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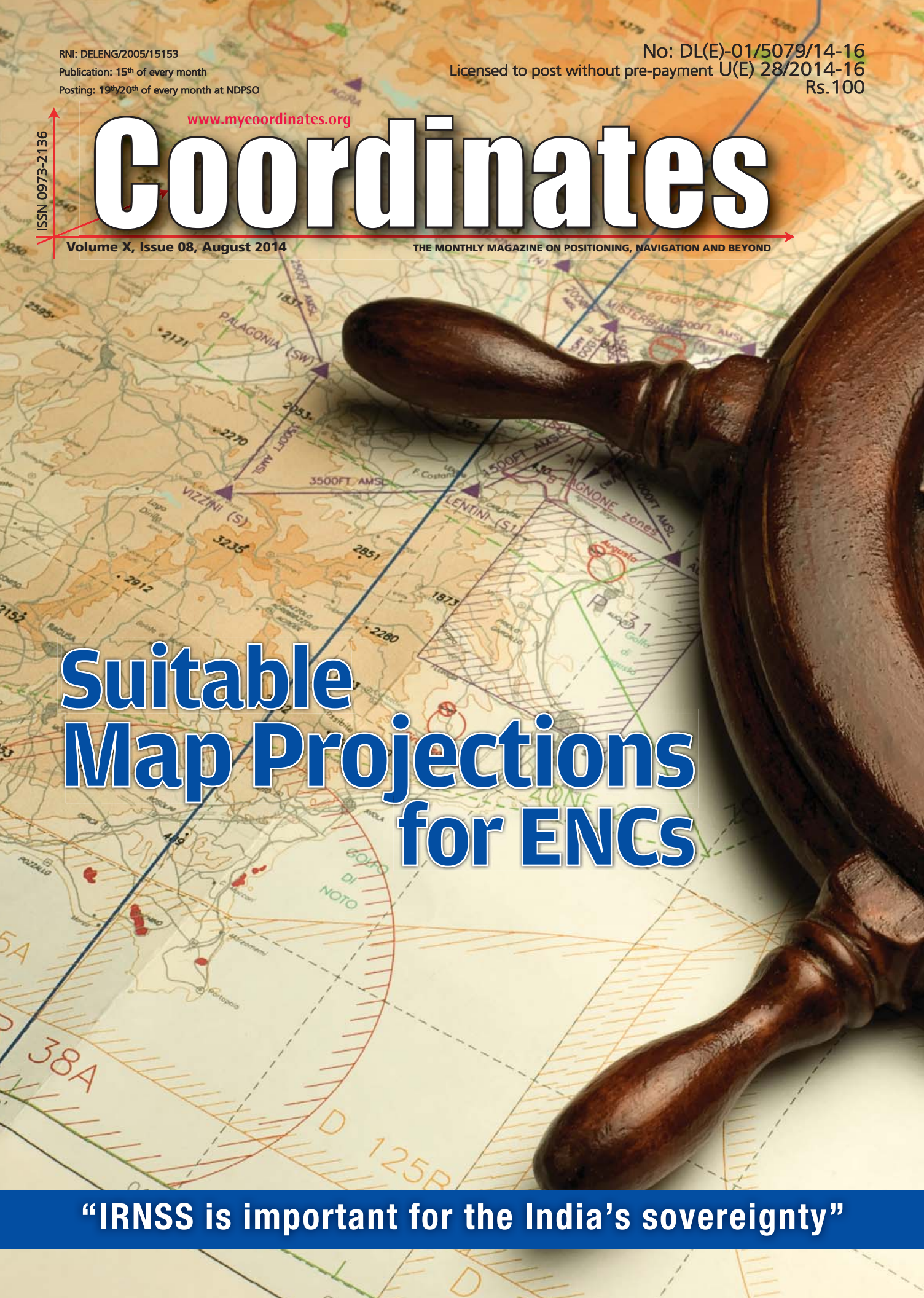

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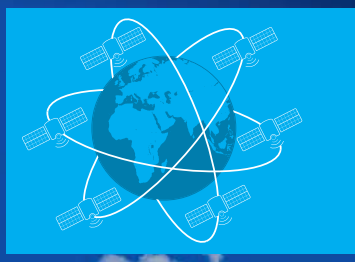

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Columns

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Wishful thinking

Some recent announcements,

Especially in the Union Budget of India for fiscal year 2014 -15.

Rs 7,060 crore for '100 Smart Cities' project,

Development of industrial corridors with emphasis on Smart Cities,

An investment of Rs 37,880 crore in National Highway Authority of India,

Proposed State Roads includes Rs 3000 crores for the North East,

Metro Projects in Lucknow and Ahemdabad,

For inland navigation, project on Ganges called "Jal Marg Vikas"

Proposal to track supplies for Public Distribution System using GPS

Pan India programme of "Digital India"

Digitization and mapping using GIS for better management and usage of Indian Railways

Bullet train project on the Mumbai-Ahmedabad route, etc. etc.

Wish these announcements not to end up as 'wishful thinking'.

Bal Krishna, Editor
bal@mycoordinates.org

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"IRNSS is important for the India's sovereignty"

says Shri Avinash Chander, Secretary Department of Defense R&D, DG R&D and Scientific Advisor to RM, Government of India

What are the key challenges for you as the head of the Defense Research and Development Organization (DRDO)?

The complexion of warfare and associated security scenario are fast changing due to rapidly advancing technologies, emergence of proxy warfare tactics and increasing number of technologically well equipped non-state players. India's security environment is even more complex due to conventional threats and unique geopolitical environment. Finding innovative technology solutions to meet resultant security challenges on a continuous basis and converting these technologies into manufactured products is a challenging task for which DRDO is geared up. DRDO is committed to indigenous development of state of the art Platforms, Weapons, Ammunitions and the Force Multipliers and leading these to production. At National level we need to develop capabilities in the Industry and nurture it to come up to the military quality standards. On the other hand, the time cycles for the products which used to be 10-15 years are now coming down to 05 to 07 years. We need to re-structure, re-invent and re-align ourselves for future challenges. The R&D capabilities for future technologies need to be developed in Academic and R&D institutes across the country. A futuristic technology management wing has been created in DRDO to pursue the advanced research in focused areas.

You were in-charge of the navigation system development of the Prithivi Missile Project in the early 70's. What has been the highlights of Indian navigation technology over these years?

Indeed, I was privileged to be one of the members of the initial team which worked on the Navigation System in the 1970s. In fact the first system what we made was Platform Navigation System which we had flight tested in Canberra Aircraft and later a Strapdown System was developed for SS45 Missile. In1988 a Dynamically Tuned Gyroscope (DTG) based INS weighing 50 kg was successfully flight tested in the first Indian Ballistic Missile Prithvi. For developing the INS, many of my team members worked day and night for almost 15 years and developed right from scratch, the algorithms, calibration and testing mechanisms, integration and interface modalities on our own. Today, the state-of-the-art systems developed and flight tested in ICBM class Agni-5 yielding better than 100 mts accuracy over a range of 5000 kms weigh just about about 150 gm. In the process, all the sensors and sub-systems such as DTG, FOG, RLG, high accuracy Accelerometers, Hybrid Navigation Systems as well as complex Algorithms, all comparable to the best available, were developed and realized indigenously. The Navigation Systems Group where my journey as a technologist began is today a world class R&D Laboratory.

No country can afford to depend on the foreign country's constellations during war scenarios

Which DRDO projects would you say are poised to make the biggest difference in India in the next two-three years?

DRDO has entered a new phase wherein very large number of critical Systems with potential to make a difference for the country are in advanced stage of operationalization. Tejas Light Combat Aircraft (LCA) is nearing 'Final Operational Clearance' (FOC), on its way to strengthening capabilities of our Air Force. Airborne Early Warning and Control System (AEWCS) is flying and will be inducted soon. Rustom II UAV currently undergoing taxi trials in preparation for its flight trials will be another force multiplier.

Induction of Long Range strategic missiles Agni IV and Agni V will be completed. The Air to Air Missile Astra is in advanced stage of its trials, while work on its MkII version with longer range is going on. Nirbhay sub sonic cruise missile will be flight tested this year.

Arjun Mark II is one of the most modern Battle tanks with very high capabilities and is slated for series of tests before production clearances. Another thrust area, which we have taken up, is the development of an advanced 155 mm Gun field gun. On the Naval side, we have strengthened our Sonar ssystems which are getting integrated in the ships. 'Varunastra' Torpedo is undergoing trials.

Electronic Warfare-EW systems is another strong and major thrust area of DRDO with very high level of self-reliance. Wide range of indigenous radar systems, Night vision devices and other electro-optic systems are in various stages of induction

and operationalisation. These indigenously designed and developed products manufactured in our own industries, I am confident, will prove to be a game changer, not just in terms of strengthening our country's defence and strategic capabilities but also in giving a boost to our industry leading to employment generation and economic growth.

As the head of DRDO as well as a person who has a background in spatial technology, how do you view the growth of mapping technology in India?

Firstly, as a Navigation man, looking into the civilian sector application, it is fantastic scenario to drive a car in India completely guided by the maps and the GPS. The maps of each and every nook and corner are available and we just need to feed the address and then it starts guiding you with directions to the eventual destination. Spatial technology has gained importance with the type of payloads providing very high resolution images, weather information, aerial survey and other applications. Satellite Navigation is used in each and every vehicle and so today many countries are trying to have their own Satellite Constellation. India's IRNSS planned to be in place by 2016. The future will be dominated by the Space technologies.

How important is spatial technology for DRDO activities?

Space has become very crucial and world over Research is going on in Spatial technologies for Defence applications. The spatial technology is used for high resolution images, weather forecasting, locating various assets of the adversaries. Spatial technology becomes important for DRDO and we need to utilize the modern space payloads like Synthetic Aperture Radars, high resolution imaging systems, Navigation Signals and Communication Systems. We need to embark in this area and effectively use space for these diversified applications.

> The R&D capabilities for future technologies need to be developed in Academic and R&D institutes across the country

What kind of research is being carried out at DRDO as far positioning, navigation and spatial technology is concerned?

Extensive research is going on in these areas of Navigation and Positioning Systems for Surface and aerial applications based on Inertial Technologies, Satellite Navigation Receivers and INS Hybrid Navigation Systems. Also, we use the Satellite Imagery for analysis.

How do you think cost-effective navigation systems for India could be developed?

Cost effectiveness of the Navigation Solutions primarily depends on the cost of the Sensors and the quantities of the Systems being produced. Today, many of the materials which are required in the Sensors are not available in the country and the required machinery is also being imported. There is need for many of these critical things to be produced in India and the required infrastructure in the country need to be created. Industry should gear up to produce the systems in large numbers competing with the world markets, both in quality and price. This will result in high volumes of production thereby reducing the cost further. Today, miniaturized navigation system what we made for smart munitions costs only about 06-08 lakh. Also the GPS-GLONASS-GAGAN Receiver (G^3OM) on a single module can be utilized for civilian applications.

What benefits can DRDO look forward to from the Indian Regional Navigation Satellite System (IRNSS) constellation? Has there been any role of DRDO labs in its development?

No country can afford to depend on the foreign country's constellations during war scenarios. IRNSS will make Indian Armed Forces self-reliant. As we know, the advanced nations like USA and Russia are having GPS and GLONASS. Countries like China, European Union and Japan are trying to have their own full-fledged or partial constellations. Our own IRNSS is important for the country's sovereignty and strategic requirements. The IRNSS is a Programme launched by ISRO and DRDO does not have a role in its Research.

What has been DRDO's initiative as far as UAV R&D is concerned?

UAVs are one of the thrust areas for us and we have been doing lot of focused research as they have potential usage in Surveillance for both Civilian and Defence applications. Rustom 2 with a long endurance of 24 hours is planned to be flight tested by the end of this year. Lakshya has been playing major role as a Target in the testing of Missiles. Also we have plans for developing Unmanned Combat Air Vehicle (UCAV) and mini UAVs.

We have been hearing about foreign direct investment in the defense sector. How is it going to be beneficial in general and to DRDO and its activities in particular?

The FDI in defence sector, as recently announced by the Governments is expected to bring in newer technologies and contemporary manufacturing processes besides infusing funds in the Indian industries. This would lead to greater impetus to indigenous manufacturing of military hardware and components. Besides meeting in house requirements, this is also likely to enhance the export potential of products manufactured in India, in turn reducing costs.

"We have become self reliant in navigation area for the defence applications"

says G Satheesh Reddy, Director, Research Centre Imarat (RCI), DRDO, Government of India

Please share the role of Research Centre Imarat (RCI) within the broader framework of DRDO.

Research Centre Imarat-RCI, part of the Missile cluster Laboratories of DRDO is responsible primarily for the Research in Avionics and mandated to deliver the advanced Avionics products to various Missiles, Aircrafts, Helicopters, UAVs, Ships, Submarines and other Vehicles of our Armed Forces. The Avionics products include the Navigation Sensors & Systems, Onboard computers & software, Control & Actuation systems, Power Supplies, Guidance algorithms, RF Seekers, Imaging Seekers, Radomes, Antennas and many other related systems. In the state of the art HILS facility complete Avionics gets evaluated for various missions. We have complete environmental test, EMI, EMC and EMP facilities for testing as per the requirements. RCI is pursuing core research in the area of Avionics to develop the cutting edge technology products.

Why do you think the Indian private sector has not been able to capitalize on the growing demand for multi satellite constellation receiversand build world class products?

The Indian Private sector is not able to invest in Research and Development (R&D). The industries have been concentrating only on manufacturing, assembly and ToT oriented products. In India, there are very few companies who invest in R&D and develop their own core products. Only one or two companies are investing in the R&D of Multi Constellation Receivers & able to come out with state of the art products and market them world over. Industry should make small investments in specialized areas and come out with innovative products and compete with the world. Wherever necessary, Industry should be funded and Research can be pursued jointly with Academia and R&D Institutions.

RCI has developed a wide variety of Satellite Navigation Receivers and is pursuing extensive Research in the spatial technology related products

How would you rate the importance of spatial technology for the research being conducted at RCI?

The Spatial Technology has gained importance since the evolution of GPS and other Navigation Satellite Systems. Satellites are being extensively used for location coordinates, Imagery and Intelligence. In line with many Navigation Systems like GPS of USA, GLONASS of Russia, GALILEO of EU, Beidou of China; India has also embarked on the journey of possessing its own Navigation Satellite System which is poised to play a very important role. In the last two decades, the world has witnessed many Satellites being launched at the beginning of the War and also during the War for Intelligence, Surveillance and Reconnaissance (ISR). Many payloads have been developed and put in orbit by advanced nations for high resolution imagery and for observing the earth radars and other installations. The future will see the War dominated by the Spatial technologies. RCI has developed a wide variety of Satellite Navigation Receivers and is pursuing extensive Research in the spatial technology related products.

Do you think that multi-GNSS scenario may result in navigation solutions with better accuracy?

The Multi GNSS scenario, may not be improving the accuracy significantly. The accuracy depends on many factors. SBAS like the Indian GAGAN will definitely improve the accuracy of the GPS to a large extent. The multi GNSS scenario, improves the visibility a lot and hence the Reliability of the Satellite Navigation is much higher. With the improvement in the visibility, the DOP improves and with proper

The Indian Private sector is not able to invest in Research and Development. The industries have been concentrating only on manufacturing, assembly and ToT oriented products

fusion of multiple data, the accuracy will also improve to some extent.

How do you look at the threats posed by jamming, spoofing and interferences to the navigation systems? Is RCI undertaking any research initiatives in these areas?

Jamming, Spoofing and other Interferences are always a threat to the Satellite Navigation. There are several methods how these threats can be dealt with. In a Hybrid Navigation System where Inertial Navigation & Satellite Navigation is combined, the System can function normally if the Jamming is for shorter durations. The systems can be designed with many techniques to counter spoofing. Receivers can be designed to work in Jamming conditions also by employing Systems like Null Steering Antennas. RCI is working on Satellite Navigation Receivers which can function normally under the conditions of Jamming, Spoofing and other Interferences. But if the Jamming signal is originating from very close vicinity with high power signal, it is difficult for the Receiver to function normally.

Your efforts in making India self-reliant in the area of navigationsystems for defense applications is well known. Do you envisage India becoming self reliant in navigation systems for civil applications as well?

We have become self reliant in Navigation area for the Defence applications. Many systems have been designed and developed with multiple Inertial sensors and are being used in many vehicles. There are many spin-offs from our range of navigation technologies developed at RCI which can be used for civilian applications. The GPS-GLONASS-GAGAN Receiver (G^3OM) on a Single Module can be produced in bulk, the high accuracy Ring Laser Gyro based Navigation System can be used for civilian aircrafts and ships. Highly miniaturized MEMS based smart low cost INS can be used in cars and other moving vehicles.I am very sure that India in coming decade, will become self reliant in navigation solutions for all its civilian applications.

Performance measurement of EGNOS Integrity and Continuity

The analysis presented in this paper will show whether EGNOS performance is in line with the ICAO SARPS for aircraft LPV approach procedures

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On March 2, 2011, the ESSP declared EGNOS' Safety of Life (SoL) signal officially available for aviation with the authorization from the European Commission (EC) to provide the service. From that moment on the EGNOS SoL service was provided openly and freely accessible without any direct charge and was tailored to safety-critical transport applications in various domains, most notably (civil) aviation applications. The service was declared compliant with the aviation APV-I (Approach with Vertical Guidance) requirements, as defined by ICAO in ANNEX 10 [1]. As a result, at various airfields within the EGNOS service area, air navigation service providers (ANSPs) started designing, validating and implementing EGNOS-based approach procedures, e.g., within the frame of the GSA funded ACCEPTA project. It is expected that within a few years, as was the case for WAAS in the US, several hundreds or even more aeronautical approach procedures based on EGNOS guidance will be available. As a result, the provided performance of this navigation system, especially its integrity and continuity-of-service, will become crucial for the safety of civil aviation within Europe. The EGNOS SoL service performance achieved, together with the system architecture, Signal-in-Space (SiS) characteristics and organizational framework that were laid down in the 'EGNOS Safety of Life Service Definition Document' [2], published by the European Commission, the latest issue 2.0 being published in June 2013. Within this document, the EGNOS SoL performance is validated at a high level versus ICAO SoL service performance requirements for APV-I.

Of the ICAO defined key performance indicators (KPI) accuracy, availability, integrity and continuity (see table 1), the latter two are the most difficult to assess- continuity because of its high requirements ($1\text{-}8x10^{-6}$/15s) and complicated concept and integrity because of its extremely high requirement of $2x10^{-7}$ in any approach of 150 seconds. This latter KPI is indeed very difficult to quantify- given the duration of 150 seconds per approach and assuming one approach at a time that all the time it turns out that an integrity failure may occur once every 23.8 years on average. Testing the EGNOS system by collecting data over 23.8 years is far from practical and still insufficient from a statistical point of view. So one needs to invent a way to do integrity tests on the basis of a limited amount of data collected within an acceptable observation time. Such a method for EGNOS integrity validation was developed by NLR, Delft University of Technology, Integricom and Science and Technology [3], [4] and implemented as a GNSS integrity validation tool called GIMAT. In [2] EGNOS, continuity was determined for the complete EGNOS service volume based on EGNOS broadcasted messages, ephemerids and clock information of all visible PRNs, while assuming a fault-free receiver operating in a nominal atmospheric environment. This however, raised the question: 'What would be the continuity and integrity performance including a (high-end) receiver in the loop, while operating under non-nominal environmental conditions, i.e., during high ionospheric activity?' Is EGNOS still compliant with ICAO requirements while taking these conditions into account? Concerning the integrity KPI in [2], only the following statement was made: 'The EGNOS integrity is compliant with the integrity requirements specified in Table 1(ICAO) for APV-I'. This means that neither a method of how this

Table 1. SoL service performance requirements (ICAO)

Typical Operation	Accuracy			Integrity			Continuity	Availability
	Horizontal (95%)	Vertical (95%)	Integrity	Time-To-Alert (TTA)	Horizontal Alert Limit (HA)	Vertical Alert Limit (VAL)		
En-route (oceanic/ continental low density)	3.7 km (2.0 NM)	N/A	1 -1x10^{-7}/h	5 min	7.4 km (4 NM)	N/A	1 - 1x10^{-4}/h	0.99 to 0.99999
En-route (continental)					3.7 km (2 NM)	N/A		
En-route, Terminal	0.74 km (0.4 NM)	N/A	1 -1x10^{-7}/h	15s	1.85 km (1 NM)	N/A	1 - 1x10^{-4}/h to 1 - 1x10^{-8}/h	0.99 to 0.99999
Initial approach, Intermediate approach. Non-precision approach (NPA), Departure	220 m (720 ft)	N/A	1 -1x10^{-7}/h	10s	556 m (0.3 NM)	N/A	1 - 1x10^{-4}/h to 1 - 1x10^{-8}/h	0.99 to 0.99999
Approach operations with vertical guidance (APV-I)	16.0 m (52 ft)	20m (66 ft)	1 -2x10^{-7} in any approach	10s	40 m (130 ft)	50 m (164 ft)	1 - 8x10^{-6}/15s	0.99 to 0.99999

integrity KPI is measured nor a distribution of the actual integrity performance over the EGNOS service area is given.

NLR, as an independent aeronautical research institute is contributing to GNSS performance monitoring, as part of its mission to improve safety in civil aviation. Given that NLR has the right tools available to validate integrity performance, an activity was started to verify the claim stated above. As a result, both integrity and continuity KPI were measured and validated with receiver and atmospheric environment in the loop.

This paper provides an analysis of EGNOS performance in order to identify whether its integrity and continuity performance is in line with the ICAO SARPS for aircraft APV-I approach procedures. The analysis will give insight in the EGNOS integrity and continuity performance distribution within the EGNOS Service Area. The ESSP EDAS service, providing archived EGNOS messages and RIMS station observables, is used as the data source for this investigation.

Concept of continuity and integrity

EGNOS has been designed and validated for ICAO's APV-I SoL service. Therefore, it shall comply with the performance requirements as specified for APV-I in Table 1. In this section, the details of the GNSS integrity and continuity KPIs definitions will be addressed.

Integrity Concept

In general, integrity is a measure of the trust that can be placed in the correctness of the information supplied by a given system. Integrity includes the ability of a system to provide timely and valid warnings to the user (alerts) when the system must not be used for the intended operation. In order to quantify integrity - which is needed to validate integrity as a KPI versus requirements, a number of definitions and related parameters are in place:

- **Protection Levels** (Horizontal and Vertical protection levels HPL and VPL) represent an upper bound of the error. A detailed description of how Protection Levels are to be computed by the receiver for EGNOS can be found in Appendix J of the RTCA SBAS MOPS [5].
- **Alert Limits** are the error tolerances not to be exceeded without issuing an alert [1]. Horizontal and vertical alert limits (HAL and VAL) are defined for each operation, e.g., for APV-I, these are 40 m (HAL) and 50 m (VAL).
- **Integrity Event** occurs when the navigation system error (i.e., Horizontal Position Error HPE and Vertical Position Error VPE) is larger than the corresponding Protection Level: HPE > HPL or VPE > VPL for some time, while the system does not trigger an alert within the Time To Alert (TTA). Such event is also called a **Misleading Information** (MI) event, where a distinction is made between MI where Protection Level and Position Error are both either larger or smaller than the Alert Limit and the **Hazardous Misleading Information** (HMI) condition where the Protection Level is smaller than the Alert Limit, while the Position Error is larger than the Alert Limit. In the latter case, the user will get the erroneous indication that the system can be safely used.
- **Integrity Risk** is the probability that the position error is larger than the protection level, i.e., HPE > HPL or VPE > VPL, while the user is not warned within the TTA.

The EGNOS system (combination of its Ground Segment and Space Segment) is declared approved for SoL applications, provided that the User Segment is also certified for SoL applications. For aeronautical users, this means that certified SoL Equipment Class shall be used, as specified in [5]. This paper validates whether EGNOS is providing the integrity risk performance under operational conditions (including User Segment and signal

propagation through the atmosphere) that the system says it is providing:

$P_{MI,OP}$= P(|xPE| >xPL | no timely alert) <$P_{Req,\ OP}$

This means that in this paper, the system is validated on the condition of Misleading Integrity Information (MII), thus validating whether the P(MI) that EGNOS provides is indeed compliant with requirements. It should be noted that non-compliance of EGNOS $P_{MI,OP}$ could be determined on statistical basis even if no single MI event is found.

Continuity Concept

Continuity of service of a system is defined in [2] as the capability of the system to perform its function without unscheduled interruptions during the intended operation. It relates to the capability of the navigation system to provide a navigation output with the specified accuracy and integrity during the approach, assuming that it was available at the start of the operation.

The SoL performance requirement (ICAO) in the context of APV-1 operations requires the probability of a loss of continuity to be less than $8x10^{-6}$ for any 15 second period [1]. To validate continuity as a KPI versus requirements, the definitions of **Protection Levels** and **Alert Limits** as defined for integrity are relevant. **Continuity** is provided when {HPL< HAL AND VPL < VAL} at the start of the defined period is continued throughout the total period without any moment of turning into non-availability {HPL > HAL OR VPL > VAL}.

Although this definition for continuity is quite straightforward, it has led to different algorithms. The algorithm used here implements the continuity risk for APV-I as specified by the EUROCONTROL APV Working Group [10]: 'EGNOS APV-I Continuity Risk is defined as the result of dividing the total number of single continuity breaks using a time-sliding window of 15 seconds by the number of samples with valid and available PA navigation solution. A single continuity break occurs if the system is available at one epoch and becomes not available during the following 15 seconds.' The algorithm estimates all sliding windows containing a continuity event which occurs when:

- at T_{i-1} HPL<HAL AND VPL<VAL
- at T_i HPL≥HAL OR VPL≥VAL

When a continuity event occurs, 15 sliding windows are affected with a continuity break. This leads to the following 'average continuity' algorithm that was used (assuming epochs of 1 second).

$$P_{disc(15s)} = \frac{N_d \times 15}{N_{total}}$$

Where N_d represents the total number of continuity events, and N_{total} is the total number of epochs in the measurement set (which corresponds to the total number of time slices in the measurement set). The obtained continuity risk according to this algoritm is considered as conservative.

For determining the 95% confidence interval of the obtained continuity risk, the bootstrapping technique [9] is applied on the obtained data set.

Note that the use of the Extreme Value Theory to estimate the continuity risk has been considered. However, the measurement set contains a sufficient number of non-continuity events which lessens the need for such a technique.

Extreme value theory

Scientific Background

Extreme Value Theory (EVT) was developed quite recently, but already well-established and mature field in statistics that provides statistical methods allowing for the estimation of the probability of events that lie beyond the observed range of the data [6]. The application areas in which EVT have been successfully used are numerous and include hydrology (flood frequency analysis), finance, insurance, meteorology (extreme wind strength, rainfall, and earthquake risk assessment) and many engineering areas, e.g., corrosion and fatigue prediction [7].

EVT is applicable regardless of the underlying error distributions of the measurement data, relieving the need for strong *a priori* assumptions (such as assuming Gaussian error distributions). The properties of the tail of the error distributions can be derived from the measurement data, so that the data can be meaningfully extrapolated into the region of MI, even when no sample values in this region are available. By finding a data-based description of the tail of the error distribution, the actual system integrity can be estimated without the need for assuming particular error distributions.

Broadly speaking, there are two principle kinds of models for extreme values. The first group of models is based on the identification of the largest observation per block of data and are therefore called block-maxima models. In our earliest efforts, we used this model for EGNOS integrity verification [8]. A second group of EVT models contains the peak-over-threshold (POT) models, which model all observations that exceed some threshold. These POT models were considered to be the most useful because of their more efficient use of the limited number of extreme values. The latter approach has therefore been chosen for the GIMAT tool. Although it is not the purpose here to describe the GIMAT functionality in detail, for correct understanding of the followed approach of EGNOS integrity validation is briefly described below.

The GIMAT tool functionality

GIMAT (GNSS Integrity Monitoring and Analysis Tool) is a software implementation of the EVT-based GNSS integrity estimation. The tool was primarily designed to validate EGNOS integrity performance, however validation of the integrity concept and performance of Galileo SoL service and GBAS GAST-C and D can be supported as well. In order to make the GIMAT tool more complete, also other more straightforward GNSS KPIs such as accuracy, availability and continuity-of-service KPIs are provided. In addition to position domain integrity estimation, also range domain satellite-pseudo range based integrity determination is available but not used in this study.

Within the POT class of EVT models, various styles of analysis exist. The fully parametric model based on the Generalized Pareto Distribution (GPD) was conceptually the most straightforward. The GPD is a three-parameter distribution with the following cumulative distribution function (cdf) for some error e (e >μ):

$$GPD_{\gamma,\beta,\mu}(e) = \begin{cases} 1 & \gamma < 0 \text{ and } e > \mu - \beta/\gamma \\ 1 - \exp\left(-\frac{(e-\mu)}{\beta}\right) & \gamma = 0 \\ 1 - \left(1 + \gamma\frac{(e-\mu)}{\beta}\right)^{-1/\gamma} & \text{otherwise} \end{cases}$$

In this equation, the location parameter μ will always be zero when fitting peaks over a threshold. Since β acts as the scaling parameter, the most important parameter is γ, the so-called shape parameter, which largely determines the behavior of the tail. For positive values of γ, the cdf has a heavy tail, while γ=0 corresponds to an exponential tail. In the case that γ is negative, the tail has a finite endpoint and the probability density function becomes zero for errors that exceed this endpoint, implying that larger errors simply cannot occur.

In the earlier section, the threshold was mentioned for determining the peak-over-threshold samples to be used for determining the distribution's tail behavior. When selecting this threshold, a compromise has to be made between choosing a sufficiently large threshold to make the distribution's asymptotic approximation hold and choosing a sufficiently small threshold to obtain sufficient excess data to accurately estimate the parameters β and γ. Unfortunately, no automatic threshold selection algorithm providing satisfactory performance is available yet. The threshold is typically selected by human intervention, based on graphical data analysis of a so-called 'Mean Excess plot' (ME), together with stable behavior of β and γ over a certain region [4].

For a correct estimate of the integrity risk performance, best is to use independent value samples. This is especially true since peaks always come in groups of samples showing considerable dependency. For this reason, the set of peak-over-threshold value samples are filtered, making the set statistically independent. Traditionally, data dependency in time series is investigated using the autocorrelation function. In GIMAT, for the tail, a more suitable approach of dependency reduction was used that avoids unnecessary loss of data: the assumption that the time of occurrence of independent observables exceeding threshold should follow a Poisson distribution. This fact can be used to determine a minimum time interval K that one needs between two samples to consider them as being independent, based on Poisson statistics behavior. Consider all data samples with errors exceeding a certain threshold value. When there are N such samples in total, define the fraction of 'large errors' that are at most a time period K apart as:

$$V_K = \frac{\text{number of pairs (i,j) for which } |k_i - k_j| \le K}{\text{N}}$$

In the case of independent samples (Poisson distribution), the expected value $E\{V_k\}$ is linear in K. When one draws a graph of K versus V_K, the graph should therefore approach a straight line above values K_T of K for which independence is obtained, while for smaller K, the graph will be either curving upwards or downwards which indicates some kind of dependence. De-clustering to obtain a set of independent observations can thus be performed as follows: use only the largest observations in each cluster, where the large errors are said to belong to the same cluster when they are at most a period K_T apart.

Finally, having information on the confidence level and intervals of the determined integrity probabilities is a necessity for making sound statements on estimated (non-) integrity probabilities. The confidence level or interval is not a system parameter, however generally relates to the quality and quantity of the measurement data set. Most straightforward would be to repeat the experiment many times and determine the confidence interval based on the distribution of the outcomes. In this test, this approach is not very practical or even impossible, therefore other methods need to be investigated. When developing the tool, two distinct methods were evaluated for obtaining 2σ confidence intervals associated with the obtained probabilities: resampling bootstrapping [9] and the Gauss-Newton iteration approach. Dividing a period into a few sub-periods of time and applying a Gauss-Newton iteration on these time periods showed that confidence intervals based on this approach seemed to be overly optimistic. Bootstrapping based confidence intervals on the other hand showed quite reliable and conservative, with additional advantage of this method being its great simplicity together with lack of need for strong assumptions. As a result, it was decided to use bootstrapping for confidence level determination in GIMAT. In our study, we used 100 bootstraps for determining confidence intervals of determined PMI for each RIMS location. Thus a range of 100 PMI distributions

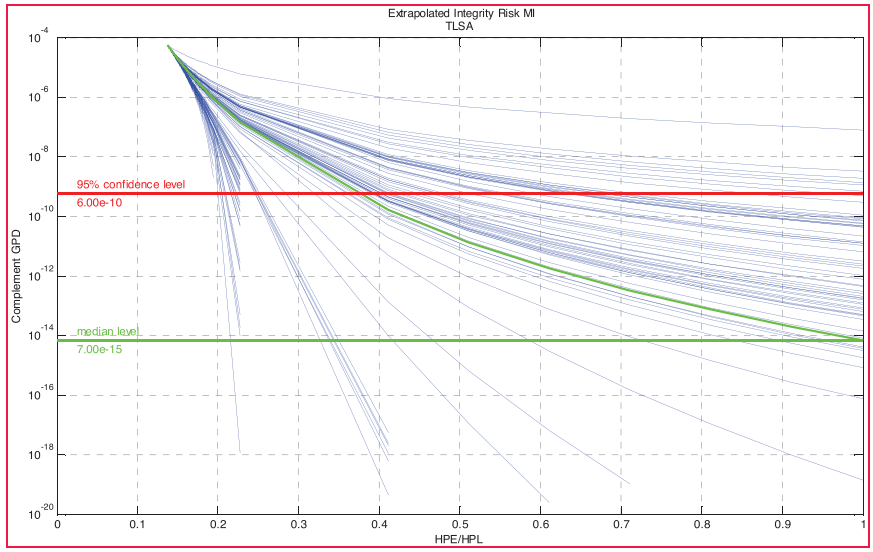

Figure 1: Bootstrapped distribution of P_{MI} for the TLSA RIMS over the investigated 3-month period

result, see Figure 1. The five highest P_{MI} values determine the upper 95% confidence interval of the distribution.

The GIMAT tool has been used a few times already, e.g., in [3], in which its capabilities were successfully shown. It has also become clear that for obtaining narrow enough 2σ confidence intervals, at least a time period in the order of three months of collected observables needs to be used.

Selected measurement approach

Baseline for our approach was to use data sources and tools which are widely accepted by the GNSS community as *de facto* standards and of excellent quality.

For Continuity and Integrity performance calculations, the following measurement conditions and assumptions are applicable:

- Selected time period:
  - The time period 2013-10-20 to 2014-01-31, (104 days in total) was selected, in order to obtain acceptable small confidence intervals. It is assumed that this period provides a robust set for Extreme Value statistics calculations. In addition, in this particular time interval, the sun has reached its 24th cycle solar max activity, which is interesting for the assessment of the influence of ionospheric activity on EGNOS performance.
- As GNSS data source, data from 34 EGNOS RIMS from the EDAS archive were used for a number of reasons:
  - RIMS are evenly spread over the EGNOS Service Area;
  - RIMS provide an excellent quality of observables, as they are the ground segment of the EGNOS SoL service;
  - In the processing chain, EDAS applies very accurate techniques to minimize receiver or local errors (e.g., multipath, cycle slips), and thus, approximates a fault-free receiver;
  - The EGNOS messages provided by EDAS are identical to the GEO broadcasted messages, however they are not sensitive to discontinuities in the provision of EGNOS SIS (Loss of EGNOS signal).
- KPI performance calculations:
  - EGNOS aided PVT and protection level calculations are performed by the PEGASUS tool. PEGASUS is considered as a baseline tool for SBAS aided calculations implementing the algorithms issued according to MOPS [2]. PEGASUS is used for manufacturer-independent verification of augmentation system performance according to ICAO Standards. Since the development of EGNOS and GBAS, the PEGASUS tool was used for its validation.
  - Only PVT solutions in mode 4 (APV-1) of PEGASUS are used for analysis.
  - Integrity performance calculations using GIMAT (EVT) functionality.
  - For continuity KPI performance calculations, no difference is made with respect to the length of the discontinuities, neither their independency. (Two successive discontinuities are independent if in between the system was continuously available (xPL<xAL) continuously for a period of 15 seconds or more.
- Using GIMAT, only the P_{MI} is investigated. When we prove EGNOS P_{MI} to be compliant with ICAO requirements, then its P_{HMI} is compliant as well, since HMI events are a sub-set of MI events.

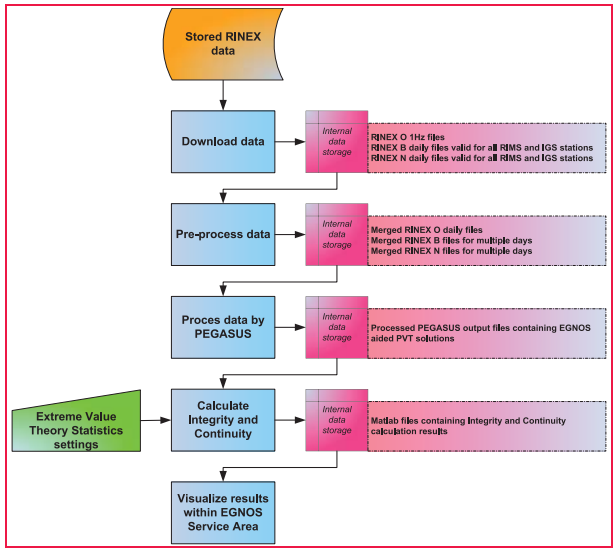

Figure 2: Measurement approach (data flow diagram)

Figure 2 shows the selected measurement approach for Continuity and Integrity performance calculations. The RINEX data files (O/B/N) were downloaded from EDAS for each of the selected EGNOS RIMS. Few IGS observables (RINEX O) were downloaded from the CDDIS server (RINEX B/N provided by EDAS since the data is station-independent) as an independent reference.

Subsequently, RINEX data files were merged into larger files to calculate EGNOS aided PVT solutions on a daily basis using PEGASUS 'Convertor' and 'GNSS_Solution' modules.

Finally, after filtering the data for the correct PVT mode (EGNOS aided PVT for Approach Procedures with Vertical guidance APV), Integrity and Continuity performance calculations were performed using the GIMAT methodologies described in chapter 2 and chapter 3 of this paper. For visualisation, the results are translated to a map-layer, which enables the integration into a geospatial data infrastructure. The results are assessed and visualized via a dedicated web interface for GNSS KPI performance parameters (http://gis.nlr.nl/flexviewers/gnss/).

Results

Table 2 shows an overview of both obtained Continuity and Integrity results at EGNOS RIMS locations spread over the EGNOS Service Area.

Continuity Performance Results

From Table 2 and Figure 3, it can be observed that the Continuity results

ZTS-320/R

Total Station

Dual-axis compensation

Absolute encoding

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Table 2: Overview of Continuity (Continuity Risk 95th percentile) and Integrity (Integrity Risk 95th percentile) performances

EGNOS RIMS	CR_95 Average Continuity	IR_95 MI (Horizontal)	IR_95 MI (Vertical)
ABSA	1.3E-02	2.6E-19	4.5E-10
ACRA	4.4E-02	0.0E+00	8.5E-10
AGAA	6.4E-03	5.1E-08	3.0E-14
ALBA	5.9E-05	1.2E-09	5.9E-12
ALYA	1.6E-02	2.7E-08	4.2E-10
ATHA	3.9E-04	7.9E-09	2.1E-09
BRNA	7.8E-05	2.0E-08	1.5E-08
CNRA	1.1E-02	9.7E-09	9.7E-09
CRKA	2.1E-05	7.5E-14	5.4E-11
CTNA	4.5E-04	6.1E-09	2.8E-09
DJAA	8.5E-03	6.1E-09	4.7E-10
EGIA	2.5E-03	1.2E-11	4.8E-09
GLGA	1.7E-04	2.9E-10	1.5E-12
GOLA	7.2E-03	1.8E-09	8.1E-09
GVLA	2.1E-04	4.1E-10	3.1E-16
JMEA	7.9E-03	9.9E-13	1.3E-10
KIRA	9.5E-03	7.7E-09	2.6E-09
LAPA	5.2E-04	8.2E-12	0.0E+00
LPIA	1.3E-02	1.7E-08	2.3E-11
LSBB	1.8E-03	1.6E-09	7.2E-14
LYRA	3.4E-02	5.7E-08	1.4E-08
MADA	5.1E-03	2.4E-08	8.0E-10
MLGA	4.9E-04	1.2E-08	4.2E-11
NOUA	1.5E-02	6.1E-08	6.0E-08
PDMA	3.7E-04	7.6E-09	4.4E-09
RKKA	6.2E-03	2.8E-09	5.9E-09
SDCA	1.2E-04	5.8E-09	1.3E-09
SOFA	6.9E-04	2.5E-09	0.0E+00
SWAA	8.1E-05	6.4E-16	5.4E-13
TLSA	8.4E-05	3.6E-10	2.4E-11
TRDA	3.0E-04	1.4E-08	3.1E-10
TROA	4.7E-03	7.9E-13	1.6E-11
WRSA	2.2E-04	6.3E-12	6.4E-10
ZURA	8.0E-05	5.2E-10	1.2E-08

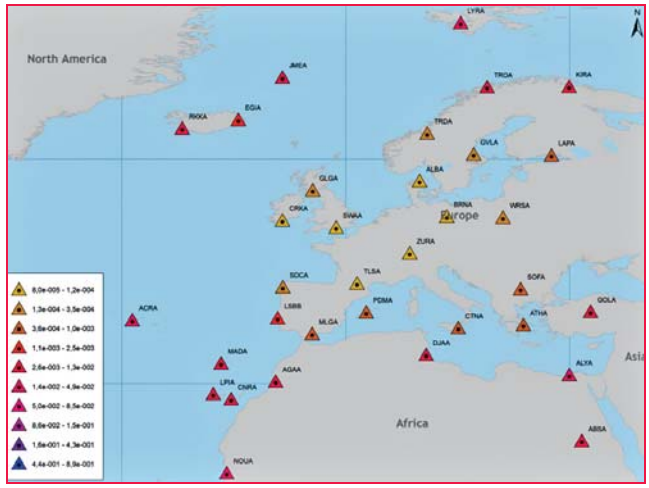

Figure 3: Continuity risk performance results within EGNOS Service Area (average continuity)

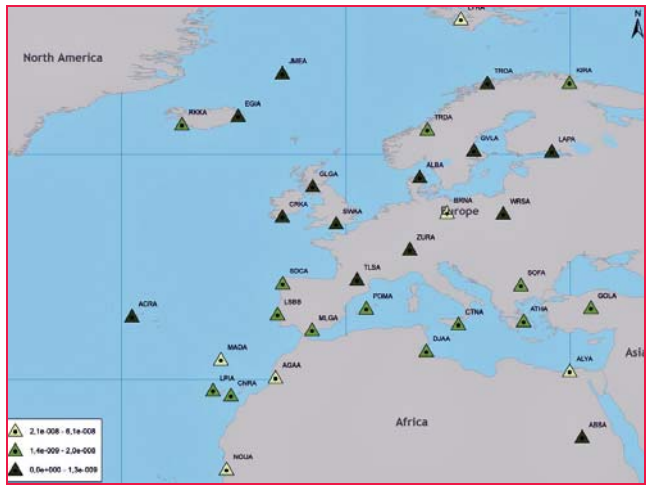

Figure 4: Integrity risk performance results (horizontal) within EGNOS Service Area

degrade from the middle towards the edge of the EGNOS Service Area. This corresponds to simulation results presented in [2]. For all stations, the ICAO requirement for Continuity is not met.

Continuity KPI performance calculations based on observables from European IGS stations showed similar results.

Integrity Performance Results

From Table 2 and Figures 4 and 5, it can be observed that the ICAO requirement for Integrity is met within the entire EGNOS Service Area. Furthermore, it can be observed that the Integrity risk performance results, in both horizontal and vertical directions, at the edge (i.e., Northern part) are not significantly worse than in the middle as it was in the case for Continuity.

Integrity KPI performance calculations based on European IGS data showed similar results.

Results With Respect To Ionospheric Storm Conditions

The selected time period was located within the solar max period of the 24th solar cycle. For that reason, the opportunity was taken to investigate influence of high solar activity on EGNOS performance. In order to investigate EGNOS performance under adverse atmospheric (ionospheric storm) conditions, PVT and protection levels calculations for two days were compared by PEGASUS: one day with high ionospheric activity ('ionospheric storm' category), and one day showing nominal ionospheric activity. This selection was based on the geomagnetic Kp-index, an indicator for solar activity at global scale. Figure 6 shows that December 8, 2013, was the only day in this period for which high ionospheric activity was measured whereas December 13, used for comparison, showed no significant ionospheric activity.

As can be seen in Figure 7, most (worldwide) geomagnetic activity were

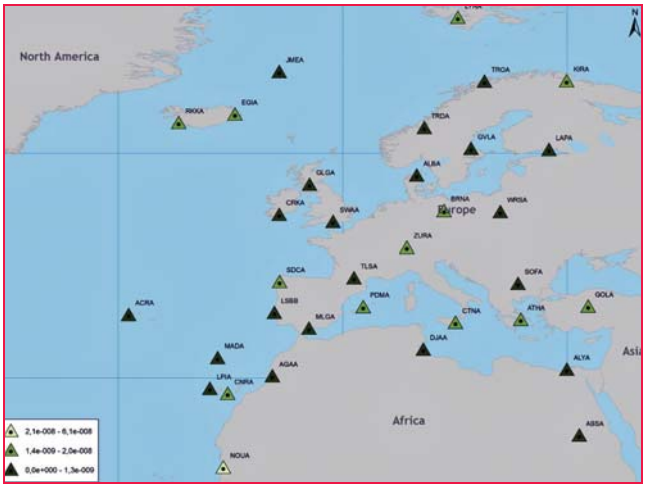

Figure 5: Integrity risk performance results (vertical) within EGNOS Service Area

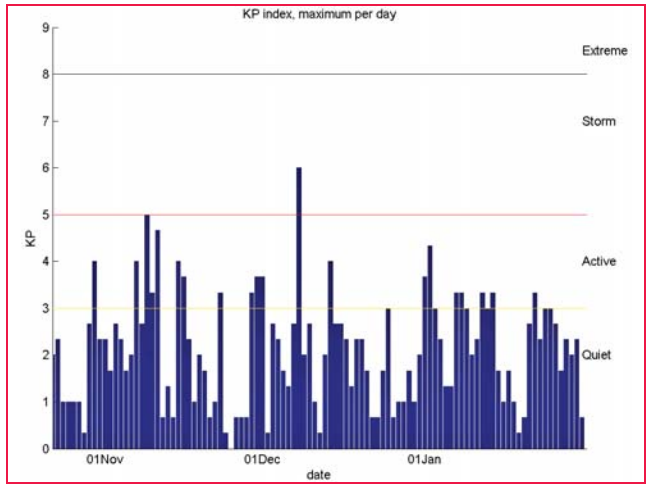

Figure 6: Geomagnetic Kp-index during the 3-month observed time period, an indication for Ionospheric activity (source: NOAA)

Figure 7: Geomagnetic Kp-index, for Decembe8th and December ,th 2013

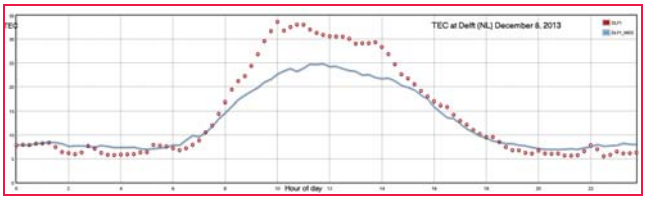

Figure 8: TEC levels on December 8th2013 relative to nominal level

present only during night time in Europe. As a result, no significant increase in Total Electron Content (TEC), see Figure 8, or - probably more important - no increase in amount of TEC - irregularities (not shown), were noticed for this day. As a result, no significant ionospheric effects were expected for December 8, 2013.

Table 3 shows statistics about the EGNOS performance results for both days at four RIMS locations ('ACR', 'TLS', 'TRD' and 'CRK'). As can be seen from Table 3, horizontal and vertical protection levels, position errors and Safety indices (SI) are slightly worse under potential high ionospheric activity compared with nominal conditions, but not dramatically so. No events of MI were observed. The preliminary conclusion therefore could be that EGNOS performance is adequate under ionospheric activity conditions. However, as only weak events could be observed within this time period, more research on this topic is required under more severe ionospheric activities in order to provide more evidence of EGNOS resilience to ionospheric activity.

Conclusions and recommendations

This paper addressed the GIMAT EVT and additional methodologies (e.g., bootstrapping) and assessed the results for EGNOS Continuity and Integrity performance with receiver and atmosphere in the loop, based on RIMS observables throughout the entire EGNOS Service Area. Thereby, Extreme Value statistics has proven to be a practical method for Integrity monitoring activities. Additional attention was given to EGNOS performance monitoring during high ionospheric activity conditions relative to nominal activity.

The EGNOS Continuity performance results are in line with simulations described in [2]. The Continuity results degrade from the center towards the edge of the EGNOS Service Area. Continuity results are not compliant with the ICAO Continuity requirement for APV-I. (This, however is expected to be only a timely problem due to the advent of Galileo SV's, which will improve DOP values.)

The EGNOS Integrity risk performance results at 95% confidence level are in line with the ICAO Integrity requirement for APV-I within the entire Service Area for both horizontal and vertical directions. Thereby, the Integrity risk performance results within the core and at the edge of the Service Area are at a similar level. In addition, over the investigated 3-month period, for all the 34 RIMS stations not a single MI event was observed.

During potential 'ionospheric storm' conditions of only limited severity (on December 8, 2013), EGNOS showed protection level and position error performances that were close to those under nominal conditions. Thus, limited reduction in KPI performance (accuracy, availability, continuity and integrity) relative to nominal ionospheric conditions was indicated. However, such

Table 3: Summary of EGNOS performance for potential high (December 8, 2013) and low (December 13, 2013) Ionospheric activity

Results	Dec. 8th ACRA	Dec.13th ACRA	Dec. 8th TLSA	Dec. 13th TLSA	Dec.8th TRDA	Dec. 13th TRDA	Dec.8th CRKA	Dec. 13th CRKA
HPL_max [m] VPL_max [m]	9.3E+02 9.7E+02	5.7E+02 7.2E+02	1.8E+01 2.3E+01	1.7E+01 2.2E+01	5.6E+01 7.6E+01	4.4E+01 7.3E+01	3.0E+01 3.4E+01	1.7E+01 2.2E+01
HPL_min [m] VPL_min [m]	9.9E+00 1.4E+01	9.7E+00 1.4E+01	6.2E+00 9.6E+00	6.2E+00 9.5E+00	5.9E+00 1.1E+01	5.8E+00 1.1E+01	6.5E+00 1.0E+01	6.0E+00 9.7E+00
HPL_avg [m] VPL_avg [m]	4.8E+01 6.0E+01	3.8E+01 4.8E+01	9.4E+00 1.4E+01	8.9E+00 1.3E+01	1.1E+01 1.7E+01	8.3E+00 1.4E+01	1.0E+01 1.5E+01	9.3E+00 1.4E+01
HPL_95 [m] VPL_95 [m]	1.7E+02 1.7E+02	1.2E+02 1.3E+02	1.3E+01 1.8E+01	1.2E+01 1.7E+01	2.0E+01 2.6E+01	1.2E+01 2.1E+01	1.6E+01 2.1E+01	1.3E+01 1.8E+01
HPE_max [m] VPE_max [m]	2.9E+01 3.4E+01	1.4E+01 2.3E+01	1.5E+00 2.9E+00	1.4E+00 2.0E+00	3.2E+00 3.9E+00	2.3E+00 3.0E+00	1.8E+00 4.3E+00	1.4E+00 2.6E+00
HPE_avg [m] VPE_avg [m]	1.9E+00 2.2E+00	1.1E+00 1.2E+00	4.5E-01 4.6E-01	5.0E-01 4.3E-01	5.5E-01 9.3E-01	3.1E-01 8.2E-01	5.7E-01 1.1E+00	5.6E-01 7.7E-01
HPE_95 [m] VPE_95 [m]	7.2E+00 8.9E+00	2.6E+00 3.8E+00	8.5E-01 1.1E+00	8.9E-01 1.0E+00	1.2E+00 1.9E+00	5.9E-01 1.6E+00	1.1E+00 2.2E+00	9.6E-01 1.5E+00
SI_H_max [-] SI_V_max [-]	1.4E-01 1.7E-01	1.6E-01 1.2E-01	1.6E-01 1.9E-01	1.7E-01 1.4E-01	1.6E-01 2.3E-01	1.4E-01 2.0E-01	1.8E-01 2.5E-01	1.6E-01 1.8E-01
SI_H_avg [-] SI_V_avg [-]	4.3E-02 3.5E-02	4.0E-02 3.0E-02	4.9E-02 3.4E-02	5.7E-02 3.3E-02	5.4E-02 5.8E-02	3.7E-02 5.8E-02	5.7E-02 7.2E-02	6.2E-02 5.7E-02
SI_H_95 [-] SI_V_95 [-]	9.3E-02 8.7E-02	8.8E-02 7.8E-02	1.0E-01 8.0E-02	1.1E-01 8.1E-02	1.0E-01 1.3E-01	7.1E-02 1.2E-01	1.1E-01 1.4E-01	1.1E-01 1.1E-01

investigation is a study on its own and more thorough investigations are required under more 'favorable' ionospheric storm conditions to confirm this indication.

With respect to the conclusions, the following recommendations are made:

- Like for all other KPIs, frequent monitoring of integrity performance should be done throughout the Service Area. For this, integrity monitoring EVT statistics is a useful approach.
- Definition of continuity does not uniquely lead to an algorithm for continuity KPI determination. Authorities (ICAO) are recommended to define a standardized algorithm for continuity determination in order to enable validation versus ICAO requirements.
- It is advised for the calculation of KPIs to take confidence intervals into account (e.g., by bootstrapping) as it was applied for the results presented in this paper.

Acknowledgements

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Choosing Suitable Map Projections for Worldwide Depiction of Electronic Charts in ECDIS

The paper provides a brief overview on the results of relevant research on the problem of the selection of suitable map projections for Electronic Chart Display and Information Systems (ECDIS). It also proposes map projections for worldwide depiction of Electronic Charts on the ECDIS screen

Athanasios Pallikaris
Professor and director of "Navigation and Sea Sciences Laboratory", Hellenic Naval Academy, Greece

International standards and industry practice on the employment of map projections for portrayal of electronic navigational charts in ecdis

The performance standards for Electronic Chart Display and Information Systems (ECDIS) published by the International Maritime Organization (IMO) as well as the international standards for Electronic Navigational Charts (ENCs) published by the International Hydrographic Organization (IHO) do not specify map projections for the display of Electronic Charts on the ECDIS screen. This lack of international standards for the employment of map projections in ENCs and ECDIS has left the choice of map projections to the manufacturer. As a result, some ECDIS systems employ map projections that bear some drawbacks and inadequacies such as:

- Poor visual perception and misinterpretations.
- Deficiency to depict Electronic Navigational Charts (ENCs) in the Arctic (ARHC 2011, ARHC 2012).

An example of poor visual perception is shown in figure 1 (Pallikaris and Tsoulos 2010). In this example we note the risk of false spatial orientation since:

- Placing the crosshair (cursor) in succession at the port of New York and the port of London, in order to obtain the geographical coordinates of these two locations, shows that the port of London is quite far north from the port of New York (more than 10º).
- Observing the position of the horizontal line of the cursor in either of these two points, give the wrong impression that the Port of London is quite far south of the port of New York. This wrong impression is enhanced by the normal practice in commercial ECDIS/ECS systems to not portray the graticule on the electronic charts covering extended geographical areas (i.e. in small scales).

The above-mentioned drawbacks and inadequacies of some ECDIS systems can be easily overcomeed by the selection of an alternative suitable map projection because in ECDIS it is not imperative to use specific map projections as it is in traditional navigation. This potentiality is true because in ECDIS the navigational computations are conducted analytically on the surface of the ellipsoid and not on the surface of the mercator and Gnomonic projections as in traditional navigation methods based on the use of mercator and gnomonic paper charts.

In practice, due to the lack of official international standards for the employment of suitable map projections in ECDIS, different commercial systems provide different capabilities and choices as follows (Pallikaris 2012):

- Some systems use only one fixed projection and the user cannot change it. If only the Mercator projection is used, the system cannot depict ENCs in the Arctic (ArHC2-09A INF1 2011).
- On some other systems the user can select between a limited number of map projections.

Figure 1: Example of poor visual perception in ECDIS (Pallikaris and Tsoulos 2010)

- On other systems the choice of the projection is conducted automatically by the system based on the location and the size of the area depicted on the screen. This automatic selection is normally done between the Mercator and the azimuthal stereographic projection. Nevertheless the automatic selection of map projections despite the inherent advantages, may in some cases cause poor visual perception and misinterpretations, as in the example of figure 1.

Research on the problem of the selection of suitable map projections for display of electronic navigational charts in ecdis

Despite the lack of official standards on the employment of map projections in ECDIS, it seems that some commercial systems have utilized the results of basic research for the effective depiction of Electronic Navigational Charts on the ECDIS screen. Unfortunately there is not written documentation for these cases, since these manufacturers have not publish, or announce the results of any relevant research. However, the results of relevant research have been detected implicitly through the evaluation of available commercial systems. An example of such implicit evidence, about research conducted, or utilized by the industry, is the capability of some commercial systems to select automatically the map projection between two alternatives. This selection is usually made between the Mercator and the azimuthal stereographic projection, in order to guarantee effective depiction of ENC in all geographical regions and overcome the inadequacy of the Mercator projection to depict polar regions. According to the results of a relevant study (Pallikaris and Tsoulos, 2010) the whatever advantages of these systems can be further improved for efficient and enhanced display of ENCs by the proper selection of map projections based on the adoption of specific selection criteria and rules. It has to be noted though that the proper choice of map projections for the depiction of ENCs on the ECDIS screen is vital for worldwide, or ocean region depiction, but for the depiction of smaller areas at medium and large scales, different map projections practically provide the same image on the ECDIS screen (Pallikaris 2012).

Concise analytical rules for the selection of map projections in ECDIS have been proposed by Pallikaris (2012). These rules suggest the choice between six different map projections according to the location and the size of the area depicted on the screen. It has to be stressed though that the choice of map projection is not necessarily unique and quite often more than one selection may fulfill equally the requirements. Moreover, in addition to the general rules and principles, it is possible to determine more specific rules and restrict the number of alternative choices for specific applications such as; the depiction of ENCs in the Arctic, the depiction over specific Ocean Regions and the worldwide depiction of ENCs. The results of a special research on the selection of suitable map projections for the depiction of ENCs in the Arctic have been recently published by Skopeliti and Tsoulos (2013). The current paper, presented in the European Navigational Conference "ENC GNSS 2014", reports on the results of another research on the selection of suitable map projections for worldwide depiction of ENCs.

Criteria and methodology employed for the identification and evaluation of suitable map projections for worldwide depiction of encs in ecdis

Basic principles and requirements

In this study, the criteria that have been employed for the identification,

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evaluation and selection of suitable map projections for worldwide depiction of ENCs in ECDIS, are based on the general principles and requirements for the selection of map projections in ECDIS presented by Pallikaris (2012). These general principles have been modified and supplemented for the consideration of the particular requirements the worldwide depiction of ENCs in ECDIS, as follows.

i. The selected map projections should be capable to depict on the ECDIS screen the image of the whole surface of the earth extending from 90° south to 90° north and from -180° west to 180° east and not a part of it as it happens with the Mercator projection and the gnomonic projection that are used in traditional navigation.
ii. In ECDIS, map projections should be dynamically parameterized and calculated so that the central point or central line of the projection coincides or approximates the center of the area displayed on the screen in order to control the amount and the distribution of angular and area distortion to limits ensuring that no serious visual deformation is generated.
iii. The employed in ECDIS map projections must have direct and inverse map transformation formulas allowing the convenient dynamic parameterization and calculation of the map projection, so that the central point or central line of the projection coincides or approximates the center of the area displayed on the screen.
iv. The shape of Great Circles (GCs) and Rhumb Lines (RLs) should depict their basic true characteristics on the spherical/ ellipsoidal shape of the earth.
v. Map projections in ECDIS should facilitate the important for marine navigation "visual perception of the relative geographical location between any two points" (spatial orientation).
vi. When possible, the selected map projections should provide visual perception of the spherical/ ellipsoidal shape of the earth, provided that, this requirement is not seriously harming other basic but incompatible requirements.

Methodology for the evaluation of map projections for worldwide depiction of ENCs in ECDIS

The analytical methodology that has been used for the identification, evaluation and selection of map projections for worldwide depiction of ENCs in ECDIS according to the above mentioned basic principles and requirements. Consists of a number of qualitative and quantitative criteria and rules, as they are briefly presented below.

Qualitative criteria for the initial selection of map projections

The initial stage of the conducted study was the determination of the set of map projections, which would be evaluated for the selection of the most suitable projections for worldwide depiction of ENCs on the ECDIS screen. The determination of this initial set of map projections has been based on the following generic qualitative criteria:

- "Ability to portray the whole globe in a familiar and pleasant view"
- "Visual perception of the relative geographical location between any two points"
- "Visual perception of the spherical/ ellipsoidal shape of the Earth"

According to the criterion *"Ability to portray the whole Globe in a familiar and pleasant view"* and after an overview of the general characteristics of all types of map projections as they are presented in standard bibliographic sources (Snyder & Voxlan 1989, Pearson 1990, Maling 1992), Conic projections and Azimuthal projections have not been selected for further evaluation for the following reasons:

i) Conic projections cannot portray the whole globe.
ii) Azimuthal projections do not portray the whole globe in a familiar and pleasant view (Azimuthal stereographic and Azimuthal Equidistant), or cannot portray the whole globe (Gnomonic).

It has to be noted that the requirement for "*Visual perception of the relative geographical location between any two points"* is incompatible with the requirement for "*Visual perception of the spherical-ellipsoidal shape of the Earth" (Palikaris 2012)*. For this reason the final selection of suitable map projections for the worldwide depiction of ENCs in the ECDIS screen has to be based eighther on on a balanced compromise between these two contradicting requirements, or, to be based on the user's precedence over one these requirements.

The criterion *"Ability to portray the whole globe in a familiar and pleasant view"* is satisfied better by the following two pseudocylindrical projections "Robinson projection" and "Loximuthal projection". These projections fulfill the requirement for v*isual perception of the spherical/ellipsoidal shape of the Earth*. The "Robinson projection" and "Loximuthal projection" satisfy partially the requirement for "visual perception of the relative geographical location between any two points", due to their property to portray parallels of latitude as straight parallels lines.

The map projections that fulfill better the requirement for *"Visual perception of the relative geographical location between any two points"* are the cylindrical projections due to the shape of their graticule (parallels and meridians are depicted as orthogonal straight lines). Cylindrical projections provide a familiar for the navigator view due to their strong visual resemblance to the Mercator projection. However, cylindrical projections do not fulfill the criterion *"Visual perception of the spherical/ellipsoidal shape of the Earth"*.

Based on the above mentioned qualitative criteria and after a comparative study of the basic characteristics of the known map projections as they are presented in standard bibliographic sources (Snyder & Voxlan 1989, Bugayevskiy & Snyder 1989, Grafarend and Krumm 2006) the following map projections have been selected for further evaluation:

- Loximuthal Projection
- Robinson Projection
- Simple Cylindrical Equidistant Projection, with standard parallel at the equqtor, known as Plate Carrée
- Cylindrical Equidistant Projection with standard parallels at ±30°, ±30° and ±45.

- Cylindrical stereographic Projection, with standard parallel at the equqtor, known as Braun projection
- Cylindrical stereographic projection with standard parallels at ±30°, known as BASM (Bol'soy Sovetskiy Atlas Mira cylindric projection) Projection
- Cylindrical stereographic projection with standard parallels at ±45°, known as Gall Stereographic Projection
- Miller Cylindrical Projection
- Miller Cylindrical Modified Projection

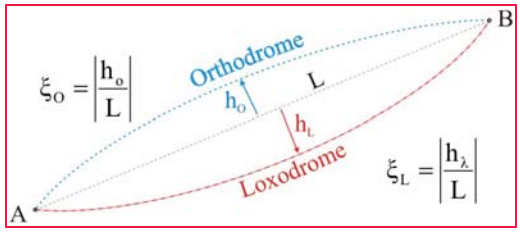

Figure 2: Loxodromicity and Orthodromicity factors (Pallikaris 2012)

Quantitative criteria for the evaluation of map projections

The second stage of the study was the conduction of analytical evaluation of the set of map projections that has been initially determined according to the above mentioned qualitative criteria. The analytical evaluation of these map projections has been conducted by the employment of the following quantitave criteria:

- "Amount and distribution of angle distortion"
- "Amount and distribution of area distortion"
- "Orthodromicity factor and Loxodromicity factor"

The criterion of the "*Amount and distribution of angle distortion"* and the criterion of the *"Amount and distribution of area distortion"* have been used in correlation to the tolerances for enhanced visual perception suggested by Bugayevskiy & Snyder (1989). According to these tolerances:

- Area distortion of values less than or equal to 8-10% is not usually detected by the human eye.
- Area distortion of values 10% - 12% is slightly detected by the human eye.
- Angle distortion of values less than or equal to 8-10% is not usually detected by the human eye.
- Angle distortion of values 10% - 12% is slightly detected by the human eye.

For the display of ENCs over regional geographical areas the selection of proper map projections can guarantee that the values of angle distortion and area distortion are kept within tolerances ensuring that no serious visual distortion is generated. Nevertheless for worldwide or hemisphere depiction it is not possible to choose a map projection in which both angle distortion and area distortion will not be detectable. For this reason, in the conducted study the criteria of angle distortion and area distortion have been used in a flexible way aiming to a reasonable compromise between the contradicting requirements for the restriction of both angle and area distortion.

The criterion of the *"Orthodromicity factor and Loxodromicity factor"* is used for the assessment of the shape of long navigational paths on different map projections (Pallikaris 2012). The values of the loxodromicity factor ξ_L and the orthodromicity factor ξ_o are given by [1] and [2].

$$\xi_L = \left|\frac{h_\lambda}{L}\right| \quad [1]$$

$$\xi_O = \left|\frac{h_o}{L}\right| \quad [2]$$

Where:

- L is the length of the straight line segment connecting the points of departure and destination on the projection (fig 2).
- h_O and h_L are the maximum distances of the line of the Great Circle (GC) or the Rhumb Line (R_L) from the straight line segment connecting the points of departure and destination on the projection (fig 2).

In addition to the employment of the above-mentioned criteria for the conduction of numerical tests, the final evaluation of the initially selected map projections, has been also based on the results of the comparative study of the general characteristics of these map projections.

Results of the numerical tests and comparative study

The analytical evaluation of the map projections that have been initially selected according to the generic qualitative criteria has been conducted by the employment of the quantitative criteria as follows:

The criteria of the *"Amount and distribution of angle distortion"* and the criterion of the *"Amount and distribution of area distortion"* have been employed by:

- The calculation of the amount and the distribution of angular and area distortion for each projection and the construction of relevant graphs as those of figures 3 and 4. The calculation of angle distortion and area distortion has been carried out by the employment of the relevant formulas provided by Bugayevskiy & Snyder (1989).
- The construction of maps showing isolines of area distortion for each projection as the maps of figures 5, 6 and 7.
- The construction of maps showing isolines of angle distortion for each projection as the maps of figures 8 and 9.

The construction of the maps depicting isolines of distortion and the maps depicting long navigational routes (Rhumb Lines and as Great Circles) has been done by the support of the S/W Matlab Mapping Toolbox after some necessary modifications of the original matlab code for some applications for the evaluation of the Miller Cylindrical Modified Projection.

The criterion of the "Orthodromicity factor and Loxodromicity factor" has been employed for the evaluation of the shape of Loxodromes and Orthodromes by the construction of maps depicting long navigational routes as Rhumb Lines (RLs) and as Great Circles (GCs) like the maps of figures 10 and 11. The criterion "Orthodromicity factor and Loxodromicity factor" has to be employed

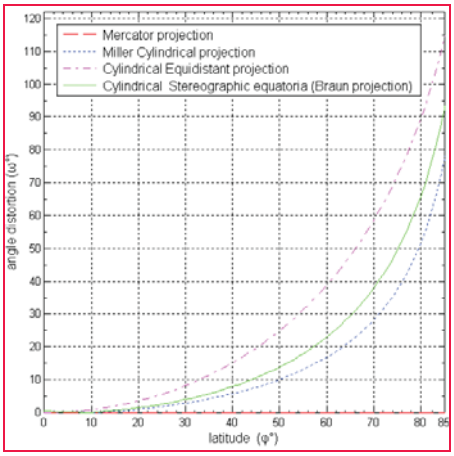

Figure 3: Angle distortion in various cylindrical projections

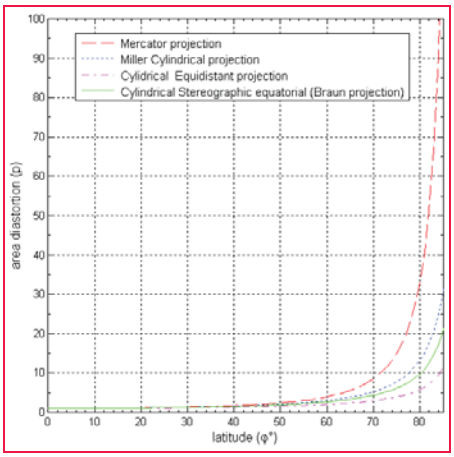

Figure 4: Area distortion in various cylindrical projections

as follows: Map projections, in which the orthodromicity factor ξ_O is smaller than the loxodromicity factor ξ_L, provide better visual perception of the true relation between the lengths of GCs and RLs. The explanation is that the condition $h_O > h_L$, implies that the line depicting the orthodrome is shorter than the line depicting the loxodrome between the same points of departure and arrival (figure 2).

In cylindrical projections, the loxodromes are practically depicted as straight lines, and consequently the values of the loxodromicity factor [1] for these projections are all equal to zero. Therefore, the assessment of the shape of long navigational paths in the evaluated cylindrical projections has been restricted only to the shape of orthodromes and has been conducted by the calculation and compareson of the values of orthodromicity factors as follows.

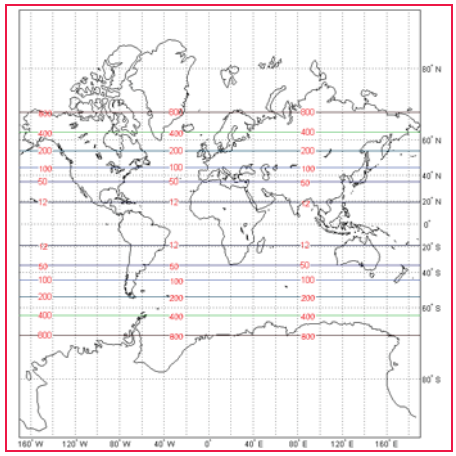

Figure 5: Isolines of area distortion in Mercator Projection

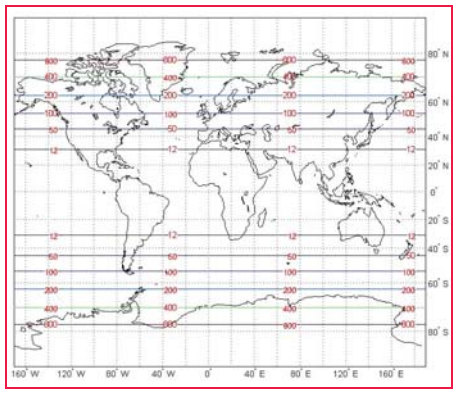

Figure 6: Isolines of area distortion in Miller Cylindrical Modified Projection

Cylindrical map projections with smaller values of the orthodromicity factor should be preferred against other cylindrical map projections, which have greater orthopdromicity factors (smaller values of the orthodromicity factor provide perception of shorter length of the portrayed navigational path - orthodrome).

The conducted comparative study and the analysis of the results of the numerical tests for the evaluation of the map projections that have been selected showed that:

Potential suitable map projection for worldwide depiction of ENCs on the ECDIS screen have to be looked for among the families of pseudo-cylindrical projections and cylindrical projections.

For the worldwide depiction of ENCs on the ECDIS screen, the best choice between cylindrical map projections is the Miller Cylindrical Modified Projection with standard parallelς at 30°. This projection restricts considerably the great area distortion of the Mercator projection and retains angle distortion to acceptable limits (≤12°) over extended geographic coverage of latitudes on the zone [-63.5°, 63.5°].

For the depiction of ENCs over wide geographical areas, other cylindrical map projections are more suitable than the proposed for worldwide depiction modification of the Miller Cylindrical Modified Projection. For example the Mercator projection with standard parallels at latitude 15° S and 15° N, provides optimum distribution of area distortion (≤12%) over a broad and continuous latitude zone extending from 24° S to 24° N.

For the worldwide depiction of ENCs on the ECDIS screen, the best choice between pseodo-cylindrical map projections appears to be the Loximuthal Projection for the following reasons:

The Loximuthal projection has the special property that from the central point (the intersection of the central latitude with the central meridian), Rhumb Lines (loxodromes) are shown as straight lines, true to scale, and correct in azimuth from the center (Snyder and Voxland, 1989).

The Loximuthal projection has simple map transformation formulas, allowing a convenient incorporation of this projection into ECDIS as well as its dynamic parameterization by the selection of the central point of the projection in the center of the displayed area.

Unlike the Loximuthal projection, the Robinson projection does not provide the capability to be dynamically parameterized, because this projection is materialized by tabulated (x, y) coordinates instead of map projection formulas.

Despite the fact that the Loximuthal Projection in its standard equatorial form has slightly greater area and angle

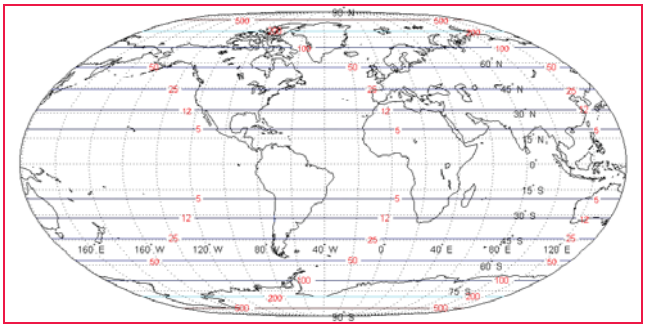

Figure 7: Isolines of area distortion in Loximuthal Projection

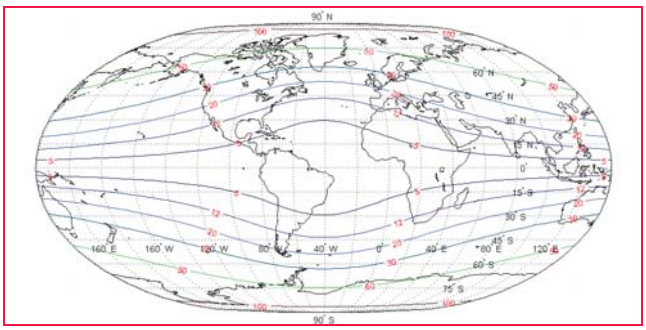

Figure 8: Isolines of angle distortion in Loximuthal Projection

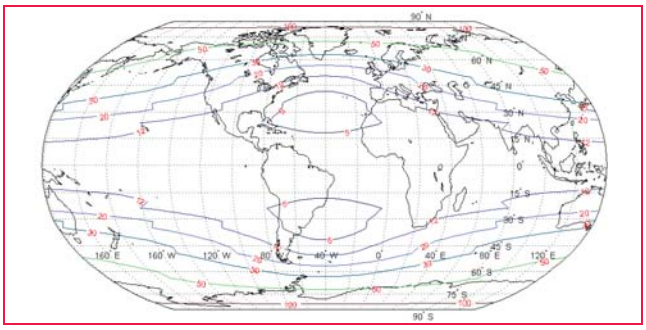

Figure 9: Isolines of angle distortion in Robinson Projection

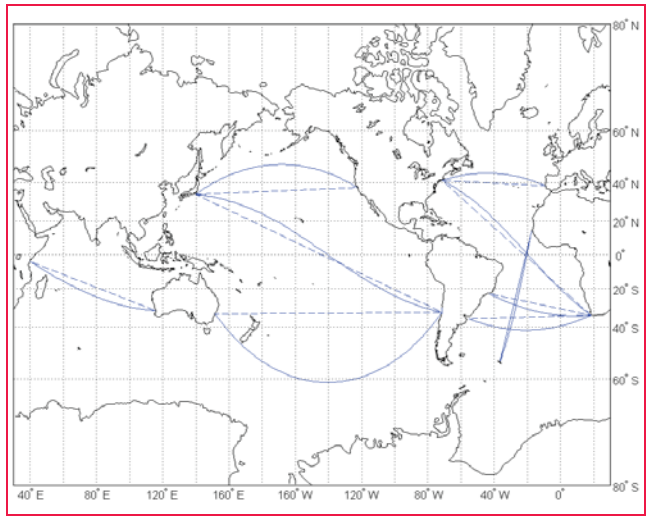

Figure 10: Long Navigational paths on the Mercator Projection

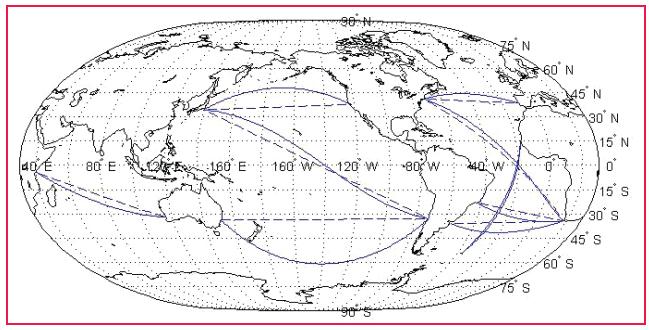

Figure 11: Long Navigational paths on the Loximuthal Projection

distortion than the Robison projection, it is possible to reduce distortion to values smaller than those of the Robinson projection by the selection of the central point of the Loximuthal projection on other than the equator standard parallel.

The amalgamation the above-mentioned findings, leads to the following general rules for the evaluation and selection of suitable map projection for worldwide depiction of ENCs on the ECDIS screen.

- If the interest of the user is focused on ocean areas that cover both the South and the North hemisphere, then the Miller Cylindrical Modified Projection with standard parallel at 30° should be used.
- If the interest of the user is focused on ocean areas over one hemisphere, then the Loximuthal Projection with its central point on the parallel of 15° (North or South) should be used.

Conclusions overview and proposals

The selection of a suitable map projection for worldwide and wide area depiction of ENCs on the ECDIS screen is vital. However for the display of ENCs over smaller areas, different map projections provide practically the same image on the ECDIS screen and therefore, in these cases the choice of a particular map projection is immaterial.

For the worldwide display of ENCs on the ECDIS screen the employment of the Mercator projection has two basic disadvantages: “inadequacy to depict ENCs at very high latitudes” and “big magnitudes of area distortion”.

In any case the selection of a suitable map projection for the depiction of ENCs on the ECDIS screen is not unique. Usually more than one projection fulfill satisfactory the requirements for effective display over a particular area (worldwide, regional, local).

The conducted study and the relevant numerical tests and comparisons showed that suitable map projections for worldwide depiction of ENCs on the ECDIS screen are the Loximuthal Projection and the Miller Cylindrical Modified Projection with standard parallel at 30°. For the display of areas over low and mid latitudes, the selection of other cylindrical projections provides slightly better results.

Conclusively, ECDIS can offer enhanced worldwide depiction of ENCs by the employment of the Miller Cylindrical Modified Projection with standard parallel at 30° and/or the Loximuthal pseudo-cylindrical projection. If the interest of the user is focused on ocean areas that cover both the South and the North hemisphere, then the Miller Cylindrical Modified Projection with

standard parallel at 30° should be used. If the interest of the user is focused on ocean areas over one hemisphere, then the Loximuthal Projection with its central point on the parallel of 15° (North or South) should be used.

Acknowledgement

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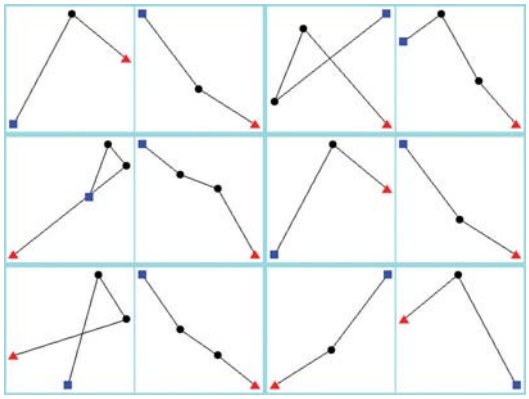
RTK Verification

Javad,
Just a note of appreciation. Thank you for implementing so many of my requests. We're doing real work with this receiver: boundary, topographic and staking. The staking routines are very productive. Every release of the software gets better and better. The hardware is solid, showing great promise in a range of environments. I was skeptical of the all-in-one box approach, but you are winning me over every time I take it out. You're breaking new ground and this system is unlike anything I've ever used.

Shawn Billings
Billings Surveying and Mapping Company



RTK Verification

Fundamental in the determination of GNSS solutions is calculating the correct number of full wavelengths (so-called ***fixing ambiguities***) in order to figure out the distances from the satellites to the receiver. In doing Real Time Kinematic (RTK) surveying, we need it fast and we need it to be correct.

Multipath, the reflections of GNSS signals from nearby objects and structures, create their own indirect measurements from the satellites to the GNSS receiver. It's as if your measuring tape is bent around an obstacle like a tree instead of a free and clear line of sight between two points.

No calculator is going to improve that result. This sort of indirect measurement is analogous to the issue involved with GNSS signals when they're being reflected from nearby objects, including the ground. Worst case is when the receiver doesn't see the direct signal at all; e.g., the satellite is behind a building, but it's still receiving the signal reflected off of the nearby structure. Such indirect signals are usually strong, unhelpful and misleading.

The other aspect impacting the veracity of a fixed solution is when there are weak GNSS signals. Frequently, weak signals are due to their penetration directly through tree canopy.

While ***J-Field*** can't move the obstacles that are creating multipath out of the way, its sophisticated engineering is designed to handle even the weakest signals like no other system with its ***RTK Verification System*** (patent pending).

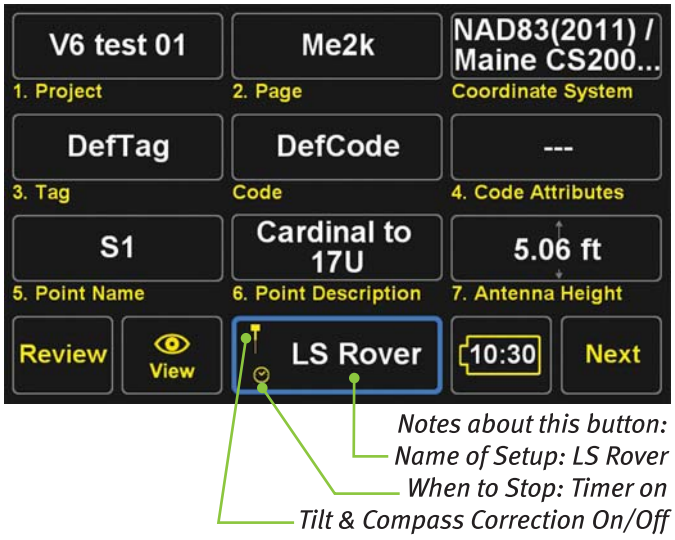
J-Field uses six RTK engines running in parallel and that are solely devoted to isolating the indirect signals by using different sets of satellites, each engine with its own and differing criterion. If too many of the signals are indirect, no solution may be found. Remember, indirect signals are analogous the bent measuring tape! ***J-Field***'s robust set of engines are tasked with finding these indirect measurements and then removing them. When you're doing RTK surveying, observe your environment and come to recognize that the structures around you are like mirrors for GNSS signals.

J-Field provides the option for you to specify the ***Minimum Number of Fixed RTK Engines*** in verifying solutions ***N*** times before a position is automatically accepted where ***N*** is a user defined value (up to a total of 16 times).

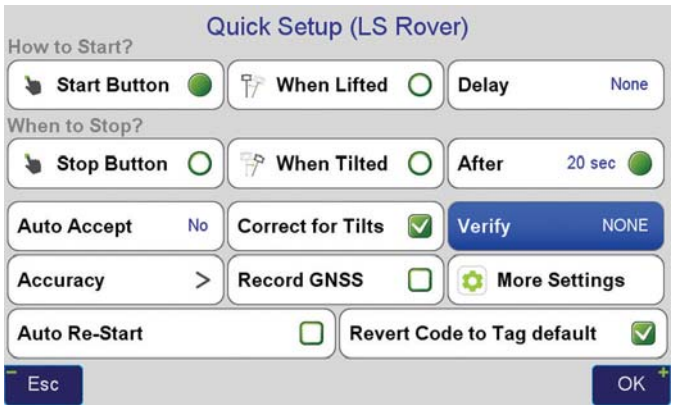
Procedure

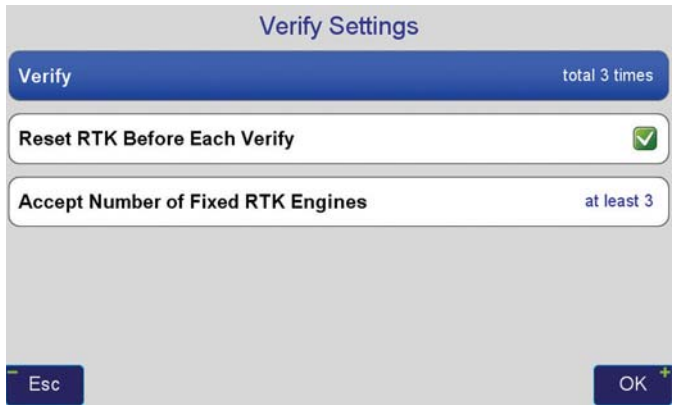
As of J-Field beta v1.10.3.12842, begin by making sure that you have selected "When To Stop" as "Timed". This is necessary in order to activate the automated RTK Verification System. The timed observation session option is easy to turn on and only one tap away.

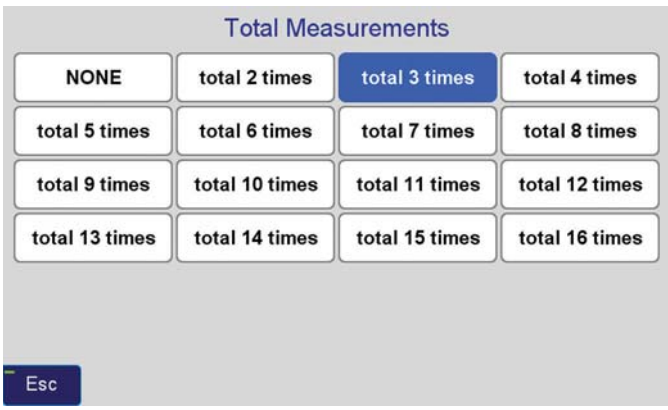
In Collect screen1 (Collect Prepare), tap on the lower middle button shortcut to quickly modify details of your Setup by bringing up the Quick Setup screen. It's worth noting that this pertains to your

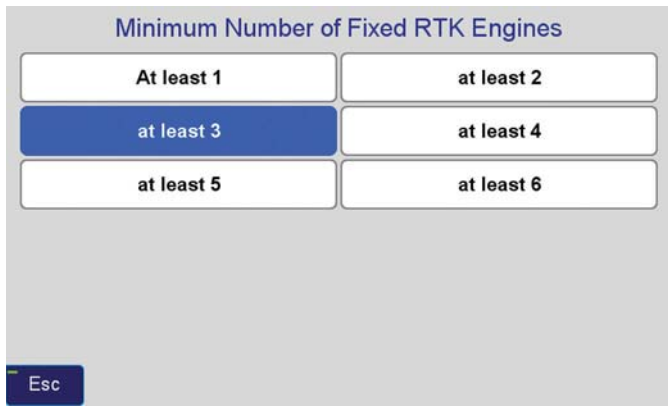


currently active setup. In the example above the name of the setup is LS Rover. The changes you make through the Quick Setup screen are retained (saved) automatically allowing for easy recall of other previously defined setups.









In this example, the timer will stop the session after 20 seconds, but you can choose any length of time that suits your needs and in combination with your previously determined epoch interval.

You can also completely change setups by tapping on More Settings which will bring up the main Setup screen allowing you to recall the one you want and then return immediately back to the Quick Setup screen.

Next, tap on Verify to 1) set the number of times (N) that automated verification will take place (or to NONE), 2) turn on the RTK Verification system - Make sure to check the box "Reset RTK before Each Verify", and 3) to specify the Minimum Number of Fixed RTK Engines in verifying solutions N times. Once you've settled on your RTK Verification System settings you'll be returned to the Collect Prepare screen, tap Next or press the Action key.

From the Map Screen you can quickly make adjustments to your RTK Verification settings and to check in on the RTK Engines' status by tapping on the upper left box displaying STN, FLT or FIX.

Javad's recommended settings: Timer set to 10 seconds; Verify 3 times; minimum number of RTK engines 1 or 2.

See the next two illustrated anatomy of these two screens.

Screen Anatomy – RTK V6

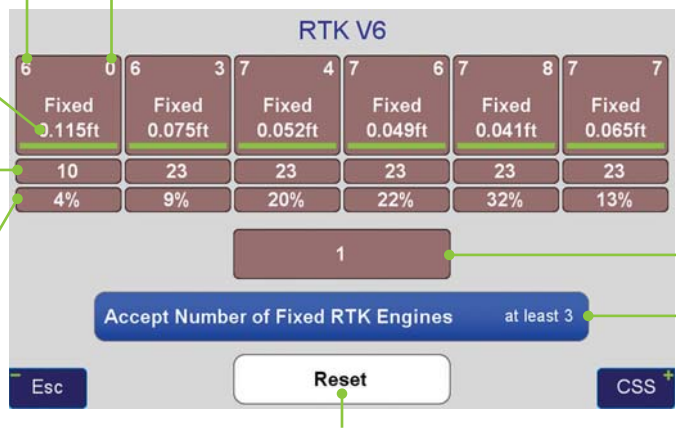
GNSS satellite count used in given engine

GPS *GLON*

Overall HVRMS for current epoch in given engine

Number of seconds since the last reset for a given engine

Percentage of weight assigned to given engine in contributing to the overall solution



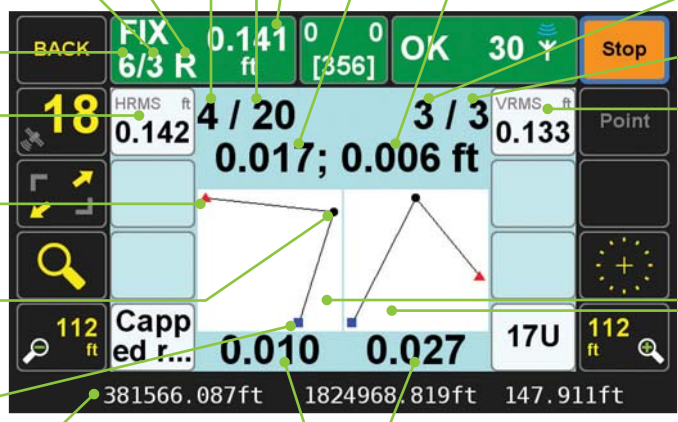
A user definable threshold showing delay in seconds in receiving corrections from base; values up to 30 seconds are acceptable (OK) causing only a few mm of error; if you're broadcasting your FCC call sign, expect to see its brief interrupting effects every 15 minutes here and elsewhere; e.g. hand scanner, Action screen and UHF status screen.

Tap this button to change the Minimum Number of FIXED RTK Engines to use for automated verification.

Manually reset engines to compell new fixed solutions when automatic verification is turned off (unchecked)

Screen Anatomy – Map Screen

a/k/a Action Screen and Collect screen2



Epoch duration for current obs session

Instantaneous RMS estimate from engines (not of points)

*RTK engines are being (**R**)eset before each verification or (**N**)ot*

Current epoch for current obs session

** at the end of Verify sets values shown are the total RMS of all sets*

*RMS of the current Verify set and average of all engines used**

Minimum number of fixed RTK engines required before solution is acceptable

Horizontal *Vertical*

Verification current

Number of fixed RTK engines (6 max)

Verification total set

Horizontal RMS for current obs session

Vertical RMS for current obs session

Red triangle current position

Dynamic graphical indicators of the RTK engines at work during verification showing on the left the horizontal and on the right the vertical (H) positions

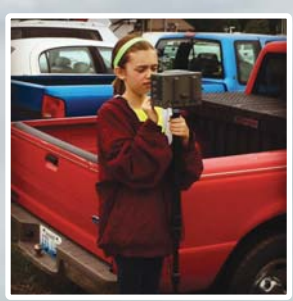
Black dot(s) previous position(s)

Blue square first position

Scale

Coordinates of current position

Please refer to the section of the guide discussing the Collect screen for further detailed information



So easy my 12 year old can do it.

Matthew D. Sibole, PLS

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

Matt Johnson, PE

Here are some photos of my boys helping me survey out in the desert yesterday.

Jack M. Smith

I worked with the TRIUMPH-LS and Triumph-2 today for a few hours. I was impressed with the ability to get a good repeatable fix in pretty thick tree cover.

I also was able to localize on an assumed coordinate system without too much trouble. I don't do this very often but was able to localize three times today (2 times just to write down try and memorize the process).

Matthew D. Sibole, PLS

VICTOR-LS

Rugged

hand-held controller

with J-Field

application software.

See **www.javad.com** for details

On high quality Courseware-Making strategies

Some high quality Courseware-Making strategies are summarized in this paper, and then their teaching efficiency in space geodesy has been compared and analyzed

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Courseware, which is centered on a computer, is a kind of modern teaching technology based on digital processing techniques and audio-visual technology. Courseware can store, transmit, process, convert and search teaching materials by integrating a variety of media information such as words, voice and images and so on, according to teachers' teaching design[1-3]. Courseware is able to improve the effect of teaching because it has many advantages such as vivid, not restricted by space-time, easy to accept by student and so on, which could activate class atmosphere, motivate students' thirst for knowledge and improve students' interest[1]. However, some problems still exist in Courseware-Making. This paper has listed some suggestions to Courseware-Making based on authors' Courseware-teaching experience, and then we have talked about its usage in Space Geodesy teaching.

The problems in Courseware-Making

The key point is not outstanding

It mainly manifests in the following respects: Firstly, all slides are put together, colors aren't matched harmonically and layout is arranged unreasonably. Thus, part of contents cannot be seen clearly and the Courseware is short of sense of beauty, thus it can hardly attract students' interests. Secondly, superficial form flashy is overemphasized, a variety of unnecessary pictures, videos and voice materials are used in Courseware. Thus the form will cover up the contents, and students' attention will be dispersed[2]. Thirdly, teaching materials without select are all written on Courseware, even some teaching contents that can be better shown by experiments and object-demonstration are demonstrated with slides, so the Courseware is the reprint of the textbook contents. This single-form Courseware doesn't give play to the advantage of multimedia instruction, and it is easy to tire students in auditory and visual.

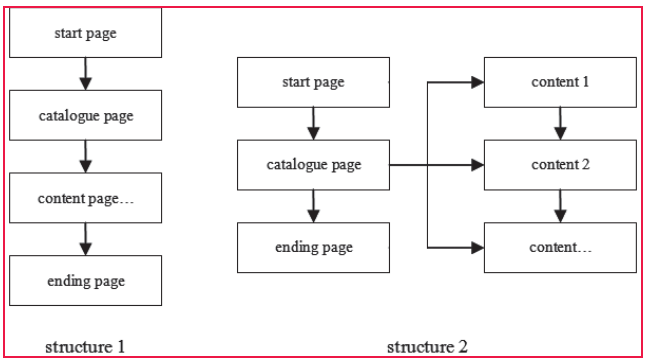

Figure 1: Two common courseware structures

Hierarchical structure and navigation lack clarity

Hierarchical structure and navigation in Courseware provide a 'roadmap' for learners to search what they want to know. But at present, most of the Courseware employs structures which are showed in Figure 1. Structure 1 starts with a headline and catalogue, and then with endless content, at last ends up with 'Thank you'. This kind of structure will not be easily understood by students and then lose focus in class. Structure 2 is also called 'link type'. This hyperlink is used in the catalogue page to allow users to skip to the content page and it is also employed to skip to the catalogue page when each chapter is completed. Compared with structure 1, structure 2 can let students easily master Courseware structure and catch up with the thoughts of teachers. But according to students' feedback, some teachers are not skilled in using hyperlink in classroom teaching, and incorrect operations often occurred in class. Thus, originally clear structures become chaotic due to wrong navigation.

Lack of materials

Currently, most of the courseware only shows listeners some simple and intuitive experiments in the form of video or animation on the screen. Although it assisted in teaching, its contents are insufficient to reflect the characteristics of large information and the wide range of knowledge that modern teaching methods own. Also, few people formulated the courseware with difficult concepts. Some of the courseware only involves 5 or 6 materials, and most of them are the illustrations in the textbook. But in fact, teachers need to provide some other related contents in their actual teaching.

Lack of frontier

As a result of computer multimedia technology, the development cycles of a courseware is shorter than traditional methods. Therefore, it should reflect the fast changes and improvements of teaching contents, especially some of the cutting-edge professional contents. However, a lot of users just move the contents of the book on the courseware, and rarely update it. So, on one hand, it does not embody the advantage of development speed of courseware, and on the other hand it also lacks flexibility.

Lack of interactivity

The fundamental feature of courseware is interactivity, which is conducive to teachers trying to master how students learn, making the teaching plan and adjusting lectures. Courseware design should fully reflect this characteristic. However, many teachers always over look this point. They mainly focus on the presentation of the courseware, occasionally with some explanations, or just list answers of some questions. In this case, students almost have no time to ask or think, and have no space to extend thinking and imagination. So it's harmful to the students.

Strategies

Some strategies are summarized based on the author's teaching experience to solve the above problems.

Optimize the Courseware on the base of students 'noting' the visual psychology

Psychological studies have pointed out that the learning process does not start from the beginning of sensory generated from stimuli of the outside world, but from the individual's learning motivation and the resulting selective attention of the sensory information. Therefore, there is no learning when no irritation occurs. And we can optimize the Courseware from the following features:

Selective: The clearest part in a person's vision is the central part, so the theme and the most important features should be highlighted when presenting teaching information with multimedia courseware.

Simplicity: Irrelevant and redundant details should be deleted in the courseware background. Novelty: New stimuli is not necessarily used for attracting the attention of learners, as long as there is obvious contrast and differentiation before and after stimulation, such as certain flashing or underlined text, drawing arrows, adding borders and so on. However, when applying novel means, students' attention should not be led to the novel means itself, but attempts should be made to try and led to the contents.

Optimize the Courseware with learners' 'concept formation' rule in cognitive psychology

To help learners grasp basic concepts is one of the most important teaching missions. When learning the concepts, the students should not only remember all relevant names and definitions, but also acknowledge the common attributions between different items by using a series of examples so that they can extract and form concepts from the examples. In order to assist the learner to form concepts efficiently, here are some suggestions for the teachers: First, use examples rather than definitions. Teachers should follow the steps from examples to attributions to definitions in teaching in which the multimedia courseware is used. In that way, the learner can achieve the leap from perception to rationality. Second, positive examples should be used as well as negative examples. The learner often can't understand all the attributions of the concepts deeply. Only by comparing the positive aspects with the negative, can the learner grasp a concept completely and correctly. Thirdly, it is more practical to list an attribute table than use words to define the concepts. The attribute table is clear for the learner so it can be impressed upon deeply. Moreover, the attribute table which helps the learner grasp the main attribute of concepts immediately so that the learner can form the concepts effectively, is more simple and obvious than sentences, which is boring causing the learner to forget it soon.

Schedule reasonable hierarchical structure

A whole Courseware can be divided into front page, overview page, catalogue page and conclusion page on the basis of different functions. The basic design style of these pages should be consistent, but small differences which are helpful for learners to distinguish different parts is also necessary. Good page layout will make Courseware coherent and clear. The application of catalogue page is

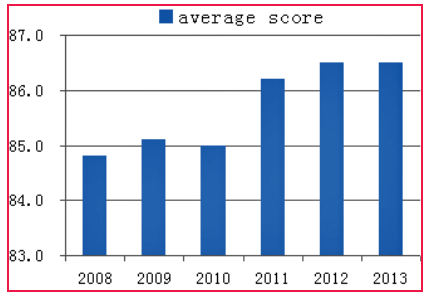

Figure 2: statistics of average score from 2008 to 2013

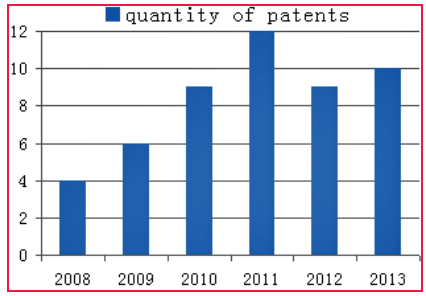

Figure 3: statistics of patents from 2008 to 2013

Table 1: published SCI and EI papers from 2008 to 2013

	2008	2009	2010	2011	2012	2013
SCI	4	10	9	13	16	20
EI	11	20	28	32	36	36

very important to hierarchical structure. Catalogue page plays a role of reminding students that it will move onto the next part. According to previous experiences, we recommend a simple but effective method: Make a catalogue page first, and then show the listener the catalogue page in which what would be taught next by will stand out by using bold words when entering into the next part. In addition, different colors and significant pictures can be employed to differentiate catalogue pages, and with the change of colors and images the next part of content will come up.

Establish personal Courseware material library

It is necessary for every teacher to set up a personal Courseware material library. Teachers should always accumulate materials in relation to their teaching content, and it will also be helpful for Courseware Making in future.

Compare and analysis of Space Geodesy teaching results

The author progressively applies the above Courseware-Making strategies in the teaching of Space Geodesy in recent years. In order to verify the practicality and validity of these strategies, some aspects like students' average score of Space Geodesy, patents and published papers in relation to Space Geodesy have been compared and analyzed in this paper by using the recent statistical data of 6 years (2008~2013) associated with Space Geodesy, which comes from School of Geodesy and Geomatics, Wuhan University.

Figure 2 shows the statistics of students' average score of Space Geodesy from 2008 to 2013, and from it we know that students' average score presents an increasing trend, except in 2010. Figure 3 lists the patent quantity in relation to Space Geodesy from 2008 to 2013. Tab.1 displays recent 6 years' published SCI and EI papers associated with Space Geodesy. Figure 3 and Tab.1 both have indicated that research and innovation ability have improved. From the above comparison and analysis, we know that the teaching level of Space Geodesy has been improving with the step-by-step application of high quality Courseware-Making strategies. This fully proved the efficiency of these strategies.

Conclusions

Multimedia teaching can make up for the deficiencies of traditional teaching, which make it rigid, dull and bald. Some innovative projects have been summarized to solve the problems in Courseware-Making in the base of author's teaching experience, and then its validity has been proven by comparing Space Geodesy teaching results. Courseware Making is a systematic work; and the author will master better strategies in future teaching on the basis of students' feedback and self-summary.

Acknowledgments

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[1] Lin Liu. Introduction of some principles and skills to Courseware Making [J]. Journal Of Guangxi Financial College,2004,17(2 Suppl):83-84.

[2] Qili Wang. Existing Problems and Solutions to Multimedia Courseware Manufactory [J]. Journal of Xi'an Aerotechnical College,2005,23(1):51-53.

[3]Kekang He, Yongbai Zheng, Youru XIE.Instructional System Design [M]. Beijing: Beijing Normal University Press,2002.

At a Glance

- SSTL wins Best Aerospace and Defence company at the Made in the UK Awards
- 1Spatial Awarded Major UK Ministry Of Defence Aeronautical Contract
- SuperGIS Training Centre in Geomatika University College, Malaysia
- Stonewall Surveying raises $1820 for Barrington charities
- Hexagon Geospatial Partners with Geoimage in Australia
- GPS Insight Receives 2014 M2M Evolution Asset Tracking Award
- Bentley's enhanced AssetWise APM V7.2 released
- NGA awards BAE Systems contract worth $335 mn
- Peru uses drones to study ancient Inca ruins
- TomTom launches real-time traffic service in Turkey
- USGS updates FEMA with 3D maps
- TerraSond wins NOAA's hydrographic surveying contract
- US national seismic hazard map updated
- Brazil, China sign MoU to share remote sensing data
- Auracle Geospatial to sell Skybox's imagery in Canada
- Skybox imaging launches SkySat-2
- Fugro acquires Geofor to strengthen its market position in Africa

KOPOS – Kosovo Positioning System

KOPOS system provides opportunities for carrying out unified, highly accurate, efficient and long-term sustainable measurements in the future

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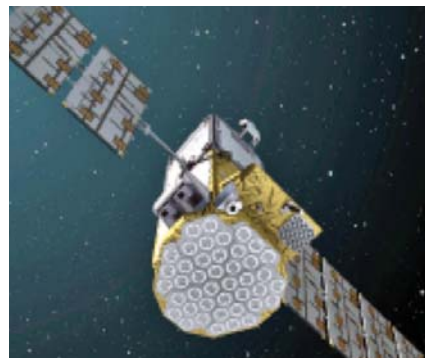
The set of satellite systems for global navigation that are functioning or are expected to be launched in the future, in English are called GNSS (Global Navigation Satellite Systems), whereas in Albanian it will be SSNG (Sistemi satelitor për navigim global). This system allows determining the position in the whole globe with an accuracy of two or three meters by even using simple equipments [DMA, 1991], [Farrell & Barth., 1999]. The possibility of civil use of these military systems has led to pioneering development in traffic enforcement, logistics, construction industry, tourism and many other technical fields and beyond that.

Some of these systems have been listed below:

- **American global positioning system (GPS)**
  Launched 1978, this system was fully configured in 1994, whereas from January 2009 it has in total 32 GPS satellites. These satellites emit radio waves: L1, L2, (L5) that are carriers of frequencies; C/A and since 2005 civil codes L2, and after 2012 civil codes L3C; P code in frequencies L1 and L2.
- **GLONASS, Russian global navigation satellite system**
  This system was launched in 1982, but its full configuration has not yet been done, whereas from January 2009 it has in total 17 satellites in use. GLONASS satellites emit radio waves: L1, L2 that are carriers of frequencies, codes L1 and L2 C/A, then L1 and L2 P-codes.

- **European system GALILEO**
  This system was launched in 2006, its full configuration and usage is expected in 2015. The satellites of GALILEO system emit radio waves L1, E1, E2, E5 and signals E6.

While using L2C and L3C, it is possible to determine ionosphere parameters. Therefore, the aim is to have a precise geodetic positioning without differential positioning techniques. L2C frequency carriers have better quality then L1, while allowing better tracking of low



satellites. L5 is designed in such a way that it would be least affected by effects of many trajectories.

Nowadays, these systems work independently from one another. The user works with one of these systems depending on the receiver selected. The American GPS system currently is used in most of cases. In geodetic applications, more and more receivers that can elaborate signals from GPS and GLONASS are used. In Europe, the European Geostationary Navigation Overlay Service (EGNOS) complements the GPS system with additional satellites, which leads to improved accuracy and reliability of measurement of the position in Europe. This is considered an advantage and cooperation between GPS and GALILEO systems.

Since the GALILEO system is multi-dimensional, it will play an important role in future applications.

In communicating with satellites in the space, the receivers determine the positions of the objects where they are fixed. The receivers should communicate with at least four satellites in the space for determining (calculating) its position. The accuracy and reliability of the GNSS systems, which are currently available, have restrictions (limitations) in presenting the common accuracy of GPS for civil works up to +1 - + 3 meters.

This technology with its new access has created the idea for modeling all errors (bugs), such as: time determination and errors in orbit, obstruction of satellite signals in their way through ionosphere and troposphere up to the point where the GNSS receiver is located for determining the correction of the observed data over unknown points.

The responsibilities of Kosovo Cadastral Agency regarding national network are foreseen by Law on Cadastre, [Law No. 04/-L-013]. These responsibilities start from the maintenance of referent network up to the maintenance of cadastral map, cadastral measurements and protection of cadastral boundary signs. Digital cadastre as a vision, but not to remain only a vision [Steudler 2006] is clearly being implemented from Kosovo Cadastral Agency for collecting and processing cadastral data in the framework of NSDI (National Spatial Data Infrastructure). All the measurements from now on, if there are no physical obstacles will be supported by KOPOS as a general and permanent national referent GNSS system.

Regular maintenance and development of cadastre will be always based on the main geodetic state network. After 1999, KCA began consolidating cadastre in Kosovo, the main task being observation of the state geodetic reference network. After observing and analysis, it has been concluded that the activity should begin with stabilization adjustment of the points in the field as a base for starting cadastre maintenance and its further development.

The principle of setting the position

GNSS technology, while receiving signals from satellites, calculates the distance based on the time differences. These distances are calculated from the moment it is transmitted up to the moment of receiving the signal. If the distances of three different satellites are known, it is possible that through spatial intersection (geodetic intersection) one can determine the antenna position in 3D (X, Y, Z) in relation to the satellites.

Such intersections doesn't provide real distance measurements because the satellite and receiver time are not harmonized, therefore the measured distances are not real distances, but are called pseudo distances. To avoid this, it is necessary during measurements to have at least four pseudo distances for calculating four unknowns (X, Y, Z, ΔT), where time factor as a fourth dimension is also included.

The accuracy and reliability of the GNSS systems, currently available, are limited mainly from:

- Ionosphere and troposphere influences
- Uncertainties in the predicted orbits of satellites

Incorporation of network KOSOVAREF01 into KOPOS

Damage of Triangulation Network, the period before 2000, and creation of new circumstances for geodesy raised the idea for developing new state geodetic network. Here, the report of the Bessel ellipsoid and other ellipsoids in the plane [Meha, 1998] should be analyzed beforehand. Therefore, the stabilization and measurement of the new geodetic network points, using GPS technology, started in 2001. First order reference network was created by 32 basic points distributed homogeneously throughout the territory of the Republic of Kosovo, while network densification was made with the second order network points a year later.

KOSOVAREF01 Coordinate System was based on the EUREF. Geodetic Datum is defined by Gauss-Krüger Projection in Terrestrial European System ETRS89 (GRS80 Ellipsoid). As a result, there is the WGS84 Coordinate System, which is based on Ellipsoid dimension, in rotation angle of Earth's rotation, and in light speed as well as constant parameters defined by US Department of Defense (DoD), as a reference frame for establishment and maintenance of GPS System.

Dimensions of Reference Ellipsoid WGS84, as accepted by the Geodetic Reference System 1980 (GRS80), are:

a = 6 378 137 + 2 m
1/f = 298.257223563

These dimensions are used for calculating geodetic measurement. Coordinates axels (XYZ) in ETRS system, are fixed in the centre of earth, where Z axel goes across North Pole, and X & Y axels lie in equator plate.

Estimates suggest that when it comes to Europe, coordinates accuracy of the points set by ETRF`89 is roughly +2cm, whereas for WGS84 calculated error of coordinates is roughly +10cm.

The Kosovo geodetic datum [Meha, 2005a, 2005b] is defined as follows:

- Reference spheroid: IUGG (International Union of Geodesy and Geophysics) ellipsoid GRS80 (Geodetic Reference System of 1980)

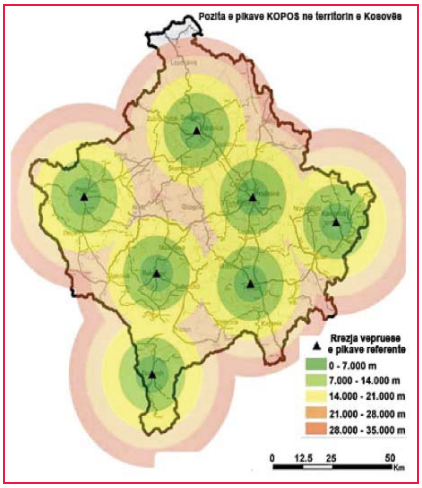


Figure 1: Established referent stations in Kosovo

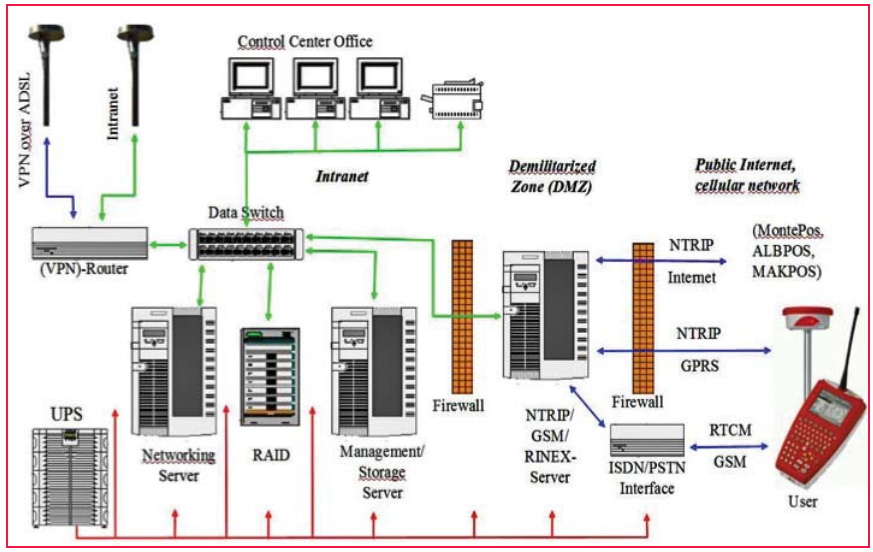


Figure 2: The graphic of the operation of KOPOS system (source: KOPOS implementation report – GIZ)

- Reference system: ETRS89 (European Terrestrial Reference System)
- Origin of coordinate system in the intersection point of projections of the central meridian 21^0 with Equator
- Origin of height: Sea Level
- Projection: Gauss-Krüger transversal cylindrical projection, conform (7th zone)
- Central meridian (21^0) with scale reduction 0.0001 (scale factor 0.9999)

The new system Kosovaref01 covers the whole Kosovo territory, where there are established or created 32 geodetic points of the Ist order and 452 points of the IInd order. These points are established as a base for cadastral and other geodetic measurements.

Therefore, stabilization of permanent referent GNSS network (KOPOS, has a priority for high accuracy geodetic measurements, but it also contributes in modeling atmospheric parameters (troposphere and ionosphere), for weather and earthquakes forecasts. Speaking in financial terms, the project in the future shall lower work-related costs and shall, at the same time, generate revenues for its maintenance, but it does not guarantee (learned from others experiences) that the system could be maintained only from revenues.

Establishment of permanent reference stations

The well known producer of surveying equipments 'Leica Geosystems' from Switzerland, after an international competitive process was the winner of the contract funded by World Bank for stabilizing eight permanent reference stations of KOPOS.

The new KOPOS network has used the most advanced technology and will be the first GNSS network in the world that has used the newest receiver Leica GR25, which has been publically presented for the first time in the equipment and geodetic instrument trade fair – INTERGEO, 2011 in Germany.

Kosovo Cadastral Agency, together with Leica experts and local experts, and also supported from GIZ (Germany) experts, have realized fully the study, establishment of referent points and testing of KOPOS system. In figure (1), the permanent station can be seen – points which cover the territory of the Republic of Kosovo. Whereas in the table (1), it is presents the geographic position of the permanent GNSS stations.

The system is designed also for eventual incorporation of reference stations from neighbor countries: MONTEPOS Montenegro, ALBPOS Albania, MAKPOS Macedonia and AGROS Serbia.

The monitoring and maintenance of permanent GNSS stations is carried out from the control centre. The operation of the system, while including the permanent stations, control centre and users, is presented in figure 2.

Some technical characteristics of KOPOS

Equipment established in permanent stations are:

- GNSS antenna AR25 (choke ring antenna) protected from different atmospheric conditions, suitable for receiving all satellite signals currently in use, and those foreseen for later usage;

Table 1: Locations and coordinates of KOPOS station points

City	Code	Latitude	Longitude	Elips. hight
Dragash	DRAG	42° 03' 43.85977"	20° 39' 16.32320"	1094.351
Kamenicë	KAME	42° 34' 52.73833"	21° 34' 42.92311"	662.296
Mitrovicë	MITR	42° 53' 19.55551"	20° 51' 57.04548"	566.531
Pejë	PEJA	42° 39' 41.30482"	20° 17' 18.50231"	581.464
Prishtinë	KCAP	42° 38' 46.64737"	21° 10' 06.01842"	581.464
Prishtinë	PRIS	42° 40' 12.72243"	21° 11' 30.61312"	709.004
Rahovec	RAHO	42° 23' 50.58087"	20° 39' 26.29440"	475.610
Shtime	SHTI	42° 26' 3.003179"	21° 02' 18.65896"	623.998

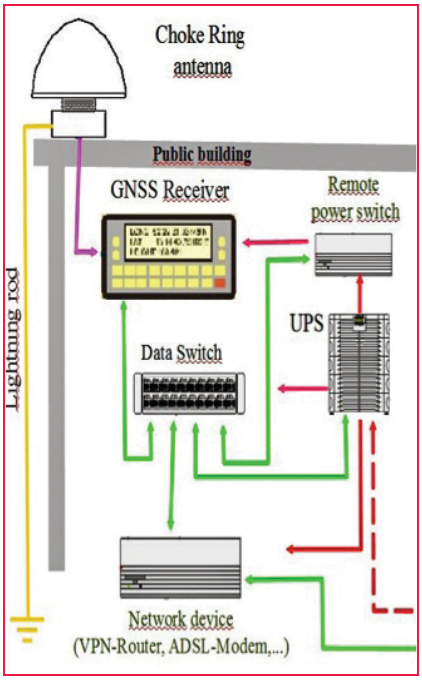


Figure 4: Scheme of GNSS permanent station

Figure 5: Equipments pleased in the cabinet and the GNSS antenna in one of the stations

- GR15 multi frequencies receiver with a sufficient number of channels, for accepting all signals currently available and those for future;
- VPS network ruter, and the necessary connection with ADSL cable;
- Constant power supply (48 hours, backup); and
- Cable, box for setting the device, the material for installation, etc.

The antenna is installed on a pipe so that it is mechanically stable. Location security is guaranteed by the effects of wind, vibration, shaking, lightning according to local standards, etc.

GNSS antenna (choke ring - the last word of the technology) is used as an antenna for reference stations. Antenna phase center is determined though an individual absolute calibration.

Antenna and the receiver must be able to receive all signals available from GPS and GLONASS systems and also GALILEO-s after it will be functional.

KOPOS services –RTK and RINEX data

Acceptance of correction data in real time (RTK) and RINEX data (post-processing) from KOPOS system is done in different ways.

Users of (RTK) products in real time could accept the corrected data in real time through internet (GPRS), or if it is needed also through GSM since KOPOS offers this possibility as well. The format of the data flow should fulfill the RTCM specifications:

- RTCM 2.3 for FKP- and VRS data (guarantee for compatibility from the highest point to the lowest point for the oldest devices)
- RTCM 3.1 for FKP-, VRS and MAC

Clients of RINEX products (post-processing) can download the data from selected referent stations in RINEX format (all formats up to the v 3.0) for a time period selected from the past. For this, the interface page for users based on the web (kopos.rks-gov.net) are available in Albanian, English and Serbian languages, through which users can download all the requested data independently. Except downloading the RINEX data, the system enables also the post processing and adjustments of static measurements. The results of data post processing and adjustment could be taken electronically (e-mail).

Accuracies expected from KOPOS network system are listed in Table 2:

SpiderWeb SBC (Spider Business Centre) program is in use for administration of the registered users, prepaid services, to search RTK usage and RINEX data, invoicing, informing of users on real time regarding the operation of the system, etc.

Benefits from KOPOS system services

The benefits from KOPOS system are different, but at the same time a creative approach in the field of geodesy for its usage in public and private sector is required, since this system enables the establishment of reliability and accuracy for geo-spatial data in terms of quality.

For this reason, cooperation of local experts with international associations in relation to this field is required. Some of the creative engagements, but also as requirements are presented below:

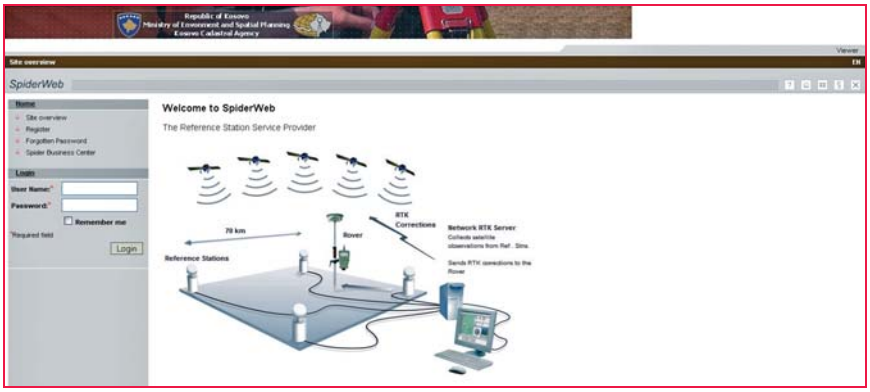


Figure 6: User interface – SpiderWeb

Table 2: KOPOS network system

Type of service	Description	Accuracy range
DGNSS	Low accuracy in real time (RTK –Code))	0.3 – 0.5 m
RTK	High accuracy in real time (RTK –Phase))	0.02 – 0.04 m
RINEX	High accuracy (Post processing – Phase)	<0.01 m

- To maintain and develop state coordinates referent system together with respective geodetic infrastructure;
- To provide access in geodetic data, in services and web based information;
- To closely cooperate with international geodetic associations;
- To provide geodetic and GNSS services for public and private sector;
- To develop awareness campaign for applicable services in high accuracy positioning; and
- To promote and advance geodesy science also through science wider community to support the government in developing the Land Administration and Management policies;

The usage of KOPOS system will support cadastral institutions, together with licensed private companies in implementing the cadastre projects in achieving the goal of heaving sustainable and stable digital cadastre [Meha, 2003].

Other economic benefits from KOPOS in the fields of geodesy, cadastre and spatial data as part of NSDI are:

- The usage of modern technology for measurements such as GNSS, digital photogrametry, aerial images and satellite images have been simplified and accelerated. In general, this approach leads to the influence in cost reduction for, e.g., surveying activities, property identification, monitoring, etc.;
- The accuracy and reliability of cadastral measurements is increased in the whole country, because KOPOS system is a unified system for the whole Kosovo territory;
- The expenses will be 8-10 times lower than the establishment and maintenance of third order reference network; and
- MCOs in Kosovo will have the opportunity to use modern GNSS rover for cadastral surveying and other geodetic works as well, etc.

The usage of GNSS system anywhere in the world has multidimensional benefits in terms of time, financial aspect, accuracy, security, etc. The fields where the system could be used are presented below:

- Geodetic measurements (cadastre, mapping, photogrametry, etc.)
- GIS
- Traffic management (land and air)
- Water management
- Emergent services
- Rail and sea transport (if the state has access to big lakes, sea, ocean)
- Public transport now and in the future (bus, trolley bus, tram, taxi etc.)
- Transportation of hazardous materials
- Vehicles navigation
- Tourism (database, maps, navigation)
- Forestry, Fisheries etc.
- Disaster management
- Inventory and valuation of immovable properties
- Urban Planning, Spatial Planning and Environmental studies
- Monitoring of engineering structures (dams, etc.)
- Environment protection
- Many other services related to the requests of society, institutors and private sector.

"The future satellite navigation systems will use improved technology and concepts, while helping the increase of usage quality and enabling to implement new navigation services for 'smart' vehicles, agricultural tools, 'smart' weapons, unmanned aircraft, mobile robots and other different advanced applications" (Farrell 2008).

The usage of measurements methods supported from GNSS now enables accelerating the work of local measurements significantly, as well as significantly reducing costs. The usage of system that now is continuously operational is a step forward in accelerating and simplifying the works and measurements in the field.

The data available should be used in a comprehensive manner, in order that the exchange of geographic data between central, local and international institutions, from INSPIRE point of view, will be significantly improved. With this, the bases for all geo-information technologies in the whole state have been established; in the field of cartography, cadastre, engineering, surveying, infrastructure, planning, environment, transport, e-governance, e-municipality, e-commercial, etc. Hundreds of users across the country will work without needing control referent points, which will increase enormously the efficiency of the work.

Conclusion

KOPOS system in Republic of Kosovo is a unified state reference network which offers in the real-time positioning accuracy in horizontal plane + 2cm and in vertical plane + 4 cm. GNSS system is the latest word of the technology for geodetic measurements, which is used in developed countries. Now as part of the GNSS family is also KOPOS referent network. This system offers the possibility to use the latest

technology for geodetic measurements for every surveyor in Republic of Kosovo. GNSS has raised the level of accuracy and reliability of geodetic measurements, because it is a globally extended, secure and with the usage possibility of (American) GPS, (Russian) GLONASS and (European in the future) GALILEO.

Economic approach in geodesy is mainly oriented in harmonizing three components: high accuracy measurement, full reliability in measurements and lowest costs for collection geo-information data. KOPOS system in Kosovo meets these three components, and as such will be 24/7 functional, under supervision of control center located in Kosovo Cadastral Agency.

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

Accuracy Assessment of Single-frequency DGPS

In this study, analysis was done using single frequency DGPS mode of acquiring data such as static and stop-n-go on various baselines

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The following are the parameters on which the accuracy of the DGPS depends- LB, OT, number of visible satellites (affects geometry), relative geometry of satellites and change in geometry and Signal to noise ratio (SNR) of received satellite signals. Joao et al 2010 had investigated the DGPS accuracy that was majorly affected by baseline length. Hayakawa et al., 2006 revealed that increase in occupation time would increase the accuracy of DGPS measurement. Accuracy of DGPS devices also depends on SNR Value (Jay et al., 1999). Different surveying methods reflect different accuracy levels. In the present research work, the single frequency (L1 receiver) on relative horizontal accuracy was studied. The companies give different accuracies in various modes such as static, stop and go with respect to different occupation time as shown in Table 1.

> Stop & GO surveying method has critical problems that cannot be carried out for very large area and baseline greater than 10 km

Methodology

Following are the steps involved for accuracy assessment:

- In case of a static survey with different baseline (short, medium and long), take the coordinates of long absorption (exact coordinate) and section editor in software dividing into different occupations. Then find out the coordinate for different occupation time. The difference with long observation (exact coordinate) in meter was found.
- In case of stop-n-go survey method, a physical circle of 10 meter radius

Figure 1: Shows the Circle Exercises adopted for Stop-n-Go Survey method

Table 1: Base length Point (Static Points & Stop-n-go)

S No.	Point ID	Static		Stop-n-go	
		Baseline	Baseline length(m)	Baseline	Baseline length(m)
1.	Cricket ground MANIT	Short	273	Short	273
2.	Bittan market/ Mayur Park	Medium	2173	Medium	1833
3.	Lalghati	Large	7088	Large	7088

Table 2: Difference in coordinates for Short baseline (with occupation time)

Duration	Point1 (short baseline, <1km) Cricket ground –MANIT-Bhopal			
	Baseline length=273m			Difference with long observation (Exact coordinate) in meter
	Easting (m)	Northing (m)	Solution	
30 min	746530.589	2569440.594	Fixed	0.000
25 min	746530.589	2569440.594	Fixed	0.000
20 min	746530.589	2569440.594	Fixed	0.000
15 min	746530.588	2569440.593	Fixed	0.001
10 min	746530.588	2569440.593	Fixed	0.001
5 min	746530.591	2569440.601	**Float**	0.009

Table 3: Difference in coordinates for Medium baseline (with occupation time)

Duration	Point 2 (medium length, 1-3km) Bittan market			Difference with Long observation (Exact coordinate) In meter
	Baseline length=2173m			
	Easting (m)	Northing (m)	Solution	
30 min	748369.649	2569479.921	Fixed	0.000
25 min	748369.647	2569479.921	Fixed	0.002
20min	748369.647	2569479.923	Fixed	0.003
15min	748370.104	2569479.893	**Float**	0.460
10min	748370.539	2569479.905	**Float**	0.892
5min	748369.675	2569479.819	**Float**	0.898

was made, and along the radius six points were taken along with a radius as shown in Figure 1. In this exercise, the centre point was taken in the static mode up to the desired observation with reference to baseline. For reference, long observation was taken into consideration in order to fix the coordinate. Other points were taken in Stop & Go with different occupation time such as (15 sec, 30 sec, 45sec, 1 min and 5 min), then Root mean square error (RMSE) was calculated for it.

- Future analysis depicted the error with references to signal-to-noise ratio (SNR). It was done by selecting a point with the same baseline, same PDOP and varies with SNR Value.

Result and discussion

In case, static point for different baseline occupation and PDOP values should be less than 2.

Short Baseline Length (Static)

The following conclusion that can be drawn from Table 2 is that variations in the coordinates of a point, solution type and deviation from exact coordinate of post processed coordinates, there is no significant change in coordinates up to 10 min, but there is a change after 5 min occupation. Also, the integer ambiguity is not resolved in 5 min occupation. So, it was found that for short baseline (<1km), 10 min occupation was enough to get accurate coordinate in mm level and to fix the integer ambiguity and graphical representation shown in Figure 2.

> Signal-to-noise ratio also plays a vital role in determining the accurate position. It depends upon internal as well as external system

Medium Baseline Length (Static)

The following conclusion that can be drawn from the data is clear that there is no significant change in coordinates up to 20 min, but changes can be observed after 15 min occupation. But the integer ambiguity is not resolved in the 15 min occupation. An estimate can be made for medium baseline length (1-3km), 20 min occupation is enough to get an accurate coordinate and to fix the integer ambiguity and graphical representation shown in Figure 3.

Large Baseline Length (Static)

There is no significant change in coordinate up to 25 min, but there is a change after 20 min that can be notified. But the integer ambiguity cannot be resolved after 15 min occupation. It can be estimated that from large baseline length (>3km), 25 min occupation is enough to get accurate coordinates and to fix the integer ambiguity as shown in Table 4 and graphical representation shown in Figure 4.

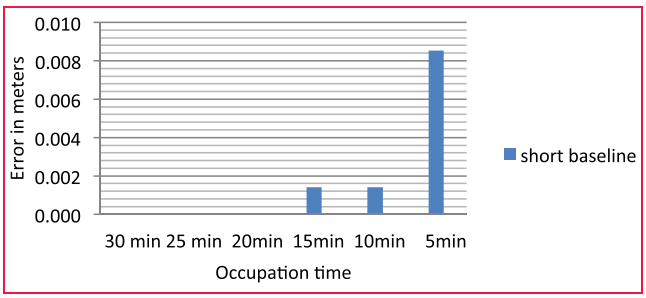

Figure 2: Distances from exact Point (Short Baseline)

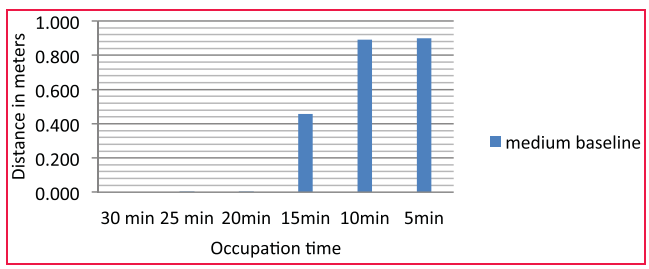

Figure 3: Distances from exact Point (Medium Baseline)

Table 4: Differences in coordinates for Large baseline (with occupation time)

Duration	Lalghati, Point 3 (large baseline >3km)			Difference with Long observation (Exact coordinate) in meter
	Baseline length=7088m			
	Easting (m)	Northing (m)	Solution	
30 min	741855.909	2576056.052	Fixed	0.041
25 min	741855.781	2576055.873	Fixed	0.089
20 min	741856.161	2576056.063	**Float**	0.252
15min	741855.758	2576055.801	**Float**	0.293
10min	741855.667	2576055.844	**Float**	0.319
5min	741855.086	2576055.898	**Float**	0.837

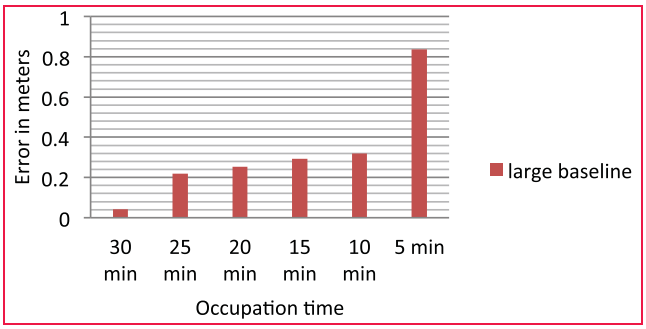

Figure 4: Distances from exact Point (Large Baseline)

Table 5: RMSE Error with occupation time (Stop & Go, Short baseline)

Occupation time	15 sec	30 sec	45 sec	1 min	5 min
RMSE (meters)	0.076	0.076	0.076	0.076	0.076

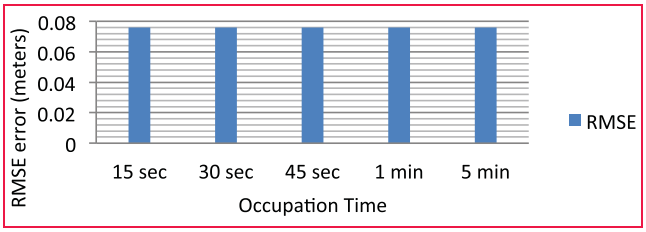

Figure 5: RMSE Error with occupation time for Stop & Go (short baseline)

In case stop-n-go point for different baseline occupation

Short Baseline Length (Stop & Go)

The number satellite varies 7 to 9 and satellite geometry such as PDOP varies from 1.8 to 2.4. After calculation of the distance from the centre point, RMSE error calculated is shown in Table 5 for each occupation time. Graph is plotted for RMSE error with different occupation time. The graph shown in Figure 6 shows that there are no changes in with occupation time, so that 15 sec occupation is enough to get 5-10 cm level accuracy for short baseline length.

Table 6: RMSE Error with occupation time (Stop & Go, Medium baseline)

Occupation time	15 sec	30 sec	45 sec	1 min	5 min
RMSE (meters)	0.083	0.069	0.068	0.066	0.068

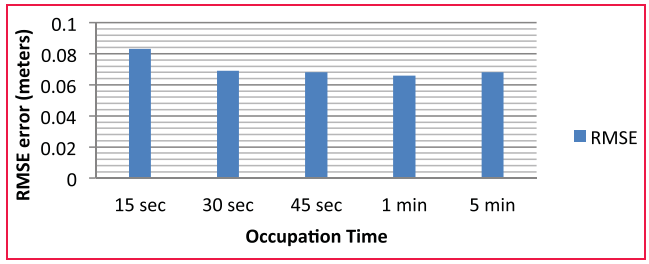

Figure 6: RMSE Error with occupation time for Stop & Go (Medium baseline)

Table 7: RMSE Error with occupation time (Stop & Go, Large baseline)

Occupation time	15 sec	30 sec	45 sec	1 min	5 min
RMSE	0.309	0.164	0.130	0.068	0.065

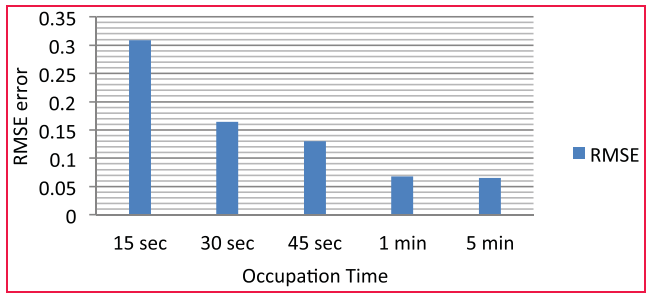

Figure 7: RMSE Error with occupation time for Stop & Go (Large baseline)

Medium Baseline Length (Stop & Go)

The number of satellite varies from 6 to 12 and PDOP varies from 1.3 to 2.7. After calculation of the distance from the centre point, RMSE error for all points, shown in Table 6, is calculated for each occupation time. The graph is plotted for RMSE error with different occupation time. The graph shown in Figure 6 shows that there are no significant changes in positioning with

Table 8: Post Processed coordinates of points (Different SNR value)

Baseline (meter)	Center Coordinates		1 min Stop & Go data (Circle periphery points)		Distance from center (meters)	Error (meters)	Avg. SNR (dB)	PDOP
	Easting (m)	Northing (m)	Easting (m)	Northing (m)				
7886.50	741856.00	2576056.00	741853.7	2576066.00	10.085	-0.085	42.044	1.8
	741856.00	2576056.00	741865.5	2576055.00	9.520	0.479	41.424	1.8


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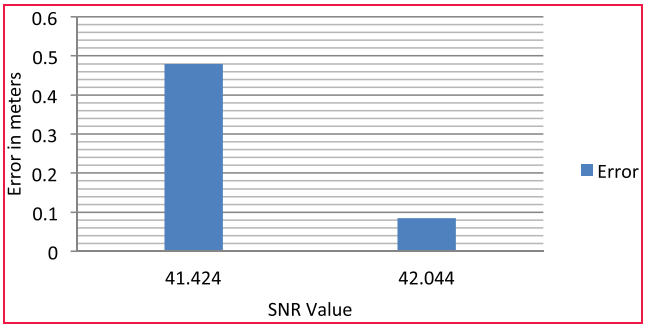

Figure 8: Positioning Error with SNR value

Table 9: shows the impact of the SNR value on error

Average SNR	47.184	45.866	44.105	42.334	37.874
6 SATELLITE ERROR	-0.153	-0.297	-0.549	-0.629	-0.395
	-0.083	-0.135	0.137	-0.020	0.515
	0.213	0.318	0.711	0.695	-6.392
	0.307	0.446	0.678	0.755	-3.131
	0.233	0.291	0.055	0.229	1.579
	0.003	-0.063	-0.485	-0.370	1.193
RMSE ERROR	0.193	0.287	0.504	0.523	3.028

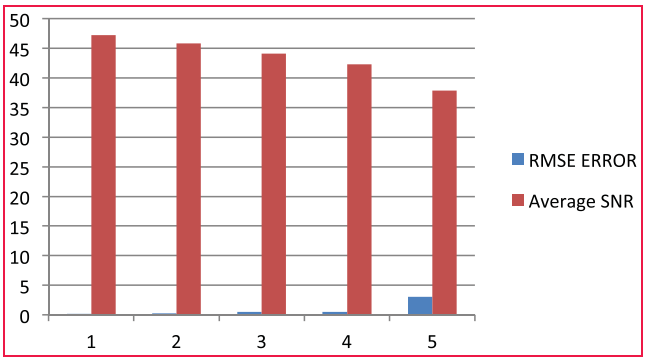

Figure 9: Shows the graphical representation RMSE v/s SNR

occupation time after 30 sec, so that the 30 sec occupation is enough to get 5-10 cm level accuracy for medium baseline length.

Large Baseline Length (Stop & Go)

The number of satellite varies from 7-9 and satellite geometry such as PDOP varies from 1.4 to 1.9. After calculation of the distance from the center point, final RMSE error for all points are shown in Table 7, that is calculated for each occupation time. Graph plotted for RMSE error with different occupation time is shown in Figure 7. It shows that there is no significant change after 1 min and accuracy is in centimeter level, so that for a large baseline, 1 min occupation time will give 5- 10 centimeter level accuracy.

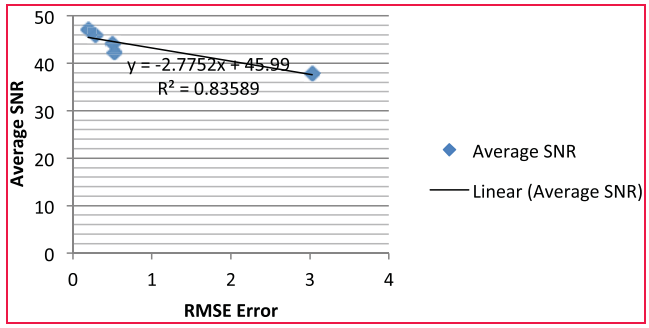

Figure 10: Shows the Linear relationship between Average SNR and RMSE

Table 10: Optimized time for static survey

Survey method	Baseline length	Estimated time	Highest Accuracy level
Static	Short	10 min	Less than 1 cm
	Medium	15 min	Up to 5 cm
	Large	25 min	5-10 cm

Table 11: Optimized time for Stop & Go survey

Survey method (Initialization Required)	Baseline length	Estimated Occupation time
Stop & Go	Short(<1km)	15 sec
	Medium(1-3km)	30 sec
	Large(>3km)	1 min

Effect of Signal-to-Noise Ratio (SNR) on DGPS accuracy

On these points, data was collected in Stop & Go method for 1 min (estimated time) because the baseline length is 7,088 m. Post processed coordinates and error is shown in Table 8. The average SNR value is also included for analysis.

Then graph is plotted between SNR value and error in positioning for both points shown in Figure 8. From the graph, it is concluded that there with increase in SNR value (good signal condition) the accuracy will increase, which means noise can produce a large error in positioning.

Further investigation had been done to see the effect of SNR on the error. In this study, only six satellites from the available GPS constellation were selected, then post processed. It was done by using GNSS solution software by deselecting the satellite, determining the SNR value of each satellite and then arranging the different SNR value in descending order. The combination of six selections for analysis were considered and the other satellite was deselected. Then error estimates based on this is shown Table 9 and graphical represention is shown in Figure 9. Investigation revealed that the error does not only depend on SNR value. We cannot have a generalized SNR value and error because it depends on the receiver capability also. By using the instrument Promark3 (Magellen), we can derive linear relation between SNR and RMSE as shown in Figure 10.

Conclusion

The accuracy of DGPS positioning with post-processing differential correction is dominantly affected by the duration of the measurement, but the same occupation time is not required for every baseline length. Following are the conclusions of the present research work investigations:

1. The static survey is mainly used for high-accuracy. Static method needs long observation, but after a certain period, accuracy does not change significantly. Following Table 10 shows the optimized time for static survey.

After analysis of post processed result of **Static** occupation it was observed that

(a) For short baseline (<1km), 10 min observation is enough. After that, no significant changes can be noticed in positioning.

(b) For next every 1-2 km baseline length, it needs 5 min more occupation on point for fixed solution and to enable efficient differential correction.

(c) For same PDOP value and occupation time, large baseline encounters more error than short baseline.

2. The Stop & Go surveying method may be an appropriate one for the DGPS survey of small areas, if no obstruction of signals takes place due to vegetation, etc. To achieve accuracy level of 5-10 cm in Stop & Go, the required occupation time is given in Table 11. However, in order to get accuracy up to the level in Stop & Go surveying method, there are some limitations like no loss of lock and site clearance for signal obstruction by objects like high rise buildings and trees.
3. Stop & GO surveying method has critical problems that cannot be carried out for very large area and baseline greater than 10 km, where signal breaks take place very frequently. Stop & Go survey is suitable for fast surveys if medium level accuracy (5-10 cm) is required.
4. Signal-to-noise ratio also plays a vital role in determining the accurate position. It depends upon internal as well as external system. Internal system must be of good quality with sufficient number of channel receivers with good noise filters. External noise is due to the external environment such as airport, high tension line, etc. So we cannot generalize the error with respect to SNR Value. But with some modern instruments, we can predefine the SNR value like PDOP value to be specified.

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Satellite technologies in Turkey

This article gives some informations about Satellite Technologies of Turkey called "Yesterday and Today of Developments in Satellite Technologies in Turkey" established by Nevsehir Haci Bektas Veli University, Engineering and Architecture Faculty, Department of Biosystem Engineering

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Turkey, in the 1980s communications satellites were purchased. In 1989, a tender was floated for the first communications satellite project. Following this development, the French Aerospatiale company on December 21, 1990 signed the 'Turkish National Satellite Communication System Agreement' with Turkey. However, the satellite TURKSAT-1 made at the launch base in French CSG launch was lost, since in the third stage of the Ariane-4 rocket launcher 24 failed in January 1994. The insurance required under the terms of the agreement, which was produced at that time, the completion of the second satellite whose development was accelerated. TURKSAT-1B construction was completed on August 11, 1994 at 42 degrees East position placed, and entered service in October 1994.

Immediately after the delivery of TURKSAT-1B, in accordance with the provisions of the contract of the insurance company, Aerospatiale Turksat started to make a new satellite, TURKSAT-1C satellite-tossed 31.3 East, and was placed in position on July 10, 1996. The first generation TURKSAT satellites by Turk Telekom was followed by a series of Spacebus 3000B3 platform and 32 high-power Ka-band transponders with Turksat-2A (Eurasiasat) satellite, and its construction began in 1998 as decided. The satellite launched in mid-2000 and was again placed in position 42 degrees East, and began operations on February 1, 2001.

Figure 1: RASAT satellite construction and testing phases in TUBITAK

As the lives of TURKSAT-1B and 1C satellites about to end, Turksat company started work on TURKSAT-3A satellite in 2006. The French-Italian joint venture with Thales Alenia Space company, bagged the tender on June 13, 2008 and sent into space TURKSAT-3A satellite on July 16, 2008 when operations began. Approximately, 25 Turkish engineers hired during the production phase of the project, was given training for the next generation communication satellite that Turksat aimed at, with the ability to partially produce it in Turkey. Turksat was firm yet tender with the TURKSAT-4A communications satellite, which was planned and partially assembled in Turkey and started planning for communication satellite Turksat-5 as the next project.

Observation satellites production technology for Scientific and Technological Research Council of Turkey (TUBITAK) technology transfer projects have been initiated. Developed and produced under the project of remote sensing earth observation satellite BILSAT, on September 27, 2003 was launched from Russia's Plesetsk base and placed into orbit. Regarding BILSAT satellite, the task was completed.

After the completion of BILSAT satellite, RASAT satellite project was activated. Making use of current satellite capabilities with this project, RASAT satellite was designed and produced in Turkey. It had high-resolution optical imaging system and new modules developed by Turkish engineers, making it the first earth observation satellite designed and manufactured in Turkey (see Figure1).

The observation satellite was sent into space on August 17, 2011. RASAT satellite that TUBITAK Space Technologies Research Institute designed and produced indigenously, aiming at helping a total of 3,856,000 sq km area on the world's image. A 7.5 m panchromatic, multispectral image of the world, can be taken. RASAT, TUBITAK-drawn images to the ground

Figure 2: GOKTURK-2 satellite being launched into space

Figure 3: TURKSAT-4A satellite launch base in Baikonur Space Base in Kazakhistan and moment of launch

station transmits in Ankara Space. The observation of Turkey with satellite images taken from the 2D satellite image database was created. Taken to ensure timeliness, the new image data base was made even richer with each passing day, and reliable satellite earth observation mission still holds.

Turkish engineers designed and realised in 2012 with the launch of operations that have been placed into orbit GOKTURK task-2 Turkey that was originally developed is the first high-resolution earth observation satellite. GOKTURK-2 System and the tasks related to the design, production and testing processes were carried out on a national engineering activities level. GOKTURK-2 Satellite which was tested before shipment was completed in the TUSAS facilities and the satellite company, and was sent to the People's Republic of China's Jiuquan Launch Center. GOKTURK-2 satellite on December 18, 2012, at 18:13 (Turkey time), was launched from China (see Figure:2).

GOKTURK-2 satellite, during the launch of the space mission to orbit, 12 minutes later settled the first signal from the satellite, at 19:39 in Tromso Norway and was taken from Ground Station. Following the commissioning process, images captured by GOKTURK-2 Satellite started downloading to the ground station located in Ankara. This 2.5 m panchromatic and 5 m multispectral satellite with resolution picture can be drawn. Orbit altitude of 700 km had a planned collected tenure of five years. With the GOKTURK-2 Project, technologies for space and satellite systems, that specialized in manpower and infrastructure development, observation and research needs of public institutions and organisations with national means and capabilities were expected to be met. These satellites, with the launch of the satellite project will work if Turkey's future professionals have been trained manpower. Satellite and equipment for this project level design, analysis, manufacturing, assembly, integration and test activities and the ability of the infrastructure have been acquired.

Turkey's Japanese and Turkish engineers recently co-produced a communications satellite which was launched. This is the satellite Turksat-4A. Turkey evaluated the new stage in the development of the satellite Turksat-4A satellite, which on February 14, 2014 from Kazakhstan's Baikonur Cosmodrome 23:09 (Turkey time), was launched into space (see Figure 3).

TURKSAT-4A satellite in space makes Turkey one of the 30 countries with a number of satellites that have increased in active operations from 4 to 5. In TURKSAT-4A satellites with the new technology, which for the first time in Turkey's satellite fleet, the Ka frequency band began to take place. In this way, part of which were previously inaccessible to sub-Saharan Africa now was also provided with an opportunity to receive television broadcasts. Ka-band covers areas through publications downloaded in the form of a small circle, and it began to be given the opportunity to broadcast more intensively and effectively. Thus, the cost of internet access was also reduced. TURKSAT-4A satellite broadcasting service in the military as well as in civil operations began to be recognized. Satellite TURKSAT-4A brought a 3-fold increase to Turkey's communications capacity, making it one of the most important part of the project. This satellite communication ensured that television broadcasts began to China's western region of Turkey, to the east of the UK, Europe, Central Asia, the Near East and Africa including the transfer of a large region. Thus, the Turkish television and radio channels broadcasting in Europe and Asia was now accessible in Africa.

Earth observation satellites currently in Turkey, is continuing studies for the production of a new satellite. The GOKTURK-2 satellite earth observation satellite, following the National GOKTURK-1 satellite began to be developed since July 19, 2009 and is still ongoing. Without geographical constraints with this project in any region of the world, high-resolution images can be taken for military intelligence. At the same time, forest area control, illegal building monitoring, natural disaster followed by damage assessment, product yield determination, geographical map data production as well as many civilian activities in the field of image needs could be met. With this project in Turkey up to 5 tons of integration and testing of all satellites can be carried out domestically, and satellite assembly, integration and test center have been established according to international standards.

As can be seen from the above developments, Turkey, on a world scale, is a developing country in the field of space technology. Started in 1980 with the purchase method, the country began using space technology, and from the beginning of the 2000s it went on a national-scale. Space technology capabilities in our country is for display purposes, satellite design, manufacture and operation of satellite imaging and communication purposes, with the use of data from space level. However, the satellite launch capability, is currently available in a few countries only. These countries are at the forefront of space technology.

Galileo update

First Galileo commercial service demonstration with encrypted signals

The Early Proof of Concept (EPOC) team has successfully tracked the encrypted Galileo E6-B and E6-C signals broadcast by Galileo satellites. As a result, the Commercial Service loop has been closed using both encrypted and non-encrypted signals.

During a 10-day testing period, receivers located in Tres Cantos, Spain and Poing, Germany, showed the successful tracking and data demodulation of the encrypted signals from the available Galileo satellites, with periods where all satellites transmitting E6 encrypted signals were tracked simultaneously. The tests verified the Galileo Commercial Service (CS) signal's encryption functionalities, with the data received containing authentication and high accuracy information previously generated outside the Galileo system. *www.gsa.europa.eu*

Veripos participates in Galileo demonstration project

Veripos confirms its participation in the successful consortium delivering the AALECS (Authentic and Accurate Location Experimentation with the Commercial Service) project launched by the European Commission in January. The AALECS Project concerns building of a demonstration platform to connect to the European GNSS Service Centre and transmit real-time commercial service data via the Galileo satellites. The platform will be operational by 2015 and will demonstrate the true performance of future high-accuracy and authentication services of Galileo. *www.veripos.com*

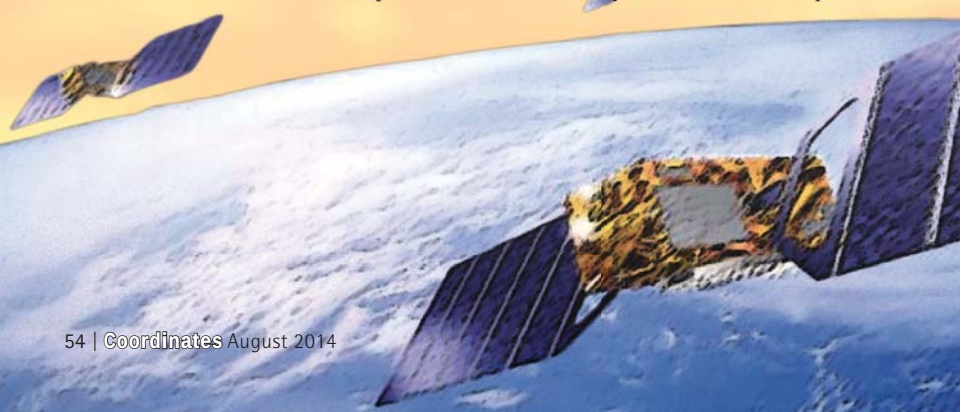
EC selects CGI to support the Galileo program's Commercial Service initiative

CGI has been awarded a contract to build the core infrastructure for the first demonstrator for the Galileo Commercial Service, part of the emerging European GNSS. The contract was awarded by the European Commission Directorate General for Enterprise and Industry (DG ENTR).

Sudden Power Loss Left a Galileo Satellite in Safe Mode

One of the four Galileo satellite stopped transmitting on two of its three channels on May 27 because of a sudden loss of power, forcing ground teams to shut down the satellite after putting it in safe mode while examining possible causes, European government officials said. The anomaly occurred in a matter of seconds and shut down the E1 signal first. That signal, which transmits Galileo's Open Service, re-established itself almost immediately. But as soon as it was back in service, the two other channels' power dropped and did not recover. The full satellite then was shut down by ground teams. They said whatever the cause of the problem, it was not related to the satellite's onboard atomic clock.

Officials said that because the four In-Orbit Validation satellites — launched two at a time in October 2011 and October 2012 — differ in both onboard power technology and manufacturer, the preparations for the next Galileo launch, set for late August, have not been suspended and are not expected to be delayed as a result of the problem.



NNG and ANS aim for factory-fitted navigation market in India

NNG and Ayana Navigation Solutions have announced scalable navigation solutions for OEMs in India, thus proving that factory-fitted navigation is available for car owners of all categories. India is becoming a fast-growing market for affordable cars. Within the next six years globally, the share of total production accounted for by low-cost vehicles is set to climb to around 20 percent.

Garmin launches personal navigation devices in India

Garmin has launched its 2014 PND range - nuvi 55LM, nuvi 65LM, and nuvi 2567LM. The nuvi 55 LM is a dedicated GPS navigator that features a 5-inch dual-orientation display, for use horizontally or vertically. nuvi 65 LM features a6-inch dual-orientation display, for use horizontally or vertically. The nuvi 2567 LM is part of Garmin's Advanced Series equipped with new navigation assist features. *http://timesofindia.indiatimes.com/*

MapmyIndia releases its official navigation app, NaviMaps, for iOS

MapmyIndia has released navigation app – NaviMaps for the iOS platform. The Android app was launched two months earlier. Millions of Apple users in India can now enjoy house-level navigation, regional language voice guidance (in 10 languages) and international navigation (Sri Lanka, Bangladesh & Nepal). The app offers automatic traffic based re-routing and real-time journey updates on Facebook (does not spam the timeline, updates a single post at regular intervals) along with a superfast and responsive experience. *www.mapmyindia.com*

13 megatonnes CO_2e as a result of Charging mobile devices

A new report from Juniper Research has found that charging mobile devices will generate more than 13 megatonnes CO_2e (CO_2 equivalent) of greenhouse gases per annum globally by 2019, against an

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Innovations Track - The latest scientific innovations which are emerging from scientific research and developing into the products and services we will see coming to the market in the not too distant future. In addition the scientific applications of new GNSS developments and innovations will be covered.

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anticipated 6.4 megatonnes this year. Nearly 50% of these 2019 emissions – equivalent to annual emissions from 1.1 million cars – will come from coal-fired Asian electricity grids powering growing smartphone use.

According to the report – Green Mobile: The Complete Guide to Vendor Strategies & Future Prospects 2014-2019 – there is low consumer awareness of renewable energy and sustainable habits in these markets. It is down to vendors to take the lead in making energy companies provide more green electricity for both industry and consumers. *www.juniperresearch.com*

Fleet management systems will reach 5.9 million in Russia/ CIS and Eastern Europe

According to a new research report from the analyst firm Berg Insight, the number of active fleet management systems deployed in commercial vehicle fleets in Russia/CIS and Eastern Europe was 2.9 million in Q4-2013. Growing at a compound annual growth rate (CAGR) of 15.7 percent, this number is expected to reach 5.9 million by 2018. The Russian market accounts for a significant share of the region's total installed base. The top 10 providers of fleet management solutions for commercial vehicles across Russia, the CIS and Eastern Europe together have an installed base of well over 1 million active units today.

Smart City Technology will reach $27.5 billion in annual revenue by 2023

According to a new report from Navigant Research, worldwide revenue from smart city technology will grow from $8.8 billion in 2014 to $27.5 billion in 2023.

The report, "Smart Cities", examines the evolution of the global smart city market, detailing the impacts on key technology markets, including smart grids, water management, transportation, building energy efficiency, and government services. It compares different approaches to the smart city and provides comprehensive profiles of noteworthy smart city projects in each major world region. *www.navigant.com*

Supergeo invest in Innovative Geographic Network Analysis

Supergeo Technologies has announced the investment plan in advanced geographic network applications. The technology collaboration is conducted by Supergeo and the Department of Geography, National Taiwan University, supported by the Ministry of Science and Technology in Taiwan. The academia-industry project mainly focuses on the production of geographic network analysis module to increase the coverage of GIS applications. This innovative project considers more social network influence than the traditional GIS analysis, which only takes distance as the main factor but ignores human activities. For example, the infection of disease may be limited by geographic environment and distance, but the community far away from the original might still get infected because of human activities. *www.supergeotek.com*

'National Map' for geospatial data in Australia launched

The federal government has launched an online map of Australia that allows users to overlay geospatial datasets made available by agencies. It is a joint effort by the Department of Communications, NICTA and Geoscience Australia. The datasets are sourced from Geoscience Australia, the Bureau of Meteorology, the Australian Bureau of Statistics and the government's data.gov.au open data repository. A range of open source software and frameworks has been used for the site, including Cesium, Leaflet, Geoserver, jquery, URI.js, proj4js, html2canvas, knockout, esri-leaflet.js, togeojson, and Tilelayer. Bing.js. *www.computerworld.com.au/*

Bentley's SewerGEMS, SewerCAD, CivilStorm, StormCAD V8i and LEAP Bridge Steel

Bentley Systems has announced the availability of its new *SewerGEMS*, *SewerCAD*, *CivilStorm*, and *StormCAD* V8*i* (SELECTseries 4) products for the analysis and design of wastewater and stormwater systems. It provide advanced hydraulic and operational capabilities for an increased depth of information modeling that empowers users to evaluate and compare a wider range of network considerations.

Bentley *LEAP Bridge Steel* is for the 3D modeling, design, analysis, and load rating of everyday steel bridges. The software, which adheres to AASHTO Load and Resistance Factor Design (LRFD) specifications, enables users to leverage the benefits of bridge information modeling (BrIM), including increased efficiency and data reuse across the bridge lifecycle. It also provides the advantages of optioneering – which enables engineers to quickly consider trade-offs between multiple design strategies.

GIS based soil fertility maps prepared for 19 states in India

Indian Institute of Soil Science has developed GIS based soil fertility maps of 19 states using data of different soil testing laboratories in India. The assessment revealed that about 59, 49 and 9% soils are low in available nitrogen, phosphorus and potassium respectively. The extent of micronutrient deficiency in soil (state-wise) was studied under the All India Coordinated Research Project on 'Micro and Secondary Nutrients and Pollutant Elements in Soils and Plants'.

The government through the National Project on Management of Soil Health and Fertility and National Project on Organic Farming promotes soil test based balanced and integrated nutrient management and use of organics (manure/ composts, biofertilizers etc.) to prevent decline in fertility of agricultural land and to improve soil fertility. *http://timesofindia.indiatimes.com/*

LizardTech's GeoGofer

LizardTech's GeoGofer was designed to streamline the process of finding, organizing, and tracking geospatial imagery. It comes with powerful search and filter features to find imagery by keyword, by projection, by file format and more. With GeoGofer, users can browse all of their imagery on a single

map, tag images for later use, and perform powerful queries using simple tools. Users can search by modification date, by number of bands, or by resolution to find the imagery they need—when they need it. *www.lizardtech.com.*

Indian state mulls over GIS mapping of vacant industrial plots

To spur industrial growth and attract investment, the Uttar Pradesh (UP) government is mulling over using GIS to map vacant industrial plots in the state. This would enable online selection of such sites by industrialists to set up units. The government is also planning to create a labour pool of industry associations based on different skill sets to supplement job-specific workforce on demand. The measures, aimed at improving the business climate in state of UP. *www.business-standard.com/*

State-wide road & bridges system for India

The Indian state of Tamil Nadu has launched a web-based GIS system for roads and bridges that can be used by multiple agencies in improving operations and planning. Implemented by the Tamil Nadu Highways Department (TNHD), the system provides a unified and complete picture across the state government so that road maintenance and improvement works carried out by different agencies can be coordinated better. The system, which uses Esri's ArcGIS for Server, is available online, making it accessible to many users at all times and on any device.

Worldwide UAV market at $91 billion

Teal Group's 2014 market study estimates that UAV spending will nearly double over the next decade from current worldwide UAV expenditures of $6.4 billion annually to $11.5 billion, totalling almost $91 billion in the next ten years. The Teal Group study predicts that the US will account for 65% of total worldwide RDT&E spending on UAV technology over the next decade, and about 41% of the procurement. *www.tealgroup.com*

FAA will miss 2015 UAV deadline

The FAA is unlikely to meet its 2015 deadline for integrating UAVs into the National Airspace System, according to a report by the Department of Transportation's Office.

The 33-page report notes that the FAA has yet to reach consensus on standards for technology that would enable UAS to detect and avoid other aircraft and ensure reliable datalink communication between ground stations and the unmanned aircraft they control.

The FAA has also been unable to establish the regulatory framework for UAS integration, such as aircraft certification requirements, standard air traffic procedures for safely mixing UAVs with manned aircraft, or an adequate controller training program for managing UAV operations. *www.flyingmag.com*

Mesa County in Colorado, USA to operate Trimble's UAS

Mesa County in Colorado, USA has received a Certificate of Authorization (COA) that will allow the Public Works Department to operate its Trimble® UX5 Aerial Imaging Solution throughout the county. A COA is an authorization from the Federal Aviation Administration (FAA) allowing the operation of an unmanned aircraft in a designated area and not for commercial use. *www.trimble.com*

Rockwell Collins to provide Micro INS for Brazil's FT Sistemas UAS

FT Sistemas has selected Rockwell Collins to provide its Micro Inertial Navigation Sensor (INS) for the Horus 100, a hand-launched UAV to be deployed by the Brazilian Armed Forces. It is an advanced INS/GPS with an integrated air data system and magnetometer that offers complete and accurate platform state data. Weighing around 100 grams, the Micro INS incorporates an internal disk-on-chip for extended data logging, and meets demanding environmental requirements for shock, vibration, temperature and humidity. *www.rockwellcollins.com*

Philippines to launch own microsatellite in 2016

The Philippines is blasting off into the space age with the planned launching of its own microsatellite in July,2016, with the cooperation of the Japan Aerospace Exploration Agency. The Department of Science and Technology (DOST) said the space venture is part of the government's disaster risk management program. *www.mb.com.ph/*

Phase One Industrial announces iX Capture

Phase One Industrial has announced the release of Phase One iX Capture, an image capture and RAW conversion application designed specifically for aerial photography. An intuitive interface displays key information such as exposure settings and history, histogram, GPS data and frame count. The image display can be paused at any time to enable operators to inspect images by zooming to 100 percent or to set white balance. iX Capture enables operators to track each capture and utilize real-time feedback to be confident that each image has been captured correctly. *www.industrial.phaseone.com*

Antrix has earned Rs 4,408 crore since 1992

Antrix, the commercial arm of Indian Space Research Organisation (ISRO), has generated Rs 4,408 crore since 1992 by rendering different services. Acoording to Minister of State for Department of Space, Antrix provides various services, including marketing and direct reception of data from Indian Remote Sensing Satellites to national and international clientele and leasing of satellite transponders on-board INSAT/GSAT satellites. *www.business-standard.com*

MOU between CGWB and IIRS Signed

A Memorandum of Understanding (MoU) has been signed between Central Ground Water Board and Indian Institute of Remote Sensing signed to facilitate a collaborative study to assess the impact of ground water abstraction on land subsidence in Northern

India. The study involves application of state of art technologies such as Space borne Geodetic observations on land subsidence, predictive modelling, inter-comparison of land subsidence, ground water depletion and space based gravity anomaly etc. Deliverables include land subsidence information for selected cities of northern India and regional groundwater depletion scenario along with recharge assessment. The study will be first of its kind in India and will have great significance in identification of hotspots affected by over exploitation of ground water. *www.business-standard.com*

Chinese remote sensing drone sets 30-hour flying record

A new Chinese UAV set a new record for thecountry's remote sensing drones by flying for more than 30 hours consecutively, the UAV'sdeveloper, the Chinese Academy of Surveying & Mapping (CASM), announced. The previous record time was 16 hours. Coupled with China's Beidou Navigation Sat elliteSystem, the UAV system can carry out rapid mapping without ground control points. CASM said that the newly developed system will make it possible for several drones to fly within one airspace simultaneously, thanks to breakthroughs in tele communications technologies. *http://english.peopledaily.com.cn/*

IRS to give data to Brazil's earth station

A new agreement has been signed by India and Brazil in Brasilia under which both sides have agreed to augment the cooperation of a Brazilian earth station for receiving and processing data from Indian Remote Sensing satellites (IRS).

The agreement says that the National Institute for Space Research (INPE), Brazil would work together with the Indian Space Research Organisation (ISRO) to accomplish the actions in the agreement. ISRO shall make available to INPE remotely sensed data of areas within the acquisition radius of INPE's earth station in Cuiaba acquired by AWiFS and LISS-III payloads of IRS satellites. *www.delhidailynews.com*

$34.9M fine by FCC for jammer marketing

The Federal Communications Commission, USA plans to issue the largest fine in its history against C.T.S. Technology Co., Limited, a Chinese electronics manufacturer and online retailer, for allegedly marketing 285 models of signal jamming devices to U.S. consumers for more than two years. The FCC applied the maximum fine allowed to each jammer model allegedly marketed by C.T.S., resulting in a planned fine of $34,912,500. "All companies, whether domestic or foreign, are banned from marketing illegal jammers in the U.S.," said Travis LeBlanc, Acting Chief of the Enforcement Bureau. C.T.S. operates a website that markets consumer electronics to individuals in the United States, where it allegedly misled U.S. consumers by falsely claiming that certain signal jammers were approved by the FCC. In fact, the use of such devices by U.S. consumers is illegal under any circumstance. *http://hraunfoss.fcc.gov/*

Putin orders development of road map for establishing state OJSC GLONASS

Russian President Vladimir Putin has ordered the government to draft and approve a road map on establishing state OJSC GLONASS with 100 percent state participation - the relevant presidential order has been posted on the Kremlin website. Concurrently, the government has been instructed to devise a development strategy for OJSC GLONASS, as well as prepare and submit to the State Duma changes to the law "On the state automatic information system, ERA-GLONASS," that are necessary for setting up, and functioning of, the joint-stock company.

The Cabinet has been instructed to outline the new company's main objectives that would include ensuring prompt receipts, thanks to the use of a satellite signal, "of information about road traffic and other incidents on Russian motorways." OJSC GLONASS should also process, store and transfer such information to emergency services and ensure access to such information in accordance with the Russian laws. *http://rbth.com/news/*

Russia keen on putting GLONASS stations in Alaska

Russia has offered the United States its GLONASS station for differential correction and monitoring to be placed on the Alaskan coast opposite Russia's Chukotka peninsula, according to Russian Space Systems' General Director Gennady Raikunov. The Russian system for differential correction and monitoring (SDKM) for mapping vertical and ionospheric delays and information on the integrity of navigation signals from global satellite navigation systems in Russia necessitates SDKM data-collecting stations to be placed abroad, including, as an option, a station in the U.S., in the city of Teller in Alaska," Raikunov said, commenting on the desirable location for the Russian ground system GLONASS. Earlier the U.S. refused to host Russia's GLONASS, citing national security concerns. *http://rbth.com/news/*

Russian GLONASS to boost yield capacity by 50%

Deployment of GLONASS satellite navigation systems to the BRICS states is very promising, the technologies allow to boost yield capacity up to 50 percent, Russian President Vladimir Putin said at the plenary session of the BRICS summit.

"The joint implementation of the Russian global navigation systems GLONASS looks very promising in a whole range of spheres: transportation, national security and even agricultural industry, where GLONASS technologies, according to the experts' estimates, allow to boost yield capacity by 30-50 percent," Putin said. *http://en.ria.ru/russia/*

Russia plans to place three GLONASS ground stations in China

Russia is set to sign an agreement this year with China to place three GLONASS ground stations on the territory of China and three Chinese stations in Russia accordingly. These navigation systems

operate well together, with BeiDou, launched in 2012, envisaging the operation of 35 satellites and GLONASS orbital grouping including and four satellites in orbital reserve and 24 in routine operation. *http://voiceofrussia.com/news/*

Alibaba locates potential in Beidou system

E-commerce giant Alibaba Group Holding Ltd is set to join with the country's largest defense equipment manufacturer to promote the Beidou satellite navigation system for civilian use, insiders said.

Numerous reports on said the cash-flush Alibaba Group has added to its latest investment spree by inking a deal with State-owned China North Industries Group Corp for a joint venture based on the Beidou system. Alibaba's latest move is expected to boost the civil use of the Beidou system, said Cao Chong, an expert with the GNSS and LBSAssociation of China. *www.chinadailyasia.com*

Harbinger Sues U.S. Government over LightSquared

Harbinger Capital Partners, a hedge fund controlled by Phil Falcone that acted as the primary financial backer of LightSquared, is suing the United States government over the failure of the proposed terrestrial broadband wireless network that would have broadcast in RF spectrum adjacent to GNSS L1 frequencies.

The complaint, filed on July 11, 2014 in the U.S. Court of Federal Claims in Washington, D.C., asserts that Harbinger entered into a "contract" with the FCC whereby the firm would be allowed to purchase the company SkyTerra, in which it had a partial stake, and use its frequencies to support a new nationwide broadband network that Harbinger would pay to build.

The FCC sought to support certain policy goals through the arrangement and set a number of terms and conditions in the agreement to support that end. Harbinger alleges the government then reneged upon the deal after Harbinger had spent almost $1.9 billion of its own funds to meet the terms.

First Satellite Masters Conference set to launch in Berlin

The first Satellite Masters Conference will provide a unique marketplace for sharing innovations based on satellite navigation and Earth observation capabilities and connecting with the world's leading network for downstream satellite business.

The conference is being organised by Anwendungszentrum GmbH Oberpfaffenhofen (AZO) and will be hosted by the German Federal Ministry of Transport and Digital Infrastructure (BMVI) in Berlin from 23 - 24 October 2014.

The Satellite Masters Conference is geared toward all those looking to benefit from the emerging satellite applications market, from start-ups, SMEs, and researchers to investors, institutional stakeholders, and members of industry. *www.satellite-masters-conference.eu*

France Uncertain About Adopting Galileo's Encrypted Service

The French government is not yet convinced that the encrypted, government-only signal to be carried on Europe's Galileo positioning, navigation and timing satellites will be secure enough to permit its wide adoption by French defense forces, the head of the French arms procurement agency, DGA, recently said. The French position, outlined even as the U.S. military prepares to make wide use of Galileo alongside the U.S. GPS constellation, suggests that what remains one of Galileo's most promising domestic markets — European militaries — has not yet been fully won over.

"We are looking for a strategic autonomy in positioning and timing," DGA chief Laurent Collet-Billon said in July 1 remarks to the French Senate at a hearing on space policy. "In this case we need guarantees of robust security for defense, equivalent to the GPS [military] code. For PRS, the production controls and the export controls need to cover the security needs of the member nations."

PRS, or Public Regulated Service, is the Galileo equivalent to the GPS military-code signal, which is available to NATO member nations.

After an initial argument, notably between France and the United States, on what frequencies would be used by PRS relative to the GPS M-code, PRS is now using frequencies that do not overlap the M-code and thus offer a backup in the event that GPS signals were knocked out in a conflict zone.

Australia's largest mapping project to mitigate floods

The Queensland State Government saved over A$99 million (US$94 million) in the largest Australian mapping project to mitigate flood by using GIS. The project's success has caught the attention of the United Nations.

Queensland is mapping 630,200 kilometers of watercourse following the state's devastating floods and cyclones in the past few years. "The aim was to produce maps that alerted councils to areas that are susceptible to flooding, ensuring appropriate preparation and mitigation strategies are in place," said Andy Stewart, from the Land and Spatial Information unit at Department of Natural Resources & Mines (DNRM).

Instead of using the traditional approach of floodplain mapping, which would have cost A$10,000 (US$9,500) per stream kilometre for a detailed flood study, it used "cutting-edge GIS technology to generate fit for purpose flood maps based on a range of existing datasets," said Stewart. "Instead of the project costing $100 million and taking a decade, we created 8,875 maps at one dollar per stream kilometre in seven months – keeping the entire cost under AU$1 million (US$950,000)," he said.

NovAtel launches CORRECT with TerraStar PPP promotion

NovAtel has announced a promotion for existing customers for the company's recently launched NovAtel CORRECT with TerraStar PPP subscription service. Customers using NovAtel legacy equipment (OEMV generation receivers or earlier) or NovAtel's current OEM6 technology qualify for the following offers:

- Trade in legacy NovAtel hardware for a FlexPak6, antenna, and one-year TerraStar subscription for $4,995.
- Buy a minimum 1-year TerraStar subscription for any OEM6 receiver and get a NovAtel CORRECT PPP receiver firmware upgrade for free. The promotion will run until September 30, 2014.

Spectra Precision SP80 GNSS Receiver Sets New Industry Standard

Spectra Precision SP80 GNSS receiver is designed to meet the evolving needs of the survey market. It combines GNSS technology and a combination of communication capabilities with a distinctive and ergonomic design. It features Z-Blade GNSS-centric technology running on a new-generation, 240- channel 6G chipset. It is capable of fully utilizing all six available GNSS systems, but also can be configured to use only selected constellations in an RTK solution (GPS-only, GLONASS-only or BeiDou-only).It is the first GNSS receiver on the market to be compliant with the new RTCM 3.2 standard, including the recently approved MSM RTCM messages, which also makes it the only receiver ready to support all available GNSS corrections. *www.spectraprecision.com*

Trimble acquires the Omega Group

Trimble has acquired the assets of privately-held The Omega Group, headquartered in San Diego, California. The Omega Group is an industry-leading provider of cloud-based and on-premise operational performance support software that integrates mapping, analytics, intelligence and mobile technologies, allowing public safety agencies to optimize patrol strategies and daily field work. Financial terms were not disclosed. *www.trimble.com*

Leica precision technology for Nottingham tram extension

A pioneering, mechanised system for track construction, developed by Alstom Transport and Leica Geosystems, is driving the speedy, high accuracy delivery of two new tram lines for Nottingham Express Transit (NET). Construction work features Appitrack™ (Automatic Plate and Pin Insertion), an automated system designed to lay concrete slab track and insert base plates with speed, certainty and to millimetre accuracy. Leica Viva TS15 total stations and Leica PaveSmart3D software position, guide and control the concrete paver and base plate insertion vehicle as they progress in convoy. The Appitrack™ system allows the construction team to work within these limitations, as the slab track can be laid in congested urban environments in a patchwork arrangement. www.leica-geosystems.com

Rockwell Collins joins European GNSS project

Rockwell Collins's flight management system (FMS) and GNSS receiver enabled the first successful demonstration of advanced arrival and departure flight operations for the EU's new airspace enhancement project. Known as FilGAPP (filling the gap in GNSS advanced procedures and operations), the programme aims to develop efficient and accurate methods of navigating airspace using satellite-based navigation and advanced FMS functions. *www.flightglobal.com*

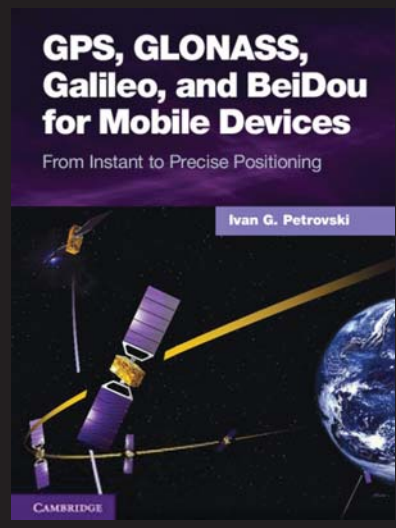
RTK receiver for the Esri community by Altus

Altus Positioning Systems has unveiled new GNSS RTK receiver designed and developed specifically for the Esri user community. The new Altus APS-NR2 provides a never-before-available combination of performance and features. It is light weight - 1.5 lbs., the APS-NR2 has a dual cellular antennae with automatic switchover ensuring minimum downtime due to signal loss. It works on virtually all RTK networks and has built-in Wi-Fi. *www.altus-ps.com*

Topcon FC-500 Handheld Data Collector for GIS

Topcon Positioning Group has released FC-500 data controller. It is a "perfect fit for any mapping application to maintain GIS databases for electric utilities, gas pipelines, disaster management, water and wastewater operations, forestry, highway maintenance, environmental applications and more. Compatible with either the Topcon eGIS or MAGNET®

BOOK RELEASE



Get up to speed on all existing GNSS with this practical guide. Covering everything from GPS, GLONASS, Galileo, and BeiDou orbits and signals to multi-GNSS receiver design, AGPS, RTK, and VRS, you will understand the com¬plete global range of mobile positioning systems. Step-by-step algorithms and practical methods provide the tools you need to develop current mobile systems, whilst coverage of cutting edge techniques, such as the instant positioning method, gives you a head-start in unlocking the potential of future mobile positioning. Whether you are an engineer or business manager working in the mobile device industry, a student or researcher, this is your ideal guide to GNSS.

Send you queries to ivan@ip-solutions.jp

Field GIS software, the FC-500 is designed to create smooth and speedy dataflow between the field and office. *www.topconpositioning.com*

GEO Business 2014 show unites geospatial industry

The inaugural GEO Business show, held in Business Design Centre in London on 28-29 May 2014, was a big success. Queues of enthusiastic visitors marked the opening of the two day show, which was attended by over 1,600 attendees from 39 countries.

Combining a bustling central trade exhibition featuring 118 exhibitors showcasing the latest geospatial technology and services, with a packed conference programme of cutting-edge keynotes and presentations plus 96 commercial workshops, GEO Business delivered on its promise to provide an essential focal event – the first of its kind in the UK. It was organised in collaboration with The Survey Association (TSA), the Royal Institution of Chartered Surveyors (RICS), the Chartered Institution of Civil Engineering Surveyors (ICES) and the Association for Geographic Information (AGI). GEO Business will return to The Business Design Centre in London on 27-28 May 2015. *www.geobusinessshow.com*

Optech Lidar Sensor for OSIRIS-REx Asteroid Sample Return Mission

Optech is pleased to announce that one of the company's lidar systems will be a critical part of NASA's Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer (OSIRIS-REx) mission to study asteroid Bennu and return a sample from its surface to Earth. Scheduled for launch in late 2016, the probe will use its OSIRIS-REx Laser Altimeter (OLA) to survey the entire surface of the 500-m wide carbonaceous asteroid repeatedly over the course of several months. The OLA will help OSIRIS-REx complete its scientific and technical goals by creating a precise 3D model of the asteroid that details its structure and volume, giving scientists insight into Bennu's density and composition. It will also provide exact ranges to Bennu to help interpret data from the probe's other sensors. Astronomers have determined that Bennu has a small chance of colliding with Earth in the next century, so this mission is crucial for determining the exact risk it poses and deciding how to steer it away from our planet if it does come too close.

US Air Force GPS technology exceeds technical requirements in critical test

The U.S. Air Force has demonstrated successful operation of its next-generation Military-code GPS signal in a jamming environment using a Raytheon Company receiver. In a recent test, the Raytheon-built Miniaturized Airborne GPS Receiver 2000 (MAGR2K) maintained GPS satellite tracking and provided accurate navigation at jamming levels far exceeding technical requirements. The MAGR2K was integrated with the Raytheon Advanced Digital Antenna Production (ADAP) system

and equipped with a specialized M-code receiver card. *www.raytheon.com*

Free SilvAssist Software To SAF Accredited Forestry Schools

F4 Tech shall contribute to future foresters' education with complementary SilvAssist software to the Society of American Foresters (SAF) accredited schools. SilvAssist is a set of compelling GIS tools for managing forest inventory data. Institutions with SAF accreditation will be eligible for licensing of the cutting-edge SilvAssist solution to integrate within their curriculum.

Students to use mapping technology on urban challenges in Singapore

For the first time, students taking part in the Singapore government's annual geospatial challenge worked with town leaders to solve problems such as improving mobility for the disabled, promoting healthy lifestyle among residents, and encouraging community bonding. The government recognised 22 student teams from the Singapore Geospatial Challenge recently for their use of mapping technology to solve such urban challenges. Teams used geospatial analytics to create accessibility maps, based on factors such as locations of sheltered pathways, time taken to walk between destinations and wheelchair-friendly areas.

Large-Area Projects with Riegl LMS-Q1560 Airborne LiDAR

Eagle Mapping Ltd has become the first commercial firm in North America to take delivery of the new Riegl LMS-Q1560 airborne laser scanner system. Designed to capture ultra-wide swaths and complex environments,the high-performance Riegl LiDAR will enable Eagle Mapping to expand into new markets including large-area, forestry and urban mapping applications for governments and first nation organizations. *www.eaglemapping.com*

MARK YOUR CALENDAR

September 2014

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

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

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

October 2014

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

6th Asia Oceania Regional Workshop on GNSS
9-11 October
Phuket, Thailand
www.multignss.asia/workshop.html

GeoForm
14-16 October 2014
Moscow, Russia
http://www.geoexpo.ru/en-GB

Esri Mid-East & Africa User Conference
22 - 24 October 2014
Kuwait
http://www.esri.com/events/meauc

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

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

NZIS Conference 2014
29 Oct - 1 Nov
New Plymouth, New Zealand
www.nzisconference.org.nz/

November 2014

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

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

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

G-spatial EXPO
13-15 November
Tokyo, Japan
http://www.g-expo.jp/

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

December 2014

European LiDAR Mapping Forum
8-10 December
Amsterdam, The Netherlands
www.lidarmap.org/europe

February 2015

The Unmanned Systems Expo
4 - 6 February
The Hague, The Netherlands
http://www.tusexpo.com

March 2015

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

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

May 2015

RIEGL LIDAR 2015 User Conference
5 - 8, May
Hong Kong & Guangzhou, China

36th International Symposium on Remote Sensing of Environment
11-15 May
Berlin, Germany
http://www.isrse36.org

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

GEO Business 2015
27 - 28 May
London, UK
http://geobusinessshow.com/

June 2015

TransNav 2015
17 - 19 June
Gdynia, Poland
http://transnav2015.am.gdynia.pl

July 2015

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

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