management is appropriate.

In a general probe vehicle system, 'perfect' anonymity of technical and conceptual sense is not required. Anonymity for probe vehicle systems may adopt those accepted by society and market is reasonable. Such a concept is often introduced in the ITS framework projects in Europe and the United States of America [7][8][9]. Secure Vehicle Communication, Deliverable 2.1; Security Architecture and Mechanisms for V2V/V2I [10] defined two categories of anonymity in order to allow the diversity of anonymity.

- ***Total anonymity** where a participant in an IVC (Inter-Vehicular communication) system remains completely anonymous, i.e., no information that could identify that participant can be gained by other parties.*
- ***Resolvable anonymity** is the same as total anonymity with the exception that under certain, well defined circumstances others may be able to identify the otherwise anonymous entity.*

Based on the classification, this study is divided into three categories of anonymity, 'Total anonymity', 'resolvable anonymity' and 'Identify'. 'Total anonymity' is a status that the data subject cannot be identified permanently. Anonymity to be discussed in the probe vehicle system is mostly 'resolvable anonymity'. Because many probe vehicle systems require some authentication method for security, traceability and linkability of a certain period of time for high quality services. 'Resolvable anonymity' is the state when only the observer who in an intimate relationship with the data subject identifies the individual.

This paper proposes a two additional classification, 'pseudonymity' and 'common anonymity' for probe vehicle system. 'Pseudonymity' is the state in which the consecutiveness of the data subject is recognized among the 'resolvable anonymity'. The consecutiveness means that it is possible to identify that it is the same data subject even though the probe vehicle system cannot be specific to the individual. For example, one probe data group contains the same member ID and the member ID cannot identify directly - this status is called 'pseudonymity'. In either case, if the tie cannot be easily individuals and have been generally known, and cannot directly identify the data subject, it has a sufficient anonymity as almost all probe vehicle systems. The other, 'common anonymity' is the state that there is no linkability of probe data. For example, the system uses the same as total anonymity with the exception that the system detects a malicious attack or there is a request from the data subject, called 'common anonymity'.

'Pseudonymity' allows probe data to be collected continuously while keeping the anonymity of the data subject. 'Common anonymity' is almost the same as total anonymity. The only difference is deniability in the data subject. Deniability is the state of being able to prove to a third party that is not the act itself. In the case of 'total anonymity' is needed, 'un-deniability' is required in the probe vehicle system. However, in most cases, it is unrealistic in terms of cost-effectiveness. Figure 2 shows the flowchart of the classification of anonymity for probe vehicle systems.

Conclusion

Probe vehicle systems have become the new focus on 'BIG DATA from Vehicle' sharing infrastructure. Basically, a probe vehicle system processes the data statistically to generate useful information, so that probe vehicle systems don't require data subject identification. On the other hand, many probe vehicle systems need consecutive data group for high quality service. Moreover, the perfect anonymity requires a high cost that is unrealistic in terms of cost-effectiveness.

This paper has analyzed privacy concerns related to probe vehicle systems and proposes the classification of affordable anonymity for probe vehicle systems in order to allow the diversity of anonymity.

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References

[1] U. Keisuke, S. Hideki, and M. Jun, "The InternetCAR network architecture: Connect vehicles to the internet using IPv6." ITST2005, June2005, pp. 187–190

[2] Huber, W., Ladke, M. and R. Ogger, "Extended floating car data for acquisition of traffic infromation", Proc of the 6th World Congress on ITS, Toronto, Canada. 1999.

[3] International Organization for Standardization (ISO), "ISO 22837:2009 Vehicle ProbeData for Wide Area Communication", International Standard, 2009

[4] Masaaki S, Michiko I, Hideki S, Keisuke U, Jun Murai, "Threat analysis and protection methods of personal information in vehicle probing system", The Third International Conference on Wireless and Mobile Communications(ICWMC), March 2007

[5] International Organization for Standardization (ISO), "ISO 24100:2010 Intelligent transport systems -- Basic principles for personal data protection in probe vehicle information services", International Standard, 2010

[6] The Organisation for Economic Co-operation and Development, "OECD Guidelines on the Protection of Privacy and Transborder Flows of Personal Data", adopted on 23 September, 1980

[7] SeVeCom, http://www.sevecom.org (Feburary 20, 2012)

[8] PRECIOSA, http://www.preciosa-project.org (Feburary 20, 2012)

[9] EVITA, http://evita-project.org (Feburary 20, 2012)

[10] Antonio Kung, "Secure Vehicle Communication, Deliverable 2.1; Security Architecture and Mechanisms for V2V/V2I", SeVeCom, August 2007

NORWEGIAN EXTREME ARTIST, ESKIL RONNINGSBAKKEN, DURING A ONE-HANDED HANDSTAND AT THE DISTINCTIVE NEEDLE PEAK, BLADET, NORWAY, 2010.

Photo: Hermod Halse

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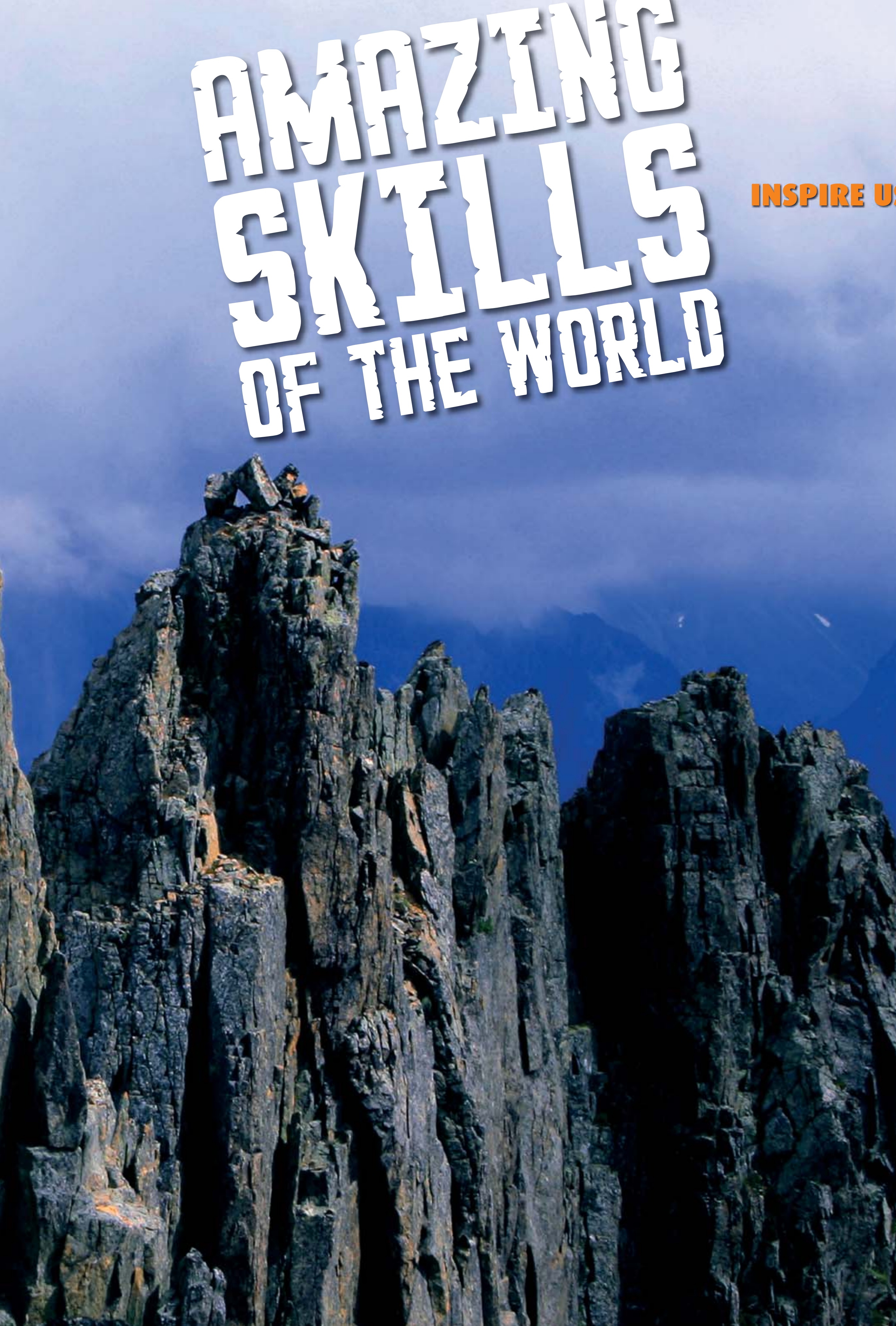

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Combining GAGAN with IRNSS

This research explored the possibility of combining the GAGAN (SBAS) with IRNSS. In addition, with new messages included, the proposed SBAS can also transmit the corrections for IRNSS

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The Indian Space Research Organisation (ISRO) is in the process of deploying the Indian Regional Navigation System (IRNSS), a dual frequency service system. Another contribution by ISRO in the area of Navigation system is GPS Aided GEO Augmented Navigation (GAGAN), an augmentation system. Till date, to the best of authors' knowledge there is no work that has explored the potential synergy between IRNSS and GAGAN. An article in the previous edition (Co-ordinates Feb 2011) showcased some research work where new locations were suggested for IRNSS satellites to enhance its regional coverage. Based on the proposed locations, this research presents an engineering synergy between IRNSS and GAGAN and highlights its distinctive merits.

To begin with, a brief introduction to GAGAN and IRNSS is presented from a signal's perspective. Following this, the optimization criterion used in this research is deduced. The main factors affecting optimization are elaborated in detail with the optimal constellation deduced. Finally, the merits of the proposed constellation are discussed in detail.

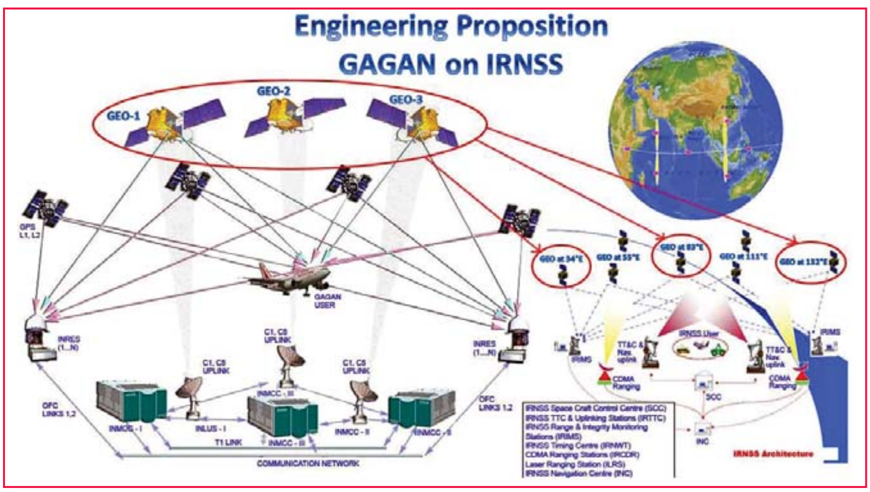

Figure 1: Control and space segment architectures of a) GAGAN b) IRNSS.

GAGAN

The void SBAS foot-print between EGNOS (Europe) and MSAS (Japan) is established by GAGAN. The following section describes the control and space segment components that make GAGAN operational.

The GPS satellites visible over the Indian subcontinent are continuously tracked at several monitoring stations. The stations are equipped with state of the art reference (survey grade) receivers that provide precise estimates of pseudoranges, carrier phase measurements and time information based on dual frequency. The stations also have the antenna located at a surveyed location. In addition, these receivers provide estimates of satellite related anomalies (for example, Signal Quality Monitoring (SQM)), if any. With these inputs and traits, measurements are formulated. Further, the integrity stations are spread across the Indian land mass (to obtain the ionosphere data for modelling), which relay the data to the master control station located in Bangalore. Based on the collated data from various stations, the messages are generated as per SiS requirements of SBAS (DO-229D 2006). These structured messages are uplinked in C-band to the GAGAN satellites as shown in Figure 1 a). ((GAGAN Architecture 2012), (Ganeshan 2012)).

GAGAN will have three geostationary satellites when fully operational with the signal footprint spanning over the Indian subcontinent (Kibe & Gowrishankar 2008). Points noteworthy of this signal are:

- transmitted in L1 band at 1575.42 MHz
- transmitted at -160 dBW, similar to GPS L1 C/A
- codes used are from the GPS L1 C/A family
- basic data rate is 250 Hz
- rate ½ 7 bit Viterbi encoding is employed on data bits and thus effective symbol rate is 500 sps.

Table 1: Assumptions towards the engineering optimization proposal.

Parameter	Description, Reasons/Examples
Backward compatibility	Two of the GAGAN satellites are already launched and deployed. GSAT-8 and GSAT-10 are in final and initial stages of testing. IRNSS is yet to be launched. It is assumed that there are no backward compatibility issues from a user perspective. This is largely valid as IRNSS and SBAS address different objectives with SBAS primarily not meant for ranging. Thus compatibility issues between IRNSS and GAGAN are not applicable as was with GPS L5 (L2C and L1 C/A signals being present)
Interoperability	This is explained as IRNSS/GAGAN (intra) and across GNSS (inter) systems: First, given that the projects have been conceived and are in the development stage, it is assumed that the signal levels do not pose a mutual problem. This is largely acceptable as the diversity that exists between GAGAN (L1) and IRNSS (L5/S1) consists of operating in different frequency bands. Further, it is comparable to WAAS and GPS L5 over the North American continent. Second, given that GAGAN (deployed) and IRNSS are largely in the developmental stage, it is assumed that all the necessary studies w.r.t these signals co-existing with other GNSS in the coverage region (Indian subcontinent) for mutual co-existence have been carried out.
Frequency filing	The first GAGAN satellite is transmitting the signal and uses codes/frequencies supported by SBAS (DO-229D 2006) In addition SBAS is a coordinated effort across GNSS bodies. Both these points assume/obviate the frequency filing proposal. For IRNSS, which is in the development stage, it is assumed that the codes/frequencies have been filed and approved by International governing bodies (Singh et al 2008).

- GPS receiver accuracies achievable over the Indian land mass with this signal will be similar to that achieved over the US with or without WAAS.

From the above points, it is clear that the signal (data) is transmitted five times higher than the GPS L1 C/A (IS-GPS-200E 2010) but its power has not been increased. This can be attributed to the following reasons:

- First, to achieve similar performance to L1 C/A (w.r.t measurement accuracies), 12 dB additional power would be required. This would act as *in-band jammer* and lift the noise floor of the GPS L1 channels (Parkinson & Spilker 1996).

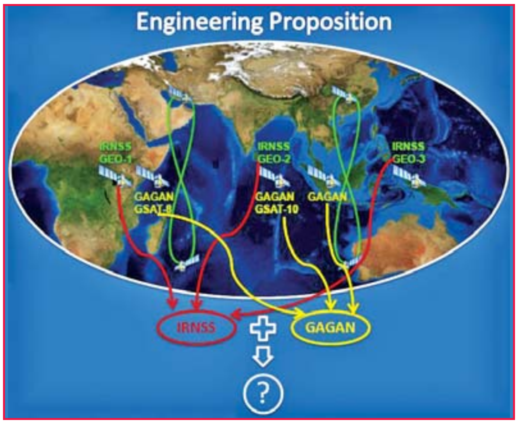

Figure 2: GAGAN (GEO-3 position assumed) and IRNSS geostationary satellites.

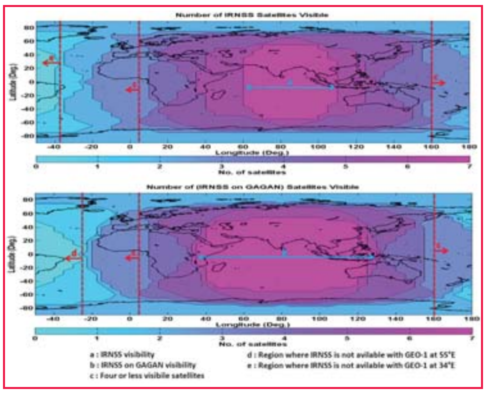

Figure 3: Satellite availability with current IRNSS and proposed IRNSS constellation

- Second, to accommodate the above requirement, the absolute power required would be -148 dBW, which *violates the guidelines for space based signal transmission* (Singh et al 2008). Thus, with -160 dBW the ranging measurement performed on SBAS will be relatively inferior to GPS L1 (Parkinson & Spilker 1996). This not being a system objective, SBAS focusses on providing integrity messages and can effectively be interpreted as a *data channel*.

IRNSS

As a second initiative in the space based navigation, IRNSS is ISRO's other contribution with an objective to provide independent regional navigation to cover its territorial footprint and slightly beyond. The system is expected to be operational by the end of 2015 (Bhaskaranarayana 2008). The system of space and control segment for IRNSS is as shown in Figure 1 b) (IRNSS Architecture 2012). The top level details of the control and space segments are as follows:

Table 2: GAGAN, Current and Proposed IRNSS constellation.

Constellation	Description	
	Geostationary Satellites	Geosynchronous Satellites
GAGAN	55°, 83° east	
Current IRNSS	34°, 83°and 132° east	55°, 111°east
Proposed IRNSS	55°, 83° and 111°east	55°, 111° east

Similar to the GAGAN control segment, IRNSS Range Integrity Monitoring Stations (IRIMS) will be deployed at several places spread across the Indian subcontinent. These stations will be equipped with high end receivers which will provide all relevant information about the satellites. With the signal transmission from the first satellite, these receivers will perform measurements and collect the NAV data. The data will be relayed to the master control station located in Bangalore. Based on this data, batch (typically) processing will be performed to generate the Keplerian parameters of all the satellites, the clock correction terms and the secondary NAV data information. Unlike GAGAN, this is a complex activity that determines the overall system accuracy (User Equivalent Range Error (UERE) (Rao et al 2011). The data generated is uplinked to IRNSS satellites.

The space segment will have a total of seven satellites, four in geostationary and three in geosynchronous orbits (Bhaskaranarayana 2008). Some features about IRNSS signals available from open sources are:

- The IRNSS L5 and S1 will transmit signals for civilian/restricted operations (Kibe & Gowrishankar 2008).
- There will be a total of seven satellites, three in geostationary and four in geosynchronous orbit as shown in Figure 1 b).

Optimization

From a regional perspective, it is clear from Figure 1 that there will be six payloads on six geostationary (3 each of IRNSS and GAGAN) satellites serving the navigation needs centered over the Indian subcontinent in the near future. From a system perspective, an obvious *engineering optimization* w.r.t the number of satellites is evident from Figure 2 *constrained by the individual specifications of each system*. Optimization w.r.t reduction in the number of satellites being the objective, the following section *proposes to reduce the satellite count, yet fully meet the IRNSS and GAGAN functionalities and finally deduce a simple third frequency option for IRNSS*.

To begin with, the assumptions made for the optimization are presented in Table 1. These assumptions are for the signals (GAGAN, IRNSS, and (GAGAN+IRNSS) w.r.t GNSS) over the Indian subcontinent. The attributes enumerated in the assumptions are backward compatible – which is applicable when a new system in proposed with a system already operational, interoperable – that is mutual existence of two systems and Frequency filing – which is a pre-requisite before a signal is transmitted from the satellite.

With the above assumptions, it is evident that the systems can be integrated without too many external issues and only constrained by the resources on the satellites. Based on the research work published in (Co-ordinates Feb 2013), the constellation as listed in Table 2 is proposed for IRNSS and GAGAN.

Advantages

The merits of IRNSS on GAGAN are explained as follows:

Availability

Availability from the proposed IRNSS is drastically enhanced (Co-ordinates Feb 2013). In addition, from Figure 3, it is very clear that the GAGAN coverage area is significantly enhanced, which is the polygon b. This is nearly a 60% increase in the coverage of GAGAN service volume.

SBAS & high dynamics

As mentioned in the earlier section, with the success of GPS and the need for correction/integrity, the SBAS program emerged. A similar proposition might arise in future for IRNSS. With few additional messages exclusively for IRNSS, GAGAN can be modified to account for the IRNSS's SBAS corrections as well. Through textual data (for example, some SBAS messages for IRNSS can be supported and, due to the inherent data rate limitations (50 Hz) and the need for some of the messages to be fast (for example, fast correction messages of SBAS), dedicated medium is required. This can be easily handled by additional messages onboard GAGAN (for example, GLONASS SBAS messages transmitted in EGNOS in addition to GPS (EGNOS 2011).

Higher user dynamics require wider Doppler search ranges. This coupled with high data rates (500 sps) puts a constraint (sensitivity) w.r.t SBAS acquisition in standalone mode (for example, no estimates of position, velocity, almanac or time). With the integrated proposal, IRNSS satellites when tracked in L5/S1 can directly assist L1 (SBAS) and thus improve performance drastically w.r.t acquisition in high dynamics.

Satellite count

An obvious advantage with this approach is that GAGAN satellites with IRNSS frequencies will eliminate three IRNSS geostationary satellites. Unlike GAGAN, IRNSS are dedicated navigational satellites. Assuming a *pessimistic estimate of 100 million USD/satellite including launch, a significant reduction in the cost is achieved (300 million USD in all) with the proposed integrated architecture*. At the same time, the specifications of both systems are effectively met.

Control segment

A synergized network can be established to effectively have a common control and monitoring station for both IRNSS and GAGAN ensuring all system parameters are obtained as required by *individual systems and collated at a common master control* station. With this, *the operational overheads are drastically reduced* resulting in the architecture shown in Figure 4.

Third frequency on IRNSS

With the geosynchronous satellites always visible over Indian subcontinent, the third frequency (L1) (when adapted on GSO's) can be used for safety of life applications as in GALILEO E6 (Galileo 2008). With the advantage that these satellites carry the L5/S1 signals and assuming collaborative tracking (Borio 2008), the data rate can be effec`tively be increased to 1 KHz on these channels without increasing power.

Conclusion

Till date the navigation and the augmentation system (satellites) have been different in every GNSS. This research explored the possibility of combining the GAGAN (SBAS) with IRNSS. In addition, with new messages included, the proposed SBAS can also transmit the corrections for IRNSS. From a regional perspective, this proposal provides the optimal coverage, ***more** advantages (for example, availability, reduced satellite count, SBAS of IRNSS)* is achieved with ***less** (without additional) satellites.*

Acknowledgements

The first author would like to thank the management of Accord Software & Systems Pvt Ltd India for partially supporting his doctoral studies.

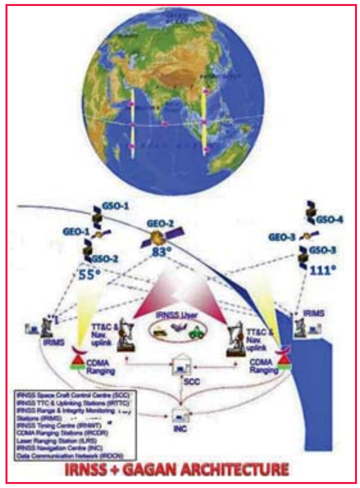

Figure 4: Proposed IRNSS+GAGAN constellation.

References

V G Rao and G Lachapelle (2013) "Want more for Less", Co-ordinates Magzine, Feb 2013, 4 pages

Bhaskaranarayana (2008) *Indian IRNSS & GAGAN,* Presentation to COSPAR Meeting, Montreal. July 15, *2008*

DO-229D (2006) *Minimum Operational Performance Standards for GPS / WAAS System Airborne Equipment*, Sc-159

EGNOS (2011) *EGNOS Safety of Life Service Definition Document*

Galileo (2008) *Galileo Open Service Signal In Space Interface Control Document, OS SIS ICD, Draft I*, European Space Agency / European GNSS Supervisory Authority, *http://www.gsa.europa.eu/go/galileo/os-sis-icd*

IS-GPS-200E (2010) *Navstar GPS Space Segment/Navigation User Interfaces, Interface Specification*

Kibe, S, V and Gowrishankar. D, *APRSAF -15: Space for Sustainable Development*, December 10th 2008, Vietnam

Parkinson, B.W. and J.J. Spilker (1996) *Global Positioning System: Theory and Applications*, American Institute of Aeronautics and Astronautics Inc, Cambridge, Massachusetts

Rao, V. G., G. Lachapelle, and S.B. Vijaykumar (2011) "Analysis of IRNSS over Indian Sub-continent," in *Proceedings of the International Technical Meeting*, , San Diego, The Institute of Navigation, 13 pages

Singh, A.K., A.K. Sisodia, and V. Garg (2008) "Modulation Designs For Indian Regional Navigation Satellite Systems," in *International Aeronautical Federation*

Ganeshan A S, GAGAN: Status and Update, Coordinates VOL VIII, Issue 9 September 2012


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Opening minds or unearthing secrets?

Following the Survey of India's complaint lodged with the Delhi Police regarding Google India's 'Mapathon 2013' contest, Coordinates asked Additional Surveyor-General of India Maj Gen RC Padhi to explain the finer details of the issue. The excerpts are as follows...

What is the controversy all about?

It has come to our notice that Google India organised a competition called 'Mapathon 2013' wherein they invited the public to participate in mapping their neighbourhoods. These maps were then supposed to be uploaded on the website of the US-based search engine. They had even announced 1,000 prizes to the top 1,000 contributors. A participant takes part and whatever detail he notices, he maps it out. However, according the National Map Policy of 2005, there are certain conditions regarding the publishing of maps for public use. The maps are supposed to be sent to the Ministry of Defence and Ministry of Home Affairs and other intelligence agencies for security checks, so as to ensure that any information released does not jeopardise national security interest.

The contest also had a disclaimer.

Yes. There was a condition for the participants that the contestants would be personally responsible for whatever information they sent, and if they violated any law of the land then they would be responsible for it and not Google. So this is like a win-win situation for Google. Why should the common man be troubled? They are the ones who should be taking all the responsibility. I don't think the common man will know the details of the national map policy. How may policies must he read and keep in mind all the time? The common man does not map neighbourhood on a daily basis. He is the user of the product not the maker. He buys a map for his personal use. So the intentions of Google are not entirely pure, since they added a disclaimer.

However, those who are professionally engaged in this domain are supposed to know these policies and the fact that even before the contest was officially announced they should have sought clearance from the government.

The contest was meant to provide more data to the public, since there is a dearth of accurate information available freely.

The Government of India has identified whatever information is required by the public. So it is not that the public is being denied of information. They have been provided with all the necessary information, which is why the information is available in the form of many devices...on your smart phones, navigational devices etc.

When you travel on an aircraft, there are certain items you are not allowed to bring with you. Such as knives, guns etc. Similarly, with maps too. You are given the information, but only certain specific information is withheld.

Information pertaining to vital installations are sensitive that affects the security aspect of the nation. It is dynamic in nature. There are certain areas where military related work may be taking place and so that area becomes sensitive for a certain period of time. Now this activity of Google, we think, is violating the national policy, and is a valid security issue also.

Mapathon 2013

The Mapathon 2013 (the **"Contest"**) is designed to encourage participants to map their neighborhoods and places they care about within the geographical boundaries of India. Eligible Indian residents having attained the age of majority (**"Entrant(s)"**) are invited to use their personal knowledge and enthusiasm to map accurate geographical information in Google Maps for India. Winners will be chosen and prizes will be awarded in accordance with these Official Rules.

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You acknowledge and agree that any content (including other User Submissions) made available or accessible through the Service is provided "as is," and you agree to use it at your own risk. Google makes no guarantee, representation or warranty of any kind, express or implied, arising by law or otherwise, including but not limited to, content, quality, accuracy, completeness, reliability, fitness for a particular purpose, usefulness, or that the Service will be uninterrupted or error-free. https://www.google.com/mapmaker/mapathon/india2013/

Has there been any instance where a contestant has violated the policy?

Let us wait for the outcome of the investigation. We are not a law enforcement agency. I saw their advertisement on the net and on further research found that this violated the National Map Policy. If the police find any proof then they should take suitable action and forward the case to the court. This contest is over by now since it started in February and closed in March. We do not know what content they have collected and what they have not collected.

Google has been in India for quite some time. So how can they not be aware of the laws?

In the past also Google has crossed similar boundaries. They had carried out a similar kind of activity in Bengaluru regarding photographing the streets. Even regarding Google Earth and Google Maps, there was a lot of hue and cry about it. Such issues have been discussed with them earlier however they have got their own way of interpreting them. It is not that Google does not know the law of the land. They are quite aware of the situation in India. They feel that there are no security issues, but we feel that there are security issues.

Survey of India alleges 'Mapathon' "likely to jeopardise national security"

Internet giant Google could land in serious trouble over its 'Mapathon 2013' as the Delhi Police have launched an inquiry into the mapping contest held in February-March this year following a formal complaint by the Survey of India.

"Mapathon 2013 activity is likely to jeopardise national security interest and violates the National Map Policy. Citizens of the country, who are ignorant of the legal consequences, are likely to violate the law of the land," the Survey of India wrote in its complaint filed at the RK Puram police station on March 25, 2013.

"We have received a complaint from the Survey of India...an inquiry has been initiated," a senior Delhi Police official said. In a letter to Google's India office on March 21, Additional Surveyor-General of India R.C. Padhi asked the U.S.-based Internet company to stop the activity which was against "India's policy guidelines." "Survey of India is only [sic] mandated to undertake 'Restricted' category surveying and mapping and no other government/ private organisations or any individual are authorised to do so," he wrote.

The Survey of India further noted that the "Ministry of Defence has identified and prepared a list of civil and military vital areas (VAs)/vital points (VPs) in consultation with the Ministry of Home Affairs, which is regularly updated. [From] national security points of view these VAs/VPs cannot be shown in the map/ data published in public domain."

The mapping organisation also pointed out that in the terms of services, Google said individuals will be solely responsible for submission and the consequences of posting or publishing the contents. Hinting that the mapping exercise could unknowingly land Indians in trouble as they might map restricted areas. When contacted, a Google spokesperson said the idea behind the Mapathon contest was to make local information accessible to every Indian – such as health providers, emergency services, eating places, and educational institutes. "The Mapathon, like all mapping activity, has guidelines that follow applicable laws. We have not been informed of any specific sensitive locations being added in Google Map Maker during the recent Mapathon exercise, or otherwise. Google takes security and national regulations very seriously," the spokesperson added.

BJP Rajya Sabha MP Tarun Vijay first raised the issue by writing to the Survey of India about what he claimed was a "major threat to national security." Mr. Vijay said Google has already provided maps where many "strategic locations" have been marked like Parliament, Sena Bhawan, and various ministries. "A criminal case should be registered against Google for violating Indian defence regulations."

Ironically, many of these "strategic" locations have been visible on Google Maps (including with satellite imagery) for years and are marked in virtually all tourist maps of the Capital.

According to cyber law expert Pawan Duggal: "If Google was trying to delve into sovereign government space, it is bound to have serious ramifications. Though there is no direct law which bars them from carrying out such activity. *www.thehindu.com*

There are many who still have access to the spatial information. Restrictions have been diluted in terms of implementation of the rules.

You must appreciate that the government is sensitive to user requirement. That is why in 2005, it came up with a good and bold map policy in which the distinction was made between defence requirement and civilian requirement. Which is why, the Survey of India has already come out with its open series of maps. So that way authenticated data prepared by the Survey of India is available to the public. And at the same time, the Survey of India has prepared enough maps for the use of security forces.

For example, if a school wanted to send its students to map their neighbourhood, will they require any permission?

No. We too organise competitions and encourage people to do neighbourhood mapping. There is no problem in this. But you should follow certain guidelines. You must collect only that much information that is required by you. Don't get into information that is not required. Why would you require information regarding some defence settlement? However, you can freely map the road network, banks and hospitals, information which are in the public domain.

Google defends 'Mapathon' amid Indian security complaint

In a statement provided to ZDNet, a Google spokesperson said the application, and its use in last month's Mapathon contest, complied with all applicable laws.

A spokesperson said Google has briefed the Ministry of Science and Technology and the Survey General of India, the national cartographer.

"The Survey of India (SOI) contacted Google regarding the Mapathon contest on March 22, and--as requested by them--we responded to them on March 25 and offered to meet them to discuss their concerns," the spokesperson said in an e-mailed statement.

"We take security and national regulations very seriously," said the spokesperson. "We have not heard back from them further, and are always available to discuss any concerns that they or other agencies might have regarding our programmes." *www.zdnet.com/in/google-defends-mapathon-amid-indian-security-complaint-7000013672/*

Using satellite altimetry to monitor and determine sea level

The paper outlines how satellite altimetry can be used as a method to fill the gaps in available mean sea level data in the Caribbean region. The technique is examined in its utility to effectively monitor and compute MSL, and subsequently derive sea level rise (SLR) rates for the Caribbean

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Even in 1996 it was reported that over half of the world's population lived within 60 km of the shoreline (Turner et al, 1996). This trend has continued with an increase in the population in question. Small Island Developing States (SIDS), such as those in the Caribbean, tend to have much of their population live along coasts. This fact makes them very vulnerable to the effects of climate change, such as sea level rise. It is therefore important for SIDS to take steps to ensure sustainable development, and to prepare to adapt to and mitigate any threat (such as sea level rise) which may be potentially be detrimental to their socioeconomic prosperity (IPCC, 2007a; 2007b).

Sea level monitoring, an excellent tool for determining and predicting changes and trends in the sea level, is typically based upon accurate and reliable and long term tide gauge observations (Church et al, 2001). Unfortunately, long term consistent tide gauge data for sea level monitoring has been lacking in the Caribbean. In this region, only a small number of these tide stations are operational, most of which are plagued by problems of sporadic distribution, faulty equipment, data gaps and discontinuous results and coverage over time periods too short to account for climatic variations. This state of affairs creates gaps in Mean Sea Level (MSL) data (Sutherland, Miller and Dare, 2008). If only data from this method of measurement is used, without taking into account its drawbacks, the resultant models would be seriously constrained in their utility for dependable future projections.

Figure 1 shows a digital elevation model of the island of Bequia, St. Vincent and the Grenadines, which includes a projected sea level of 1.4 metres above the mean that apparently seriously compromises the airport. This model is a potentially valuable tool to assist in developing appropriate adaptation and mitigation strategies. The lack of consistent long term tide gauge measurement, however, detracts much from the models predictive capabilities, underscoring the points made in the previous paragraph.

The lack of tide gauges and long term tidal data in most of the Caribbean means that MSL is currently undefined at many locales, as in the case of Bequia, or benchmarks can no longer be verified or updated. In this paper, a modernistic approach to sea level monitoring and MSL determination is presented, through the use of satellite altimetry. The potential of satellite altimetry is examined, within the context of the challenges of maintaining an effective tide gauge infrastructure.

Sea level and satellite altimetry

Satellite altimetry has developed into an established technology for measuring sea level. In contrast to the sparse network of coastal tide gauges, measurements of sea level from space by satellite altimetry provide near global and homogenous coverage of the world's oceans. Altimetry, as shown in Figure 2, uses pulse-limited radar to measure the altitude of the satellite above the closest point of the sea surface *R*. Global precise tracking along with orbit dynamic calculations are used

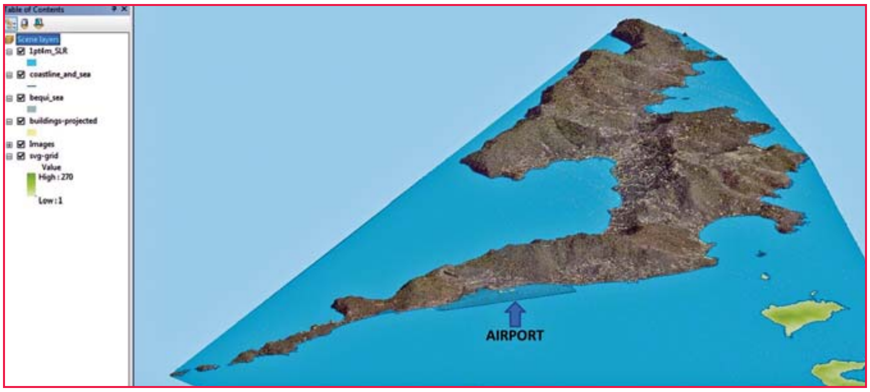

Figure 1 – Digital Elevation Model of the Island of Bequia

to determine the height of the satellite above the ellipsoid, H. The difference between these two measurements results in the sea surface height, h given as;

$$h = H - R$$

However, accurate estimates of R and H are not sufficient for oceanographic applications of altimeter range measurements. The sea surface height, h relative to the reference ellipsoid is the superposition of a number of geophysical effects. In addition to the dynamic effects of geostrophic ocean currents that are of primary interest for oceanographic applications, h is affected by undulations of the geoid, h_g about the ellipsoidal approximation, tidal height variations, h_r and the ocean surface response to atmospheric pressure loading, h_a. These effects on the sea-surface height must be modelled and removed from h in order to investigate the effects of geostrophic currents on the sea surface height field (Chelton et al., 2001). Thus the sea level is given as

$$h = H - \acute{R} + \sum_j \Delta R_j - h_g - h_r - h_a$$

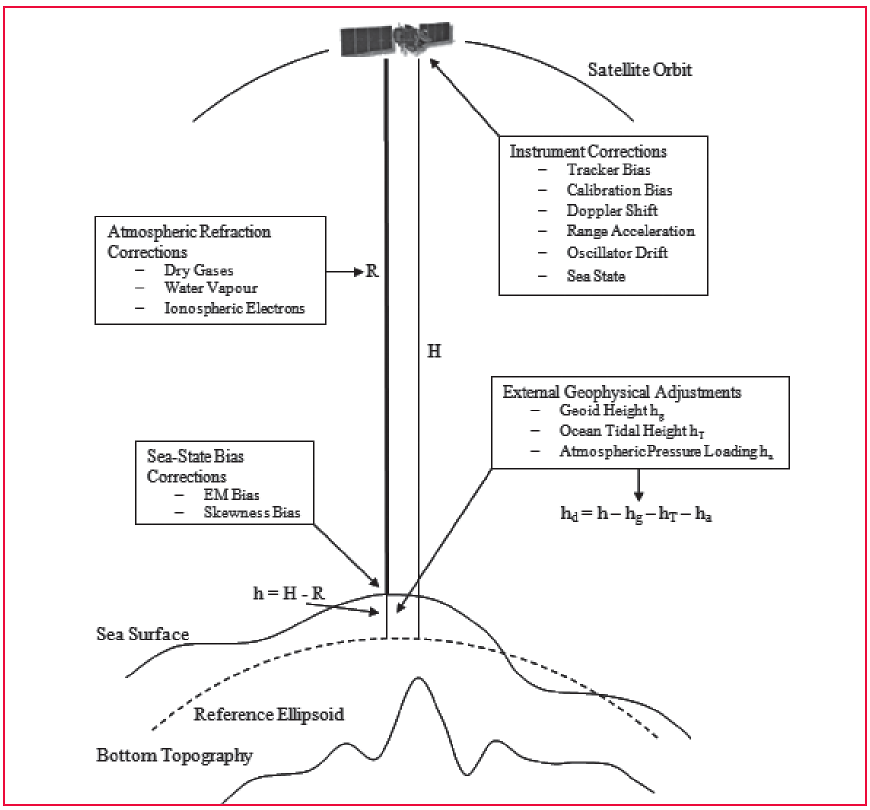

Figure 2 – Principle of Satellite Altimetry

Attaining the required sub-millimetre accuracy for sea level rise monitoring, is challenging and requires satellite orbit information, geophysical and environmental corrections and altimeter range measurements of the highest accuracy. It also requires continuous satellite operations over many years and careful control of biases (Church and Gregory, 2001).

Over the past 20 years satellite altimetry has provided a global, high resolution, consistent monitoring of sea level and ocean circulation. The launch of Topex/Poseidon mission in 1992 was the advent of accurate altimetric based sea level data. With a repeat period of ten days, satellite measurements globally provided more details than in-situ tide gauge based observations over the last hundred years. Later in 1995, the European based ERS-2 satellite was launched followed by the Jason-1 in 2001, Envisat in 2002 and more recently Jason-2 in 2008. This multi-mission satellite period brought increasing data quality with the reprocessing of measurements, along with the continuity and homogeneity of data. At present the Envisat satellite with a 35 day cycle, Jason-1 and Jason-2 satellites with a 10 day cycle are in orbit providing very precise sea level data.

Sea level monitoring in the caribbean through satellite altimetry

The spatial and temporal distribution of satellite altimetric data, combined with the fact that it is a space-based measurement system means that it has the potential to address many of the problems that plague tide gauge installation, distribution and maintenance. It is therefore a particularly advantageous alternative to tide gauge measurements in regions like the Caribbean where these problems are characteristic to the challenge of effective sea level monitoring and consequently coastal zone management.

Several studies have been undertaken to show the applicability of the use of altimetric data as an alternative to tide

Figure 3 – Jason satellite groundtrack in relation to the selected tide gauges (Jaggan and Davis, 2012)

gauge measurements (Madsen et al., 2007; Ginzburg, 2010 and Robinson, 2010). Jaggan and Davis (2012) describe a comparison of sea levels within the Caribbean between altimetric and tide gauge data. In the study, eight tide gauge sites in distributed in Puerto Rico and the Gulf of Mexico, as shown in Figure 3, were compared to interpolated satellite altimetry measurements for the period 2001 to 2010.

The results displayed an encouraging agreement between the tide gauge and altimetric data as shown in Figures 4 (a), (b) and (c), which depict the differences from three randomly selected sites of the eight investigated. Overall, the variations were generally of the order of 2cm in the mean and 5cm in the RMS between the tide gauge and satellite altimetry measurements.

In the determination of sea level rise rates, a linear regression analysis was performed on the altimetric data with a summary of the results presented in Table 1. Taking into account the temporal and spatial differences between the measurement parameters; the altimetry being a 10-day discrete, open water measurement system vs. continuous coastal measurements for the tide gauges, the sub millimeter agreement for the sea level change demonstrates the applicability of the technology for sea level monitoring in the region.

Altimetry as a tool to determine mean sea level

Currently many Caribbean states lack an accurate and definitive reference of mean sea level due to the absence of long term functioning tide gauges. As a result, islands such as St. Vincent do not have a vertical reference system that can be easily maintained or verified. Although the geoidal model, CARIB97, exists as a reference surface, the geoid does not equate to mean sea level as the latter is not an equipotential surface.

Sideris and Fotopoulos (2006) highlight a few approaches to determine a vertical reference system (MSL).

- Using a network of tide gauges, a free-network adjustment is done by holding one station fixed. A correction factor is applied to the adjusted heights so that the mean height of all tide gauges equals zero. However, this method relies heavily on measurements from a single tide gauge and ignores mean sea level (MSL) observations made at other stations.
- MSL can be measured by a network of reference tide gauges situated along the coastlines and fixing the datum to zero at these stations. This can result in distorted heights since it ignores land motions and subsequent movements of tide gauges.
- Using the best model for the Sea Surface Topography (SST) at a network of tide gauge stations and then adjusting the network by holding MSL to zero for all tide gauges. SST models are not accurate near the coasts and can result in distortions for MSL.
- Using estimates of orthometric heights derived from ellipsoidal heights and precise gravimetric geoidal heights along a network of tide gauges. This relates the regional vertical datum to a global vertical reference surface (ellipsoid) and supports the realization of a World Height System.

Satellite altimetry has provided two decades of near global, continuous sea level data. However, while consistent and reliable data is available, altimetric data is based on the open ocean and its weakness lies in coastal measurements and monitoring. A vertical reference system must be localized

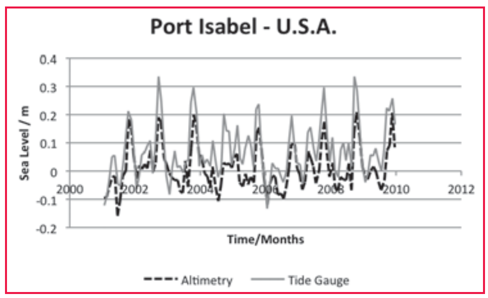

Figure 4 (a)– Sea level anomalies averaged over a month for Port Isabel 2001 – 2010 (Jaggan and Davis, 2012)

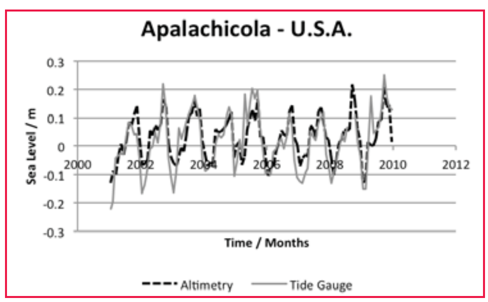

Figure 4 (b) – Sea level anomalies averaged over a month for Apalachicola 2001 – 2010 (Jaggan and Davis, 2012)

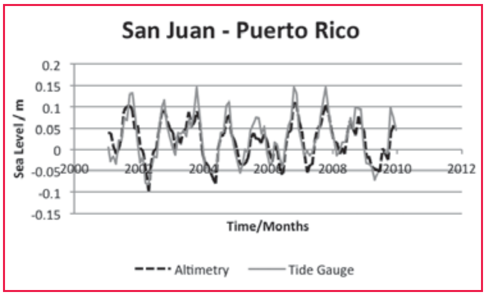

Figure 4 (c) – Sea level anomalies averaged over a month for San Juan 2001 – 2010 (Jaggan and Davis, 2012)

Table 1: Comparison of sea level change rates for tide gauge and altimetry (Jaggan and Davis, 2012)

Station Location	Sea Level Change Rates (mm yr^{-1})		Differences (mm yr^{-1})
	Tide Gauge	Satellite Altimetry	
Sabine Pass, Texas	4.58	3.87	0.71
Port Isabel, Texas	7.14	7.80	0.66
Apalachicola, Florida	3.55	4.45	0.90
Clearwater Beach, Florida	7.88	7.86	0.02
Key West, Florida	6.09	6.34	0.25
Grand Isle, Louisiana	3.27	3.18	0.09
Isabela De Sagua, Cuba	0.97	0.85	0.12
San Juan, Puerto Rico	-1.92	-1.07	0.85

as local factors influence its determination. Hence, satellite altimetry derived data alone is not sufficient to effectively and accurately determine mean sea level.

To compensate for the weaknesses of the altimetric measurements closer to land, a method using a combination of satellite altimetry and short term tide gauge sea level monitoring, is proposed in an attempt to address this problem in Bequia, St Vincent and the Grenadines. The realization of a vertical datum would necessitate the installation of a network of tide gauges collocated with GNSS receivers at strategic points along the coast of Bequia to record short term sea level data. The GNSS measurements will monitor and allow corrections for any vertical land movement taking place. Since tide gauges measure sea level relative to land, satellite altimetric based data will be used to tie the tide gauge data in an absolute reference frame. Studies by Dong et al. (2002) and Mitchum (1998 and 2000) have been successful in verifying and integrating satellite altimetry data with tide gauges. These studies provide the basis and methodology that will be used to integrate the different measurement techniques in order to determine a MSL reference datum.

With MSL established, appropriate scenario analysis can now take place applying the sea level rise rates determined through the satellite altimetry. Applying the sea level rise parameters to an incorrect vertical datum will clearly overestimate or underestimate any potential impacts and consequently affect any coastal zone planning policy mitigation strategies adopted.

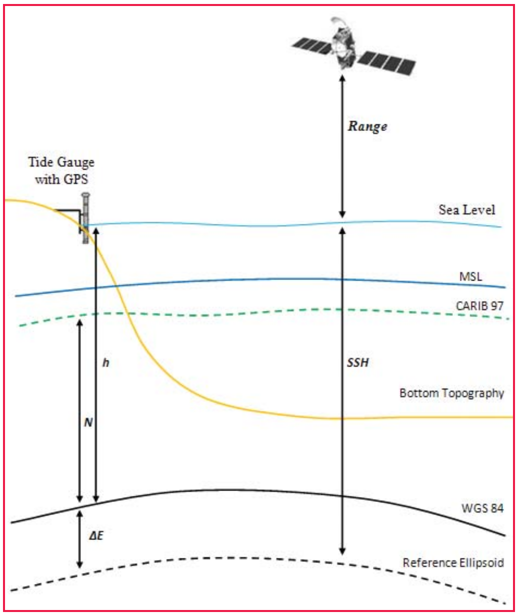

Figure 5 – Concept of MSL determination using Satellite Altimetry and Tide Gauges

Conclusions

The situation regarding the vertical datum establishment and monitoring in Bequia, St Vincent and the Grenadines is a representative of many of the states in the Caribbean. Considering the vulnerability of the region to changes in sea level, the definition of the vertical datum is a major concern. This critical issue however has largely been overlooked because of the difficulty in establishing and maintaining adequate tide gauges as well as tide gauge records.

Satellite altimetry provides consistent accuracy, coverage, and independent space-based measurements in a geocentric reference frame, which are all necessary for the practical realization of a vertical datum. From the same altimetric datasets, there is the potential not only to obtain data to establish MSL, but also to monitor changes in sea levels. Currently, there is 20 years' worth of altimetric data available, which would represent a long term data set for tide gauge records, adequate to establish MSL. Satellite altimetry gives an even spatial distribution free from issues of vandalism, theft or lack of proper maintenance that can account for the lack of tide gauges in the region. It therefore has the potential, once calibrated with tide gauge and GNSS data, to fulfil two of the major functions of the missing tide gauges in the region; establishing MSL and monitoring sea levels

References

Chelton, D. B., John C. Ries, Bruce J. Haines, Lee Lueng Fu and Philip S. Callahan. 2001. "Satellite Altimetry". In Satellite Altimetry and Earth Sciences A Handbook of Techniques and Applications. Edited by Fu, Lee-Lueng and Cazenave, Anny. Chap. 1. Academic Press, San Diego.

Church, J.A. and Gregory, J.M. 2001. Changes in Sea Level. IPCC Third Assessment Report. http://www.grida.no/publications/other/ipcc%5Ftar/?src=/climate/ipcc_tar/wg1/408.htm. (Cited 02/03/2012)

Dong, X., Woodworth, P., Moore, P. and Bingley, R. 2002. "Absolute Calibration of the TOPEX/POSEIDON Altimeters using UK Tide Gauges, GPS, and Precise, Local Geoid Differences". In *Marine Geodesy*. Vol 25, pp. 189-204.

Jaggan, S. and Davis, D. 2012. "Evaluating Satellite Altimetry for Monitoring Caribbean Sea Level Rise". In *The West Indian Journal of Engineering*. Vol.35, No.1. In press.

Ginzburg, A.I., A.G. Kostianoy, N.A. Sheremet, and S.A. Lebedev. 2010. "Introduction and assessment of improved coastal altimetry strategies: Case study over the northwestern Mediterranean Sea". In *Coastal Altimetry*. edited by S. Vignudelli et al. chap. 14. Springer, New York.

Intergovernmental Panel on Climate Change (IPCC) (2007)a. Climate Change 2007: Synthesis Report. Based on a draft prepared by the Core Writing Team, adopted by IPCC Plenary XXVII, Valencia, Spain November 12-17. Cambridge University Press, Cambridge UK, 7-22.

Intergovernmental Panel on Climate Change (IPCC) (2007)b. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group 11 to the Forth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, EDS., Cambridge University Press Cam-bridge UK, 7-22.

Madsen, K. S., J. L. Hoyer, and C. C. Tscherning. 2007. "Near-coastal satellite altimetry: Sea surface height variability in the North Sea–Baltic Sea area". In *Geophys. Res. Lett*. Vol 34, L14601.

Mitchum, G.T. 1998. "Monitoring the Stability of Satellite Altimeters with Tide Gauges". In *Journal of Atmospheric and Oceanic Technology.* Vol 15, pp. 721-730.

Mitchum, G. T. 2000. "An Improved Calibration of Satellite Altimetric Heights Using Tide Gauge Sea Levels with Adjustment for Land Motion." In *Marine Geodesy.* Vol 23, No. 3, pp. 145.

Robinson, I. S. 2010. *Discovering the ocean from space: the unique applications of satellite oceanography.* Heidelberg; New York: Springer; Chichester, UK. 638 pp.

Sideris, M.G. and G. Fotopoulos. 2006. World Climate Research Program (WCRP) Workshop on Understanding Sea-level Rise and Variability. Paris, France, June 6-9, 2006.

Sutherland, M., P. Dare and K. Miller. 2008. "Monitoring Sea Level Change in the Caribbean." In *Geomatica*, Vol. 62, No. 4, p. 428-436.

Turner R.K., Subak S., and Adger W. N. 2006. Pressures, Trends and Impacts in Coastal Zones: Interactions Between Socioeconomic and Natural Systems. *Environmental Management* Vol. 20, No. 2, pp. 159-173.

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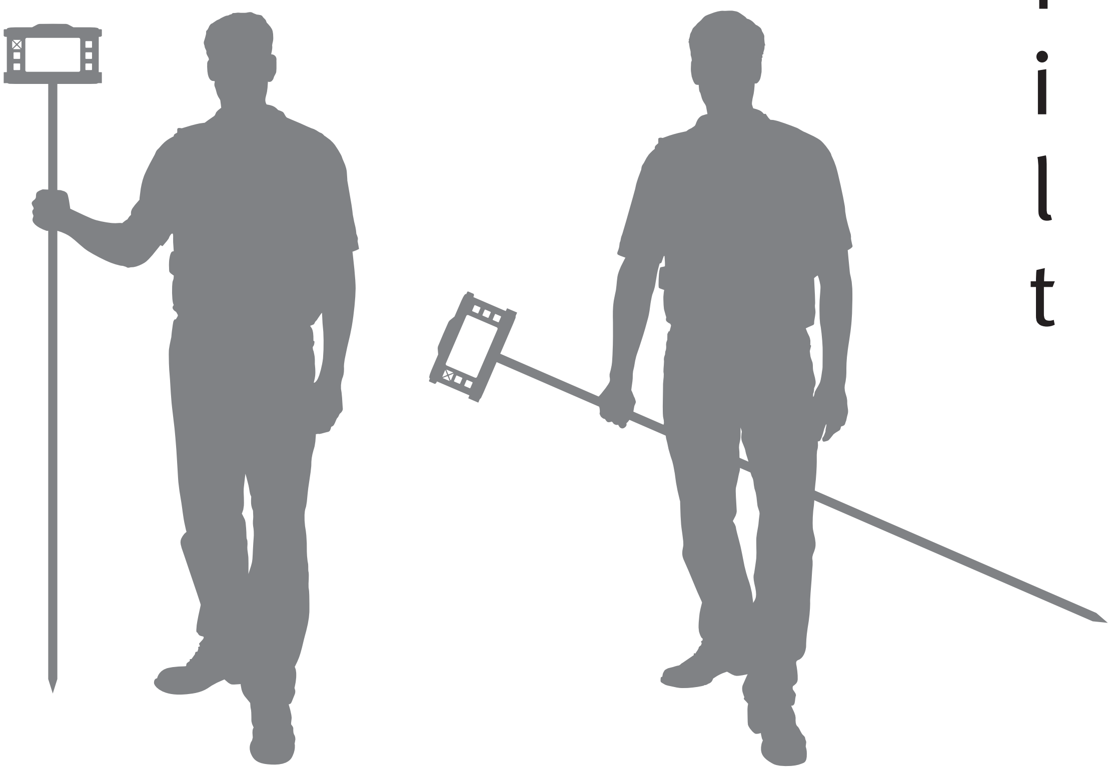

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Mitigating the systematic errors of e-GPS leveling

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

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Test results and discussion

Tainan e-GPS System

Tainan City Government has established its e-GPS system in September 2007. The e-GPS system contains 6 reference stations, and covers the whole city. Five reference stations, SCES, NJES, RFES, WHES, BKBL, evenly distributed in Tainan city's borders, forming a nearly regular pentagon network; and the approximate geographic center in Tainan City setting of the sixth reference station, KAWN, its location just in the pentagonal-shaped center. And, it makes all the distances between the reference stations less than 30 km. In order to improve the accuracy and efficiency of e-GPS surveying in the mountain area, the seventh reference station, YJLO, was installed in April 2010. Hence, the Tainan e-GPS system has 7 reference stations since then. All reference stations are equipped with Trimble NetR5, and the mobile stations are equipped with Trimble R8. Both types of receivers, Trimble NetR5 and Trimble R8, can track signals from GPS satellites and GLONASS satellites. The distribution map of 7 reference stations of Tainan e-GPS system is shown in Figure 1.

Figure 1: The distribution map of 7 reference stations of Tainan e-GPS system.

Tainan e-GPS system, through the field testing, achieving the following accuracies: ±2cm in plane coordinates (x, y), and ±5cm in ellipsoidal height h, its accuracy is sufficient to be applied to the cadastral surveying, engineering surveying, etc. (Tainan, 2012).

Test data

Three data sets of Tainan area (with total area of about 2,192 square kilometers or 219,200 hectares) are used to test the proposed methods. The data sets including: (1) data set 1 of 145 first-order benchmarks, with orthometric height H from first-order leveling and plane coordinates (x, y) and ellipsoidal height h from static GPS surveying of 2003, provided by the Ministry of the Interior, Republic of China; (2) data set 2 of 145 first-order benchmarks, with orthometric height H only from first-order leveling of 2009, provided by the Ministry of the Interior, Republic of China; (3) data set 3 of 118 first-order benchmarks, with plane coordinates (x, y) and ellipsoidal height h from Tainan e-GPS system of 2011, provided by Tainan City Government.

Test results and discussion

Accuracy Analysis of e-GPS Leveling: The following procedures are performed to evaluate the accuracy of e-GPS leveling:

(1) 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 benchmark; p_1 denotes the number of neurons in the hidden layer; 1 represents the output layer has 1 element, undulation N of each benchmark), in order to construct a regional geoid model of Tainan City, with 145 first-order benchmarks of data set 1; (2) Estimate undulation $\hat{N}$ of all 118 first-order benchmarks of data set 3, using the trained $2 \times p_1 \times 1$ BP neural network and the plane coordinates (x, y) of each benchmark; (3) Calculate the orthometric height $\hat{H}$, using the formula of $\hat{H} = h - \hat{N}$, with the ellipsoidal height h from e-GPS system and the estimated undulation $\hat{N}$ from the above procedure, of all 118 first-order benchmarks of data set 3; (4) Compute the height difference ΔH, using the formula of $\Delta H = H - \hat{H}$ (H denotes the orthometric height from data set 2, and $\hat{H}$ represents the estimated orthometric height from procedure 3), of all 118 first-order benchmarks of data set 3.

According to the preceding procedure 1, in order to construct a regional geoid model of Tainan City with BP neural network, 145 first-order benchmarks of data set 1 are divided into two groups, one group as the reference point (109 points) to train a BP neural network; another group as a check point (36 points) to assess the accuracy of the regional geoid model.

Since orthometric height H and ellipsoidal height h of each benchmark of data set 1 are known, the undulation N of each benchmark can be calculated using the formula $N = h - H$. And, it is assuming that N is the true value. Suppose further that the undulation of each benchmark estimated by the trained BP neural network is $\hat{N}$, then, the undulation difference ΔN of each benchmark, is defined by the following equation.

$$\Delta N_i = N_i - \hat{N}_i, i = 1,2,\cdots,n \qquad (17)$$

where $i = 1,2,\cdots,n$ stands for the sequential number of check points; n is the total number of check points.

After trial and error tests, it is found that a $2 \times 35 \times 1$ BP neural network can offer better

Table 1. The statistics of ΔN of 36 check points of data set 1, using a geoid model from $2 \times 35 \times 1$ BP neural network

m (m)	σ (m)	Mean (m)	Maximum (m)	Minimum (m)
±0.029	±0.028	0.009	0.089	-0.054

Table 2. The statistics of ΔH of 118 first-order benchmarks of Tainan City

m (m)	σ (m)	Mean (m)	Maximum (m)	Minimum (m)
±0.072	±0.050	-0.051	0.061	-0.213

regional geoid model accuracy (Lin, 2007; Lin, 2012). The statistics of ΔN of 36 check points of data set 1 are shown in Table 1. In Table 1, 'm (m)' indicates mean square error in units of meter; 'σ(m)' indicates standard deviation in units of meter; 'Mean (m)' indicates mean value in units of meter; 'Maximum (m)' indicates maximum value in units of meter; 'Minimum (m)' indicates minimum value in units of meter.

Based on the previously mentioned procedures 2 to 4, compute the height difference ΔH of all 118 first-order benchmarks of data set 3. The statistics of ΔH of all 118 first-order benchmarks are shown in Table 2. It can be seen from the results of Table 2 that the standard deviation of ΔH is ± 0.050m.

The accuracy of h from e-GPS system is ± 0.050m (Tainan, 2012). Besides, the accuracy of estimated undulation $\hat{N}$ is ± 0.028m, according to the results of Table 1. Based on the formula $\hat{H} = h - \hat{N}$ and according to the principle of error propagation, the accuracy of $\hat{H}$ from e-GPS leveling is ±0.057m.

By definition of $\Delta H = H - \hat{H}$, where the accuracy of H is ±0.009m (Yang et al., 2003); the accuracy of $\hat{H}$ is ±0.057m. According to the principle of error propagation, the accuracy of ΔH from e-GPS leveling is ±0.058m.

Therefore, further examining the results of Table 2, it is found that (1) the standard deviation and mean square error of ΔH varies considerably (0.022m), and (2) the mean value of ΔH is -0.051m (not 0.000m). Therefore, judging the test results of the e-GPS leveling, it may still have some systematic errors to be corrected.

Test results of proposed methods: $P = \{P_1, P_2, \cdots, P_n\}$ and $Q = \{Q_1, Q_2, \cdots, Q_n\}$ data of 118 first-order benchmarks of data set 3, will be used to test the three proposed methods. The number of reference points n_1, check points n_2 and validation point n of data set 3 are 89, 29, and 118 respectively.

Test results of CFM

Based on the above-mentioned procedures of CFM, data of 118 first-order benchmarks are used to test the performances of 4-parameter, 6-parameter, and 10-parameter CFM. The statistics of ΔH of 118 first-order benchmarks, before and after correcting systematic errors estimated by 4-parameter, 6-parameter, and 10-parameter CFM, are shown in Table 3. In Table 3, $\Delta H(N/A)$ denotes the value of ΔH before correcting systematic errors; $\Delta\tilde{H}(4-par)$, $\Delta\tilde{H}(6-par)$, and $\Delta\tilde{H}(10-par)$ denote the value of ΔH after correcting systematic errors estimated by 4-parameter, 6-parameter, and 10-parameter CFM respectively.

Can be seen from the results in Table 3, after correcting systematic errors estimated by 4-parameter CFM, the standard deviation of $\Delta\tilde{H}$ decreased ±0.037m (close to the mean square error value), and the mean of $\Delta\tilde{H}$ dropped to 0.000m; after correcting systematic errors estimated by 6-parameter CFM, the standard deviation of $\Delta\tilde{H}$ decreased ±0.034m (close to mean square error), and the mean of $\Delta\tilde{H}$ dropped to 0.000m; after correcting systematic errors estimated by 10-parameter CFM, the standard deviation of $\Delta\tilde{H}$ decreased ±0.028m (With mean square error differ by ± 0.002m), and the mean of $\Delta\tilde{H}$ dropped to- 0.011m.

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Table 3. The statistics of ΔH of 118 first-order benchmarks, before and after correcting systematic errors estimated by 4-parameter, 6-parameter, and 10-parameter CFM

ΔH	m (m)	σ (m)	Mean (m)	Maximum (m)	Minimum (m)
ΔH(N/A)	±0.072	±0.050	-0.051	0.061	-0.213
$\Delta\tilde{H}$ (4–par)	±0.036	±0.037	0.000	0.091	-0.136
$\Delta\tilde{H}$ (6–par)	±0.034	±0.034	0.000	0.070	-0.122
$\Delta\tilde{H}$ (10–par)	±0.030	±0.028	-0.011	0.098	-0.087

Table 4. The statistics of σ_{ref}, σ_{chk} and σ_{val} of $\delta\hat{H}$ of 118 first-order benchmarks, after changing the number of neurons (p_1=1,2,...,15) in the hidden layer of 2xp_1x1 BP neural network

p_1	1	2	3	4	5	6	7	8
σ_{ref}(m)	0.032	0.028	0.028	0.027	0.028	0.028	0.033	0.027
σ_{chk} (m)	0.039	0.034	0.033	0.034	0.034	0.036	0.041	0.032
σ_{val} (m)	0.035	0.032	0.030	0.030	0.031	0.032	0.038	0.029
p_1	9	10	11	12	13	14	15	
σ_{ref}(m)	0.029	0.028	0.029	0.029	0.028	0.030	0.029	
σ_{chk} (m)	0.036	0.034	0.033	0.033	0.033	0.033	0.034	
σ_{val} (m)	0.033	0.030	0.030	0.031	0.031	0.030	0.031	

Table 5. The statistics of σ_{ref}, σ_{chk} and σ_{val} of $\delta\hat{\hat{H}}$ of 118 first-order benchmarks, using a 2x5x1BP neural network

σ_{ref}(m)	σ_{chk} (m)	σ_{val} (m)
0.029	0.032	0.029

Table 6. The statistics of ΔH of 118 first-order benchmarks, before and after correcting systematic errors estimated by BP&BP

ΔH	m (m)	σ (m)	Mean (m)	Maximum (m)	Minimum (m)
ΔH(N/A)	±0.072	±0.050	-0.051	0.061	-0.213
$\Delta\tilde{H}$(BP1–2x8x1)	±0.044	±0.030	0.032	0.119	-0.063
$\Delta\tilde{\tilde{H}}$(BP2–2x5x1)	±0.029	±0.029	-0.007	0.077	-0.105

Table 7. The statistics of ΔH of 118 first-order benchmarks, before and after correcting systematic errors estimated by BP&CFM algorithm.

ΔH	m (m)	σ (m)	Mean (m)	Maximum (m)	Minimum (m)
ΔH(N/A)	±0.072	±0.050	-0.051	0.061	-0.213
$\Delta\tilde{H}$(BP1–2x2x1)	±0.042	±0.031	0.029	0.119	-0.079
$\Delta\tilde{\tilde{H}}$(CFM2–6–par)	±0.029	±0.029	0.000	0.066	-0.105

Test results of BP&BP

Based on the specific procedures of BP&BP, systematic errors of e-GPS leveling, $\delta\hat{H}$ and $\delta\hat{\hat{H}}$, should be estimated by $2\times p_1\times 1$ and $2\times p_2\times 1$ BP neural networks respectively. In order to determine the number of neurons p_1 and p_2 using trial and error method, $P=\{P_1,P_2,\cdots,P_n\}$ and $Q=\{Q_1,Q_2,\cdots,Q_n\}$ data of 118 first-order benchmarks are used to train $2\times p_1\times 1$ and $2\times p_2\times 1$ BP neural networks respectively. In order to demonstrate the procedures of determining the number of neurons p_1 with trial and error method, the statistics of σ_{ref}, σ_{chk} and σ_{val} of $\delta\hat{H}$ of 118 first-order benchmarks, after changing the number of neurons (p_1=1,2,…,15) in the hidden layer of $2\times p_1\times 1$ BP neural network, are shown in Table 4. It can be seen from Table 4 that when the number of neurons p_1 is 8 the results are best. Hence, a $2\times 8\times 1$ BP neural network will be used to estimate values of $\delta\hat{H}$, $\tilde{H}$, $\Delta\tilde{H}$ of 118 first-order benchmarks.

Then, the number of neurons p_2 of $2\times p_2\times 1$ BP neural network is determined, using trial and error method, with $P=\{P_1,P_2,\cdots,P_n\}$ and $Q=\{Q_1,Q_2,\cdots,Q_n\}$ data of 118 first-order benchmarks. It is found that the number of neurons p_2 is 5 the results are best. Hence, a $2\times 5\times 1$ BP neural network will be used to estimate values of $\delta\hat{\hat{H}}$, $\tilde{\tilde{H}}$ and $\Delta\tilde{\tilde{H}}$ of 118 first-order benchmarks. The statistics of σ_{ref}, σ_{chk} and σ_{val} of $\delta\hat{\hat{H}}$ of 118 first-order benchmarks, using a $2\times 5\times 1$ BP neural network are shown in Table 5.

Table 6 shows that the statistics of ΔH of 118 first-order benchmarks, before and after correcting systematic errors estimated by BP&BP. In Table 6, $\Delta H(N/A)$ denotes the value of ΔH before correcting systematic errors; $\Delta\tilde{H}(BP1-2\times 8\times 1)$ and $\Delta\tilde{\tilde{H}}(BP2-2\times 5\times 1)$ denote values of ΔH after correcting systematic errors estimated by $2\times 8\times 1$ BP neural network and $2\times 5\times 1$ BP neural network respectively. Be seen from the results in Table 6, after correcting systematic errors estimated by a $2\times 8\times 1$ BP neural network, the standard deviation of $\Delta\tilde{H}$ decreases to ±0.030m (difference between the standard deviation and the mean square error is ±0.014m), the mean of $\Delta\tilde{H}$ declines to 0.032m. After correcting systematic errors estimated by a $2\times 5\times 1$ BP neural network, the standard deviation of $\Delta\tilde{\tilde{H}}$ decreases to ±0.029m (equal to the mean square error), and the mean of $\Delta\tilde{\tilde{H}}$ declines to -0.007 m.

Test results of BP&CFM

Based on the specific procedures of BP& CFM, systematic errors of e-GPS leveling, $\delta\hat{H}$ and $\delta\hat{\hat{H}}$, should be estimated by a $2\times p_1\times 1$ BP neural network and a 6-parameter CFM respectively. In order to determine the number of neurons p_1 using trial and error method, $P=\{P_1,P_2,\cdots,P_n\}$ data of 118 first-order benchmarks are used to train a $2\times p_1\times 1$ BP neural network. It is found that the number of neurons p_1 is 2 the results are best. Hence, a $2\times 2\times 1$ BP neural network will be used to estimate values of $\delta\hat{H}$, $\tilde{H}$, $\Delta\tilde{H}$ of 118 first-order

Table 8. The statistics of ΔH of 118 first-order benchmarks, before and after correcting systematic errors estimated by CFM, BP&BP, and BP&CFM respectively

ΔH	m (m)	σ (m)	Mean (m)	Maximum (m)	Minimum (m)
N/A	±0.072	±0.050	-0.051	0.061	-0.213
4-CFM	±0.036	±0.037	0.000	0.091	-0.136
6-CFM	±0.034	±0.034	0.000	0.070	-0.122
10-CFM	±0.030	±0.029	-0.011	0.098	-0.087
BP&BP	±0.029	±0.029	-0.007	0.077	-0.105
BP&CFM	**±0.029**	**±0.029**	**0.000**	**0.066**	**-0.105**

benchmarks. Then, 6 parameters of CFM are estimated, using least squares method, with $Q = \{Q_1, Q_2, \cdots, Q_n\}$ data of 118 first-order benchmarks. Finally, values of $\delta\hat{H}$, $\tilde{\tilde{H}}$ and $\Delta\tilde{\tilde{H}}$ of 118 first-order benchmarks are estimated by a 6-parameter CFM.

Table 7 shows statistics of ΔH of 118 first-order benchmarks, before and after correcting systematic errors estimated by BP&CFM. In Table 7, $\Delta H(N/A)$ denotes the value of ΔH before correcting systematic errors; $\Delta\tilde{H}(BP1-2\times2\times1)$ and $\Delta\tilde{\tilde{H}}(CFM2-6-par)$ denote values of ΔH after correcting systematic errors estimated by $2\times2\times1$ BP neural network and 6-parameter CFM respectively.

It can be seen from the results in Table 7, after correcting systematic errors estimated by a $2\times2\times1$ BP neural network, the standard deviation of $\Delta\tilde{H}$ decreases to ±0.031m (difference between the standard deviation and the mean square error is ±0.011m), the mean of $\Delta\tilde{H}$ declines to 0.029m. Then, after correcting systematic errors estimated by a 6-parameter CFM, the standard deviation of $\Delta\tilde{\tilde{H}}$ decreases to ±0.029m (equal to the mean square error), and the mean of $\Delta\tilde{\tilde{H}}$ declines to 0.000 m.

Summary

The statistics of ΔH of 118 first-order benchmarks, before and after correcting systematic errors estimated by CFM, BP&BP, and BP&CFM respectively, are summarized and shown in Table 8. In Table 8, N/A stands for the value of ΔH without any systematic error correction; 4-CFM, 6-CFM and 10-CFM denote values of $\Delta\tilde{H}$ after correcting systematic errors estimated by 4-parameter, 6-parameter, and 10-parameter CFM respectively; BP&BP denotes the value of $\Delta\tilde{H}$ after correcting systematic errors estimated by a $2\times8\times1$ BP neural network and a $2\times5\times1$ BP neural network respectively; BP&CFM indicates the value of $\Delta\tilde{\tilde{H}}$ after correcting systematic errors estimated by a $2\times2\times1$ BP neural network and 6-parameter CFM respectively.

Can be seen from the results of Table 8, after systematic error correction estimated by CFM, BP&BP, and BP&CFM, the standard deviation of ΔH can be reduced considerably. Among them, the performances of BP&CFM and BP&BP are the best. In terms of reduced the mean of ΔH, BP&CFM, 4-CFM and 6-CFM perform the best. Then, it is checked that whether the mean square error of ΔH is equal to the standard deviation of ΔH or not? It is found that BP&CFM, BP&BP and 6-CFM meet the requirements. Therefore, on three aspects into consideration, i.e. (1) Is the standard deviation of ΔH the smallest? (2) Is the standard deviation of ΔH equal to the mean square error of ΔH? (3) Is the mean of ΔH is equal to 0.000m? It is found that the performance of BP & CFM is the best, and followed by BP&BP. The ΔH comparison charts of 118 first-order benchmarks, before and after correcting systematic errors estimated by BP&CFM, are shown in Figure 2. In Figure 2, "No Corr." denotes the value of ΔH before correcting systematic errors; "After BP1 Corr." and "After CFM2 Corr." denote values of ΔH after correcting systematic errors estimated by $2\times2\times1$ BP neural network and 6-parameter CFM respectively; the vertical axis expresses the value of ΔH (m); and the horizontal axis stands for the sequential number of 118 first-order benchmarks.

Conclusions

Address the systematic errors of estimated orthometric height $\hat{H}$ of e-GPS leveling, three methods, i.e. CFM, BP&BP, and BP&CFM, are proposed in this paper. Three data sets of Tainan City are used to test the proposed methods. The test results show that, among the three methods, BP & CFM is the most effective way to mitigate the systematic errors of e-GPS leveling, followed BP&BP, and 6-parameter CFM. Using BP & CFM algorithm, for example, the standard deviation of ΔH is reduced to ±0.029m from ±0.050m and the mean of ΔH is equal to 0.000m.

In this paper, it is found that the systematic errors of e-GPS leveling can be mitigated effectively if BP&CFM is applied, using the data sets from Tainan City. However, if the test area is increased, such as the southern region of Taiwan, and even extended to the entire island of Taiwan, the BP & CFM

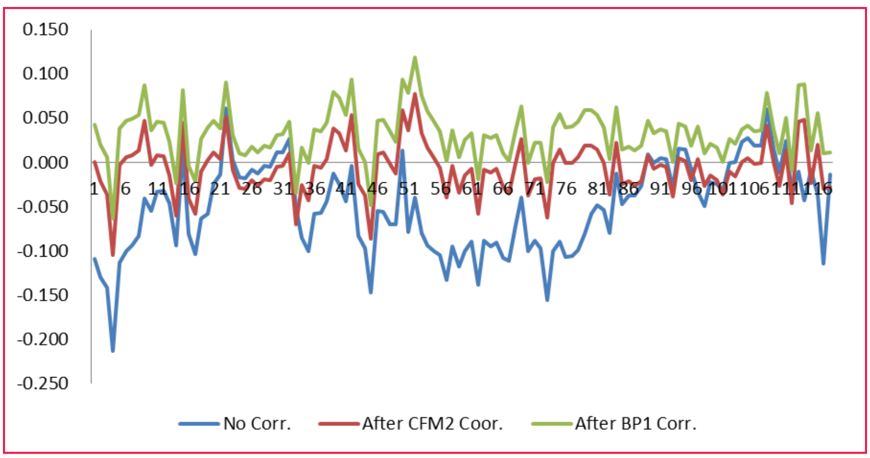

Figure 2. The ΔH comparison charts of 118 first-order benchmarks, before and after correcting systematic error estimated by BP&CFM.

algorithm, is still valid? Remains to be further validated in the future.

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Data sets of 145 first-order benchmarks of Tainan City, provided by the Satellite Surveying Center of the Ministry of the Interior; data set of 118 first-order benchmarks from Tainan e-GPS system , provided by the Tainan City Government; hereby together Acknowledgements.

References

References from Journals

Hu, W., Y. Sha, and S. Kuang, 2004, New method for transforming global positioning system height into normal height based on neural network, *Journal of Surveying Engineering,* 130(1), pp. 36-39.

Hu, W. and L. Sun, 2009, Neural network based method for compensating model error, *Journal of Southern University* (English Edition), Vol. 25, No. 3, pp. 400-403.

Kavzoglu, T. and M.H. Saka, 2005, Modelling local GPS/leveling geoid undulations using artificial neural networks, *Journal of Geodesy*, 78, pp. 520-527.

Kuhar, M., B. Stopar, G. Turk, and T. Ambrozic, 2001, The use of artificial neural network in geoid surface approximation, *AVN. Allg. Vermess.-Nachr*., jahr. 108, 1, pp. 22-27.

Lin, L.S., 2007, Application of a Back-Propagation Artificial Neural Network to Regional Grid-Based Geoid Model Generation Using GPS and Leveling Data, *Journal of Surveying Engineering*, 133(2), pp.81-89.

Lin, L.S., 2012, Study on the accuracy of e-GPS leveling, Accepted by Journal of Taiwan Land Research.

Stopar, B., T. Ambrozic, M, Kuha, and G. Turk, 2006, GPS-derived geoid using artificial neural network and least squares collocation, *Survey Review*, 38 (300), pp. 513-524.

Yang, M., K.H. Chen, and S.W. Shiao, 2003, A new height network in Taiwan, *Survey Review*, 37 (290), pp. 260-268.

Zaletnyik, P., L. Völgyesi, and B. Paláncz, 2008, Modelling local GPS/levelling geoid undulations using Support Vector Machines, *Periodica polytechnic, Civil Engineering*, 52/1, pp. 39-43.

References from Books

Ghilani, Charles D., 2010, *Adjustment Computations: Spatial Data Analysis*, 5th Edition, Wiley, John Wiley & Sons, Inc.

References from Other Literature

Tainan City e-GPS System Portal, 2012, *http://egps.tainan.gov.tw*.

Investigating effects in GPS time series

In this study, when height (Up) components of permanent GPS stations' coordinates are studied, seasonal effects are observed and it is researched if these Up constitutes have a relationship with temperature and pressure

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Time series that can find application in every area of science as related to its associated technology are often indispensable application area in the science of statistics, and sometimes in econometrics. Time series are a set of values and observed measurements over a period of time. For example, a weekly amount of product exported from the factory, highway accidents that occur annually, seasonal sea-level height or a fixed point are an example of an annual time series of coordinate changes. The use of time series can be expressed in the form of reporting results of the forward predictive which established by the mathematical models or in unknown time intervals in any way before the temporal data can be obtained from measurements made at regular intervals or expected to occur in future situations.

Time series analysis is of great importance in the field of engineering. We consider that a very high cost and labor-intensive, seen in their realization of the plan-project phases and steps of structures such as dams, bridges, towers and to ensure the continuation of engineering structures. These structures show a different behavior in life expectancy under different loads, such as deformation and displacement. The necessary measures will be provided in time with continuous monitoring of behavior and with this pre-determination of the possible accidents that may occur.

Time series

At the periodic points of time, collecting data through observation of a response variable is called a time series (Sincich 1996). Time series appear while saving sequential values of variable in clear time space. Free variable can change content of study topic in time series. It can appear as in geodesy science with changes of coordinate components or in economy science the wholesale price index yearly, exporting of one product yearly for any firm. Data recording space is usually acceptable as equal. However, in practice it usually comes upon with no equal time series. This situation creates problems in the analysis step.

Economists, businessmen, administrators are require knowledge to make decisions with recording time period. Time series can be used for future plans and estimation in long term periods as 5, 10, 20 years (Mann 1995). Time series analysis produces summarization properties of a series and outstanding of a series structure. This process can handle frequency dimensions like the time dimension. In other words, while the frequency dimension periodic moves can be considered, in the time dimension there is a given point for the appearance of different observations on time's different points. Both the dimension analyses have properties that are vital and the same knowledge provides different ideas about time series' qualitative in different ways.

In statistics, signal processing, econometrics and mathematical finance, a time series is a sequence of data points measured typically at successive time instants spaced at uniform time intervals. Time series analysis comprises methods for analyzing time series data in order to extract meaningful statistics and other characteristics of the data. Time series forecasting is the use of a model to predict future values based on

previously observed values. Time series are very frequently plotted via line charts.

Time series components

Analysis of time series requires decomposition of the series component. For the purpose of decomposition of a series from components, a clear relation between the four components must be conjectured. Generally, the route followed is conjectured which produces a total or a multiplication of few components of a time series (Akalın, 1990).

In a classical model, the time serial has four components (Mann 1995).

1. Long-term common trend, T
2. Conjecture wave, C
3. Seasonal wave, S
4. Variation and irregular randomly motions, I

Y=T.C.S.I

Thus, time series aim for the statistical investigation in each of the four components mentioned above and how effective the value is on the event.

Trend

The data to be analyzed deviates more or less due to various reasons. However, a longer time trend of data may be a fixed value.

A Trend is the naming of a time series which shows a clear route tendency. If the trend components are found in time series, conforming of line or curve equation with LSM could be obtained for separation of this component from series.

Few methods used for calculation of Trend

- The graphical method is one of them. This method utilizes an orthogonal coordinate system. While the horizontal axis is marked as time, the values are marked on the vertical axis. When one combines with signs of series, the trend of time series occurs.
- Moving averages method is usually used in series, showing the rise and sudden drop in values. Therefore, by taking an average of previous and subsequent values of this degradation and increases, the possibility of balancing occurs. Moving averages method is used to destroy the cyclical and seasonal fluctuations (Sincich 1996).
- A moving average is a set of numbers, each of which is the average of the corresponding subset of a larger set of data point. For example, mathematically, a moving average is a type of convolution and so it can be viewed as an example of a low-pass filter used in signal processing. When used with non-time series data, a moving average filters higher frequency components without any specific connection to time, although typically some kind of ordering is implied. Viewed simplistically, it can be regarded as smoothing the data.
- Principle of least squares method reveals the functional relationship between time and the results. Choosing the type of function which best describes the trend of; the event graph is plotted by marking of time on the X axis and marking of event values on the Y axis. This graph indicates the development in the long run incident. So, the type of graph function can be expressed and the degree of the curve is determined by the bending point.

When the type of function is not possible to determine by its graph, the standard errors of function types can be calculated. Thus, the function type is selected with accordance to the smallest standard deviation and the function type is selected with the smallest standard deviation (Akdeniz, 1998).

Types of time series

A time series is a quantity of interest over time in an ordered set. The purpose of this analysis with time-series is the face of reality represented by a set of observation and over time in the future values of the variables to predict accurately (Allen 1964).

The different examples are encountered, when one examines the types of time series such as autocorrelation function, partial autocorrelation function, the moving average (Moving Average, MA) series, autoregressive (auto regressive, R) series, difference equations, autoregressive moving average (ARMA) series, Holt-Winters exponential smoothing forecasting model, the Fourier technique and seasonal time series.

In permanent GNSS stations factors affecting time series

Over time, in the observation values of the time series values, some form of changes are observed, whether they increase or decrease. The various reasons, such as using receivers and antennas, reflective surfaces, atmospheric conditions change direction and intensity of time series. The changes in time series can be listed as trend, seasonal variations, cyclical variations and random variations. These changes are in general called the time series basic components or factors. The other factors are the effect of satellites, long-term multipath effects, atmospheric effects, hardware effects, seasonal effect (ocean loading, streams of ocean) tidal effect, etc.

The satellite effect: Effects related to the gravitational pull of the determination of satellite orbit can easily be modeled. Acceleration due to gravity is not easily modeled and solar radiation pressure on satellite panels affects the satellite position **(**Urschl et al 2005**).**

The long-term multipath effects: The satellite signal reflected from the environment instead of the original source comes from the GNSS satellite receiver. This error is called multipath error. It occurs when GNSS receivers cannot receive satellites signal or the GNSS receiver computes wrong coordinates due to the multipath error with reflected surface. Thus, time series are affected by systematic multipath path error.

Atmospheric effect: GNSS uses radio waves. Waves sent by satellite to receivers on earth reaches the receiver along the way through the two main layers as ionosphere and troposphere. The ionosphere is the top layer of the atmosphere. The ionospheric

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effect may be modeled or eliminated by using different wavelengths. If two carrier phase measurements are used, the ionospheric effect is eliminated by the linear combination of these carrier phase measurements. Due to water vapor, radio waves undergo the delay in the troposphere which is near the ground. Tropospheric effects are effectively irreducible by using double difference carrier phase observations of GPS solutions (Dai et al, 2006). To reduce the tropospheric effects, water vapor, humidity, temperature monitoring can be carried out more carefully. Thus, results can be achieved with high accuracy. It is difficult to determine the correct long-term temperature trend and seasonal changes in the troposphere (Matthias et al, 2002). Thus, this effect can change the results of time series (Piboon, 2002).

Hardware effect: Antennas meet signal moving in the atmosphere. To increase the accuracy of the height component, the calibration of the antennas is of great importance. The changing between the electrical center of the antenna and geometrical center antenna is not fixed and the constant changing can be reduced or increased (Wübbena et al, 2006). Antenna radomes are used to protect signal quality due to external factors affecting the height component of the solution. This problem is currently under investigation (Hugentobler et al, 2006), (Schmid, 2006).

In the case of several weeks of discontinuation of the data in a station, extraction station periodic movement is not possible. For this purpose, different locations on the same station would be obtained if a different provision of GPS equipment and data can ensure the continuity of time series.

The other factors affecting the time series are as outlined below:

- The local meteorological effect, snow effect on the radome, local refraction, etc.,
- The seasonal effect, ocean stream (golfstream, labrador), tidal effect, glacial effect
- Earthquake effect (post-seismic, co-seismic and inter-seismic effect), fault movements
- Global plate movements, etc.

Figure 1: GNSS station Used in time series analysis

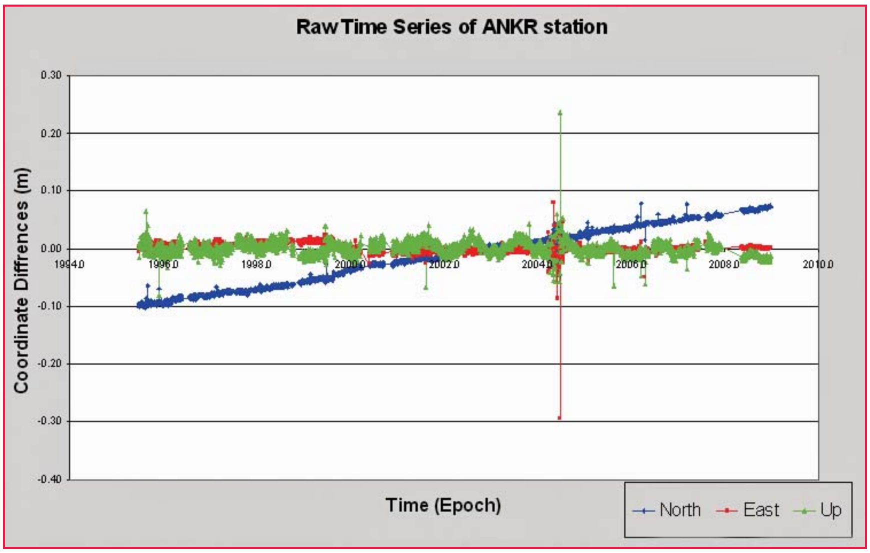

Figure 2: Time dependent changes in time series of ANKR station

Numerical application

Time series raw data of ANKR (20805M002), TUBI (20806M001), ISTA (20807M001) and TRAB (20808M001) stations have been used in the application (Figure 1). The raw data of N (North), E (East) and U (Up) local coordinates components of these stations have been provided from the Scripps Orbit and Permanent Array Center (SOPAC) GPS archive (web-1, 2009).

These local coordinates transform different Cartesian coordinates between reference epoch and measurement time epoch. These coordinates are composed of ITRF2005 reference epoch coordinates (X_0, Y_0, Z_0) and daily local coordinates N, E, and U. Dates of the data cover the period from 26/06/1995 to 12/21/2008 in ANKR station, the period from 21/12/1995 to 08/05/1998 in TUBI station, the period from 26/12/1999 to 12/21/2008 in ISTA station, the period from 26/12/1999 to 28/11/2007 in TRAB station. For the N, E, and U coordinate components of the four stations, time series graphic has been drawn by Microsoft Excel on one graphic (Figure 2).

The Up component of four stations' coordinate time series is similar to the periodic due to seasonal effects and it appears to have been seen to act. In addition, the unusual changes were noticed in Up component and it is assumed that these changes were caused by earthquakes. Firstly, the data interruptions of stations and gaps in time series were examined. For these gaps and interruptions, the time series were analyzed. The long-term discontinuities in the stations were analyzed separately for different ranges

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of epochs. Then the V-test was performed to determine outliers. Thus, the outliers were eliminated from time series. Then, in the height component of time series, periodic changes or seasonal effects were detected. So covering the years from 1995 to 2008 daily, the average temperature and pressure values of four stations were obtained from General Directorate of State Meteorology Affairs.

Table 1: Outliers of ISTA station time series

Epoch	Year-Doy	N(m)	E(m)	U (m)
2001.223	2001 082	-0.0284	-0.0817	0.0198
2001.330	2001 121	-0.0211	-0.0851	0.0110
2002.484	2002 177	-0.0109	-0.0444	0.0054
2002.580	2002 212	-0.0218	-0.0266	0.0115
2002.596	2002 218	-0.0213	-0.0349	0.0393
2003.604	2003 221	-0.0168	-0.0185	0.0394
2004.062	2004 023	-0.0041	-0.0026	0.0169
2004.684	2004 251	0.0082	0.0086	0.0041
2005.722	2005 264	0.0051	0.0384	0.0231
2008.575	2008 211	0.0453	0.1026	0.0111
2008.578	2008 212	0.0509	0.1039	0.0107
2008.742	2008 272	0.0496	0.1128	-0.0089

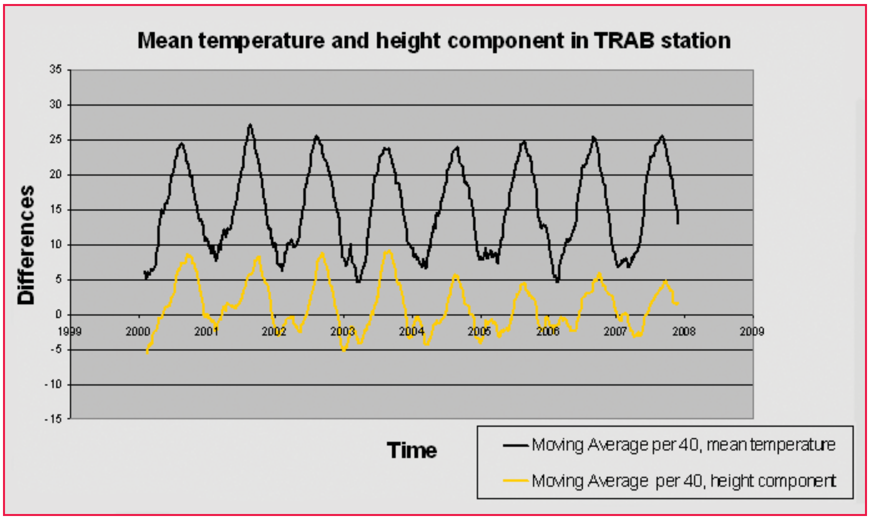

Figure 3: TRAB station's height component and temperature

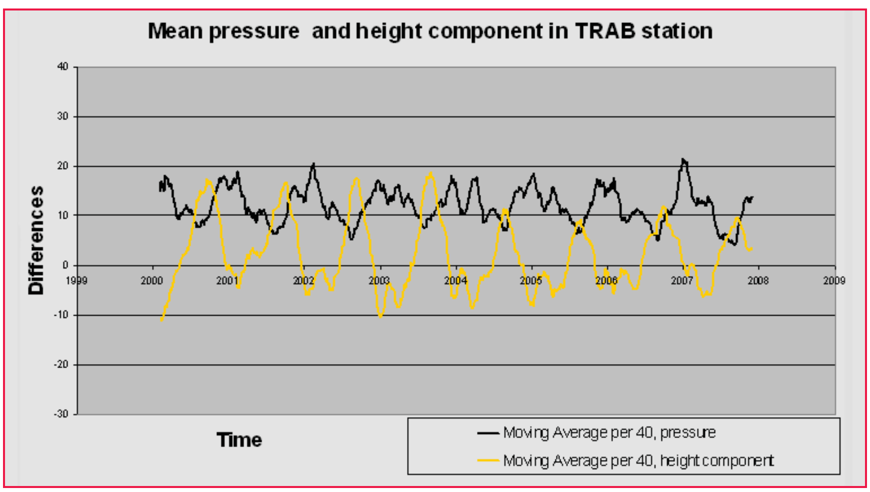

Figure 4. TRAB station's height component and pressure

Regression analysis of height component was performed according to the average pressure and average temperatures.

V - Statistics

In the measures made for sample the elements x1, x2, ..., xn, V-statistics is used to examine the values, showing the greatest difference in whether belonging to the same set or not. (Yerci, 2002)

For the implementation of this test

$$S = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2} \qquad 5.1$$

value must be calculated. Here V;

$$V = \frac{\left|X_E - \bar{X}\right|}{S} \qquad 5.2$$

The size of the test is calculated by equation 8.2. Hypothesis is established. If the hypothesis is smaller than V table values, the hypothesis will be considered valid according to the V table with n measurements and α significance level.

N, E and U components of stations' coordinates divided periods of 6 months. V – Statistics were performed separately for every period of application because of big range of data. The purpose of this test, one can understand whether the series are stationary or not when one investigates the long periodic time series. As a result values not outlying must stay in their time series. According to V-statistics, outliers were extracted from time series of four stations. In table 1,outliers of ISTA station are seen. There is much outlier in the other stations. But in this paper, other outlier tables are not presented due to the large quantity of data.

Regression analysis of height components in ANKR, TUBI, ISTA ant TRAB GNSS Stations with average temperature and pressure

Each station's average temperature and pressure values with height components are shown in the graphics. e.g., in Figure 3 and Figure 4 TRAB station height components with temperature


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F50
F60
RTS350
RTS330
GTA1800

Table 2. Regression Analysis of height components in ANKR Station with average temperature

Part number	a	b	Correlation coefficient, R
1	0.0006	-0.0067	0.4874
2	0.0008	- 0.0094	0.7575
3	0.0006	- 0.0081	0.6451

Table 3. Regression Analysis of height components in ANKR Station with average pressure

Part number	a	b	Correlation coefficient, R
1	-0.0006	0.5155	-0.2761
2	-0.0006	0.5404	-0.3029
3	-0.0007	0.6150	-0.3772

Table 4. Regression Analysis of height components in other stations with average temperature

Part number	a	b	Correlation coefficient, R
ISTA	0.0011	- 0.0162	0.7876
TRAB	0.0009	- 0.0134	0.6897
TUBI	0.0007	-0.0101	0.6370

Table 5. Regression Analysis of height components in other stations with average pressure

Part number	a	b	Correlation coefficient, R
ISTA	-0.0005	0.5047	-0.3124
TRAB	-0.0007	0.7063	-0.4691
TUBI	-0.0006	0.5924	-0.4605

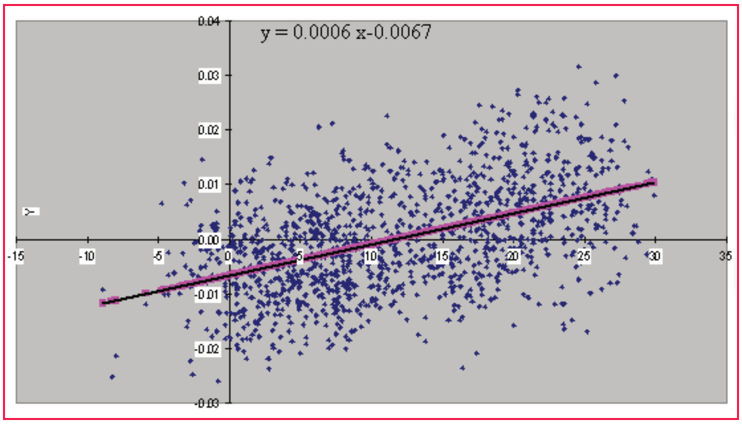


Figure 5. First part of ANKR Station regression line of height components with average temperature

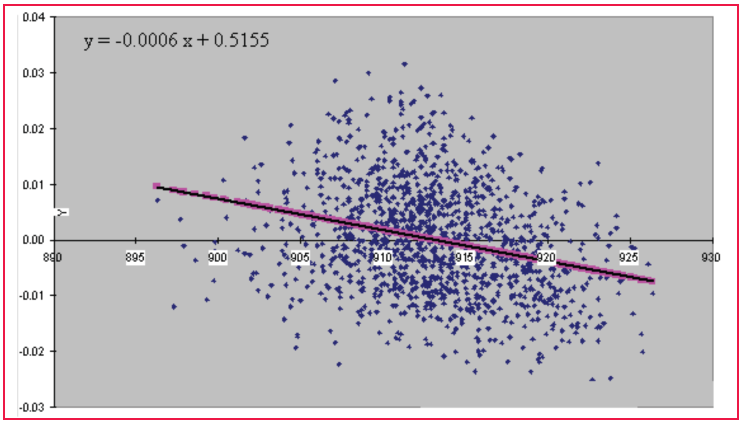


Figure 6. First part of ANKR Station regression line of height components with average pressure

and pressure values. In these graphics the y column has no unit, just two variables multiplied by specific coefficients for better understanding of the visual. Then, regression analysis of the height component was performed with accordance to the average pressure and average temperatures.

Regression is setting up of equality with the help of the known is thought to predict the form for later cases. In other words, regression was used to measure the relationship between two or more variables. Regression provides both descriptive and inferential statistics. If X is the only variable point to an incident, and dependent variable Y, between these two variables Y = f (X), the equation can be considered a link.

It is assumed that, according to the result of a series of measurement, (X1, Y1), (X2, Y2), ..., (Xn, Yn), values on a plane are obtained from specified points in quantitative cases. If the frequency distribution of these points is examined, the maximum frequencies of the classes are different straight line from X and Y axes and the values are dispersed around the straight line.

The distribution of these series may be non linear distribution. If one has the impression that a suitable non-linear distribution, it is named suitable curve. But if the distribution is linear, it is named as the linear regression line or adjusting line.

Regression analysis in ANKR station

ANKARA station data was divided into three parts because of long term gaps and regression analysis was made separately for the three sections. The first part of ANKR station, the dates cover the period from 13.08.1999 to 26.06.1995. The second part, the dates cover the period from 17.03.2004 to 25.11.2000. The third part, dates cover the period from 30.11.2007 to 20.07.2004. In table 2, regression analysis coefficients and correlation coefficient with temperature are seen as y=ax+b regression equation. In table 3, regression analysis coefficients and correlation coefficient with pressure are seen as y=ax+b

Regression analysis in other stations

In table 4, in TUBI, ISTA, TRAB station, regression analysis coefficients and correlation coefficient with temperature are seen as y=ax+b regression equation. In table 3, regression analysis coefficients and correlation coefficient with pressure are seen as y=ax+b

Conclusions

One of the non secular behaviors often observed in GPS time series is the periodic variations with an annual period. The most obvious environmental factors with such period are temperature and pressure. Non-uniform temperature distributions and pressure of Earth surface due to solar radiation and tropospheric layer can cause thermal stress, expansion, subsidence and hence change in displacements and instability at the geodetic sites. In this study, we analyzed time series of GPS stations with temperature and pressure variations in a longer period of time. The GPS time series of stations lead us to assume that the displacement change of the GNSS station was due to temperature and pressure. Also there is a linear correlation between height component of station coordinates and temperature. On the other hand inverse correlation between height component of station coordinates and pressure has been seen.

References

Akalın, S., 1990, Business Statistics, Bayraklı Press, İzmir (in Turkish)

Akdeniz, H., A., 1998, Applied Statistics II, Nine September University, Faculty of Economics and Administrative Sciences, İzmir (in Turkish)

Allen, R.G.D., 1964, Statics for Economists, MC - Millan, UK

Dai, W.J., Ding, X.L., Li, Z.W., Kwok, K.C.S., Campbell, S., 2006, Tropospheric Effects on GPS Measurements, Hong Kong

Hugentobler U, van der Marel H, Springer T (2006) Identification and Mitigation of GNSS Errors, *IGS Workshop*, Darmstadt.

Mann, S. P., 1995, Statistics For Business and Economics, Wiley, USA

Sincich, T., 1996, Business Statistics By Example, Prentice- Hall International Editions, fifth edition, USA

Pibon, M., 2002, Analysis of Periodic Behavior of GPS time Series at Pacoma Dam, California, Massachusetts Institute of Technology, Master of Science thesis,

Schmid R vd ,2006, Generation of igs05. atx –status quo, *IGS Wokrshop*, Darmstadt

Urschl C, Gurtner W, Hugentobler U, Schaer S and Beutler G (2005) Validation of GNSS orbits using SLR observations, *Advances in Space Research*, 2005, 412-417.

Wübbena G, Schmitz M, Boettcher G ,2006, Absolute GNSS antenna calibration with a robot: repeatabiltiy of phase variations, calibration of GLONASS and determination of carrier-tonoise pattern, *IGS Workshop*, Darmstadt.

Web-1, 2009, ftp://garner.ucsd.edu/pub/timeseries/

Galileo update

Real-time PVT calculation using Galileo IOV satellites with Septentrio receiver

Septentrio has announced that they have obtained, based on live ICD compliant Galileo messages from the four Galileo IOV satellites, a first autonomous real-time Galileo PVT calculation. The standalone position was calculated from in-orbit navigation messages using a standard PolaRx4 GNSS receiver equipped with commercially released firmware. *www.septentrio.com.*

PLAN Group tracks Galileo Satellites for Positioning in Canada

The PLAN Group of the University of Calgary was successful in capturing and processing the signals from these satellites as they emerged. Galileo PRN 11, 12, and 19 were found and tracked on E1B/C. The PLAN software GSNRx was also able to track simultaneously GPS L1 and GLONASS L1 and produce combined position solutions.

Examining the Galileo navigation message transmitted on the E1B signal, it was found that the satellite health status is flagged as $E1B_{HS}$=3 meaning *Signal Component currently in Test,* and the data validity status is flagged as $E1B_{DVS}$=1 meaning *Working without Guarantee.*

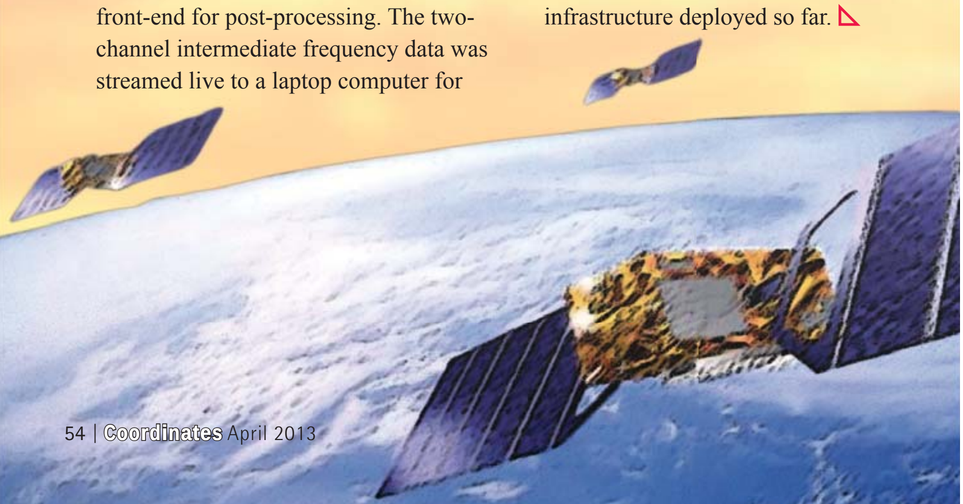
Data was collected using a roof-mounted NovAtel 702GG antenna and an in-house two-channel digitizing front-end clocked by a high quality OCXO and also a three-channel National Instruments front-end for post-processing. The two-channel intermediate frequency data was streamed live to a laptop computer for real-time processing with GSNRx. Two RF channels were processed, the first centered at 1574.0 MHz with an IF bandwidth of 10.0 MHz, for the GPS L1 C/A and Galileo E1B/C signals and the second centered at 1602.0 MHz again with a bandwidth of 10.0 MHz, for the GLONASS L1 OF signals. The GPS and GLONASS signals were tracked using a Kalman-filter-based tracking strategy while the Galileo signals were tracked using a specialized data-pilot algorithm.

Galileo fixes Europe's position in history

Europe's new age of satellite navigation has passed a historic milestone – the very first determination of a ground location using the four Galileo satellites currently in orbit together with their ground facilities. This fundamental step confirms the Galileo system works as planned.

"Once testing of the latest two satellites was complete, in recent weeks our effort focused on the generation of navigation messages and their dissemination to receivers on the ground," explained Marco Falcone, ESA's Galileo System Manager.

This first position fix of longitude, latitude and altitude took place at the Navigation Laboratory at ESA's technical heart ESTEC, in Noordwijk, the Netherlands on the morning of 12 March, with an accuracy between 10 and 15 metres – which is expected taking into account the limited infrastructure deployed so far.



PetroVietnam University selects Intergraph® solution

PetroVietnam University (PVU) has joined the Intergraph® Education Grant Program, selecting SmartMarine® Enterprise solutions for its curriculum to support Vietnam's offshore oil and gas industry. PVU is located in the offshore oil and gas hub of southern Vietnam, and was established to focus on the development of the country's oil and gas industry. *www.pvu.edu.vn*

New OS VectorMap District available now

A new version of OS VectorMap District is available through OS OpenData. Since its alpha release in 2010, the product has become one of the most popular downloaded datasets, with free to use terms, from Ordnance Survey's OS OpenData portal. Over the last three years Ordnance Survey has continued to work closely with customers to improve and develop this flagship product, resulting in the development of a significantly upgraded version 1.0 of OS VectorMap District. *www.ordnancesurvey.co.uk/*

Intermap announces $750,000 Mapping Services Solutions Contract

Intermap has been awarded a US $750,000 task order from Dewberry Consultants LLC for the fourth phase expansion of its previously announced airborne radar mapping services project in Alaska, USA. *www.intermap.com*

World Bank gives $40 million for land registration

More than 90,000 Nicaraguan families in the northern departments of Jinotega and Nueva Segovia will benefit from a $40 million World Bank project to regulate property rights and modernize government institutions charged with issuing property titles, according to a World Bank press release. The project will fund the second phase of the government's Property Regularization Program (PRODEP II), which started in 2002. When the project began, only 8% of land in Nicaragua had been registered and titled. Phase I increased the amount of officially registered land to 18% by 2012, including 13,000 km2 of land in the departments of León, Chinandega, Estelí and Madriz. Phase II of the project aims to increase the amount of registered land to 25% by titling properties in Jinotega and Nueva Segovia. *www.nicaraguadispatch.com*

N51.4 bn contracts for 13 roads, imagery map by Nigerian government

The Federal Executive Council, FEC has approved the award of N51.4 billion contracts for the construction and rehabilitation of 13 roads across Nigeria. Contracts also included that of a satellite imagery map of Nigeria, which has been awarded to Infotera of the U.K. in the sum of N3.7 billion and had a completion period of 24 months. *http://premiumtimesng.com*

Hong Kong launches GIS-based weather portal

The Hong Kong Observatory (HKO) has launched two new online weather portals which aims to provide citizens with more personalised and location-based weather information. The new website my.weather.gov.hk has user-customisable content, while another, maps.weather.gov.hk, is a regional weather webpage based on GIS, which integrates a variety of weather information on the same map. *www.futuregov.asia*

Kerala, India to map marine biodiversity

The Kerala State Biodiversity Board (KSBB) has initiated a programme to prepare a Marine Biodiversity Register (MBR) documenting the underwater ecology of the inshore areas and the traditional knowledge systems of fishermen in the State. The pilot phase will cover a 20-km stretch of the Thiruvananthapuram coast from Valiathura to Puthukurichy. The KSBB has taken up the project in association with Protsahan, a Thiruvananthapuram-based NGO. *www.thehindu.com*

Electronic navigations charts released for India

Dr Vishwapati Trivedi, IAS, Chairman, Inland Waterways Authority of India (IWAI) recently released the Electronic Navigation Charts (ENCs) in IHO, S-57 format and a real time navigation software namely 'Inland Waterways Navigation (IWN) Software' for Sagar-Farakka stretch (560 km) of National Waterway- 1 (the Ganga- Bhagirathi-Hooghly River system). These products have been developed as per International Standards by the consultant M/s IIC Technologies Limited, Hyderabad. *Inland Waterways Authority of India*

Lack of 'tall buildings' slows down Delhi govt's 3D data project

Lack of government-owned high-rise buildings in the Indian capital has slowed down Delhi government's ambitious 3D GIS Delhi State Spatial Data Infrastructure project. The cameras, which constitute an essential part of the plan, are supposed to provide real-time data. This data can be utilised for several pur-poses such as managing disasters, checking encroachment and unauthorised construction activities. The information technology department, which is in charge of the project, was asked to install 63 cameras in such buildings. So far, it has been able to install only 10 cameras due to the absence of 'tall buildings' and other vantage points where the cameras can be put up without being targeted by miscreants. Officials said the cameras have to be installed at a certain height for optimal utilisation. But the lack of tall government buildings has resulted in a search for alternatives. *www.hindustantimes.com*

New mapping database for Thailand

A mapping database using a 1:4,000 scale will be made available in the next five years in a move to standardise usage as well as help prepare for long-term planning and development in the country, Deputy Premier Plodprasop Suraswadi said. The GPS system would be useful when implementing some projects under the Bt350-billion water-management scheme and the Bt2.2 trillion strategy for large-scale infrastructure, he said, in addition to other projects such as setting out farming zones or forest and land management. Aerial photographs, satellite images and modern mapping technology assisted by the GPS will be incorporated into the database to make mapping and re-designation very accurate. *www.nationmultimedia.com*

YR 10 billion to build digital map of Sana'a, Yemen

An estimated $93 million, has been dedicated to developing municipal infrastructure in Sana'a, including building bridges, sanitation facilities and paving streets. Half of that will be used for building a digital map of the city. *www.yementimes.com*

TUBITAK develops information system for use in defense

The Scientific and Technological Research Council of Turkey (TÜBİTAK) has developed an information system that will be used in defense as part of important steps it is taking to create a situation in which Turkey can rely more on domestic production of defense equipment than foreign sources. TUBİTAK has now developed its own GIS that will enable Turkish engineers to develop important technology for domestically produced unmanned aerial vehicles (UAVs), helicopters and airplanes. *www.worldbulletin.net*

Pakistan: Bill drafted to regulate surveying, mapping

The National Assembly Standing Committee on Defence has submitted a report on 'The Surveying and Mapping, bill, 2013' to regulate and stop unqualified and unregistered firms to take part in surveying and mapping activities. According to report, the Survey of Pakistan, being the national mapping organisation, is responsible for meeting the surveying and mapping requirements of armed forces as well as civilian organisations and departments, which falls under the administrative control of the Ministry of Defence. In the absence of any regulatory authority, it is technically and legally difficult to keep a check on unlawful activities. *www.na.gov.pk*

BGBES to improve BEIDOU precision

A ground system aimed at enhancing the navigation precision of BeiDou Navigation Satellite System (BDS) was approved in central China's Hubei Province. The BeiDou Ground Base Enhancement System (BGBES), a network consisting of 30 ground base stations, an operating system and a precision positioning system, was approved by the evaluation committee led by Sun Jiadong, an academician with the Chinese Academy of Sciences (CAS) and chief designer of the BDS. The system is expected to help improve the BDS' positioning precision to two centimeters horizontally and five centimeters vertically via tri-band real-time precision positioning technology, and to 1.5 meters with the single-frequency differential navigation technology. *www.laboratoryequipment.com*

India to launch first navigation satellite in June

India is scheduled to launch the first of its seven navigational satellites of the Indian Regional Navigation Satellite System (IRNSS) in June, 2013, a top official of Department of Space told.

IRNSS-1, the first of the seven satellites will be space lifted aboard by the polar satellite launch vehicle, PSLV-C22, from the launch pad in Sriharkota, Andhra Pradesh. IRNSS is a navigation satellite system specially designed to provide position of an accuracy of 10 metres over India and also to the region around 1500 km around the country, told K Radhakrishnan, chairman of Indian Space Research Organisation (ISRO).

IRNSS-1 is designed to provide a very accurate real-time Position, Navigation and Time (PNT) services to the users on different platforms with 24×7 service availability under all-weather conditions with standard positioning service for common users and restricted service for authorised users. The space agency also plans to launch the next navigation satellite in three months after in-orbit tests of the first IRNSS-1, and the remaining five by 2014-15. *http://truthdive.com/*

China: Coca-Cola asked about GPS Use

Coca-Cola has said it is cooperating with Chinese authorities who are investigating whether its employees engaged in illegal mapping using GPS devices in Yunnan Province. The investigation was reported by a provincial Web site on Feb. 28, and a reporter at China Radio International asked an official with a national mapping agency about that case and others involving illegal mapping at a legislative session in Beijing. The official, Li Pengde, did not mention Coca-Cola but expressed concern that some information could have been given to "foreign intelligence agencies." A Coca-Cola spokeswoman said some bottling plants had adopted electronic mapping and equipment that was "commercially available in China through authorized local suppliers." *www.nytimes.com/*

Warrant for GPS tracking, cellphone location Data

In the USA, two bills introduced in the House and Senate would compel law enforcement agents to obtain a warrant before affixing a GPS tracker to a vehicle, using a cell site simulator to locate someone through their mobile device or obtaining geolocation data from third-party service providers.

The comprehensive bills would also prohibit private investigators and other private individuals from using a GPS device to surreptitiously track someone's location without their consent.

The Geolocational Privacy and Surveillance Act (H.R. 1312) has gained wide support from the American Civil Liberties Union and the Electronic Frontier Foundation, who say the bills are very strong and, if passed, would finally bring legislation up to date with the invasive use of new technologies. *www.wired.com*

China targeting navigation system's global coverage by 2020

China's homegrown navigation system BeiDou is expected to achieve full-scale global coverage by around 2020, a leading scientist told Xinhua. It will then be able to provide highly accurate and reliable positioning, navigation and timing service with the aid of a constellation of 35 satellites, said Ye Peijian, chief commander of Chang'e-3, China's lunar probe mission. "So far, China has successfully launched 16 navigation satellites and four other experimental ones for BDS," Ye said. *http://news.xinhuanet.com/english/*

Africa and the EU: implementing satellite navigation technologies

In the context of the collaboration between Africa and the EU on the implementation of satellite navigation technologies that could make a major impact on economic development, the GSA (the European GNSS Agency) has launched the project 'Awareness in Africa' (AiA) with the aim of organising workshops to bring together relevant stakeholders from public institutions and the private sector and highlight the benefits of GNSS (Global Navigation Satellite Systems) in African countries. *http://brussels.cta.int/*

ASECNA to lead African SBAS implementation project

Pan-African air navigation services provider ASECNA has been given the go-ahead to start work preparing for the future deployment of Global Navigation Satellite System/European Geostationary Navigation Overlay Service (GNSS/EGNOS) in the region.

ASECNA, in consortium with consulting and engineering group Egis, engineering company Pildo Labs and European satellite services provider ESSP has been appointed by the African, Caribbean and Pacific Group (ACP) to implement the Satellite navigation services for African Region (SAFIR) project, which is being funded by the European Commission through the 10th EDF Intra-ACP envelope. The fund is secured within the framework of the EU-Africa common Strategy adopted in 2005 and the Joint EU-Africa Partnership established in December 2007. *http://atwonline.com*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Kaga teams with u-blox to launch HSPA M2M card in Japan

Tokyo-headquartered Kaga Electronics has integrated u-blox' high-speed UMTS modem technology into their U130-KG wireless 3G air-interface card. The card is designed for machines, PoS terminals, meters, signage and security systems used throughout Japan. It integrates u-blox' LISA-U130 UMTS/HSPA module to deliver lightning-fast wireless performance: 7.2 Mb/s download and 5.76 Mb/s upload speeds. *www.u-blox.com*

Navigator Mobile App for the iPad

Bentley Systems has released *Navigator Mobile* app, providing unrivalled review of 3D models on the iPad, and the next generation of Bentley's i-models, which serve as containers for open infrastructure information exchange. It enables construction workers in the field, architects and engineers on the move, and other project stakeholders to navigate – online or offline – 3D architecture, engineering, and construction models intuitively and fully using i-models, as well as to browse a broad range of project documents in various formats. *www.Bentley.com/NavigatorMobile.*

TomTom launches in-car GPS PND for Goa in India

TomTom expands map coverage and content covering all the major beaches, 34,000 points of interest across 264 categories, more than 170 prominent tourist destinations around Goa with turn by turn voice guided navigation from more than 5800 cities and towns across India. The device will not only enable the tourists but locals to explore Goa and nearby getaways. *www.tomtom.com*

Apple buys WiFi startup to aid indoor navigation

Apple has bought WiFiSLAM, a startup that has been developing a way to use WiFi hotspots to help smartphones navigate large indoor spaces, like stores, airports and conference centers. *www.nwherald.com*

Apple patent shows pen with GPS, phone

The U.S. Patent and Trademark Office has reissued a patent to Apple for a mobile computer encased in a pen, adding cellular and GPS capabilities. Originally assigned to British Telecommunications PLC in 1998, the U.S. rights were transferred to Apple in 2008 but the patent was reissued with additional features included, Apple Insider reported.

The original patent describes a multifunction device equipped with a pair of accelerometers to recognize handwritten input and a built-in display; the new patent adds 11 new claims to the original, most having to do with cellular connectivity and GPS capabilities. *www.upi.com*

Market witnessing an increased replacement of PNDs by smartphones

TechNavio's analysts forecast the Global GNSS market to grow at a CAGR of 20.98 percent over the period 2012-2016. The Global GNSS market has also been witnessing the increased replacement of PNDs by smartphones. However, the reduced investments due to global recession could pose a challenge to the growth of this market. The main factor that drives the demand for GNSSs is the increasing popularity of LBSs, which are information services used by advertising professionals to promote location-specific products and services. LBSs are highly beneficial not only to advertising professionals, who can efficiently promote their products and services, but also to the end-users of the products, who can reap the benefits of regional offers. *ww.researchandmarkets.com*

China to launch Earth-observation satellite

China will launch its first high-resolution satellite for Earth observation in April, according to a government agency. China plans to launch five to six satellites before the end of 2015 to build a spatial, temporal and spectral high-resolution observation system, it said. *http://zeenews.india.com*

PCI Geomatics Software supports SPOT-6 Sensor

PCI Geomatics now supports SPOT-6 imagery within its software suite. SPOT-6, a new satellite built and operated by Astrium was launched on September 9th, 2012 from the Satish Dhawan Space Centre in India. SPOT-6 is an optical imaging satellite capable of imaging the Earth with a resolution of 1.5 m Panchromatic and 6 m Multispectral (Blue, Green, Red, Near-IR). The support for SPOT-6 will be available in the Geomatica 2013 SP2 product release. *www.pcigeomatics.com*

LINZ Suggests Freemium Model for Imagery Service

Land Information New Zealand (LINZ) is considering a "freemium" business model as a way of ensuring free public access to a multi-sourced database of land imagery of "national significance".

Under the suggested scheme a basic imagery service would be provided free of charge. However, says LINZ, "we do not intend to provide a premium imagery service, and we are open to solutions that wrap a commercial premium offering around our primary objective."

The premium service will involve extra value-added services, says programme manager Rachel Gabara; there will be no difference in imagery quality between the two services. *Source: Computerworld*

Aerial Photography ban proposed in New Hampshire, USA

A bill currently before the New Hampshire House of Representatives Criminal Justice and Public Safety committee would "prohibit images of a person's residence to be taken from the air by a satellite, drone, or any device not supported by the ground." The bill was sponsored by Representatives Neal Kurk, a Republican representing the Hillsborough region of the state. The bill is still in committee, and in most state legislatures, that is where many bills go to die. The bill's listing on the New Hampshire legislature's website does not list any co-sponsors. *www.aero-news.net*

Ashtech 6D GNSS Sensor

Trimble has introduced the Ashtech ADU800 for GNSS attitude determination and real-time positioning. The ADU800 is a 6D positioning solution providing position plus orientation for system integrators. It provides precise heading, pitch and roll with 3D positioning up to centimeter-level accuracy and velocities at a rate of up to 20 Hz for static and dynamic platforms. It is an ideal solution for a wide variety of airborne, marine and terrestrial applications. The ADU800 from Ashtech is a three antenna GNSS solution utilizing "on-the-fly" integer ambiguity resolution techniques with carrier phase measurements from the three on-board GNSS receivers to provide instantaneous 3D attitude information.

It is housed in a small, weatherproof, lightweight, rugged enclosure, and is built using the GPS/GLONASS/SBAS MB100 and MB800 boards. Embedded Z-Blade™ signal processing technology provides powerful performance and uses multiple GNSS constellations. The ADU800 can be operated in harsh environments while requiring minimal space for its installation. *www.Ashtech-OEM.com*

IFEN opens U.S. operations

IFEN has announced the opening of its U.S. subsidiary, IFEN Inc., to address the American market for GNSS test equipment. The Poing, Germany–based company has named Mark Wilson as vice-president of sales at IFEN Inc. Dr. Günter Heinrichs, head of customer applications and business development, said that the subsidiary operations, located in California, will greatly facilitate order placement, delivery, and support for U.S. customers. IFEN offers a range of simulators capable of reproducing all signals and frequencies of all GNSS constellations as well as a multi-GNSS software receiver.

ProMark 700 GNSS Network RTK Rover

Spectra Precision has introduced the new ProMark™ 700 GNSS receiver to meet the evolving needs of the land survey market. It is an ideal RTK rover specifically designed for network RTK applications.

Weighing only 650 grams (1.4 pounds), the ProMark 700 is the lightest GNSS RTK smart antenna available on the market today. Its light weight, together with a very compact and slim design, makes the receiver portable and comfortable for field use. It features a long battery life (typically over 10 hours) for all-day operation without the need for battery recharging or replacement. With its rugged, waterproof design and a wide operating temperature range, the ProMark 700 can be used in harsh outdoor environments.

The new receiver is equipped with 220 dual-frequency and dual-constellation GNSS channels that allow tracking of all available L1/L2 GPS/GLONASS satellite signals. It provides all the necessary features for effective network RTK operations, without the unnecessary complexity of rarely-used modules or options. *www.spectraprecision.com*

Leica ADS100 airborne digital sensor

Leica ADS100 is latest airborne digital sensor from Leica Geosystems .It offers a swath width of 20,000 pixels for all multispectral bands (RGBN) and multispectral capability in forward, nadir and backward, making it the most productive airborne sensor available today. It provides the world's first large format CCD line with TDI (Time Delay and Integration) to increase sensitivity despite a smaller pixel size. By doubling the cycle rate, high resolution images can now be acquired at much higher ground speeds. To provide the best stabilization performance, the new Leica PAV100 gyro-stabilized mount is equipped with revolutionary adaptive control technology. *www.leica-geosystems.com*

Spectracom Simulator compatible with Beidou Navigation System

The Spectracom GSG Series 5 and Series 6 GNSS signal simulators, released last year, are designed to be field upgradeable to simulate current and future GNSS constellations. GSG simulators are capable of outputting the frequencies, modulations and data formats of anticipated GNSS systems. The recent release of the Beidou ICD specification has confirmed that Spectracom GPS/GNSS simulators will be able to emulate these satellite signals with a simple field-upgradeable firmware update. *www.orolia.com*

I-Site 8200 laser scanner for underground survey

Maptek new laser scanner is designed specifically for underground applications. The I-Site 8200 is ultra-versatile. It can be coupled with a range of accessories to provide a complete scanning system for underground drives, tunnels and stopes, as well as surface stockpiles and silos. Processing of scan data can be undertaken in I-Site Studio and I-Site Void software.

The I-Site 8200 has all the hallmarks of I-Site systems - speed and accuracy of data collection, portability and rugged industrial design.

Microsoft introduces new oblique UltraCam Osprey

Microsoft UltraCam Osprey is a new digital aerial system that combines a high performing photogrammetric nadir camera with oblique image capture capabilities.

This third generation UltraCam camera builds on the UltraCam Eagle technology, including advanced electronics to achieve an exceptional signal/noise ratio; solid state storage of 3.3TB; and a modular housing concept that integrates all components into one unit. To achieve high flight efficiency, it is designed so that the full swath width of the nadir cone (11,674 pixels) can be used, and oblique wing images overlap enough to generate oblique orthos. The 60 MP backward and forward wing images and the 32 MP left and right wing images, combined with a 2.2 second frame rate, ensure adequate coverage. Due to the overlap with the nadir part of the camera, the wing image orientation can be further improved by automated tie point matching.

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- ***FLEXIBLE AND SCALABLE***
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- ***EFFICIENT***
  Small, lightweight and rugged design for the most demanding field work
- ***SUPPORT***
  Worldwide network of local service centers and dealers

CSR Location Platforms go live with BeiDou-2 satellite tracking

SiRFstarV™, SiRFprima® and SiRFatlas® location platforms are now able to acquire and track satellites and utilise location data froom BeiDou Satellite Navigation System (BDS) to help these devices achieve best-in-class location positioning and navigation performance anywhere in the world. *www.cambridgewireless.co.uk/news/*

MicroSurvey software is free for educational institutions

Microsurvey has highly invested in the education of the next generation of surveyors, law enforcement specialists, and construction professionals. They have given away over 10 million dollars in software licenses to over 150 educational institutions across the globe and would continue to do in future.

Optech CS6500 aerial digital camera

Optech has released CS-6500 aerial camera system. A direct advance from the Optech CS-4800 camera, it inherits the CS-4800's robust and proven design while providing enhancements and new features. As a result, the CS-6500 is a highly efficient camera.

Get new Esri App from Apple App Store, ArcGIS Online & Google Play

Esri has created two new applications to monitor daily operations and simplify field data collection. *Operations Dashboard* for ArcGIS provides a common operating picture and allows decision makers to monitor, track, and report on daily operations. *Collector for ArcGIS* allows users to capture and report spatial and/or tabular information directly from their iPhone or Android smartphone in the field. The Operations Dashboard and Collector applications are available to organizations that have either a 30-day trial or have purchased an ArcGIS Online subscription. *esri.com/smartphones*

MARK YOUR CALENDAR

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

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

ICL-GNSS 2013
25 – 27 June
Torino, Italy
www.ICL-GNSS.org

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

CASLE International conference on Management of Land and Sea Resources
7-10 July
Glasgow, Scotland
www.casle.org

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

ESA International Summer School on GNSS 2013
15 - 25 July
Davos, Switzerland
www.congrexprojects.com/13m07

IGNSS 2013
16-18 July
Gold Coast, Australia
www.ignss.org

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

5th International FIG LADM Workshop
24 - 25 September
Kuala Lumpur, Malaysia
www.isoladm.org

October 2013

Intergeo 2013
8 – 10 October
Essen, Germany
http://www.intergeo.de/en/index.html

Asian Conference on Remote Sensing
20 – 24 October
Bali, Indonesia
www.acrs2013.com

November 2013

GSDI World Conference (GSDI14) and the AfricaGIS 2013 Conference
4 - 8 November
Addis Abbaba, Ethiopia
www.gsdi.org/gsdiconf/gsdi14/

Introducing the UltraCam Osprey oblique digital aerial sensor system.

The UltraCam Osprey brings UltraCam performance and quality to your oblique aerial data acquisitions. This new UltraCam sensor system collects oblique imagery along with nadir PAN, RGB and NIR data all in a single pass and at image footprints of 13,450 (oblique) and 11,674 (PAN nadir) pixels across the flight strip. In doing so, the UltraCam Osprey provides you with a highly efficient and ideal system for a wide range of projects ranging from 3D urban mapping to classification to photogrammetric applications requiring high-geometric accuracy and superior radiometry.

The UltraCam Osprey is fully supported in the UltraMap 3.0 workflow software to perform aerotriangulation (AT) and to generate high accuracy point clouds, DSM, DTM, and DSM/DTMorthos.

Get details and see UltraCam Osprey image samples at www.UltraCamOsprey.com.

ULTRACAM OSPREY ULTRAMAP 3.0 Workflow Software System Microsoft