RNI: DELENG/2005/15153
Publication: 15th of every month
Posting: 19th/20th of every month at NDPSO

No: DL(E)-01/5079/14-16
Licensed to post without pre-payment U(E) 28/2014-16
Rs.100

ISSN 0973-2136

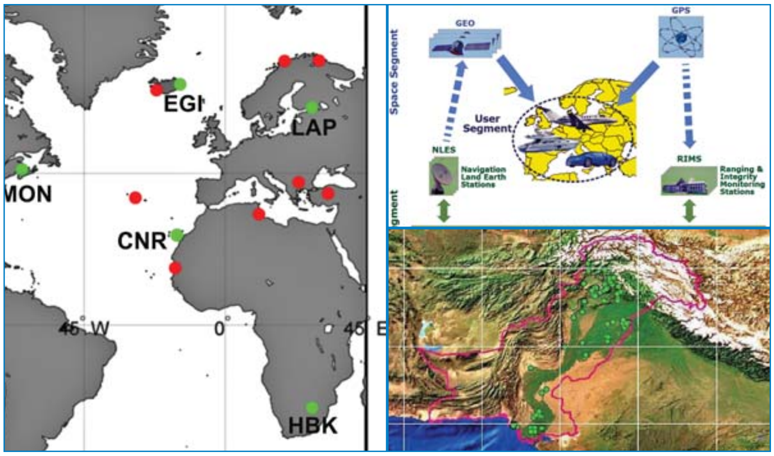
www.mycoordinates.org

Coordinates

Volume X, Issue 03, March 2014

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

Striving towards Robust Interoperable Seamless Multi-frequency SBASs



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This issue has been made possible by the support and good wishes of the following individuals and companies
Asmat Ali, AK Jain, Carmen Aguilera, Deane Bunce, Didier Flament, Florian Kressler, Frédéric Lecat, Gi Wook Nam, Hannes Stratil, Hua Su, Jean-Marc Pieplu, Jörg Pfister, Keerthi Narayana, Markus Schenk, Munir Ahmad, Roman Srp,Takeyasu Sakai, V Somasundaram and Zuzana Bělinová and; Foif, Hemisphere GPS, HiTarget, Javad, KCS Trace Me, Navcom, NovAtel, Riegl, Rohde & Schwarz, Spectra, Supergeo, TI Asahi, Trimble, and many others.

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Web www.mycoordinates.org

Annual subscription (12 issues) [India] Rs.1,200
[Overseas] US$80

Printed and published by Sanjay Malaviya on behalf of Centre for Geoinformation Technologies at A221 Mangal Apartments, Vasundhara Enclave, Delhi 110096, India.

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Designed at Spring Design (springdesign@live.com)

Printer Thomson Press India Ltd., B 315, Okhla Phase I, New Delhi - 110020, India

This issue of Coordinates is of 64 pages, including cover.

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SBASs: Working together

WAAS, EGNOS, GAGAN, MSAS, SDCM, K-SBAS …

All SBASs are regional systems.

The need of a seamless transition between SBAS service areas

Not only underlines the importance of adequate cooperation

But also makes issues of compatibility and interoperability critical.

The endeavors by the ICAO and SBASs

To target the development of dual frequency multi constellation SBAS by 2018

Not only may help address the ionospheric issues

But will also lead to a robust infrastructure

Enabling proper service delivery to end users and maximizing the benefits.

Bal Krishna, Editor
bal@mycoordinates.org

SBASs: Striving towards seamless satellite navigation

At the International Civil Aviation Organization (ICAO) 4th Ionospheric Study Task Force (ISTF/4) and 26th Interoperability Working group held at New Delhi from 5-7 February 2014, Coordinates interacted with experts on issues and challenges pertaing to different Space Based Augmentation Systems (SBASs)

After the recent landmark achievement of certification of Indian SBAS System GAGAN for RNP 0.1 operations, India is hosting two back to back high-level technical meetings i.e. 4th Ionospheric Study Task Force (ISTF/4) under the aegis of ICAO and the 26th Interoperability Working group in New Delhi , providing further impetus to harmonized development of Satellite Based Navigation systems across the world.

ICAO ISTF has been tasked with the objective of collecting data, studying and developing Region-specific ionospheric models for implementation of Satellite Based Augmented Systems in Asia Pacific Region. As Asia Pacific Region comprises states that lie in equatorial ionospheric region and are affected by ionospheric scintillations which may result in loss of GNSS signal, developing an appropriate algorithm to mitigate them has become necessary.

The inter-operability Working Group is the forum for SBAS Service Providers, set up with the objective of harmonizing the global SBAS systems and ensuring seamless navigation with inter-operable systems.

Mr V Somasundaram, Board Member of AAI for Air Navigation Services, welcoming the delegates of both the meetings, emphasized the need for a collaborative approach among all the States, ANSPs and SBAS providers for finding a common solution to mitigate the Ionosheric Effects and work towards Harmonizing SBAS Standards and Systems leading to Global Harmonization.

Mr Frederick Lecat ,Regional Officer, ICAO and Mr Dean Bunce, FAA, WAAS Program manager, delivered their technical address. The officials thanked India for supporting the ICAO initiatives on SBAS and congratulated India on becoming the 4th certified SBAS developer in the world.

Mr A S Ganeshan, Outstanding Scientist, ISRO elaborated on GAGAN development leading to the certification for RNP 0.1 operations and the upcoming IRNSS which is set to become operational by 2015. IRNSS is an Independent Regional Navigation Satellite System being developed by India indigenously and in conjunction with GAGAN would provide accurate position information service to users in India.

Mr Ashok Lavasa, Secretary Civil Aviation , delivering the keynote address, appreciated the Indian ANS initiatives leading to safety and efficiency of aircraft operations and remarked that the huge 12th Five Year outlay for Aviation Industry would foster the Aviation Growth in the country. The Secretary also sought the attention of the participating States to the need for close collaboration among the States in finding solution to the complex Ionospheric issues and called for taking up all the required steps in ensuring interoperability of various SBAS systems across the world for seamless navigation.

India's much-needed initiative in hosting both the meetings at the same venue brings together the prospective SBAS providers and the Asia Pacific States of on a single platform to support, research and develop reliable and interoperable SBAS systems leading to seamless satellite navigation regardless of boundaries.

GAGAN certified for aviation use by DGCA

On 14th February 2014, GAGAN signal-in-space was made available for providing Operational service to en-route flights within the entire Indian Flight Information Region covering both Bay of Bengal and Arabian Sea Regions.

This will now enable appropriately certified aircraft to derive the benefits of GAGAN. It will also enable AAI to develop and flight validate appropriate procedures using certified SBAS receivers. AAI will develop procedures to use GNSS for approach and landing in the coming months.

The GAGAN is designed to provide the additional accuracy, availability, and integrity necessary to enable users to rely on GPS for all phases of flight, from en route through approach for all qualified airports within the GAGAN service volume. GAGAN will also provide the capability for increased accuracy in position reporting, allowing for more uniform and high-quality Air Traffic Management (ATM).

"GAGAN is available for aviation use from 14th February 2014"

V Somasundaram, Member Air Navigation Services (ANS), Airports Authority of India on the significance of GAGAN (GPS Aided GEO Augmented Navigation) certification

GAGAN achieves RNP 0.1 certification. Can you explain the significance?

RNP 0.1 service capability provides horizontal accuracy (95% containment) within ± 185 meters of the intended route of operation. RNP 0.1 is capable of supporting:

a) Reduced lateral and longitudinal separation minima and enhanced operational efficiency in oceanic (Bay of Bengal – Arabian sea-Indian Ocean within Indian Flight Information Region) and remote areas where the availability of navigation aids is limited.
b) Flexible ATS routes and airspace structure. Normally associated with continental airspace but may be used as part of some terminal procedures.
c) Arrival, Initial/Intermediate Approach and Departure; also envisaged as supporting the most efficient ATS route operations.

Based on the performance based navigation road map, India has published standard instrument departures (SID), standard arrival routes (STAR) for all major airports, LNAV (2D) / Baro VNAV approaches at Cochin and are in the process of publishing RNAV GNSS approaches at major airports.

All the above processes can be efficiently done by use of SBAS equipped aircraft without the need for additional RAIM (Receiver Autonomous Integrity Monitoring essential for GPS).

How GAGAN can benefit?

GAGAN has provided the capability for continuous real time monitoring and recording of GPS/ GAGAN data and is able to provide the users the advance predictability required for flight planning purposes.

GAGAN is already being utilized for non-aviation users such as:

a. Estimating Indian plate movements velocity
b. GCPL Network (Ground Control Point Network)
c. Station Coordinate estimation, Update GCPL network
d. Demonstrated rapid GCP collection using GAGAN SBAS signal with an accuracy of better than 1m with observation time of 10min
e. Densification of GCPs through GCPL Ph3 project for future high resolution Cartographic mission
f. Integrating GAGAN SBAS data with GIS for navigational applications
g. Atmospheric studies –Tropo using GAGAN reference station data
h. Studies on scintillation in L-Band during equinox over India
i. Regular Station Coordinates estimation
j. Performance monitoring of GAGAN system
k. SBAS-SIS messages monitoring, comparison with other systems

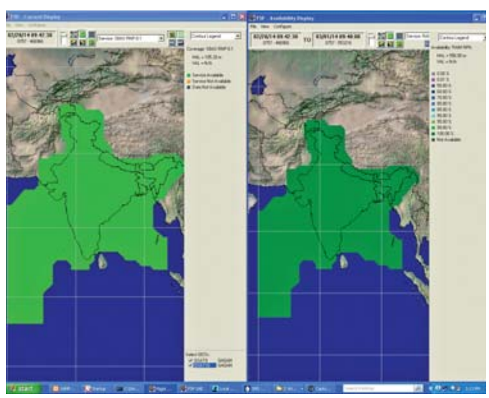
> The need for rewriting the algorithm meeting the EIA region required research work from the Indian Scientific community spear headed by ISRO

GAGAN is available for aviation use from 14th February 2014. Initially performance monitoring and predictability tool is provided and the new procedures will be developed and published.

Which are the user segments other than aviation likely to be benefitted by the GAGAN?

Different user segment likely to be benefited by the GAGAN are as follows:

a. Road transport: - a wide range of applications including navigation devices to automatic toll systems, safety applications and pay-per-use insurance.
b. Air transport: - improved accuracy and integrity of navigation systems to optimize flight planning and so lower fuel use, time and emissions.
c. Maritime: - Vessel tracking and tracing inland water transport. Port approaches.
d. Rail transport: - signaling and train location systems. Improved safety of speed control and operating systems.
e. Agriculture: - Optimize crop control, reduce fertilizer and pesticide inputs, and ensure effective use of land and water.
f. Search and rescue: - allowing near real-time reception of



distress messages from anywhere on Earth with precise location information between rescue centres and people in distress.

g. Location-based services: - Customers will be able to access specific ‘vicinity’ information through their mobile phone (e.g. the nearest restaurant or cash point machine, the best way to the nearest hospital).

h. Oil and gas: – Exploration and exploitation of oil and gas fields.

Being the first SBAS in equatorial ionospheric region, do you see some operational challenges?

Being the first SBAS in the equatorial ionospheric region, there have been many operational challenges. The need for rewriting the algorithm meeting the EIA region required research work from the Indian Scientific community spear headed by ISRO. India had installed a total of 26 Total electron Content stations for collection of Iono data from all over India since 2004. The data analysis was further augmented from the inputs of eight GAGAN reference stations installed in 2007 under the technology demonstration phase. The algorithm working group formed by ISRO continued its work in coordination with many Indian Universities over the last five years to provide the new algorithm that would work for GAGAN. The results was reviewed by a Technical review Team formed by DGCA to look into certification. The algorithm is undergoing the process of fine tuning. GAGAN is expected to be ready for Approaches with vertical guidance (APV1) by the end of 2014.

How important is the issue of interoperability in the context of SBAS?

Only those receivers that can process SBAS messages can be used for receiving GAGAN messages. But all those receivers that can receive WAAS/EGNOS or MSAS can receive GAGAN and GAGAN is interoperable with other SBAS receivers.

Taking Stock of EGNOS

Jean-Marc Pieplu

Carmen Aguilera

Didier Flament

Coordinates spoke with Jean-Marc Pieplu, Head of the EGNOS Exploitation Program and Carmen Aguilera, Market Development Officer at the European GNSS Agency, and Didier Flament, Head of EGNOS and SBAS Division at the European Space Agency about the service, its current success and plans for the future.

What is the status of EGNOS?

Everyday EGNOS delivers the services it has been designed for, with a remarkable level of stability and performance. The Open Service improves the accuracy of GPS horizontally and vertically to meter-level and the Safety-Of-Life service delivers continuous integrity protection in compliance with ICAO Standards, allowing APV-I approaches with an over 99% availability. The EDAS Service provides EGNOS data to professional users for added-value applications and scientific use.

EGNOS Operations continue to manage technological transitions as needed to renew any obsolete infrastructure. For example, migration to a modernized ground communications network technology was successfully deployed in January 2014, migration to the two new geostationary dual-frequency transponders on-board SES-ASTRA satellites is underway (new L1 signals foreseen in 2014 and 2015), and renewal of obsolete ground stations and processing centres is under preparation.

Continued EGNOS operations and service provision has been ensured through a new contract awarded by the GSA to the ESSP last year. This contract is now implemented in the framework of the new GNSS Regulation 1295/2013 adopted by the European Union in 2013. This ensures the multi-year financing of the EGNOS program until 2020, and establishes a new governance structure where the GSA responsible for EGNOS Exploitation under delegation by the European Commission. This includes the development of future system evolution to be implemented through an arrangement with ESA.

In the past, the Service improvements focussed on APV-1 availability and coverage provided thanks to changes implemented in the Ionospheric Processing and the addition of some stations. The APV-1 service, as offered by the release V2.3.2, is now much more robust to ionospheric perturbations than when EGNOS was declared operational. The next improvement will be the delivery of the LPV200 service which is under study and for which a preliminary service area should come with the V241M / V241P. After this, the next major system evolution (v2.4.2) should be operational by 2017 aiming at solving the remaining obsolescence issues. Finally the second generation of EGNOS, ‘EGNOS Dual Frequency Multi-Constellation’ (or EGNOS V3) is under study by ESA in their EGEP Program. EGNOS V3 is planned to offer significantly improved service performance (accuracy, continuity of service, lower vertical alert limit, coverage) thanks to new signals and Galileo satellites. These services are prepared for the second generation EGNOS/GPS/Galileo User Receivers (avionics) planned to equip aircraft before 2025.

Which areas does EGNOS benefit?

EGNOS aims to cover the territories of the 28 EU Member States. Today, EGNOS has almost reached this goal, with several border areas still to be covered. The extension to full EU-28 coverage is a main program objective and a priority for the next system evolution. The system is facing obsolescence of some ground monitoring stations which is limiting the capacity to deploy new monitoring sites in the short term. New developments should be launched to ensure the technology refresh required to deploy and maintain further coverage extension capacities.

What are your plans to ensure interoperability?

The compatibility and interoperability between SBAS, and with neighbouring systems, is necessary to ensure proper service delivery to end users and to enjoy maximum benefits from SBAS technology. It impacts the design of system evolution towards multi-frequency and multi-constellation service provision, but also day-to-day operations. For example, EGNOS is currently addressing with our Russian partners the compatibility between the EGNOS signals transmitted by Inmarsat 3F2 and the new signals transmitted by Luch 5B. SBAS are delivering regional signals and services over coverage areas which are mutually complementary or overlapping. Cooperation between SBAS service providers is thus a key enabler for all SBAS and a clear program objective for EGNOS since it is in the best interest of users.

There are several international technical working groups used to sustain the current and future interoperability between SBAS. These include the sub-groups of the Standardisation bodies (ICAO, RTCA, Eurocae) as well as the Interoperability Working Group IWG. The IWG was created by US FAA and European ESA in early 2000's and is meeting twice a year. One of the important tasks of this group is the development of the Dual Frequency Multi-Constellation Definition document and associated Interface Control Document. This ICD is the first important step towards the second generation SBAS Standard that will continue to guarantee full interoperability between all SBAS.

What is the progress in developing user standards?

Europe is active in the development of future SBAS standards, which are a cornerstone for the new generation of EGNOS. Two main lines of activities are under way: the development of standards for Galileo signals use and the development of DFMC (Dual-Frequency Multi-Constellation) SBAS standards. Concerning the new SBAS standards, a stable definition of the new L5 messages is expected to be established with our SBAS partners in 2014 in order to be proposed to avionics manufacturers within the year and launch the preparation of associated MOPS for Aviation. A similar effort supporting the Maritime user community has been initiated and will continue.

Any plans to develop multi-frequency capacity?

We intend to develop this capacity for EGNOS, which is expected to bring additional service robustness against ionospheric perturbation and ease the service coverage extension with a minimum number of ground monitoring stations. SBAS will then become even more reliable. The mission requirements are currently under consolidation and should be stabilized before year end. We will then benefit from the EGEP Program financed by ESA Member States, the results of which will be re-used in the Exploitation phase. The EGNOS space segment compatible with this multi-frequency capacity will be fully deployed in 2014 with three transponders on-board Inmarsat and SES-ASTRA satellites. The Service Provision capacity, for which development still depends on the joint definition of a new L5 ICD, will require a multi-year ground segment and operations transition that is currently envisaged to be completed between 2021 and 2023.

Two contracts are on-going within ESA for the definition of the G/S Evolution to provide this DFMC capability. In parallel, ESA is also developing system test beds prototyping the DFMC system for experiments and demonstration of the benefits of augmenting new GPS signals as well as Galileo signals. Demonstrations are planned for 2015 using deployed Galileo satellites (IOV + FOC).

Which user segments does EGNOS focus on?

EGNOS is currently mainly driven by Aviation users, for which GNSS SoL services are already part of their operations. However, other transport modes such as Maritime and Rail can also benefit from EGNOS. Finally, as a regional augmentation system, EGNOS has the potential to enter many other markets which cannot be fully addressed by global constellations.

What are your plans for increasing EGNOS market penetration?

GSA Market Development has established a specific action plan responding to the needs of each market segment.

EGNOS safety and economic benefits for airspace users are acknowledged and take up in Europe is expected to increase. More than 100 airports are already benefitting from EGNOS and more than 400 runways plan to use EGNOS-enabled approaches by 2018. Activities in aviation are focused on supporting States to identify the aerodromes which can most benefit from EGNOS, map them in the national PBN plan and assisting LPV operational implementation. On the operator side, GSA helps regional, business, general aviation and helicopters to get EGNOS on-board and approved to perform LPV approaches, while ensuring availability of cost-effective avionics solutions. The tools in place include incentive schemes, specific training, technical and business assistance and research and development.

The opportunities for EGNOS in maritime are promising. While leisure boats are already benefitting from EGNOS, further needs of the maritime community are being assessed together with the European Maritime Radio navigation Forum (EMRF) in view of EGNOS v3. The GSA's strategic objective for rail is to enable the use of E-GNSS in safety critical railway

"The current goal is to have a DFMC MOPS available in 2018"

Says Deane Bunce, the Federal Aviation Administration (FAA) Wide Area Augmentation System (WAAS) Program Manager

Please update with the status of WAAS and its coverage?

WAAS provides Localizer Performance with Vertical guidance (LPV) capability to 200 feet decision height in the coterminous United States (CONUS) and Alaska. WAAS also provides Required Navigation Performance (RNP) capability throughout North America and for much of South America.

What are your plans for dual frequency operations?

The United States Government (USG) Federal Register Notice states 'sunset' for L2 P(Y) signal use in December 2020. WAAS plans to support a dual-frequency service when WAAS transitions from L2-semicodeless to the use of L5. As such, the FAA is currently modifying the WAAS infrastructure to support receipt and processing of the L5 signal. The FAA plans to test and validate dual-frequency algorithms when sufficient L5 signals are available. The dual-frequency service will improve the availability and extend the service area for LPV-200.

Explain the significance of transition from L2 to L5?

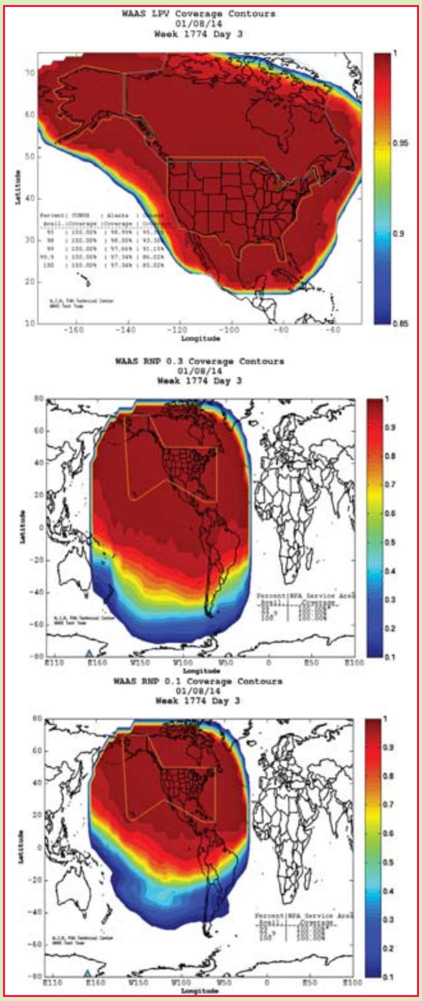
The transition from L2 to L5 within the WAAS will need to be completed prior to the sunset of the L2 P(Y) signal and will require that 24 GPS satellites are operationally broadcasting the L5 signal.

How do you look at the issue of interoperability in view of emergence of several SBAS?

The expectation is that emerging SBAS providers will develop and check interoperability as part of their SBAS' approval process. SBAS that follow the International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARPS) should be compatible and usable by all airborne equipment. Recent FAA flight testing demonstrated the capability of approved SBAS avionics equipment to transition between WAAS and EGNOS. Presumably, any compliant SBAS whose signal meets the existing standards can be used.

What are your plans in developing the user standards?

User standards are developed jointly with industry through the RTCA Special Committee 159 on GPS and GPS augmentations. The FAA plans to support the committee activities. The FAA is also working with the SBAS Interoperability Working Group (IWG) on a definition document that provides the basis for interface design and Minimum Operational Performance Standards (MOPS) development for L1/L5 and multi-constellation. The current goal is to have a Dual-Frequency Multiple Constellation (DFMC) MOPS available in 2018.



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What are the key issues in international collaboration?

The SBAS IWG was established by the SBAS service providers to provide a forum for international collaboration and to address interoperability questions. The IWG is currently working to define key aspects of the Dual-Frequency Multiple Constellation (DFMC) SBAS. The key issue is ensuring that the written requirements are interpreted consistently. Based on the successes of SBAS IWG collaboration in the past, successful collaboration is expected on this issue.

What are key commonalities between WAAS and GAGAN?

Both WAAS and GAGAN have been developed to be ICAO SARPS compliant. As such, key commonality is compliance with the SARPS and broadcast of standard SBAS messages. Operationally, the expectation is that GAGAN will operate and behave in a manner similar to WAAS.

Many of the same organizations that have supported the development of GAGAN have supported the development of WAAS. This includes, but is not limited to, Raytheon, Stanford University, and MITRE.

What has been FAAs' association with the development of GAGAN?

The FAA's association with the development of GAGAN has been similar to its involvement with other SBASs. The FAA was not directly involved with GAGAN development, but does share technical knowledge and lessons learned with GAGAN and other SBAS service providers throughout the world. The purpose of this collaboration is to grow global SBAS coverage and ensure interoperability.

How vulnerable is WAAS to the threats of jamming, interference and spoofing etc?

There are multiple studies and reports available on the impact of jamming, interference, and spoofing of GPS receivers. WAAS has experienced episodes of interference at several reference station locations but due to the distributed nature of the WAAS reference stations and the data validation and integrity monitors, WAAS service availability has not been impacted.

Besides aviation, how has WAAS benefitted other segments users?

Even though WAAS was designed for aviation, it is widely used for non-aviation applications. WAAS is used extensively for mapping, surveying, shipping, and boating. For example, municipalities across the U.S. use WAAS survey receivers to map assets such as fire hydrants, road markings, light poles, and other items. WAAS has been used in the Puget Sound, in Washington, to precisely locate derelict fishing gear and crab pots. Additionally, many recreational boaters and shipping companies have transitioned to high-performance GPS L1 receivers, using WAAS optimized for non-aviation users, to help them navigate safely into harbors. As more applications are identified, WAAS use continues to grow within the non-aviation sector.

applications, specifically low density line signalling and evolutions of the European Rail Traffic management system (ERTMS). UNISIG, an industrial consortium created to develop the ERTMS/ETCS technical specifications, is defining requirements for EGNOS corrections in specific rail environment for EGNOS evolutions.

Beyond transport, EGNOS is the preferred choice of European farmers using GNSS, estimated at nearly 200.000 tractors, out of which two-thirds use EGNOS. Looking to the future, falling prices should drive further growth in precision agriculture.

Is industry encouraged to participate in EGNOS?

Concerning downstream activities, the EU's FP7 R&D program has been replaced by the new H2020 R&D program which will continue to support application development. Industrial associations are fostering EGNOS adoption and drive evolution. Collaboration with the European Business Aviation Association, European Regional Aviation Association, AOPA Europe, etc. helps keep the service in line with user needs. It is essential to bring EGNOS to airspace users and request implementation of LPV approaches to airports within their network. Today, almost all new navigation equipment sold by general aviation manufacturers is SBAS capable and IFR pilots can decide to install a stand-alone SBAS enabled receiver for a relatively low price. In rail, UNIFE (The European Rail Industry) is pursuing the introduction of EGNOS in ERTMS through its UNISIG working group. Looking at agriculture, a partnership with industry has been successful in promoting use in precision farming, as well as coordination with the Council of European Geodetic Surveyors (CLGE) is valuable in mapping.

Concerning upstream activities (infrastructure development and service provision), most activity is externalized by GSA and ESA to the private sector, benefiting industry directly. ESA is running the GNSS Evolution Program with many industrial activities (until 2015) to prepare the new technology and industry for the development of the second generation of EGNOS.

Can you highlight the challenges before EGNOS?

In the next 10 years EGNOS will need to complete the obsolescence management implementation program to secure service continuity, in particular with respect to the 2020 US deadline (removal of guarantee to sustain L2P(Y) signals); continue to improve performance robustness vis-à-vis the ionosphere; and transition to the second generation of EGNOS infrastructure and services in a fully interoperable manner to provide the multi-constellation (GPS & Galileo at least) SBAS signals to a second generation of EGNOS Users.

On the market side, the loss of traffic due to the economy impacts the decision of aerodromes and operators to invest in new technology. Making the right tools and support available to users will accelerate adoption and we aim at surpassing the plan for 400 runways using EGNOS-enabled approaches by 2018. One of the main challenges for EGNOS adoption in maritime is to enable transmission of corrections via AIS (Automatic Identification System) as a complement to DGNSS infrastructure. In rail, EGNOS can become the key technology of the train positioning subsystem, if GNSS is included in the European rail command and control standards.

EGNOS is a success, yet it has not reached its full potential. This is due in part to long equipment cycles in Avionics but also to barriers to market adoption which are still very present and mostly due to fragmented regulations at national level and/or absence of unified standards (i.e. Rail sector). As GNSS SoL services are clearly left to SBAS regional systems (this trend being now consolidated by the growth in number of SBAS in operation), the increasing reliance on EGNOS will require enhancing its robustness through the adequate management of obsolescence and the provision of dual-frequency and multi-constellation capacity. The successful future for EGNOS Service Provision will require significant investment for which a clear and stable program plan will be developed in the months to come.

"The current MSAS provides horizontal navigation only"

Says Dr Takeyasu Sakai, Chief Researcher, Electronic Navigation Research Institute (ENRI), Japan

What is the current status of MSAS?

The MSAS has been operational since September 27, 2007. Japan Civil Aviation Bureau (JCAB) began the MSAS program in 1993 and launched the first and second geostationary satellites for the MSAS in 2005 and 2006.

They also have aeronautical communication and weather observation missions. The MSAS consists of 2 geostationary satellites, MTSAT-1R at 140E and MTSAT-2 at 145E, 2 MCS (Master Control Station) in east and west parts of Japan, 4 GMS (Ground Monitor Station), and 2 RMS (Ranging and Monitor Station) in Hawaii and Australia.

The current MSAS provides horizontal navigation only due to the ionosphere problem. The vertical navigation is not supported by the MSAS because the ionosphere at the low magnetic latitude region including the southwestern islands of Japan is highly active and affects the propagation of radiosignals.

Who uses MSAS? Can you give some idea about your user segment in addition of aviation?

In the aviation sector, the most of MSAS users come from general aviation. Some regional commuter planes and general aviation planes equip SBAS-capable navigation sensors. In Japan,

Unfortunately, MTSAT-1R and MTSAT-2 have no transponders for L5 frequency.

SBAS is available as a primary navigation source for approaches and a supplemental navigation for enroute. 40 RNAV and RNP-AR approaches are available in Japan as of May 31, 2013.

In other sectors, many people, including cell phone (and smart phone) users, may implicitly use the MSAS through SBAS-capable GPS chips.

What are concerns and challenges before MSAS?

The ICAO (International Civil Aviation Organization) adopted FANS (Future Air Navigation System) concept in 1991 which clarified the necessity of transition to usage of satellite navigation systems. In this context, GPS-based navigation looked beneficial in terms of coverage and cost because they would be able to reduce conventional ground-based navigation aids. Thus, JCAB decided to introduce satellite-based navigation by implementing the MSAS as an infrastructure of navigation supporting the whole airspace of Japan.

Dual frequency SBAS is an essential solution against the ionosphere problem which is the major error source limiting the performance of the SBAS.

Would you like to explain the concept of dual frequency SBAS?

Dual frequency SBAS is an essential solution against the ionosphere problem which is the major error source limiting the performance of the SBAS.

As you know, in terms of aviation, 'dual frequency' means usage of L1 and L5 civil signals both within the ARNS bands. Additionally, considering the sunset of L2 P/Y signal, usage of L1 and L5 for dual frequency operation is a realistic way.

Unfortunately, MTSAT-1R and MTSAT-2 have no transponders for L5 frequency. The plans for supporting L5 have not been decided yet.

How do you look at the issue of interoperability in the context of MSAS?

Flight crews have little knowledge on which SBAS is used in operation because the onboard FMS automatically choose SBAS to be used.

In such a situation, each SBAS must meet required navigation performance at least for enroute at everywhere in its broadcasting coverage regardless its intended service area. In addition, using SBAS operated by another state involves some legal issues.

In particular, MSAS will have many other SBAS whose coverage is overlapping with MSAS in near future; Russian SDCM, Korean SBAS, and Chinese BeiDou are planned to broadcast SBAS signals. They might have some interoperability issues, for example switching SBAS, with a dependency upon avionics.

"The K-SBAS is expected to be declared operational for open service in the year 2018"

Gi Wook Nam, PM of K-SBAS Program, Korea Aerospace Research Institute, Korea on objectives and plans of K-SBAS

What is the basic structure and coverage area of proposed SBAS system of Korea?

The objective of the K-SBAS program is to implement a certifiable SBAS system providing APV-I service in Korea for the benefit of civil aviation users in the Korean air space using satellite-based navigation. When commissioned for the target of APV-I SoL service, the K-SBAS will provide a civil aeronautical navigation signal consistent with ICAO's SARPs for seamless aircraft navigation.

The preliminary configuration of K-SBAS comprises:

- 5+ wide area reference stations which collect measurement data (GPS L1/L2 and GEO L1) and forward to central processing facilities
- 2 Central processing facilities which carry out correction, safety, and SBAS message processing
- 2 Central control facilities in which the tasks include system control and maintenance, system status and performance monitoring, performance analysis, support to users, etc.
- 2 GEO uplink stations which format navigation messages for GPS compatibility and transmit them to the GEO satellites, and also provide ranging capability
- 2 GEO satellites to be leased which will receive a navigation signal in C-band and transmit GPS L1 compatible navigation signal

The coverage area serviced by K-SBAS will be the South Korea region, and the K-SBAS area-of-coverage performance objectives are to provide a primary means of navigation service for all phases of flight, ranging from en-route through precision approach within the area and to expand the benefits of SBAS to non-aviation users including car navigation, LBS, etc.

When it is likely to be operational?

Tentatively, the K-SBAS is expected to be declared operational for open service in the year 2018 and its full operational capability will be likely reached at the year 2019-2020. Subsequently, the K-SBAS delivering a Safety of Life service for aviation is expected to be made from the year 2022.

What are the likely benefits of the proposed SBAS of Korea?

It has been required the propulsive strategy for gearing up the change of the nation's current air traffic surroundings and handling future demand in Korea due to the fact that:

- Overall air traffic volume in Korea increases annually by a factor of 7.3%
- Expected air traffic volume in Incheon Airport will be from 160,000(FY2005) to 490,000(FY2025)
- Expected air traffic volume in Incheon FIR will be 1,033,000(FY2025)
- It is difficult to install additional conventional air traffic infrastructure due to limited air space available
- It keeps increasing the request of precise position information in non-aviation use (car navigation, LBS, etc)

Thus, K-SBAS will play an important role in Korea airspace modernization and be a key technology for improving the efficiency of Korea airspace operations. We believe that it has the potential to modernize the airspace, reduce flight delays, save fuel and improve safety of flight over such congested Korean Flight Information Region. In addition, it can be expected a huge benefit over existing navigation infrastructure for aviation.

How do you look at the interoperability issues with other operational SBAS?

Although all SBAS are currently defined as regional systems, it is commonly recognized that there is a need to establish adequate cooperation/coordination between the different systems, so that their implementation becomes more effective and part of a seamless worldwide navigation system. To guarantee seamless and worldwide system provision and clarify/harmonize technical implementation issues which may have an impact on the adequate interoperability of SBAS systems, we plan to attend Interoperability Working Group (IWG) meetings regularly. With that respect, specific requirements could be included in K-SBAS so that interoperability with those systems may be achieved.

Also, during initial and final operational phase, international assistance will be sought for the definition of interoperability for K-SBAS, system validation, testing, and certification.

Since there is an operational SBAS in neighboring region, how the Korean SBAS is going to complement the overall efforts regarding SBAS in the region?

It has not been examined regarding a detailed consideration on harmonization/cooperation with an operational SBAS in neighboring region and further study on such issue will be carried out after the initiation of the K-SBAS program.

"IWG targets the development of dual frequency multi constellation (DFMC) SBAS"

Says Frédéric LECAT, Regional Officer Communication, Navigation, Surveillance, International Civil Aviation Organization (ICAO), Asia and Pacific (APAC) Office, Thailand

Would you like to highlight the Standards and Recommended Practices (SARPs) of ICAO?

The SBAS SARPs in Annex 10 Volume I are the basis that ensure uniformity and interoperability across different implementation of SBAS and a seamless transition between SBAS service areas. Standardized procedure design criteria for SBAS approach are contained in ICAO Doc 8168 (PANS-OPS). Coordination of technical developments on SBAS is conducted at the international level by the Air Navigation Commission through its Navigation Systems Panel, which involves a large number of States at the global level. Coordination of SBAS implementation at the regional level is conducted by the relevant PIRGs.

What are the objectives of SBAS interoperability group?

SBAS interoperability group is not an ICAO group, but an informal group coordinated by FAA and ESA.

SBAS operators meet regularly in this group (IWG) to conduct informal coordination of operational issues and technical development as required, and GBAS operators meet similarly in the GBAS IWG. These informal groups have proven their relevance by their early work on interoperability issues, which feeds in turn Eurocae/ RTCA publications. They also work in close liaison with the ICAO NSP.

Please highlight the key benefits of SBAS.

By providing differential corrections, extra ranging signals via geostationary satellites and integrity information for each navigation satellite, SBAS delivers much higher availability of service than the core satellite constellations with ABAS alone. In certain configurations, SBAS can support approach procedures with vertical guidance (APV) and in many cases lower minima than those associated with non-precision approaches, resulting in higher airport usability.

SBAS may also enable States and their Air Navigation Service Providers to decommission progressively ground-based navigation aids for en route and terminal operations, guided by associated safety and performance cases as necessary, which would in turn reduce their operating costs.

What are your plans in developing standards to support the dual frequency multi-constellation users?

From 2020 GNSS receivers capable of tracking multiple frequencies and multiple core constellations are expected to become available. This is a great opportunity for aviation users to increase the global safety and performance of GNSS based navigation.

As part of its work plan, IWG targets the development of dual frequency multi constellation (DFMC) SBAS. The ICAO Navigation System Panel will make use of IWG results when developing the DFMC SBAS SARPs. The IWG through its working group on ionospheric matters is contributing to identify new mitigation techniques for propagation delays and scintillation but also... new failure modes. Probably at that time, ionospheric disturbances will then contribute for much less to the TSE (total system error).

Nevertheless, considering the pace and cost to equip the worldwide aircraft fleet with multi-constellation/multi-frequency receivers, navigation during Solar Cycle 25 (2019-2030) may still mostly rely on single frequency/constellation user equipment for more than one decade, with all associated challenges.

What are key priorities and challenges?

Key priorities:

Performance based Navigation based on GNSS is already providing significant improvements in safety, regularity, efficiency and economy of air transport. GNSS provides a foundation for seamless global ATM system upon which States can deliver improved services to aircraft operators. A recent development illustrating this is the certification of GAGAN SBAS augmentation system to RNP0.1 for En route and Non Precision Approach.

In the APAC Region particularly, PBN Terminal will be proposed for endorsement to the next APANPIRG in September 2014 as the priority one among seven Top Priority items:

- All international high density aerodromes should have RNAV 1 (ATS surveillance environment) or RNP 1 (ATS surveillance and non-ATS surveillance environments) SID/STAR by end 2015
- Where practicable, all high density aerodromes with instrument runways serving aeroplanes should have precision approaches or APV or LNAV by end 2015.

The Navigation Strategy for the Asia and Pacific Region adopted by APANPIRG/24 in June 2013, was revised accordingly:

- implement GNSS with augmentation as required for APV and precision approach or RNP AR (Authorisation Required) operations where it is operationally required and economically beneficial;

- implement the use of APV operation in accordance with the Asia/ Pacific Seamless ATM Plan;
- rationalize terrestrial navigation aids, retaining a minimum network of terrestrial aids necessary to maintain safety of aircraft operations.

SBAS expansion can help reaching those objectives.

But the Asia-Pacific aviation community is also relying more than ever on a single frequency GNSS infrastructure which needs to be robust against threats like ionospheric effects, until the future multi-constellations are operational and used by a majority of airspace users.

Key challenges:

Hence one key challenge in the meantime is the need for robustness of this GNSS-based infrastructure which was fully acknowledged by the 12th Air Navigation Conference specifically through its Recommendation 6/9 – Ionosphere and space weather information for future global navigation satellite system implementation and its Recommendations 6/7 (Assistance to States in mitigating global navigation satellite system vulnerabilities).

Through this recommendation the global aviation community has accepted to study the optimum use of space weather information that is globally applicable from low to high magnetic latitude regions for enhanced global navigation satellite system performance at a global context.

En route and terminal area navigation services prove to be robust against ionospheric delay effects such as those caused by severe ionospheric storms or by unique equatorial phenomena. This robustness is due mostly to the relatively large alert limits associated with those flight operations.

However, for APV SBAS approaches in low-latitude areas, the variability and unique phenomena of the equatorial ionosphere reduce the availability of APV service. Severe ionospheric scintillation may sometimes cause temporary losses of service, particularly in low latitude. But the severity of the service degradation as a function of solar activity, geographical area and number of core constellation satellites has not been characterized in detail. Here again we need sufficient statistical history.

Such characterization may be needed by some States so as to assess how far they should maintain a certain number of ground-based radio-navigation systems in order to mitigate the risk of loss of GNSS service due to ionospheric scintillation effects, while relying on single frequency SBAS, and if needed, new regional ionospheric threat models could be built and implemented by system suppliers and navigation service providers, be it for SBAS or GBAS.

In this regard the ICAO Ionospheric Task Force, chaired by Dr. Susumu Saito, senior researcher from ENRI, Japan, is already bringing a great contribution from the APAC region by characterizing the effects of ionospheric activity in the APAC region and assessing the need for regional ionospheric threat models.

Another challenge faced by airspace users is the cost of equipment, training and certification associated with SBAS, whilst valuable alternatives are often available: ABAS-based procedures for en route and non precision approach, and APV Baro for approach procedures with vertical guidance, provided a local altimeter reference (QNH) is safely managed.

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Potential use of GBAS techniques to improve SBAS signal quality monitoring

In this paper, Space Based Augmentation System (SBAS) and Ground Based Augmentation System (GBAS) are compared regarding their specifications, architectures, status and advances with an introduction to the target service levels

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From 1992 to 2011, air traffic grew by approximately 72% in Germany [1] which is equivalent to a yearly increase of about 4%. As air traffic continuously increases, ground infrastructure like airports, number of runways and necessary capacity of air traffic routes need to grow too. To enable safe (automatic) guided precision approaches also under reduced visibility conditions, systems like the Instrument Landing System (ILS) and Microwave Landing System (MLS) exist. These systems provide a good and reliable solution; however, they have the same limits in terms of cost, ability to support simultaneous landing approaches, flexibility in waypoints and area navigation. Thus, a need for systems that can be used for enhanced precision approaches within a local, regional or wide service area rose. In aviation, GPS/Receiver Autonomous Integrity Monitoring (RAIM) is used for en-route navigation down to non-precision approaches.

However, this technology has two limitations for precision approaches. First, the accuracy of GPS as standalone is not sufficient enough, and the second, integrity of the measured position is not available. To overcome these two limitations, several concepts, SBAS, GBAS and RAIM (which is not considered further in the context of this paper), are accepted by the aviation industry and the International Civil Aviation Organisation (ICAO).Though these systems need GPS range measurements as inputs, and produce range corrections as output, along with the integrity information, they vary strongly in actual realization. This paper first presents these two systems for their architectures and operation. Second, it focuses on EWF monitoring in order to improve the detection capabilities by reducing false alarms driven by multipath. Some ideas of GBAS SQM techniques are adapted to the need of SBAS by using EGNOS as an example.

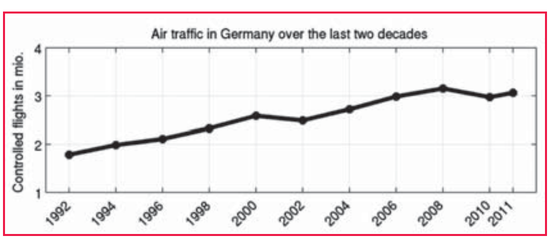

Figure 1: Air traffic in Germany over the last two decades

Augmentation systems – SBAS and GBAS

SBAS and GBAS are the two main augmentation systems using navigation satellites that support SoL applications. SBAS supports wide-area or regional augmentation through the use of additional messages broadcast by geostationary satellites, whereas, GBAS supports local (typically an airport area) augmentation through the use of terrestrial radio messages with a Very high frequency Data Broadcast (VDB).

System standardization

SBAS as a wide area augmentation system and corresponding aviation user equipment are standardized, e.g., in ICAO SARPS Vol.1 Annex 10 [2] and RTCA DO-229D [3] to enable not only interoperability between the airborne receivers, but also between various SBAS systems. Standards for GBAS, also called Local Area Augmentation System (LAAS), and user equipment can be found. (For e.g., in [2, 4, 5, 6, 7 and 25]).

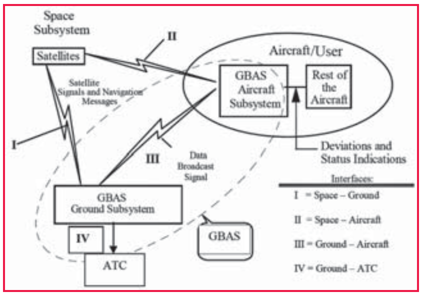

Figure 2: Basic GBAS system architecture [4]

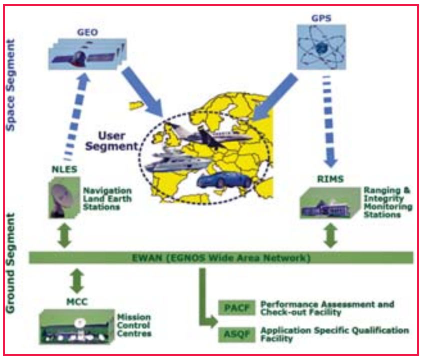

Figure 3: EGNOS (SBAS example) architecture [8]

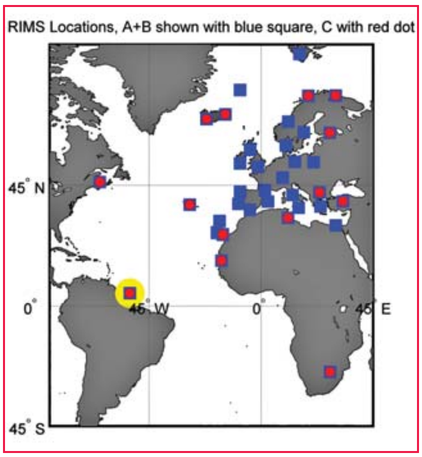

Figure 4: RIMS Network: RIMS-A and B marked with blue squares, RIMS-C marked with red dots. Note that RIMS-A, B and C at KOU (marked with yellow) in French Guyana are on test and not operational.

Basic architecture

GBAS as a local augmentation system (shown in Figure 2) used at airports utilizes four antenna receiver combinations located in a 5 km radius around the furthest supported landing threshold point (considering precision approaches). The GPS L1 frequency measurements and navigation messages are sent to a central GBAS station inclose vicinity. The station is equipped with redundant hardware to compute a single set of corrections and to provide integrity by ensuring the correctness of the broadcast corrections. These corrections as well as data related to the approach segment are broadcast via VDB, and also verified at reception via the internal VHF receivers. Antennas, receivers and central GBAS station as well as the broadcast units are considered as GBAS Ground Subsystem.

On the other hand, SBAS antennas are distributed within the entire wide service area and beyond. Since it is a wide service area, the ionospheric delays can have significant variations inducing different error ranges even in the undisturbed scenario. In order to mitigate these errors, dual frequency reference antenna receiver combinations are used. Due to the wide distribution (e.g., European Civil Aviation Conference (ECAC) service area) of the reference stations, a network is needed to deliver the recorded data to centralized processing facilities which generate the set of corrections. GEO stationary satellites (GEO) and their corresponding uplink stations are used to broadcast these corrections over a wide service area.

There are several SBAS that are either operational or under development: e.g., US Wide Area Augmentation System (WAAS), EGNOS in Europe and Multi-functional Satellite Augmentation System (MSAS) in Japan, along with the Russian System for Differential Correction and Monitoring (SDCM) and the Indian system GPS Aided Geo Augmented Navigation (GAGAN) under development.

In EGNOS (cf. Figure 3), the reference stations (Ranging and Integrity Monitoring Stations (RIMS)) used for computing the GPS range measurements are widely distributed. Current EGNOS RIMS network configuration consists of 37 sites, equipped with two types of RIMS. RIMS-A and RIMS-B antenna receiver combinations are used for two independent data processing channels to meet the needs of SoL constraints. In addition, in 14 of those sites, a RIMS-C is installed to monitor the GPS signals for wave form deformation (cf. Figure 4).These site observations are distributed via the EGNOS Wide Area Network (EWAN) to the Mission Control Centres (MCC). The computed corrections from MCC are then sent via Navigation Land Earth Stations (NLES) to GEOs for broadcast.

Service levels and achievement status

For civil aviation users, the international landing categories, approach types and corresponding performance needs are specified in detail, e.g., in Figure 6.

Following the performance requirements, the existing operational SBAS systems achieve different approach categories. While WAAS achieves RNAV operations with Localizer Performance with Vertical Guidance (LPV) to 200 ft. minima in the US National Airspace, EGNOS currently achieves APV-I service level for most European countries.

The goals for GBAS are set to precision approach categories CATI and CATII-III. While GBAS CATI stations are already in operation in various countries, GBAS CATIII stations are about to be certified and become operational in the next years.

Applying GBAS techniques to improve EGNOS SQM performance

As GBAS is preparing to achieve CATIII service performances, it has adapted its SQM techniques for better performance. Some of these approaches can be tailored to improve SBAS, in particular EGNOS SQM.

Table 1: Landing approach types: NSE accuracy and continuity probability [6, 8, 25]

Used for	NSE Accuracy		Continuity probability
	Lat. 95%	Vert. 95%	
APV-I	16 m	20 m	$1\text{-}8\times10^{-6}$ in any 15 s
LPV200	16 m	4 m	$1\text{-}8\times10^{-6}$ in any 15 s
CAT I	16 m	4 m	$1\text{-}8\times10^{-6}$ in any 15 s
CAT III	TSE performance, aircraft dependent		$1\text{-}8\times10^{-6}$ in any 15 s

Table 2: Landing approach types: Integrity [6, 8, 25]

Used for	Integrity Probability	Time to alert	Lateral alert limit	Vertical alert limit
APV-I	1-2x10^{-7} in any 150 s	10 s	40 m	50 m
LPV200	1-2x10^{-7} in any 150 s	6.2 s	40 m	35 m
CAT I	1-2x10^{-7} in any 150 s	6 s	40 m	10 m
CAT III	1x10^{-9} in any 15 s vert., 30 s lat.	2 s	17 m	10 m

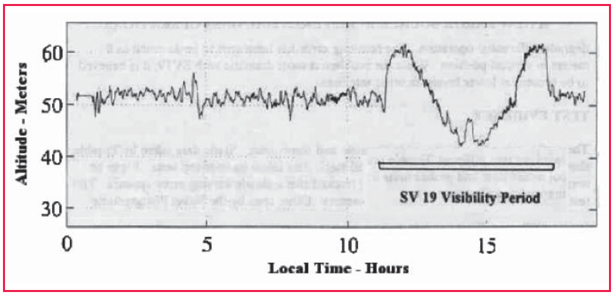

Figure 5: User differential vertical position error during the visibility period of SV-19 [11]

Table 3: SBAS operational achievements

	Today	Future
EGNOS	En-route to APV-I	LPV200, CATI
WAAS	En-route to LPV200	LPV200, CATI
MSAS	En-route to NPA	APV-I

Table 4: GBAS operational achievements

	Today	Near future
GBAS	CATI	CATIII

SV-19 failure – first occurrence of EWF

The GPS satellite SV-19, using PRN19, was launched on October 21, 1989 and declared operational on November 14. *It is assumed that after approximately 8 months in orbit, an anomalous condition developed that resulted in carrier leakage in the observed L1 signal spectrum which is normally carrier suppressed* [9]. The first evidence of significant end-user impact of the failure was in March 1993 during differential GPS landing system tests by Trimble. Followed by this, various tests with differential L1 C/A equipment were performed and offsets of 2 to 8 meters were reported if SV-19 was included in the position solution depending on different types of differential GPS loop architectures [10] (c.f. Figure 5). The source of the error was analysed and identified by different institutions, leading to its correction by switching to the satellites on-board redundant signal transmitting hardware on January 3, 1994. However, during the complete time span between fault onset and fault mitigation, the satellite was set to healthy.

Since it cannot be ensured that such a failure will not occur anymore and the induced error by the user depends on the implementation of the GPS tracking loop architecture, monitoring for SV-19 like failures is needed for augmentation systems which support SoL application. The phenomenon of SV-19 events is termed as EWF because of their unpredictable and varied nature of impacts for different differential users.

2nd Order step (2OS) threat model

The ICAO adopted the 2OS threat model, developed in [12, 13], to describe potential EWFs on GPS L1 frequency. The model is capable of creating dead zones, distortions and false peaks on the receiver correlation peak as observed during the SV-19 failure.

It is modeled via three threat types A, B and C with three parameters lead/lag Δ, damped frequency f_d and damping factor σ.The range of the underlying parameters is shown in Table 5.

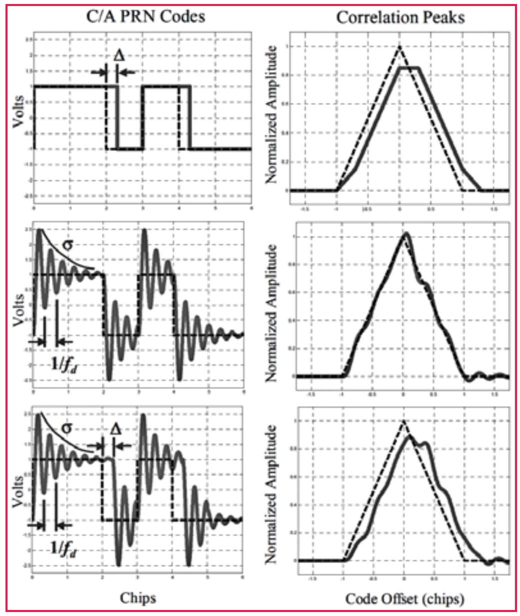

Figure 6: 2nd order step model type A (top), B (middle) and C (bottom) for evil waveforms on GPS L1 [12]

Table 5: Threat model parameters for type A, B and C [12]

Type	Lead/lag, Δ [chips]	Damped frequency, f_d [MHz]	Damping factor, σ [MNepers/s]
A	-0.12 to 0.12	-	-
B	-	4 to 17	0.8 to 8.8
C	-0.12 to 0.12	7.3 to 13	0.8 to 8.8

Current state of EWF monitoring in SBAS

As of today, monitoring for EWF is done within WAAS and EGNOS using the 2nd order step model as threat model. Both these systems have Novatel GII receivers [14] at their reference stations. WAAS uses the Alpha metric [15, 18, 26] algorithm and EGNOS applies the delta ratio algorithm [16, 17]. However, in EGNOS, it is desired to reduce the false alarm rate impacting the availability performance. Most of the false alarms originated due to local multipath effects at receiver antenna site, inducing similar erroneous behaviour in the receiver correlator as with an EWF. Therefore, by taking EGNOS as an example, techniques to reduce the number of false alarms are explored.

As mentioned before, GBAS evolves to serve CATIII automatic landing approaches, and several improvements including the EWF detection/Signal Quality Monitoring are envisaged to meet the tighter integrity and false alarm bounds required by CAT III [19, section IIC]. To achieve this, the GBAS community utilized improved SQM techniques also described in literature. These modernized EWF detection methodologies can be adapted to the existing SBAS implementations, to improve their SQM availability performance, i.e., in terms of minimizing false alarms without impacting the missed detections.

Used algorithms for SQM

Various methods are developed and described in literature, for which most require supplementary reference receiver correlator samples besides the tracking pair.

- CCC [20] (without supplementary correlator measurements)
- SQM2b [12, 21, 22]
- Delta Ratio Tests [16, 17]
- Alpha Metrics [15, 18]
- SDM [23]
- …

The realisations of these algorithms must be capable of protecting all ICAO accepted user receiver designs and must be robust to variations in receiver pre-correlation filters [21]. Without sticking to a single algorithm, this paper discusses a method to improve measurement quality of correlator samples that augment detection of EWF for SBAS.

The effect of multipath on correlator measurements

Multipath is considered as the driving factor for high false alarm rates for the algorithms detecting EWF. This is because both, multipath and EWF produce similar effect on code tracking, as shown on the right side of the correlation function (c.f. Figure 7). As shown, the distortion of the triangular shape due to multipath or EWF can lead to a similar correlator measurement output.

Therefore, for all EWF detection algorithms based on correlator

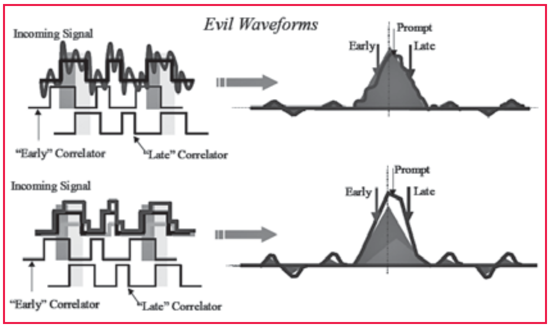

Figure 7: Effect of EWF (top) and multipath (bottom) on L1 code tracking [12]

outputs or even pseudo-ranges, the minimization of multipath leads to a higher measurement quality and as a direct follow to a lower false alarm rate.

To meet the stringent accuracy requirements for CATIII landing approaches, various multipath limitation or mitigation techniques are applied to GBAS. Some could be directly transferred to SBAS. The next chapter presents an approach of mixed antennas to reduce correlator noise for low elevations in order to lower the false alarm rate for SQM. To achieve this, an analysis is performed by replacing some of the currently used

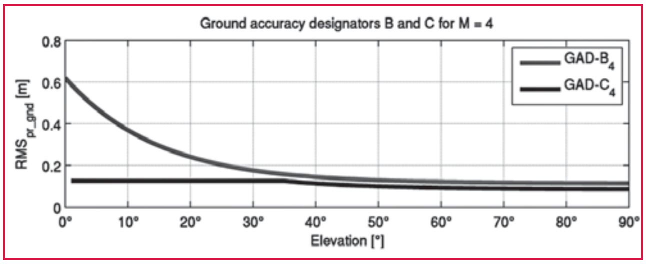

Figure 8: Ground Accuracy Designators (GAD) B + C for M = 4 receivers

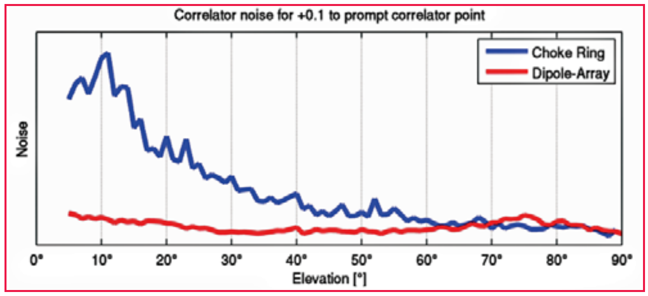

Figure 9: Correlator noise (0.1 chip distance to prompt) for both antenna types; the benefit of a dipolearray antenna for low elevations can be clearly seen if compared to the used choke ring antenna.

choke ring antennas by a different antenna type, called dipolearray antenna.

Mixed antenna types for the existing EGNOS RIMS-C sites

GBAS CATIII stations have to provide a significantly better performance, especially for low elevation satellites, compared to the GBAS CATI stations or to existing SBAS. For CATIII approaches, the GAD-C curve is used while for CATI approaches, GAD-B is seen as sufficient (cf. Figure 8) [19].

Better performance at low elevations, especially in the presence of multipath cannot be achieved with a commonly used choke ring antenna. Therefore, more expensive but more accurate dipolearray antennas are preferred.

At present in EGNOS, the number of RIMS-C stations is limited only to 13 in operation. Therefore, in this paper, a mixed antenna scenario or mixed RIMS-C network is considered by partially replacing the existing choke ring antennas by the dipolearray antennas. The analysis is carried out based on the performance of real data of both antenna types mounted in close vicinity, on Thales Alenia Space facility roof top in Stuttgart, Germany. By applying the observed properties of these antennas in a multipath rich environment on the RIMS-C network, using simulations the performance in terms of correlator noise, including multipath is analyzed.

In the current EGNOS implementation, in order to monitor a satellite (*monitorability condition*), i.e., to provide corrections and integrity information, at least one RIMS-C [24] and two RIMS-A and B observations are needed for the given satellite. Thus a single RIMS-C is sufficient to determine EWF. However, this condition can be seen as the most critical (*critical condition*) in terms of to the susceptibility to false alarms. If more than one RIMS-C observes a satellite, a majority voting is performed (which is able to lower the false alarm rate).

Actually as shown below, the first condition applies to a significant period of time for all GPS satellites. Mitigation for the *critical condition* is to change the RIMS-C antennas at certain sites as described below.

The minimum elevations above which RIMS-A and B monitor a satellite are defined as 5°. For RIMS-C, the nominal configuration is used where the elevation mask varies between 10° to 40° depending on the site. The reason for the high elevation masks is the susceptibility of the existing RIMS-C antenna for low elevation multipath and the site specific multipath environment.

As a first approach, the analysis of mixed antennas in the RIMS-C network is kept simple and independent of all algorithms. The measurement noise is calculated for both antenna types for one degree elevation bins, using smoothed correlator measurements from the same type of receiver at 1 Hz, with a standard smoothing window of 100 seconds and chip distance of 0.1 to prompt. The output rate as well as the smoothing time constant and filter is consistent with existing SBAS systems.

Using a simulated GPS constellation for a side real day-based on broadcast ephemeris, the elevations to all satellites are calculated for all operational RIMS-A, RIMS-B and RIMS-C sites and the *monitorability* is derived. For the reason of comparability to the existing configuration, the current mask angles are kept for both antenna types in the mixed configuration.

Analyses show that only some RIMS-C sites on the outer boundary of the service area are subject to the condition that they see a satellite alone. Note that this outer boundary is not entirely coinciding with the geographical outer boundary as a result of the different elevation masks for RIMS-C antennas.

An example in Figure10 for satellite PRN 1 demonstrates the monitoring by all RIMS-C sites, and highlighting the *critical condition* at EGI in Island, CNR in Canary Islands and HBK in South Africa.

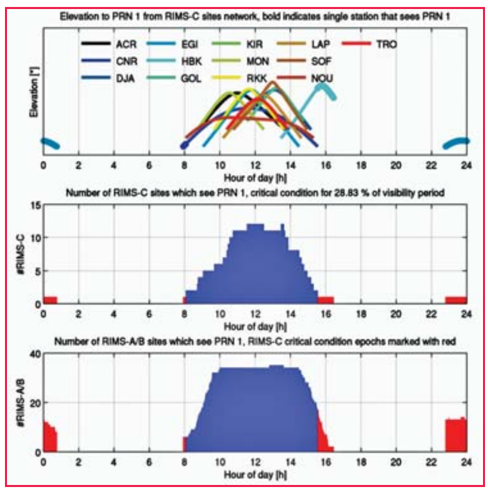

Figure 10: Monitorability of satellite PRN 1 at RIMS-C sites and the number of RIMS-C sites meeting the critical condition (bold lines on the top plot and by the red bars in the middle one) at the same time. Bottom plot shows the number of RIMS-A and B sites that monitor PRN 1 in parallel to RIMS-C.

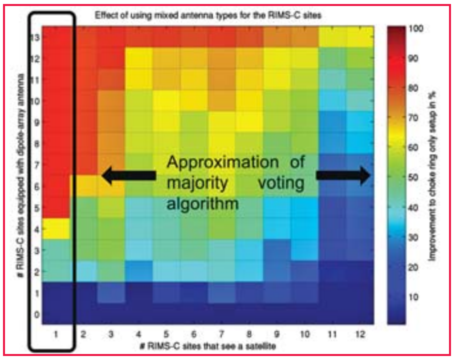

Figure 11: Result of the mixed antenna type analysis (disregarding majority voting for more than one antenna)

For PRN 1, the *critical condition* exists for nearly 29% of the visibility period.

Summing up the results of all PRNs, only the five RIMS-C sites, EGI, HBK, CNR, MON in Canada and LAP in Finland encounter this *critical condition* (cf. Figure 13). This is consistent with the expectation that the outer sites are the most critical ones. In total, the *critical condition* is met for 26% of the visibility periods of all satellites.

Via error propagation, the noise on the correlator measurements for each epoch is assumed for the whole network and complete visibility duration. Even if this approach is not consistent with the current majority voting algorithm, it can be seen as an applicable approximation, because the focus of the analysis is set to the *critical condition* where no majority voting is performed. In order to find the most promising and cost effective solution for mixed antennas, an extensive simulation covering over 8,200 possible mixed antenna combinations is performed.

For each combination, the highest occurring elevation θ dependent correlator measurement noise $\sigma(\theta)_{l,s}$ (which is mostly the noise level when the critical condition applies and a satellite is seen with minimum elevation) is chosen to describe the combination in a conservative way. In the follow up step, the optimal combinations opt (n) for each number n of RIMS-C sites equipped with a dipole-array antennas are chosen *(1)*. To meet this, the focus is set to find the combination that provides the best measurement quality for the *critical condition* identified before.

$$opt(n) = \min_{\forall comb(n)}\left(\max\left(\sigma(\theta)_{l,s}\right)\right)\Bigg|_{\substack{l \in \text{RIMS-C sites} \\ s \in \text{GPS-PRNs} \\ \text{2 or more AB sites}}} \quad (1)$$

The result of the simulation confirms the sensitivity of the sites in the border of the service area. In Figure 11, the x-axis describes the number of sites that see a certain satellite under the worst case conditions, while the y-axis shows the number of RIMS-C sites equipped with dipole-array antennas. For each combination, the improvement of the worst case condition to the actual choke ring only setup is given by colour codes. Considering only the *critical condition* (marked with the black box), a change of five RIMS-C antennas – namely at the sites EGI, HBK, CNR, MON and LAP – to high performance dipolearray antennas (DP) improves the noise on correlator measurements for the most *critical condition* by up to 84% as shown in Table 6 and Figure 12.

Table 6: Improvement ratio for critical conditions

#DP	0	1	2	3	4	5-13
Imp. %	0	0	43	43	64	84

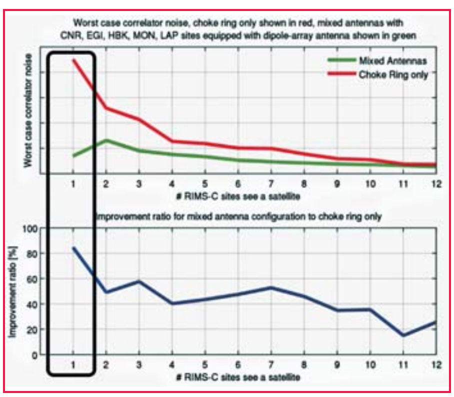

Figure 12: Worst case correlator noise with the RIMS-C network equipped with five dipole-array antennas at sites CNR, EGI, HBK, MON and LAP (top); Improvement ratio for mixed antenna configuration to choke ring only configuration (bottom).

Table 7 shows the overall noise reduction for number of used dipolearray antennas (DP) as an improvement percentage ratio to the simulated current choke ring (CR) antenna configuration for the worst case correlator noises according to *(2)*. It is weighted by the probability of occurrence prob (m) for each number of RIMS-C sites m that see a satellite during the sidereal day. It is to be noted that in the current EGNOS RIMS-C configuration a maximum of 12 RIMS-C sites can see a satellite simultaneously.

Table 7: Overall weighted noise reduction in percentage for the worst case epochs

nDP	0	1	2	3	4
Imp(n) [%]	0	8	35	41	46
n DP	5	6	7	8	9
Imp(n) [%]	48	59	63	64	65
n DP	10	11	12	13	
Imp(n) [%]	67	70	72	80	

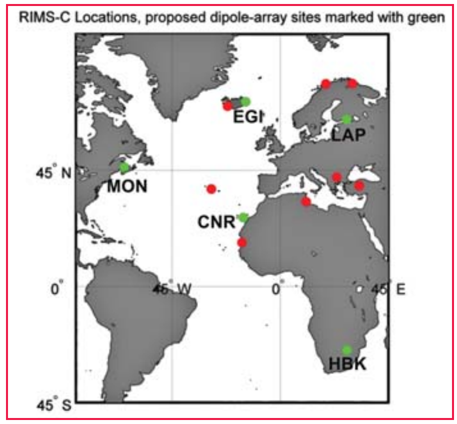

Figure 13: Proposed operational sites to be equipped with dipolearray antennas, marked ingreen

$$Imp(n) = \sum_{m=1}^{12}\left(1 - \frac{\sigma(n,m)}{\sigma(CR)}\right) \times prob(m) \quad (2)$$

Besides, the overall noise reduction for the worst case epochs of 48% for five dipolearray antennas, the most critical situations are mitigated. Therefore, the proposed change of only five antennas can be considered as a good trade-off between noise reduction and additional costs. The location of these five sites is given in Figure 13.

Conclusion

Within the framework of the paper, both systems GBAS and SBAS are described and their current service level status is shown. The paper demonstrates that the advanced techniques of Signal Quality Monitoring of GBAS, with respect to antenna type used, can be applied to meet the SBAS needs. In this paper, SBAS is considered as EGNOS. The adaptations are also focussed to gain maximum benefit with low impact on the cost especially regarding extensive re-certification. The changes focus on mitigating multipath – the driving factor for high false alarms on EWF monitoring. Simulations confirm that it is recommended to change the antennas to high performing ones (especially for low elevations), at certain boundary reference sites of the service area.

In case of EGNOS, five such boundary reference sites are identified for the currently used elevation masks: EGI, HBK, CNR, MON and LAP. It is recommended to equip them with high performance antennas, for example, dipole-array antennas instead of the currently used choke ring antennas to reduce EWF false alarm rate.

These first simulation results are promising. Further system level studies and investigations, to evaluate the applicability of the proposed methods and applied assumptions on the existing SBAS, can affirm the proposed solutions.

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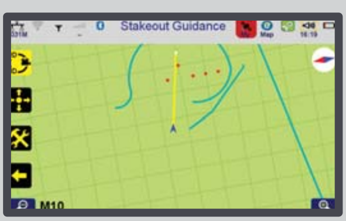

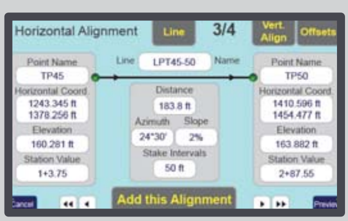

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hours

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~~10~~

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~~50 (110)~~

~~30 (66)~~

~~20 (44)~~

~~10 (22)~~

~~5 (11)~~

2.5 (5.5)

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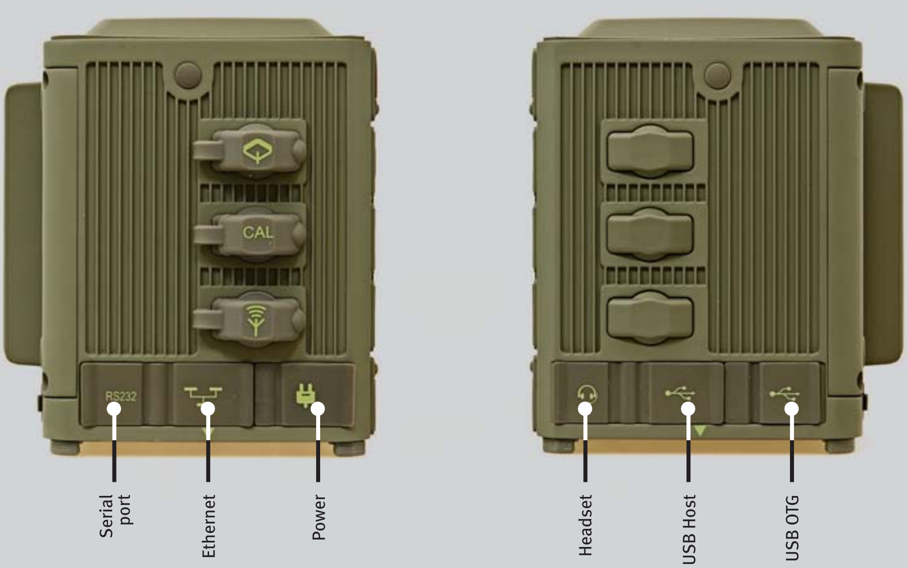

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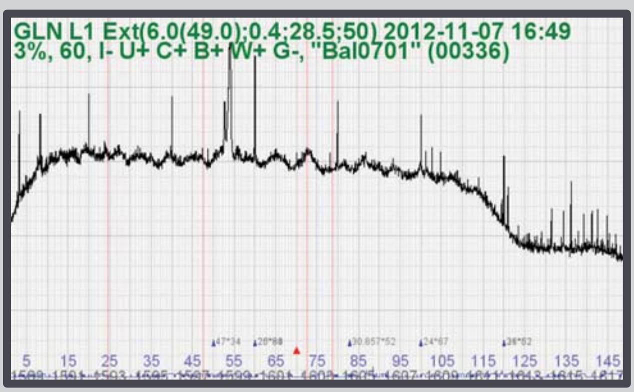
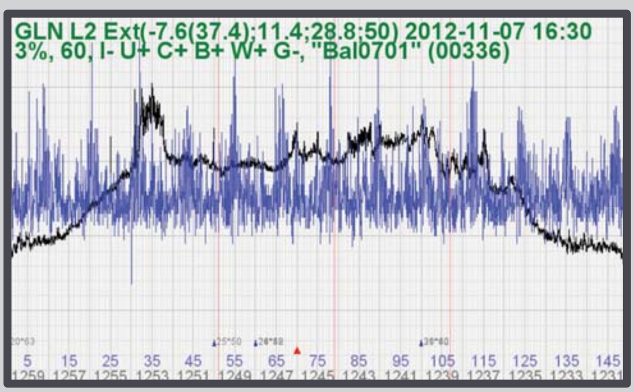


Some interference



Big interference

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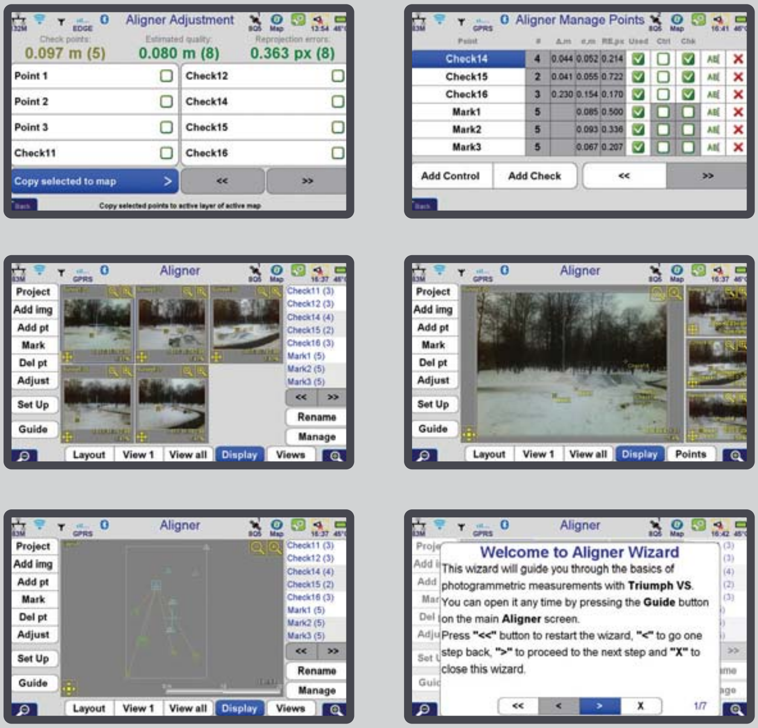

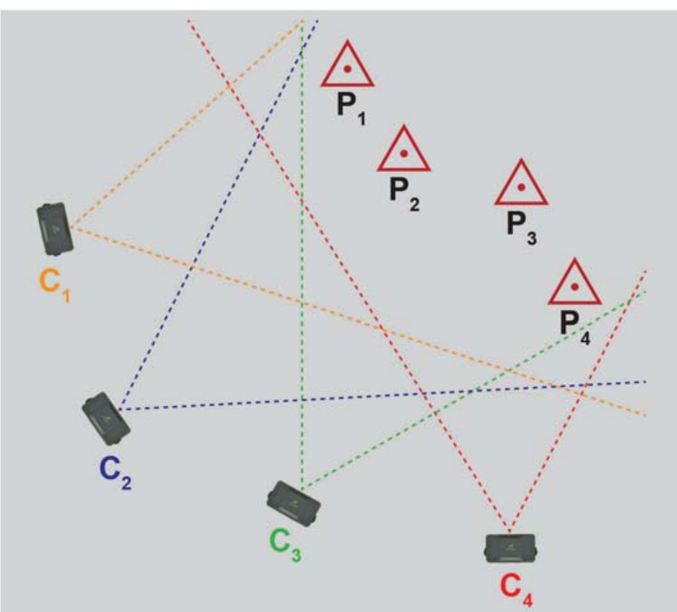

Retrospective Gap Filling – the Easy-OBU Way

Easy-OBU is a European Research Project co-funded in the 7th framework of the European Commission and managed by the European GNSS Agency (GSA)

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Satellite navigation relies on the visibility of a sufficient number of satellites. As the number of satellites increases, some problems such as shadowing in urban areas are reduced although not completely removed. In other instances, such as in tunnels, positioning by satellites is not possible. So the choice here is either to wait until visibility is available again and accept data gaps, or to rely on back-up systems. For land navigation, dead reckoning forms one possibility to measure vehicle speed and turn rate, and combine these information in to a sequence of positions. For accurate data this, however, requires high performance sensors, extra installations with an additional interface to the in-vehicle system, and complex data processing, making it not feasible for most applications. In addition, systems which ensure robust positioning should always contain some dissimilar redundancy. This ensures that a single error event cannot influence all the measurements to the same extent. Consequently, a single error event will be detected by the system and can be isolated, thus enhancing the reliability of the provided positioning information.

If real-time positioning information is crucial then the user will have to rely on expensive and complex solutions. However, many applications do not necessarily need real-time availability, but still would benefit from accurate positional information even with a certain time delay. This applies particularly to many professional applications, such as route controlling, generation of vehicle logs and so forth.

The goal of Easy-OBU is to provide position information with a quality that is comparable to that when navigation satellites are available under conditions when this is normally not possible (e.g., in tunnels). In addition, the system must be affordable, highly flexible and portable. The approach of Easy-OBU to address this is to use, in the absence of GNSS, data collected by inexpensive sensors installed on an OBU. These data are stored and analysed with an intelligent filtering approach (non-causal filtering – NCF) to calculate highly accurate positioning information, while accepting the limitation that this information is only available after a sufficient number of navigation satellites is visible again. Due to the high computational requirements it was decided to perform calculation in a back-office environment which is linked to the OBU. This also helps to reduce the costs of the OBUs and makes the use of more OBUs, e.g., for car fleets, very efficient.

Basic concept

Areas and scenarios where no or insufficient signal reception occur are manifold: tunnels, urban canyons, shadowing, intended or unintended signal distortion interference from various sources, and so forth. What they all have in common is that either no or insufficient information is available to calculate a reliable position. The use of information from inertial sensors in the OBU is one approach to overcome this problem. However, as the outage continues, some errors may rise with quadratic order and can dominate the total error, if the outage period takes longer than a few minutes. The reason comes with the contained deterministic error influences, which cannot be compensated by an inertial navigation computation, if standard filtering is applied. With respect to the vehicle speed, a single accelerometer, without any information about its pitch angle, will measure a small part of gravity as deterministic disturbance that has a dominant impact on the resulting positions. With the continuous integration, even small parts of gravity can lead to significant deviations, with respect to the true velocity computation. Thus, the resulting error of the determined positions can rise very fast. An example for such behaviour is shown in Figure 1, which is based on real measurements carried out in a 1.700 m long tunnel section. With one fibre optic gyro (for the vertical axes) and one accelerometer (for the longitudinal axes of the vehicle) and using normal filtering, the error starts to add up, reaching up to 800 m at the end of the tunnel section even though the applied inertial sensors are of high quality.

If one is a private user these might lead to annoyances, but for professional applications this may have considerable consequences, especially if the system is used for applications which have monetary or legal consequences. Examples of such applications are:

- Insurance (pay per use);
- Route controlling (e.g. for hazardous goods);
- Electronic toll collection (ETC), road user charging (RUC);
- Control of usage behavior for car rental;
- Documentation for winter service;
- Cost determination for Car-Pool;
- Car sharing (pay per use);
- Generation of vehicle logs for public transportation and recording (security service).

What all the aforementioned examples have in common is that they do not rely on real time information. In the end, it is quite enough if correct and reliable information is available by the time invoices are sent out or an account of the work performed is made (e.g., for road maintenance carried out). This leads to the concept to Easy-OBU. The aim is to achieve robust positioning with adequate performance on the basis of low cost inertial sensors and with the innovation of the NCF approach.

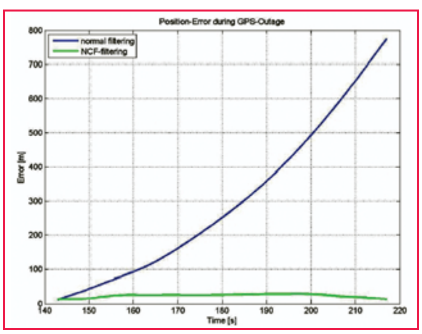

Figure 1: Lateral error over time with normal and NCF filtering

The example shown in Figure 1 already demonstrates the large potential of this innovative filtering approach. For demanding applications, this approach can bring an improvement with respect to the weak points of a solely GNSS-based system and provide robust positioning at adequate quality. In contrast to these first tests, the OBU developed for Easy-OBU will feature 3-axis gyroscope and 3-axis-accelerator, providing six degrees of freedom compared to two as used in the tests described above. This can bring further improvements to the stability of the positioning information, but at the same time will increase storage, computational and communication demands. As the concept is not suitable for real-time applications, some of these tasks must not be carried out in the OBU, but can be performed in an external environment. This makes it suitable for different applications and can also increase efficiency for large scale applications (e.g., for whole fleets). In the following sections, the technical set-up of the Easy-OBU system will be discussed followed by the system requirements.

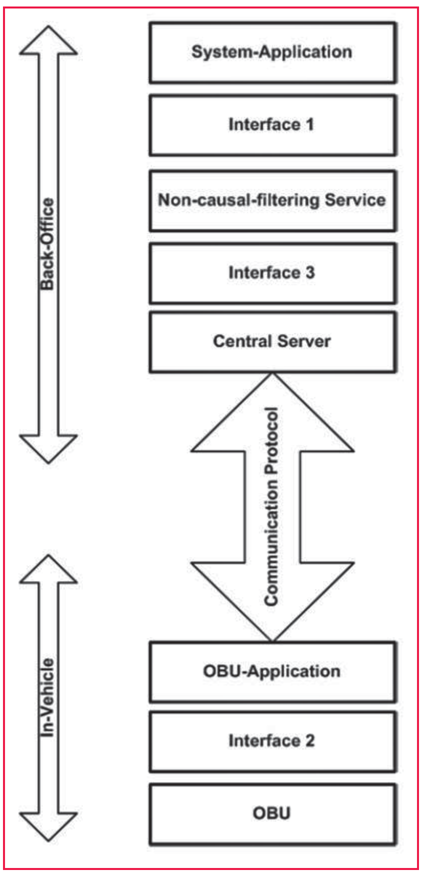

Figure 2: Easy-OBU System architecture

Technical setup of Easy-OBU

The Easy-OBU system consists of two main elements. One is the on-board equipment in the vehicle, and the other is a central server in a back-office. The OBU and central server are connected via a communication link (see also Figure 2).

Crucial for the whole system architecture are the interfaces connecting the various elements. The interfaces 1 and 2 are open interfaces and described in a publically available deliverable of Easy-OBU [1]. This ensures that the system does not depend on a specific OBU and that it is up to the user which applications should be run. Internal interfaces of the Easy-OBU system are communication interface between the OBU and the central server and the internal interfaces at the back office (Interface 3). The protocol used for the communication between the OBU and the central server is a proprietary protocol designed for the Easy-OBU system. The other proprietary part of the system is the non-causal-filtering service carried out in the back office. The main tasks of the central server are to:

1. Communicate with all OBUs;
2. Collect data received from OBUs;
3. Adjust position data with non-causal filtering service and
4. Make adjusted position data available to the system application.

The data transfer between the central server, NFC service and system application is realized as a chain of databases. Interface 3 describes the relevant OBU data, which the NFC service needs for position data correction. Interface 1 describes the OBU data which is made available to the system application. Depending on the system setup, the back office can also be a distributed system as the infrastructure of the back-office has no influence on the data flow from the OBUs to the Easy-OBU application database.

In case of a GNSS outage, the Easy-OBU system waits for GNSS re-acquisition and bridges the gap by recalculating the measurements from the inertial sensors, located inside the OBU. Thus, the complete behavior of the vehicle during the outage is known right afterwards (e.g., distance travelled, trajectory, speed direction, etc). Initially the information will be stored in the back office where it can be used for further processing. If required, the information could also be transferred back to the vehicle, although this will not be implemented during the Easy-OBU project.

In order to define the system and performance requirements, different applications were described as listed in section II. With these as a basis, interviews and workshops with potential users and developers were carried out in order to further elaborate and better define the technical requirements. Based on these, the performance parameters for Easy-OBU were defined as follows:

- Availability: > 99.9 %
- Position accuracy: < 10 m (CEP95)
- Heading accuracy: <5° (1 sigma)
- Velocity accuracy: < 2 km/h (1sigma)
- Distance accuracy: < 1 %
- Time accuracy: < 0.5s (1 sigma)
- Update rate 1 Hz

In addition, further requirements have to be fulfilled in order to make the OBU attractive for the targeted user community:

- Light weight (< 0.5 kg);
- Small size (view through windscreen should not be disturbed)
- Highly portable and easy to install in vehicles (only connected to power supply of the vehicle);
- Flexible to access through well-defined interfaces;

Figure 3: On-board unit

- Highly affordable, as OBU comes at competitive cost (including vehicle integration); and
- Flexible in regard to its usage, as it may serve a whole spectrum of different applications.

The OBU itself used for the project is small in size (11 cm x 7 cm x 3.5 cm) and can simply be mounted behind any vehicle's windscreen or on the dashboard (see Figure 3). It needs only to be connected to the car power and car ignition via an adequate fuse.

The OBU has the following main elements:

- GPS module for the processing of EGNOS data;
- Integration of accelerometer sensors in 3-axis, to capture the vehicle speed during GNSS outages;
- Integration of a gyrometer sensors in 3-axis, to capture the vehicle turn rate during GNSS outages;
- Implementation of self-calibration to determine the right levelling (orientation) of the OBU after installation, because each user may cause a different way of installing;
- Extension of the OBU-software for proper measurement acquisition of the additional sensor information;
- Usage of GPS timing capability for exact synchronisation between all measurements and information in the OBU;
- Optimization of the data aggregation inside the OBU and the data fusion of the communicated measurements into the control centre; and
- Analysis of the data content which needs to be transmitted to the control centre, in order to drive the NCF-filtering.

As the Easy-OBU has to be able to perform with a wide variety of applications and in very different system environments, it is only possible to examine the system performance for selected examples. As a start, the sensor and NCF performance was examined, while the performance of the Easy-OBU system will be examined at a later stage, moving more and more to a complete operational environment.

First test trials and NCF

First tests for the technical feasibility have been executed in the region of the City of Vienna and combines urban sections and highways. The goal of these initial tests was to examine how the data recorded from the six inertial sensors (acceleration in three axis and orientation in three

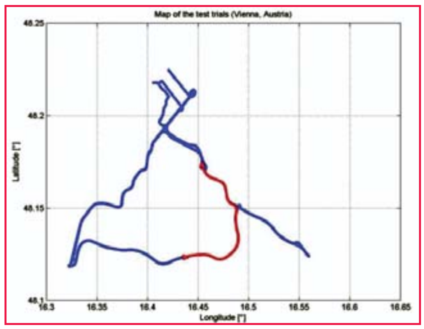

Figure 4: Reference trajectory for test trial

Figure 5: Reference equipment in test vehicle

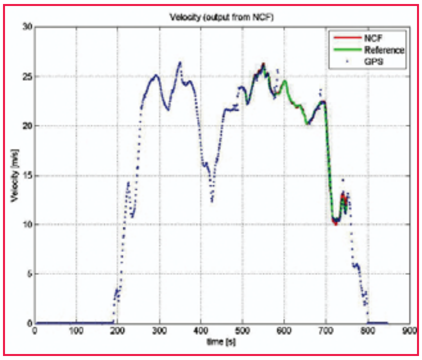

Figure 6: Results of determined velocity via NCF-filtering

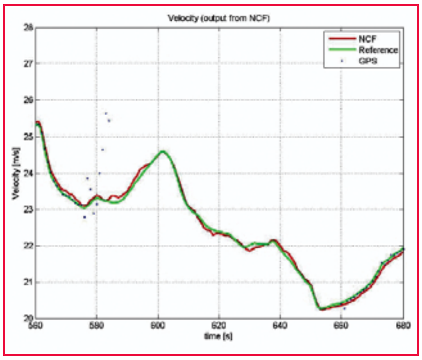

Figure 7: Results of determined velocity via NCF-filtering (zoom)

axis) can be used with NCF to correctly calculate the acceleration and turn rate.

The selected route contains various tunnel sections, which are suitable for the Easy-OBU objectives to provide improved positioningservice into areas, where GNSS signals cannot be received. A map of the covered road sections is presented in Figure 4 on the basis of a reference trajectory. For the initial evaluation of the performance of NCF, a subset was selected (shown in red).

The length of this section is nearly 20 km and the test time is more than 800 seconds, with the test vehicle travelling at approximately 80 km/h on average. The reference data was collected independently in the same vehicle using high quality satellite and inertial navigation equipment (see also Figure 5).

The selected test track contains one tunnel of nearly 2 km length where no GNSS reception is possible. This gap must be bridged with information derived from inertial sensors. In order to examine the

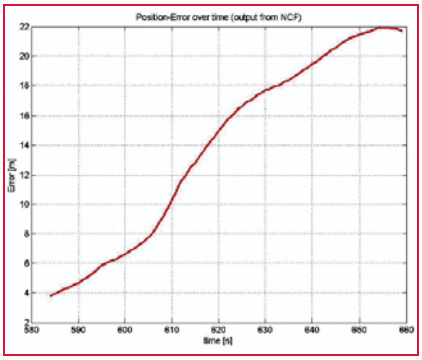

Figure 8: Position-error of NCF-results over

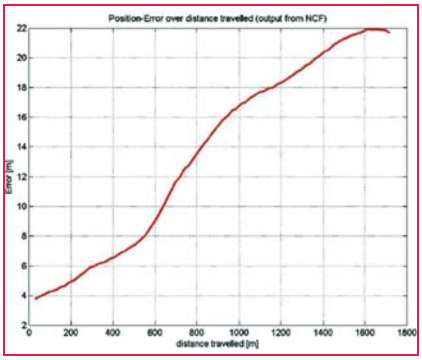

Figure 9: Position-error of NCF-results over distance

result of the NCF methodology, Figure 6 shows the velocity calculated based on GPS data (blue dots) and the bridged gap (during GPS outage) by NCF (red). For comparison, the true reference data (green) is also depicted. It can be seen that between the 580 and 660 seconds no GPS reception was available and that before and after the tunnel GPS returned large errors.

Zooming into the time window in question (see Figure 7), it can be seen that NCF could very well reproduce the velocity during the tunnel section. In addition, NCF is very stable before entering the tunnel and after leaving it.

Figure 8 shows the two dimensional position errors over time for the situation of GNSS outage. Here an error drift can be recognized, which is typical for inertial systems. The parameter of time on the x-axis of the diagram is also the first choice, because the drift rises due to the double integration of the acceleration signals over time. This is in contrast to dead reckoning procedures, which show rather a drift that depends on the distance travelled.

In Figure 9 the position error is shown with the distance travelled on the x-axis of the diagram. From the shape of the error behavior both plots look quite similar. This is again due to the road character of highways and the fact that the vehicle was driving with a speed of around 80 km/h with little acceleration or deceleration activities.

Conclusion and outlook

In this paper, the basic concept of a system for retrospective gap filling was presented. This system is based on an on-board unit fitted out with low costs sensors. In the event of loss of satellites data from these sensors are stored in the on-board unit and, once satellite visibility is available again, transferred to a back office were these data are used to calculate the route using non-causal filtering operations. The advantages of this system are that it provides high accuracy positioning data which would otherwise not be available at very low costs with the addition of high flexibility and transferability. A number of cases have been identified which could benefit from such a system. First tests have already shown the stability of the non-causal-filtering operations with data derived from low cost sensors in the absence on GNSS signals. In the next step, the system will be further developed and tested with potential users in order to test the usability of it and provide feedback for further improvement. The community at large will benefit from the open system approach, as it can be used irrespective of the type of OBU and the type of application foreseen.

Acknowledgment

The research leading to these results has received funding from the European Union Framework Programme (FP7/2007-2013) under grant agreement no.: 287217.

References

[1] Easy-OBU Deliverable; D2.2: "Open System Interface Specification"; Version 1.0; December 2012.

Geospatial data sharing in Pakistan: Possibilities and problems

In Pakistan, immense geospatial data is available with various public and private sector organizations. Although, the Government of Pakistan (GoP) is funding public sector organizations to develop geospatial data, but at the same time, its role lacks in reducing redundancies in geospatial investments

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The problems in sharing of geospatial data among public sector organizations is a well established fact (Onsrud et. al., 1995; McLaughlin, 2003; Williamson et. al., 2004; Nebert, 2004; Masser, 2005; Georgiadou, 2006; Nama Raj Budhathoki and Zorica Nedovic-Budic, 2006; Rajabifard et. al., 2009). The reasons for non-sharing of the data cannot be exactly the same for developed and developing countries, though it may have some commonalities. For example, developed countries may face more institutional rather than technical problems, whereas the situation in some other countries may be the reverse, i.e., more technical and less institutional problems. A study carried out by Canadian Geospatial Data Infrastructure (CGDI) committee underscores quality, access and legal issues that hamper sharing of geospatial data, whereas unavailability of digital datasets, non existence of infrastructure, policies and standards, unavailability of skilled human resources and lack of funding impede data sharing in Uganda (GIC/ESRI Canada, 2011).

We argue that detailed and in-depth study is essentially required for finding out problems related to sharing of geospatial data for a specific country. Therefore, the main objective of this research is to investigate issues that impede sharing of geospatial data in Pakistan. Additionally, the research also explores possibilities for data sharing and proposes guidelines for its objective implementation.

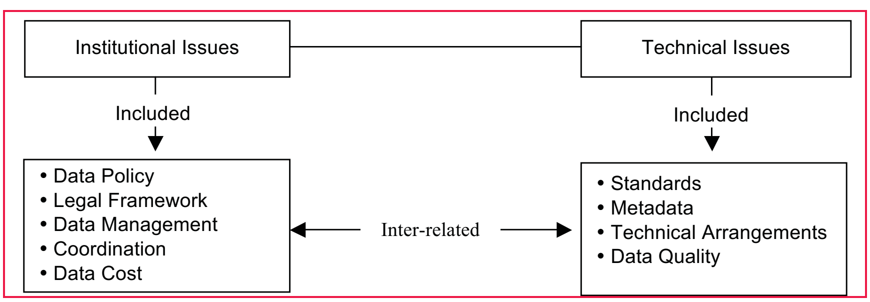

Figure 1: Research Focus

Research methodology

After critical review of literature, the case study method was selected for this research. A case study is an examination of the phenomenon in which the primary purpose of the observer is to carry out research rather than to implement a system or improve an operational environment (Onsrud et. al.,1992). It is an ideal methodology when a holistic and in-depth investigation is needed (Feagin et. al., 1991; Yin, 2003). Based on literature review and study carried out by Asmat (2008), a questionnaire comprising many technical and institutional issues was developed and distributed among various public and private sector organizations dealing with geospatial information. After getting the responses, the research was focused on only those technical and institutional issues that were pointed out by the majority of the respondents (Figure 1). Some brief interviews were also conducted telephonically as part of this research.

Geospatial data–Pakistani scenario

In Pakistan, immense geospatial data is available with various public and private sector organizations. The major part of this data is being produced by public sector organizations to facilitate their mandated responsibilities. These organizations are continuously busy in collecting, processing,

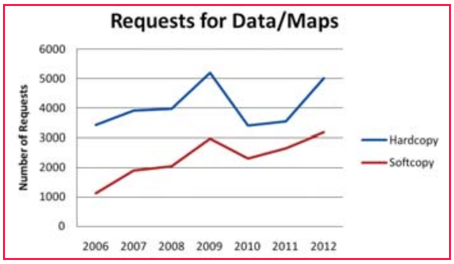

Figure 2: Yearly Analysis of Data/ Maps Requests Made to SoP

updating and disseminating such data. People are increasingly accessing and using geographic map[s] and location-based services, (Oxera report for Google, 2013). The demand for maps and geospatial data is growing in Pakistan too. For example, many public and private sector organizations, in addition to individuals, have approached the Survey of Pakistan (SoP) for provision of geospatial data. As a standard procedure adopted by SoP, each customer's data/map request is documented. The analysis of these data/map requests indicates that almost every year the demand for geospatial data is growing (Figure 2).

The public sector organizations that produce geospatial data include Survey of Pakistan (SoP), Pakistan Space and Upper Atmosphere Research Commission (SUPARCO), Pakistan Agricultural Research Council (PARC) and Census Department, etc. Table 1 displays list of major geospatial datasets and their custodians in Pakistan.

Geospatial data sharing in Pakistan – Problems and possibilities

The President of Pakistan has recently promulgated Surveying and Mapping Ordinance 2013, tabled by the Survey of Pakistan (SoP) that includes development of National Spatial Data Infrastructure (NSDI) for the country. SoP has been identified as the lead organization for the development of SDI at national level. But 'SDI is an enabling platform that facilitates access to spatial data and sharing spatial resources' (Rajabifard et. al., 2009). The focal concept of SDIs is sharing of geospatial data as asserts McLaughlin (2003), Williamson et. al., (2004), Nebert (2004), Masser (2005), Georgiadou (2006), Nama Raj Budhathoki and Zorica Nedovic-Budic (2006).

Table 1: List of Major Geospatial Datasets and Their Custodians in Pakistan

Dataset	Custodian
Topographical data & Geodetic Control	Survey of Pakistan (SoP)
Geological data	Geological Survey of Pakistan (GSP)
Satellite Imagery	Pakistan Space and Upper Atmosphere Research Commission (SUPARCO)
Soil data	Soil Survey of Pakistan (SSP)
Water and Power resources data	Water and Power Development Authority (WAPDA)
Weather information	Pakistan Metrological Department
Population Census information	Pakistan Bureau of Statistics (PBS)
Railway Lines Network	Ministry of Railways
Roads Network	National Highway Authority
Landuse and landcover data	Pakistan Agricultural Research Council (PARC)
Data of earthquakes, floods & landslides etc	National Disaster Management Authority

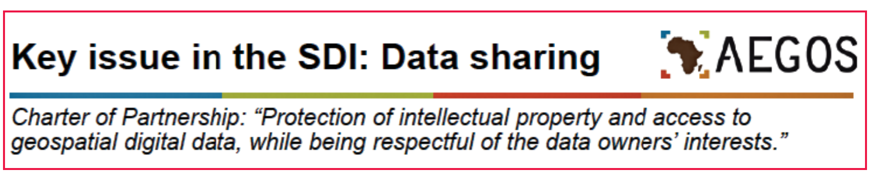

Figure 3: Snapshot of Marc (2013) Slide

Source: The Spatial Data Infrastructure for Georesources in Africa

Indeed, the focal concept of SDIs is data sharing, but at the same time data sharing is one of the key issues in SDI as argues Marc (2013) in a seminar at Brussels.

The sharing of geospatial data among public sector organizations is itself an issue (McLaughlin, 2003; de Montalvo, 2003; Radwan, 2004; Masser, 2005; Lance, 2006). Therefore, it is necessary to investigate issues related to data sharing and their possible solutions as a first step towards implementation of NSDI in Pakistan.

Institutional issues

Institutions are defined as 'the rules of the game in a society or, more formally, institutions are the humanly devised constraints that shape human interactions' (North, 1990). Institutional issues are always tackled with the help of constitutions, specific acts, laws, legislations, and regulations. These issues play a significant role in enabling sharing of geospatial data which is the crux of SDIs. Georgiadou et. al., (2005) finds that Indian NSDI failed at its early stage because of institutional issues. The detailed findings of this research about institutional issues related to geospatial data sharing in Pakistan have been elaborated later.

Data policy and legal framework

This research finds that the map policy has been one of the main reasons for hampering geospatial data sharing in Pakistan. The Survey of Pakistan (SoP) prepares the policy as SoP is legally mandated to collect, maintain and disseminate geospatial information of the country. To cope up with the 'map mania era', SoP prepared a comprehensive Surveying & Mapping Act which in principle supersedes the old map policy. The aforesaid Act has been recently promulgated by the President of Pakistan as Surveying & Mapping Ordinance 2013.

Some of the salient features of the ordinance are:

- Various terms related with Surveying, Mapping, Geospatial Data, GIS, Geodesy and National Spatial Data Infrastructure (NSDI), etc., have been officially defined in the history of Pakistan.

- To avoid duplication of efforts in collection of the same datasets, sharing of data has been underscored.
- The value of data standards and specifications have been highlighted, and it has been made compulsory for all public as well as private sector organizations to produce standardized geospatial datasets for its effective and objective usage.
- The need to have inter-agency coordination for acquisition, processing, and maintenance of geospatial data, has been inked.
- The emerging need for development of National Spatial Data Infrastructure (NSDI) for Pakistan with the collaboration of all major stakeholders has been briefly outlined.

Indeed, the ordinance is a good mix of technical and non technical aspects for production, access, dissemination and sharing of geospatial data, but its implementation would be a challenge due to the prevailing organizational culture of the public sector in Pakistan.

Data management

The significant importance of data/ information management for governments can be noted from Obama Executive Order, 2013. In Pakistan, plenty of geospatial datasets are available with public and private sector organizations. The findings of this work indicate that most of the datasets are not properly managed and therefore are not ready for sharing. We argue that due to advancements in geospatial technologies, data is increasing in volume as well as in variety of formats, which has made data management a challenge. Data management is an institutional matter as can be noted from the Executive Order-Obama, (2013). Managing large volumes of datasets require sophisticated Data Storage (DS) and Archiving System (AS) as well as sufficient trained human resources. The storage of large amount of data is an issue, as finds Kevany (1995), - "Data storage can also become an issue for sharing because adequate storage capacity is required." The cost of a data storage system is so high that no organization can meet its cost from the usual allocated annual budget. Survey of Pakistan was allocated special budget grant for procurement of data storage system with much efforts and lobbying.

Once the data storage system is in place, it is also important to have specially trained staff in the discipline of geospatial information management, as argues Onsrud and Rushton (1995), as well as de Montalvo (2003). Unfortunately, no such training facility is available in Pakistan.

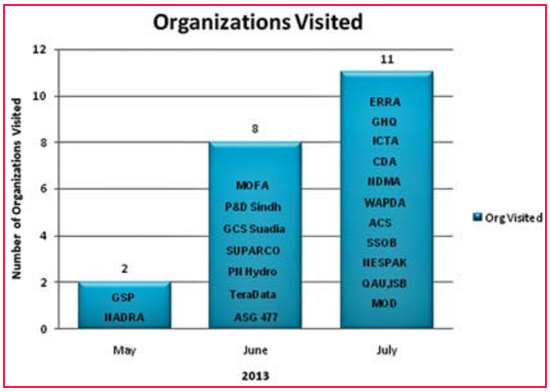

Figure 4: Reflection of SoP's Initiative to Promote Inter-Agency Coordination

Coordination

Most of the respondents of the questionnaire mentioned that lack of coordination among public sector organizations was the main reason for non-sharing of geospatial data in the country. Zahir (2013) noted that coordination among organizations is essential for data sharing in Pakistan. During an interview, Maj (R) Muhammad Tanvir, Director Map Publication, Survey of Pakistan underpinned this issue as the most significant problem in the context of sharing of geospatial data in the country. There is a degree of mistrust among data producer and data consumer organizations/users, he added. Katleen (2013) also highlights that trust is the main issue while dealing with sharing of geospatial data among organizations. Israel (1997) finds, "Nothing is more difficult in management than achieving coordination among different agencies. If institutional capacity is weak, coordination is practically impossible or perverse." It is argued that mutual trust is the foundation for coordination. To win trust, it is essential to communicate and interact. It merits mentioning here that Survey of Pakistan is continuously interacting with various public and private sector organizations. Recently, more than 20 public and private sector organizations (Figure 4) have been visited by a delegation of SoP, headed by the Surveyor General of Pakistan. Visits to more sister organizations are also planned. The main objective of these visits is to promote inter-agency coordination for sharing of geospatial data in the context of NSDI implementation in Pakistan. To seek support from the international community for capacity building and technology adoption, a visit to the office of USAID and JICA in Pakistan is planned, too.

Data cost

All NMOs in the world are under pressure due to availability of almost free of cost geospatial data on the internet. Indeed, Google which is now also a mapping company instead of being just a search giant, is the major competitor of all NMOs. It is important to mention that data downloaded from the internet may not be ground verified, and therefore, accuracy as well as reliability of such datasets cannot be guaranteed (Asmat and Munir, 2012).

The findings of this study reveal that end users of geospatial data in Pakistan are reluctant to buy data due to its cost. But to revise the cost of data is beyond the full control of organizations. Ministries are also involved in setting the cost of such datasets. Hence, data cost is an institutional subject that limits data sharing in the country.

Technical issues

Many technical issues are barriers in sharing of geospatial data in Pakistan besides institutional issues mentioned earlier. However, majority of the questionnaire respondents pointed out standards, metadata, technical arrangements and data quality as the most significant. Therefore, these issues are addressed in detail, because without a comprehensive investigation of technical issues (Crompvoets et. al., 2008) a viable solution cannot be proposed.

Standards

The findings of this study divulge that most of the public sector organizations are producing geospatial data without adopting any standards, except Survey of Pakistan and SUPARCO. However, awareness about the importance of standards is rising in the country. For example, to mark the value of standards, a national conference was jointly arranged by Pakistan Bureau of Statistics (PBS) in collaboration with UNFPA and UN HABITAT. It was held in Islamabad in March 2013. The event highlighted not only the added value of geospatial data standards, policies and sharing of geospatial data, but also the urgent need to develop NSDI in the country. A large number of participants, including three-member delegation from SoP attended the conference. Some of the participants presented work done by their organizations in the subject of spatial discipline. All the participants appreciated the work done and presented by the Urban Unit. Qazi Ismatullah, Deputy Census Commissioner (G) PBS, Islamabad, efficiently coordinated with all the participants to make this event successful.

Metadata

The findings of the study disclose that the situation regarding creation of metadata is the worst in public sector organizations. One of interviewee stated, "We have not yet thought about metadata." Presently, Survey of Pakistan (SoP) is the only public sector organization of the country that is producing standardized metadata. SoP has adopted ISO 19115:2003 Geographic Information – Metadata Standards. The creation of standardized metadata would give a jump start to NSDI implementation in the country. The standardized metadata prepared by Survey of Pakistan (SoP) enables other public and private sector organizations to harvest potential benefits of data collected by SoP and also to avoid duplication of efforts in collection of the same datasets.

Technical arrangements

Data sharing is the electronic transfer of data or information between two or more organizations as found by Calkins and Weatherbe (1995). In the context of this study, data sharing means sharing of geospatial data via wire. Therefore, to enable geospatial data sharing practically, lots of technical arrangements such as availability of secure Local Area Network(LAN)/Wide Area Network (WAN), Portals, Web Servers, online data transaction system and high speed broadband internet service, etc., are a prerequisite. The study investigated these arrangements in a detailed manner which is served next.

Backbone network infrastructure

Backbone network infrastructure means a medium, i.e., LAN, WAN and Internet arrangements to actually transfer data between two locations. In Pakistan, such arrangements in the form of centralized or distributed networks do not exist among public sector organizations. However, there are few individual efforts made by some departments to share data via the internet. The details of such departments, their datasets and the format of data being shared are tabulated as Table 2.

Table 2: List of departments sharing data via web

Organization	Dataset	Format	Pricing
Survey of Pakistan (SoP)	Topographical Maps	PDF	Free and Priced
Geological Survey of Pakistan (GSP)	Geological Maps	PDF	Free and Priced
Pakistan Space and Upper Atmosphere Research Commission (SUPARCO)	Satellite Mapping Products	PDF	Free and Priced
Pakistan Bureau of Statistics (PBS)	Population Census Information	PDF	Free and Priced
Pakistan Agricultural Research Council (PARC)	Land Use and Land Cover Maps	PDF	Free
National Disaster Management Authority (NDMA)	Maps of Earthquakes, Floods &,Land Slides etc	PDF	Free

There is an emergent need to establish such networks for geospatial data sharing. To start with, lessons can be learned from PERN (Pakistan Education & Research Network) that has now upgraded to PERN 2 as NREN (National Research & Education Network of Pakistan). The network has evolved significantly and is providing valuable services, like high-speed internet, audio/video conferencing, and access to digital library resources.

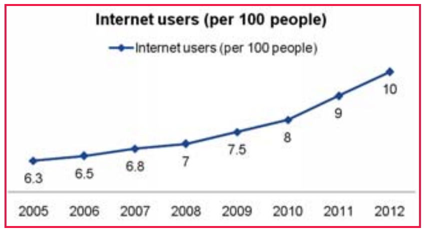

Figure 5: Internet Users (per 100 people)
Source: http://data.worldbank.org/

Besides implementation of network infrastructure, there is an equal importance of existence of internet users to get benefits from such networks. The study has, however, witnessed growth in internet users in Pakistan as portrayed in Figure 5.

Geospatial imagery is regarded as fundamental dataset. But it possesses large volume. Therefore, to share this type of geospatial data quickly and efficiently, the need to have broadband internet service cannot be denied. Significant improvement in this context is also evident from data collected by the World Bank.

Presently, many public sector organizations are not equipped with these interconnecting technologies, such as high speed internet and fully established LAN/WAN, therefore making sharing of geospatial data impossible.

Portal

In Pakistan, geoportals are not yet developed by all public sector organizations to share data. Survey of Pakistan (SoP) has developed

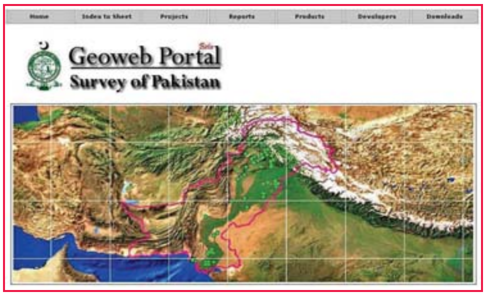

Figure 6: Geoweb Portal Developed by SoP

a geoportal which is accessible through LAN (Figure 6).

Security concerns

In Pakistan, security of cyber space is at high node as identified by Shahid Nadeem (2011). According to the study, many organizations prefer not to share data online due to the challenge of information security. However, studies conducted by World Bank finds that number of secured internet servers in the country have been increasing over the past years. Despite this, information security is one of the main reasons that hamper sharing of geospatial data in Pakistan.

Data quality

This study reveals that fear of exposure of poor data quality is one of the technical reasons that impede data sharing in Pakistan. To ensure production of good quality data, it is essential to make data quality control arrangements comprising skilled manpower as well as latest and state-of-the-art geospatial tools and technologies. Public sector organizations were questioned about Data Quality Control (QC) arrangements. Except, Survey of Pakistan (SoP), no such arrangements were found visible by any other public sector organization.

From the above discussions a lot can be learnt about the problems that hamper sharing of geospatial data in Pakistan. This study also identified possibilities for sharing of the data in the country, in addition to presenting some guidelines for their implementation. The findings of this study are summarized as SWOT Analysis in Table 3.

Conclusions and future work

In Pakistan, geospatial data is not being shared due to various institutional and technical problems. The findings of this study reveal that the institutional issues include; lack of data policy and legal framework, data management, lack of coordination among organizations and relatively high cost of the data itself. Whereas, technical issues that contribute towards non-sharing of the data are absence of data standards, non-availability of metadata and nonexistence of infrastructural arrangements as well as fear of exposure to data quality. Technical issues can be resolved with the assistance of international agencies such as GSDI, FGDC and JICA as these agencies are providing technical as well as financial support to implement data sharing related projects in many developing countries. However, one of the hardest problems in sharing of the data is lack of coordination among organizations, which money can't buy. Therefore, Government of Pakistan should come forward and enable a conducive environment for promoting coordination, collaborations and collations among public sector organizations especially by introducing and implementing requisite supportive policies.

This study reveals that a number of activities have taken place in the country that can contribute towards data sharing arrangements. The most significant is the recent promulgation of Surveying and Mapping Ordinance-2013. Some of the other possibilities include; SoP's initiative to promote inter-agency coordination and development of standardized metadata as well as data quality control arrangements, growing awareness about NSDI, growth in secure internet servers, availability of broadband internet, existence of websites of major public sector organizations and Pakistan's E-Government program, etc.

NSDI is a relatively new concept not only for Pakistan but also for most of the other developing countries. Moreover, there is no blue print available for its implementation. Therefore, efforts should be made to learn from the experience of other countries that have implemented SDIs at national level such as UK, Canada, USA and China, to initiate in the right direction and implement successfully NSDI in Pakistan, as well. An in-depth study as future work is recommended to identify other issues, which could not be addressed in the current research such as political, economical and cultural etc that impede sharing of geospatial data in the country.

Table 3: Strengths, weaknesses, opportunities and threats to data sharing in Pakistan

Strengths	**Weaknesses**
• Surveying & Mapping Ordinance-2013	• No inter-agency coordination
• E-government	• Lack of data sharing mechanism
• Multiple geospatial datasets	• Heterogeneity of datasets
• Availability of software/hardware	• Unavailability of metadata
• Existence of websites of major public sector organizations	• High cost of data
Opportunities	**Threats**
• SoP's initiative to promote inter-agency coordination	• Data Security
• Availability of latest technology	• Culture of public sector organizations
• Availability of broadband internet	• Budgetary constraints
• SoP experience in metadata creation	• Mistrust among producers and consumers of geospatial data
• Growing secure internet servers	• Data Quality
• Growth in internet users in Pakistan	

The paper was presented at GSDI 14, Addis Ababa during November 4-8, 2013.

ICT as a catalyst of urban transformation

A smart city provides infrastructure services such as water, energy and transportation, with the intelligent networks, sustainable buildings and systems

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Urban Population in India increased from 62 million (19%) in 1951 to 377 million (31%) in 2011, and is expected to increase up to around 37% by 2021. Consequently, the number and size of cities have also increased considerably. As per 2011 census, over 833 million Indians live in 6.4 lakh villages and 377 million live in 7935 urban centres.

The census towns have increased by 2,774 between 2001 and 2011. However, the growth of urban infrastructure did not match with the growth of urban population. Indian cities are facing the challenges of infrastructure services and housing shortage (18.78 million Dwelling Units). 24% (94.98 million) of urban population still lives in slums. The status of drinking water supply, public transportation, sewage and solid waste management is much lower than desired. Only 74% of households are served by piped water and just 65 out of 423 class 1 cities have a formal bus city service (2012). Traffic delays cost Rs 40 billion annually. Only 30 per cent of cities have sewage treatment, 32.7% of urban population has access to the municipal sewer system and 12.6% of urban population still defecates in the open. In Indian cities, only 72% of the solid waste is collected and only 30% is segregated, with a poor treatment and disposal. More than 80% of cities do not have statutory plans.

Table 1: Growth in Number of Cities and Towns in India

Type of Urban Unit	2011 Census	2001 Census
Cities/Towns	7935	5161
Statutory Towns	4041	3799
Census Towns	3894	1362
Urban Agglomeration	475	384
Out Growth	981	953

Source: Census of India Reports

12th Five Year Plan

The objective of the 12th Plan is faster, more inclusive, innovative, equitable and sustainable growth. It aims at cities which are free from slums and provide adequate opportunities for productive employment and decent quality of life to all its inhabitants. The cities would be the engines of growth and by attracting the investments nationally and internationally, they must be transformed to provide world-class infrastructure services, viz:

- Affordable housing
- Sustainable livelihood and enterprise
- Universal access to water supply and sanitation
- Quality and affordable public transport
- Clean and healthy environment

The strategy to deliver these targets comprises five enablers:

- Strengthen local governance systems
- Integrate planning organization and processes
- Build capacity across all levels
- Financially empower ULBs
- Promote innovation in urban management

The innovation has a key role to play in transforming the cities. The 12th Five Year Plan aims to promote innovation and technology which would unlock significant potential in building capacity across the ULBs, related to operations and maintenance in areas like water supply and sanitation, solid waste management, transport, infrastructure, health and education and urban planning. Indicative outlays of Rs 1,20,557 crore for Ministry of Urban Development (MOUD) and Rs 43,521 crore for Ministry of Housing and Urban Poverty Alleviation (MOHUPA) have been made, which include a provision of Rs 1,01,917 crore for the JNNURM (MOUD Rs 66,246 crore and MOHUPA Rs 35,671 crore)

The concept of innovation and Smart City

With the aim of making cities equitable, inclusive, smart and environmentally sustainable, the ICT has a key role to play in leveraging IT systems and innovations. Cities are complex systems which involve multiple stakeholders, agencies, departments and organizations. It is a necessity to innovate and respond to a new generation in terms of communication, health, education, recreation and urban services, while efficiently running daily operations. It must provide services that support the social, health and educational needs of citizens. A smart city provides infrastructure services such as water, sanitation, drainage, SWM, sewage, energy and transportation with intelligent networks, sustainable buildings and systems. A smart city focuses on intelligent computing infrastructure with cutting–edge advances in cyber–physical systems, and innovation support. Since a city is composed of numerous buildings, these also need to be smart and green. By innovation and renewal of existing operations it may be possible to reduce energy consumption. Integration of major systems on a common network helps optimize use assignment and space configurations, eliminating unused or underperforming space.

The breakthrough in technology has multiplied the space, energy and time. It has now been realized that 'less is more' with the application of microchips, micro-computers, microwaves, nano–technology, etc. The buildings and services are yet to capture this breakthrough. It is time that new forms of energy, services and construction are evolved. Renewal energy and recycling must be the key concepts in services and buildings. A new pattern of shrinking space and time is emerging. The network of society, cyber–space and e–topia is changing the familiar borders like inside–outside, private–public, here–there, city–country and yesterday–tomorrow. The world of space and place is characterized by online exchange of information, interactions, dynamic networks and floating nodes.

A smart city focuses on intelligent computing infrastructure with cutting–edge advances in cyber–physical systems, and innovation support

Environmental sustainability is important in a world where resources are scarce and where cities increasingly base their development and wealth on natural resources. Their exploitation must guarantee a safe and renewable use of natural resources. The availability and quality of the ICT infrastructure is essential for a smart or intelligent city. However, it is also necessary to stress the role of human capital, education and learning in urban development. It has been shown that the most rapid urban growth rates have been achieved in cities where a high share of educated labor force is available. Innovation is driven by entrepreneurs who innovate in industries and products which require an increasingly more skilled labor force. Because not all cities are equally successful in investing in human capital, an educated labor force - 'the creative class' – is spatially clustering over time. This makes the cities diverse in terms of human capital, and the cities which are endowed with a skilled human resource, have managed to achieve spatial homogeneity by progressive clustering of human capital.

ICT has the potential to play the role of a catalyst for the transformation of a city into a smart city with integrated and open interface of information management and governance platform. Urban development and transformation are intrinsically linked to the knowledge-based society where innovation and technology are main drivers of growth collective community intelligence and local capacity. This requires a planning paradigm pertinent for local-urban-regional development and innovation management. By developing sector–focused, cluster–based intelligent city strategies, territories can set in motion innovation mechanisms of global dimensions and enhance substantially their services and systems. The critical factors are those that affect use of resources and carbon emissions, such as energy use, transportation, waste prevention and recycling, air quality, water quality, affordable housing, green space and buildings. This implies the need to rethink and reshape the urban environment, comprising transportation infrastructure, zoning, building codes, waste management, open space and greens, etc., which make the city more efficient, sustainable, and smart. ICT can help in the integration of citizen participation, governance and online consultation over plans and programmes of local development.

As per Gartner Research Note (Sept. 2011), 'A smart city is a sustainable urban area utilizing information and communication flows between systems in different vertical domains, such as utilities, transportation, healthcare, public safety and education. Such flow of information, as well as their impact on services are analyzed and acted on in order to make the city's wider urban eco-system more resource-efficient and sustainable.' Intelligent Network and Sensors make services, buildings and mobility energy efficient and reduce carbon emission, which make a city smart. The smart city concept includes the following:

i) Smart Energy: The smart grid is all about creating the capabilities of electricity demand and supply to interact intelligently and integrate renewable generation. Geothermal heating and cooling system by circulating water through a grid of underground tunnels and wells, where the earth's temperature is 15°C to 20°C, can provide environment-friendly solutions to micro-climate and energy needs. The living pattern and city services should manifest a circular metabolism, replacing the existing linear system of input-output.
ii) Smart utilities aim at high quality water supply, drainage, sewerage, streets, waste management in catering

to growing population. Recycling of waste water, rain water harvesting, coupled with waterless toilets contribute in saving the environment and avoid impending water crisis. For water supply, ICT solutions such as SCADA system enable enhanced efficiency and transparency. Similar benefits are available with respect to solid waste management and other utilities. It is difficult to conceive of urban infrastructure without ICT solutions. Common Utility Ducts or tunnels carrying electricity, water, pneumatic waste ducts, cable television and broadband internet minimize damage from traffic, road repairs, rains, etc., and make repairs easier. A series of low carbon zones across the city with co-located trigeneration energy systems (combing power, cooling and heating), dual piping for recycled water and automated, segregated waste collection and recycling would lead to bundling 'green infrastructure' together. Solid waste extracted from sewage at treatment plants can be burned to make electricity. Three bins recycling system adopt separate bins for trash, recyclable and compost. Collection charges drop as trash drops. Bio-technology, enzyme-based STP, bio-remedial treatment, sludge gas/energy recovery, vermi-culture, fossilization and composting options should be explored for waste treatment. Water-saving toilets (with recycled wastewater cistern) and water tanks can save millions of water. Satellite controlled park and lawn micro-irrigation system cuts water consumption and pumping power. Wastewater recycling, with dual piping would reduce water demand. Vertical farms could reduce fertilizer and freshwater use, shorten transport and recycle gray water. Taxing property owners on the volume of storm-water and waste-water from kitchen and toilets that runs off promotes retrofits that reduce wastewater volume. Zero-run off, swales, porous paving, bio-drainage and storm-surge gates in river, drains and canals can protect low lying areas and infrastructure from floods and reduce drainage load.

Table 2: ICT Enabled Functions and Specifics (with Examples)

	ICT Enabled Functions	Implementation Specifics
1	Energy	Energy networks, smart grids Smart meters, smart buildings (Amsterdam, Chattanooga, Dublin, Malaga, Masdar) Renewable energy grid (Malaga) Electric vehicle (Amsterdam, Malaga) Power quality monitoring (Lavasa) Energy conservation monitoring (Shenyang) Bionic Controls Intelligent management/maintenance, MIS
2.	Public Utilities	Intelligent water and sewerage networks with minimum losses and leakages Intelligent metering, billing and payment Waste management Food Supply (Shenyang) Plug the Non-Revenue Water (NRW) losses Identifying leaks using non-invasive techniques and advanced analytics, by managing the pressure in the network at pumps and valves, and by reducing energy consumption of pump motors
3	Smart mobility	Simulation modeling Smart cards Smart signals, traffic controls, variable signage, mobile-enabled real time maps/routes, way finding ICT-enabled traffic control Safety and security, accident monitoring, forensic analysis Infrastructure integration Maintenance, MIS and management
4.	Intelligent Community Framework	Guide for Intelligent Community Planning (Dakota County) Education (Gdansk) Recreation (Gdansk, Chattanooga) Residential (Masdar, Trondheim)
5	Smart and Green Buildings	Integrated environment measures (Lavasa) Smart building (Masdar) Building Information Management City Administration Centre (Suwon) Environment management (Shenyang) Technology and Innovation Centre (Masdar &MIT)
6	Telecom Network Public Service and Governance	Land Information System, digitized mapping, SDI, Geo-portal, GIS-based property records, plans and transactions Online building plan approval Broadband development (Chattanooga, Dakota Country) Home automation (Lavasa, Malaga and Masdar) Internet access in public libraries (Cape Town) ICT support and training (Cape Town) Library business corners for starting and running small businesses (Cape Town) Public Security System and Safety Digital business centre, automated messaging/ mass short message service (SMS) Consolidated billing (Lavasa) Business incubation center (Suwon) Climate street (Amsterdam) Electronic trade office (Suwon) Geo-portal (Delhi), MAINet (Maharashtra)

e-Inclusive City

iii) Smart Mobility: Effective public transport and improved traffic flow are necessary for a safer, comfortable and inclusive mobility with reduced emission. Intelligent transport solutions can provide seamless, safer, efficient and effective management of public transport systems. Similar results are also visible with the use of IT in the planning and management of transport infrastructure and services like taxies, autos, goods transport, signaling system, signage, transport simulation, etc.

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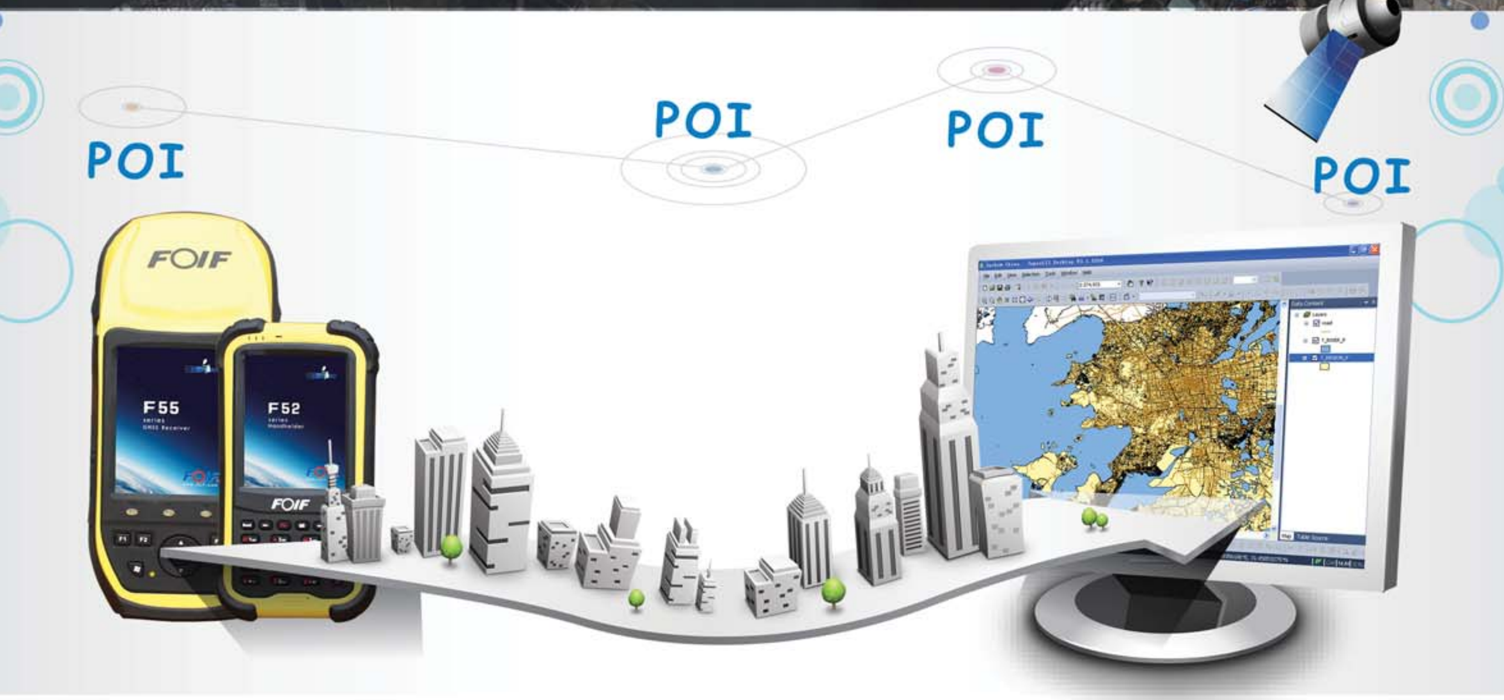

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JANAK

Figure 1: Aamchi Mumbai (My Mumbai) provides e-services which are transparent, time-bound and integrated with related modules like property, town planning, trade and market license, water billing, etc. It reduces processing time for service delivery and is convenient due to single touch point services. It has yielded an image overhaul of ULB with better and corruption-free citizen services.

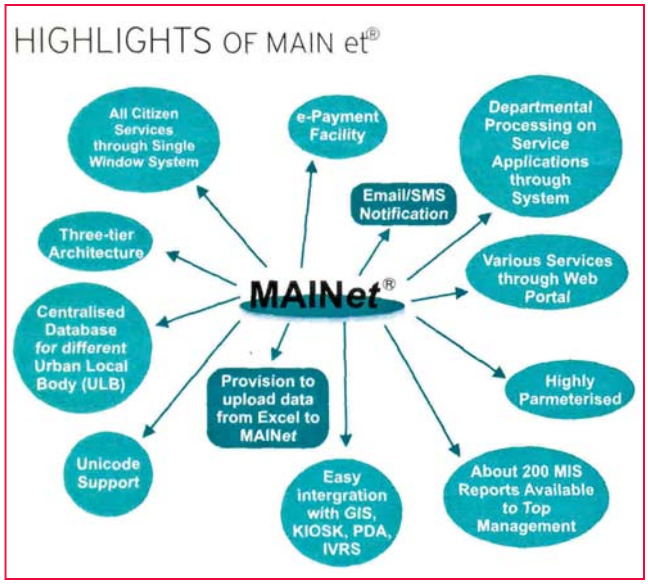

Figure 2: Municipal Administrative Information Network (MAINet) is a platform for governance and services. It aims to optimize transparency and accountability by automated access to more than 100 citizen services in Maharashtra

iv) Intelligent Community Frameworks: Community facilities such as health, education, recreational and other neighborhood services need to be planned to the highest standards of leadership in energy and environmental design (LEEDS) that save energy, materials and emissions. A smart neighborhood strives to achieve infrastructure efficiency, conservation of water, energy and natural resources.

v) Smart and Green Buildings can give energy saving up to 30%, reduce carbon emissions, provide higher efficiency and comfort with lesser energy consumption. The city and buildings have not only to be comfortable, green and efficient, but also intelligent and integrated. Rooftop PVC and solar panel can generate electricity instead of power plants and also shade rooftops to lower a building's cooling needs. Solar energy can be collected through a decentralized grid for distribution. Solar panels on the roof move as the sun moves across the sky. Rooftops painted white reflect heat, lowering a building's cooling cost and a city's heat build-up. Rooftop vegetation can insulate building against heat and cold and absorbs storm-water. Super-insulated windows quadruple the thermal performance of double panes and can be made from the glass in existing windows. A sensor controlled photo-voltaic cell fits between two panes of a window. Smart glass technology saves on air- conditioning and high energy cost.

vi) Telecom Network, Public Services and Governance: ICT can enable coordination and e-governance, together with sharing the information amongst the various city departments, residents and other stakeholders.

In any city there are more than 100 citizen services that require engagement with civic authorities for enquiries, registration, form submissions, payments, grievances, etc. It is a time taking process for the citizen. The availability of e-gateway for citizen service delivery has attracted much attention in municipal governance and bringing out a silent revolution in many city corporations, breaking away barriers of distance, class and gender. The GIS enables any citizen to take a photo on mobile and send an SMS to the administration. The dashboard will capture and address the complaint and even escalate the matter to higher authorities, if unaddressed. Mumbai has

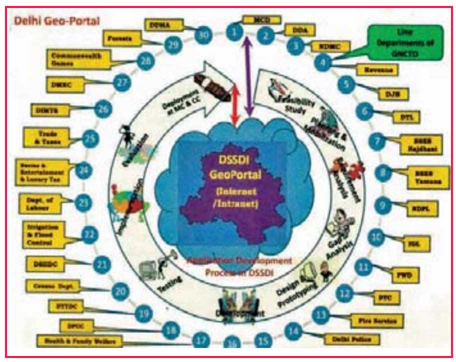

Figure 3: Delhi Geo-Portal

60 layered features of GIS mapping which is geo-referenced. The key municipal services provided online by Mumbai Mahanagar Palika include the following:

- Complaint redressal platform
- Town planning permission and licensing
- Water and property tax administration
- Public works - estimates and payments
- Octroi management
- Birth and death certificate
- Property registration
- Land services and slum surveys
- GIS-based Spatial Data Infrastructure.

Geo- Portal

The Delhi geo-portal aims to bring together various line departments on a platform for e-service delivery. The system is mobile and internet-based, dynamically scalable. It helps in technology enabled management of land and infrastructure, planning, development. This yields better co-ordination and exchange of information, cost and time management. Citizen engagement becomes much easier and viable by virtual Town Hall interactions. Hybrid data centre, which is integrated yet decentralized, virtualizes the resources according to the requirements of each department. The geo-portal infrastructure platform enables '*Infrastructure as a Service (IaaS)*' and '*Platform as a Service (PaaS)*'. It provides a virtual environment for the delivery of service. Besides responding to immediate demands, the geo-portal creates a 'future ready government' with spread, speed and on-line e-service.

Conclusions

The 12th Five Year Plan envisages urban development as an engine of growth and socio-economic transformation. To achieve the objective of a faster, inclusive and sustainable growth, innovation and technology have been assigned a key role. In this context, ICT can be a catalyst in the provision of world-class, smart and intelligent infrastructure services (energy, water supply, utilities, mobility, green buildings, etc.), public services and governance. Some cities have successfully initiated ICT-based planning, development and services, which need to be up-scaled with spread and speed across all 640 districts and 7,935 towns and cities of India. The national urban programs such as JNNURM and RAY may mandate ICT-based geo-portal and e-inclusive governance in its reform agenda, which can be a catalyst of urban transformation.

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SNIPPETS

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- Satellite imagery to spot whales in Argentina
- Lockheed, AeroVironment to jointly pursue UAS markets
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- UK to invest $25mn for environmental satellite projects

Galileo update

STMicroelectronics' Galileo-Compatible Satellite-Tracking Chips are ready for eCall approval

STMicroelectronics has released Teseo II single-chip satellite-tracking IC to the European Space Agency (ESA) and the European Commission Joint Research Center (JRC) for testing for eCall approval. The testing campaign is coordinated by the European GNSS Agency (GSA) as part of its effort to accelerate Galileo adoption.

The Galileo tests will be conducted by the ESA and JRC over the next months to validate ST's latest firmware release. In addition, the tests will evaluate Teseo II compatibility with the European Geostationary Navigation Overlay Service (EGNOS) and with Galileo for the eCall in-vehicle system that automatically sends notification messages from vehicles involved in an accident. *www.st.com*

10,000 km road trip proves Galileo satnav works, says ESA

ESA boffins revealed this week that since March 2013 test vehicles around the world have run tests to determine the accuracy of positions returned by Galileo satellites in what was called the " In-Orbit Validation (IOV) phase" of testing. More than 10,000 kilometres of driving later, "Many terabytes of IOV data were gathered," according to Marco Falcone, ESA's Galileo system manager, and once they had been analysed the data showed that "Galileo's observed dual-frequency positioning accuracy is an average 8 m horizontal and 9 m vertical, 95% of the time. Its average timing accuracy is 10 billionths of a second".

The tests also showed that 77 per cent of simulated distress locations could be located to within two kilometres and 95 per cent to within five kilometres. Alerts reached Galileo's mission control in 90 seconds, nicely below the design requirement of ten minutes. *www.theregister.co.uk*

Galileo Achieves In-Orbit Validation

The in-orbit validation of Galileo has been achieved, according to the ESA. Europe now has the operational nucleus of its own satellite navigation constellation in place — the world's first civil-owned and operated satnav system.

"IOV was required to demonstrate that the future performance that we want to meet when the system is deployed is effectively reachable," said Sylvain Loddo, ESA's Galileo Ground Segment manager. "It was an intermediate step with a reduced part of the system to effectively give evidence that we are on track."

Preparation for Satnav mass market

The European Space Agency (ESA) is working with European manufacturers of mass-market satnav chips and receivers to ensure that their products are Galileo-ready.

"Our objective is to make sure, ahead of the European Union's declaration of early Galileo services that mass-market devices are ready and able to make use of them," explained Riccardo de Gaudenzi, head of ESA's Radio Frequency Systems, Payload and Technology Division.

"In coordination with the European GNSS Agency, we put out an open call to satnav manufacturers offering testing with our laboratory facilities."

Wi-Fi positioning where GPS doesn't work

Ruckus Wireless has unveiled the Ruckus Smart Positioning Technology (SPoT) service. This cloud-based service gives carriers, service providers and enterprises the ability to deliver location-based services using Wi-Fi in locations where GPS is not effective. By knowing where clients are located, companies are able to help them get wherever they need to go. *www.crn.com.au*

TeleCommunication Systems launches DopplerNav

TeleCommunication Systems, Inc has introduced Gokivo(R) 2.0 navigation solution. It leverages TCS' current market-leading LBS technologies to deliver an enhanced smartphone user experience that incorporates unique technology solutions. It offers navigation experience with innovative enhancements for all smartphone users. Animated DopplerNav(TM) weather overlay displays real-time weather conditions on the map. *www.telecomsys.com*

Geotrigger service for mobile developers

Esri cloud-based Geotrigger Service is easier for developers to add location awareness and messaging to their iPhone and Android apps. With the Geotrigger Software Development Kit (SDK), mobile apps can send custom messages when a user enters or leaves locations specified by the application developer. It expands on the native geofencing features available within iOS and Android, including the ability to create complex polygon geofences and notify other servers or services when triggers are fired. *www.ciol.com*

Trusted Positioning launches Enhanced Indoor Location Software

Trusted Positioning has launched T-PN ME, the first navigation software to use motion sensor data from multiple mobile/wearable devices to more accurately locate a person indoors. The software collects movement information from the user's phone, tablet, watch, wearable or glasses simultaneously to better position how a person is walking

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or driving when GPS is unavailable in places such as shopping centers, airports or urban centres. *www.trustedpositioning.com*

Indoor GPS Market Revenue to Top $3.5 Million by 2018

Frost & Sullivan's new analysis, Breakthrough Innovations in Indoor GPS, expects the indoor GPS market to reach more than $3.5 million in revenue by 2018. The most common tools used for indoor positioning include various types of sensors and communication networks, such as Bluetooth and Wi-fi. However, these approaches lack the level of accuracy end users expect.

There is also a need to create a standard technology for indoor GPS solutions as solution providers are currently using technologies designed for other purposes, such as communication and illumination. Technology convergence and collaboration with standardization bodies is crucial to address this requirement. *www.pcbdesign007.com*

Secretive Boeing Black smartphone appears on FCC website

Boeing, which said nearly two years ago it was developing a super-secure Android smartphone, apparently is getting ready to release it. In a Feb. 24 filing with the Federal Communications Commission, the company said what it called the Boeing Company Black Smartphone has undergone testing to meet FCC standards.

Boeing is keeping most details about the phone secret, but the dual-SIM smartphone will use micro-SIM cards and will support GSM, WCDMA, and LTE. And although the company had said it was working on a Android phone, the FCC filing makes no mention of the operating system. *http://defensesystems.com*

Microsoft and Foursquare sign $15 Million Deal

Microsoft HAS announced that it has made a four year deal with Foursquare, the location based social networking app. Microsoft will invest $15 million as a part of a licensing procedure after which the tech giant will be able to mesh the colossal location-based service's data into Microsoft's web and mobile platforms. When tech giants make such big investments, there is a high chance that they are going to launch some product in which there will a use of the related product and the experts predict that Microsoft is working on its next flagship of mobile or Xbox in which its aiming to mesh the best location based built in services like never before. *www.morningnewsusa.com*

Radio-Tagged Bees Take Tasmania by Swarm

In a world first, a swarm of 5000 bees with tiny radio tags attached to them are being released in Tasmania. For the unusual project, CSIRO scientists have teamed up with researchers at the University of Tasmania, as well as beekeepers and farmers.

"Each bee has a different tag, so we are able to track the information about their movements," says study leader, Dr Paulo de Souza at CSIRO Computational Informatics. The 2.5sq.mm radio frequency identification sensors (RFID) – which work in a similar way to the e-tags used by drivers on toll roads – will reveal when bees pass checkpoints at feeding sites and hive entrances.

LocationSmart launches U.S. Cellular Mobile Location Services

LocationSmart has announced support for U.S. Cellular, one of the largest wireless telecommunications networks in the US, to extend location information services to U.S. Cellular customers through LocationSmarts cloud-based platform. This partnership with U.S. Cellular expands the reach of LocationSmarts customer applications and enterprise solutions, providing immediate opportunities for additional location-based services revenues. The platform provides enterprises access to over 95% of mobile subscribers nationwide. This launch makes U.S. Cellular immediately locatable for existing LocationSmart customers simply by obtaining the consent of the user. *uscellular.com*

Kazakhstan seeks to launch new spacecrafts

Kazakhstan will launch one communication satellite and two remote sensing satellites in 2014. Moreover, Kazakhstan will commission ground facilities for a remote sensing space system, as well as a high-precision satellite navigation system. *www.azernews.az*

New LIDAR chip will sharpen aerial mapping and autonomous car vision

A new breed of LIDAR technology is being developed and tested by the US Air Force at a base in Massachusetts. This system is capable of precisely mapping over 300 square kilometers from the belly of an airplane in about half an hour. While it is considerably more advanced than consumer models, the new Air Force LIDAR works on the same basic principle– laser light is projected toward the target, and a sensor detects the photons upon their return. The time it takes is used to calculate the distance, to varying degrees of accuracy. In advanced systems like those used by the military, LIDAR can create a topographic map of the area it is pointed at. *www.extremetech.com*

Unmanned Aerial Positioning System by Topcon

Topcon Positioning Group have recently released the Topcon SIRIUS PRO powered by MAVinci, an Unmanned Aerial System (UAS) designed to produce solutions for automated mapping of construction sites, pipelines, disaster areas, mines, quarries and myriad sites without regard to terrain. *www.mavinci.de*

DARPA, Lockheed Martin advance cargo UAV concept

Lockheed Martin's Skunk Works advanced development unit is building an unmanned vertical takeoff and landing (VTOL) air vehicle under a U.S. Defense Advanced Research Projects Agency (DARPA) program to demonstrate a cargo UAV capable of carrying interchangeable mission payloads. DARPA plans to fly the prototype next year. The so-called Aerial Reconfigurable Embedded System (ARES) program has entered its third and final phase, which involves designing and building the prototype. The air vehicle design calls for twin, tilting ducted fans to provide hovering and landing capabilities "with rapid conversion to high-speed cruise flight similar to small aircraft." *www.ainonline.com*

Antrix to launch satellites from UK and Singapore

Antrix Corporation Limited (Antrix), the commercial arm of Indian Space Research Organization (ISRO), signed Launch Services Agreement with DMC International Imaging (DMCii), the wholly-owned subsidiary of Surrey Satellite Technology Limited, UK, for launch of three DMC-3 Earth Observation Satellites being built by SSTL, on-board ISRO's Polar Satellite Launch Vehicle (PSLV). On 5th February 2014, Antrix signed another Launch Services Agreement with ST Electronics Pte Ltd, Singapore, for launch of TeLEOS-1 Earth Observation Satellite, on-board PSLV. These launches are planned during end 2014 to end 2015. *www.isro.org*

Algerian Space Agency signs agreement with UNITAR

Acting Head and Executive Director of UNITAR Ms Sally Fegan-Wyles have signed a cooperation framework agreement with the Algerian Space Agency (ASAL), Director General Azzedine Oussedik. Under this agreement, UNITAR's UNOSAT programme and ASAL will collaborate on data exchange, training and capacity development related to applications of earth observation data and the use of GIS. Areas of collaboration include natural disaster management, disaster risk reduction and development. *www.unitar.org*

Airbus Defence and Space contract with Republic of Korea

Airbus Defence and Space will deliver the radar antenna and electronics for the Republic of Korea's new Earth observation satellite, Kompsat-6. The contract was signed in Seoul, in the presence of Peter Friedrich, Minister for International Affairs of the Federal State of Baden-Wuerttemberg, by Hyokoo Lee, CEO of LIG Nex1 Co. Ltd and Eckard Settelmeyer, Head of Earth Observation of Space Systems in Germany.LIG Nex1 is accountable to the Korea Aerospace Research Institute (KARI) for handling all aspects of the radar sensor. *www.astrium.eads.net/en/*

Esri and GEOSS unite to improve earth observation analysis

Esri is working with the Group on Earth Observations (GEO) to create a GIS platform for the program Global Earth Observation System of Systems (GEOSS). Esri technology will make

GEOSS earth observation data available to a wider audience for understanding, monitoring, and making decisions about the planet.GEOSS is a portal between a flexible network of earth observation content providers. *esri.com/agol*

Bluesky announces commercial trials of Airborne Air Quality Mapper

Aerial mapping company Bluesky is launching a service to map air quality across towns and cities. It is seeking new sites in the UK to trial its ground breaking survey technology. Using a world first spectrometer, developed by scientists at the University of Leicester, mounted on an aerial survey plane the system can accurately record levels of nitrogen dioxide across entire cities. *www.bluesky-world.com*

India joins elite club with heliborne geo-survey capability

India has become the seventh nation to own a heliborne geophysical survey system (HGSS), which has been integrated on the advanced light helicopter's (ALH) latest version — Garuda Vasudha.

The ALH, which is the brainchild of the Hindustan Aeronautics Limited (HAL) has been integrated with HGSS procured from Pico Envirotec Inc, Canada.

Garuda Vasuda is equipped with state-of-the-art latest magnetic, spectrometric and gravity heliborne geophysical survey systems. It is equipped to provide high resolution images, and has the ability to catch mineral signatures even 300 metre below the earth's surface. GSI, which has been using fixed wing aircraft for aerial surveying used to hire services from foreign countries for heliborne survey.

R Sridharan, Secretary, Ministry of Mines said that India, unlike countries like Australia which have completed 100 mapping of their resources, has a long way to go. "Only ten per cent of our country is mapped. We have a long way to go, and systems like these would help us expedite the process," he said. *Times of India*

Google's Project Tango whips up new mapping tech

Project Tango is an ambitious attempt by ATAP, a skunkworks division with Defense Advanced Research Projects Agency (DARPA) roots that's been peeled away from Motorola Mobility, to give smartphones the ability to do realistic 3D mapping and create virtual experiences as the phone's owner moves through the real world. It exists as a 5-inch Android phone prototype, running customized hardware and software which can track the "full 3D motion of the device, while simultaneously creating a map of the environment," says Google. Suggested applications range from the mundane, such as capturing the dimensions of a home before furniture shopping simply by waving the phone around a room, to the helpful, such as aiding the visually impaired inside unfamiliar buildings, to the frivolous, such as turning a hallway into a virtual-reality game space. *http://news.cnet.com*

Singapore government launches GIS-based property app

Singapore's Urban Redevelopment Authority (URA) has launched a new map-based app using GIS technology to ease information search on general planning decisions. Information on properties and the Authority's plans are highly sought after by the public and professionals. Last year, URA reported more than 20,000 searches on its online database.

Urban planning with the help of GIS in Hong Kong

"As part of the Planning Department's commitment to ensure the quality of living and working environments in Hong Kong, we recently developed a GIS-based site search tool which greatly improved the current practice of identifying and assessing potential commercial and residential sites," said Stanley Tsoi, Senior Systems Manager, Hong Kong Planning Department.

The tool, which contains 13 types of criteria and 45 data layers, operates on a raster-GIS environment. It was developed based on customised algorithm designed to meet various local situations as well as the business operational needs of the Planning Department. In addition, the tool leverages ArcGIS Spatial Analyst, which is an extension of ArcGIS for Desktop, to perform overlaying, buffering, focal and zonal statistics operations.

Google Earth to bolster new digital land catalogue

The public will now have access land surveys, titles, valuations and aerial photography after the government unveiled NSW Globe – a new way to view government data.

NSW Globe uses Google Earth technology to present complex and detailed spatial information in a more accessible and user-friendly way. It combines spatial data with detailed satellite and aerial imagery and is able to display display property, local government and electoral boundaries, as well as road and rail networks. *www.arnnet.com.au*

No GIS road info in Nagaland, India

Remote sensing and GIS techniques can be effectively utilized for the mapping of all road networks and generation of these databases for information system in Nagaland, India. As of now, there is no proper inventory or mapping of road network or database for management of road for the entire state of Nagaland in GIS environment. This was stated in the publication of 'Science and Technology Intervention in Nagaland' published by The Nagaland Science & Technology Council (NASTEC). *www.morungexpress.com*

Work processes for project execution and plant operations made easy

Intergraph® has released SmartPlant® P&ID 2014. It features new ducting and instrumentation diagram functionality and the solution scope has been extended with enhancements to more efficiently support work processes for project execution and plant operations, and lower the cost of ownership. The new


PENTAX
W-800
Reflectorless
WinCE Total Station
A truly integrated system
G3100-R1
Positioning System
Precision satellite surveying,
with wireless communications
R-2500DN
Reflectorless Total Station
w/built-in digital camera
Capture the full picture!
BL-100
Digital
Automatic Level
Increase your Efficiency!

ducting and instrumentation diagram (D&ID) capability in SmartPlant P&ID 2014 lets users "Experience the Power of Smart Engineering" by creating a schematic representation for air handling or process systems. It configures the ducting system with the connectivity, components and instruments that can next be used in downstream tasks like SmartPlant Electrical and SmartPlant Instrumentation and ultimately, the physical design in Intergraph Smart™ 3D, the world's most advanced and productive 3D design solution. *www.intergraph.com*

Bentley Partners with S-Cube Futuretech

Bentley Systems, has its partnership with S-Cube Futuretech Pvt. Ltd., the leading developer of software products for concrete structural engineering in India. Working smarter, together, the two companies are delivering *STAAD. building*, a software integration facilitating B/IM for concrete building design workflows that will enable users to meet the demanding standards of the Indian market. *www.bentley.com/STAAD*

Manage Parcel Data with Ease

SuperGIS Desktop 3.2, by Supergeo Technologies, the newest desktop GIS software, supports Land Parcel Editor to assisting users in managing parcel data with ease.

In addition to performing Multiple Map Frames, Advanced Editor, Land Parcel Editor and Feature Guided Pages, Georeferencing Tool and OGC Add-on in it are also enhanced to support various kinds of GIS tasks. *www.supergeotek.com*

Express Server 9 LizardTech

LizardTech has launched Express Server® 9 software. It is the leading image-delivery software for compressed raster imagery, including multispectral imagery. It uses patented technology to reduce storage costs, decrease image loading times and handle thousands of image requests, all without sacrificing visual quality. The latest version comes equipped with the *Express*Zip web application for exporting imagery straight from the web browser. The entire *Express*Zip application is open source and completely customizable. *www.lizardtech.com*

Laos to produce its largest digital topographic map

Laos will produce its biggest ever digital topographical map with $3.5 million of support from the Republic of Korea (ROK). The map will cover some 4,600 hectares of the nation's capital Vientiane, encompassing the city's four inner districts. The three-year project aims to provide geographic data that could be used for the construction of new towns in the capital while strengthening the capacity of the Lao Survey and Mapping Center to conduct large scale mapping initiatives. *http://www.globaltimes.cn*

Violence mapping project in South Africa

With national elections approaching, concerns about the levels of public violence - and their implications for a peaceful poll - are mounting. ISS has launched the country's first open access project to map all forms of public violence. Building on existing academic research and efforts to monitor protest action, the ISS will track levels of public violence over time, as well as responses to incidents. Each incident is uploaded onto a map to produce a picture of where hotspots exist and where they may be emerging.

With more than 10 year's experience in analysing violence data and working with criminal justice officials on strategy and policy, the ISS is well placed to lead a project of this nature. *www.issafrica.org*

3D model of Noida, India

Noida Authority is getting set to create a 3D model of the city. Digital mapping of surface and underground objects will be used to create the model. Once in place, the 3D model will prove to be a very powerful tool not only for city planning but for security as well. *http://timesofindia.indiatimes.com*

GPS IIF-5 successfully launched

Aerojet Rocketdyne has successfully propelled the fifth GPS IIF military navigation satellite into orbit on February 20th. It was launched from Cape Canaveral Air Force Station in Florida by a United Launch Alliance Delta IV medium rocket. The GPS satellite, built by The Boeing Company includes a pair of Aerojet Rocketdyne propulsion systems which will be used periodically to restore the satellites to their designated orbits and to eventually decommission them.

The IIFs are designed to improve navigational accuracy for civil, commercial and defense applications worldwide. They feature more capability and improved mission performance, including predicted signal accuracy that is two times greater than heritage satellites; a 12-year lifespan that provides longer service and reduced operating costs; and a military signal that has better resistance to jamming in hostile conflict areas. *www.Rocket.com*

Veripos to provide GNSS Positioning Services for MEO's Fleet

Singapore-based Miclyn Express Offshore (MEO), a leading provider of offshore support vessels across South East Asia, Australia and the Middle East, has awarded Veripos a five-year contract for provision of high-precision GNSS positioning services in support of its fleet of 27 ships.

Veripos will provide MEO's fleet with VERIPOS Ultra Precise Point Positioning (PPP) service designed to deliver decimetre-level accuracies globally along with associated integrated mobile receivers.

Delta 4 rocket boosts GPS navigation satellite into space

Up to Seven GLONASS Ground Stations Planned outside Russia in 2014.

Russia will deploy up to seven ground monitoring and augmentation stations for GLONASS outside of Russia, according to GLONASS/GNSS Forum

Association Executive Director Vladimir Klimov. “It is planned to deploy about six or seven stations on foreign territories this year,” Klimov said.

About 50 GLONASS ground stations are planned for construction. The stations will significantly improve GLONASS performance and provide efficient applications for high-precision navigation services and smooth monitoring of systems of coordinates and Earth rotation parameters, he said. Currently, there are 46 GLONASS ground stations on Russian territory, eight in neighboring countries, three in Antarctica, and one in Brazil.

Monastir airport uses new EU navigation satellite system

New satellite navigation systems are being introduced at Monastir airport in Tunisia with the assistance of the EU-funded MEDUSA project, implemented under the Euromed Transport GNSS II project.

According to the Enpi website (www.enpi-info.eu), MEDUSA had validated GNSS-based Localiser Performance with Vertical Guidance (LPV) approach procedures designed by the project for Monastir airport, as part of the project’s assistance actions for promoting the use of satellite navigation in the Euro-Mediterranean partner countries. Only a few months after the availability of partial EGNOS (European Geostationary Navigation Overlay Service) coverage in North Africa, the validation flights campaign was carried out with the support of the European Satellite Services Provider (ESSP), the EGNOS Services Provider, which performed the EGNOS feasibility assessment. *www.ansamed.info*

Taiwan creates its first space-based GPS receiver

Scientists in Taiwan have developed the nation’s first space-based GPS receiver, which boasts several improvements over versions obtainable from overseas and can help cut the country’s reliance on foreign imports. The first locally developed space-borne GPS receiver, which helps satellites navigate in space, is expected to offer more freedom and independence for space missions, as exports of such products are normally kept under tight control by countries around the world, Chang Guey-shin, who heads Taiwan’s National Space Organization (NSPO), said. *http://focustaiwan.tw/news/*

Global location chip for wearables by Broadcom

Broadcom Corporation has introduced GNSS system-on-chip (SoC), designed for low-power, mass-market wearable devices such as fitness trackers and smart watches. The Broadcom(R) BCM4771 GNSS SoC with on-chip sensor hub enables consumers to more accurately track and manage their health and wellbeing by delivering precision activity tracking and location data while consuming less power than traditional architectures. *www.broadcom.com*

FORM IV

Place of publication:	New Delhi	Publisher’s name:	Sanjay Malaviya
Periodicity:	Monthly	Nationality:	Indian
Printer’s name:	Thomson Press	Address:	499D, Shipra Sun City, Indirapuram, Gaziabad
Nationality:	Indian	Editor’s name:	Bal Krishna
Address:	B-315, Okhla Industrial Area 1, New Delhi	Nationality:	Indian
		Address:	A 002, Mansara Apartments, C 9, Vasundhara Enclave, Delhi – 110096

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

March 1, 2014 Signature of publisher

Spirent Launches SimSAFE to Address GNSS Signal Vulnerability

Spirent Communications has announced the introduction of Spirent SimSAFE, a software solution that concurrently simulates legitimate GNSS constellations and spoofed or hoax signals to evaluate receiver resilience and help develop counter measures. It was developed in conjunction with Qascom, GNSS signal security and authentication experts.

As GNSS become increasingly embedded in modern infrastructure for application timing and device positioning, the opportunities for interference and spoofing attacks become greater, Spirent said. Hoax or spoofing attacks work by mimicking genuine GNSS signals, which mislead GNSS receivers. From mobile telephony to Internet banking, GNSS timing signals are used in many key systems, and yet there is no requirement on GNSS equipment to demonstrate any degree of robustness to block or even detect malicious attacks that disrupt performance. Often, affected receivers do not recognize when they are receiving fake signals and continue to operate normally, but provide false time or position information. *www.spirent.com*

All Archer 2 models shipping worldwide

After passing further testing and receiving additional certifications, all models of the Archer 2 from Juniper Systems are shipping worldwide. The new Archer 2 has an extra-bright IllumiView display, a super battery that can last well over 20 hours, enhanced GPS capabilities, and IP68 rating to prove it can withstand the most extreme environments. *www.junipersys.com/archer2*

Extended recording plus other new features for LabSat 3

The latest LabSat 3 update allows the use of 128Gbyte SD cards, giving up to nine hours of high quality RF recording. Also included in the update is the ability to use external USB hard drives and the addition of a serial/USB NMEA output, generated by the internal GPS engine during a replay. Along with SD card recording, LabSat 3 features inbuilt battery power, dual channel recording of GPS/Galileo/QZSS/SBAS, BeiDou, or GLONASS, and logging of other external signals such as CAN and RS2232 – in a small, rugged, and light enclosure. *www.labsat.co.uk*

First survey-grade LiDAR for UAS by RIEGL

RIEGL Laser Measurement Systems has been developing the world's first survey-grade UAS LiDAR sensor, the VUX-1. The innovative sensor was designed to meet the challenges of emerging surveying solutions by UAS, gyrocopters, and ultra-light aircraft, both in measurement performance and in system integration. The VUX-1 is an ultra lightweight LiDAR sensor with less than 4 kilograms (less than 9 pounds) overall weight, that can easily be mounted onto professional UAS/RPAS. It has a 300 degree field of view and produces the extremely high quality LiDAR data users expect from a *RIEGL* product. Internal storage offers the ability to collect data for several hours at altitudes/ ranges up to more than 1,000 ft. Scanner applications include, but are not limited to: Agricultural and Forestry, Defense, Wide Area Mapping, Flood Zone Mapping, Glacier and Snowfield Mapping, Topography and Mining, and the Academic Markets. *www.riegl.com*

Trimble News

New airborne LiDAR systems

The Trimble® AX60i and AX80 are highly capable, versatile systems that meet the demands of aerial survey operators for corridor and wide area mapping projects. The new airborne systems, together with flight planning and analysis software tools, have been designed to provide rapid and efficient point cloud capture as well as high-resolution images and proven workflows with high productivity. *www.trimble.com*

V10 Imaging Rover

Trimble® V10 Imaging Rover is now available through its Geospatial Division distribution network. It enables professionals in a broad range of industries to quickly capture rich positioning data and 360 degree documentation of their surrounding environment. In the office, users can take measurements and create comprehensive deliverables using Trimble Business Center office software. *www.trimble.com*

Ekinox Subsea Series by SBG Systems

SBG Systems have recently released the Ekinox Subsea Series. It is a product family of survey-grade inertial systems designed for underwater applications – up to 6,000m. The series includes the Ekinox-M, a Motion Reference Unit (MRU), and the Ekinox-U, an underwater Inertial Navigation System (INS)

Smart coupling of iXBlue and Septentrio technologies creates ATLANS-C

iXBlue, a leading provider of navigation, positioning, and mapping solutions, has launched its new ATLANS-C position and orientation system, developed in close cooperation with Septentrio Satellite Navigation. The system is designed to provide continuous and accurate positioning in urban environments, where GNSS signals are obscured, intermittent, or possibly distorted by reflective surfaces. *www.septentrio.com/products*

New Spectra Precision® SP80 GNSS receiver

Spectra Precision has introduced its next-generation Spectra Precision® SP80 GNSS receiver. The new SP80 is an innovative survey solution that combines cutting-edge GNSS technology and a unique combination of communication capabilities with a distinctive and ergonomic design. The SP80 is an ideal GNSS receiver specifically designed for mainstream surveying and construction applications such as cadastral, topographic, control, stakeout and network RTK. Spectra Precision SP80 features exclusive Z-Blade™ GNSS-centric technology running on a new-generation, 240-channel 6G chipset. The SP80 is capable of fully utilizing all 6 available GNSS systems (GPS, GLONASS, BeiDou, Galileo, QZSS and SBAS), but can also be configured to use only selected constellations in an RTK solution (GPS-only, GLONASS-only or BeiDou-only). The SP80 is also 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*

StreetMapper to Map Indian Infrastructure

StreetMapper is being deployed to Laser Map city centres and transportation networks across India. The system has been purchased by Geokno, a technology company in India specialising in GIS. The specially customised StreetMapper was selected for its proven accuracy, reliability and quality of support and service from developer 3D Laser Mapping.

u-blox introduces GNSS antenna module

ublox has introduced the CAM-M8Q GPS/GLONASS/BeiDou/QZSS antenna module. The module integrates a u-blox M8 satellite receiver IC plus SAW filter, LNA, TCXO, RTC, passives and a pre-tuned GNSS chip antenna in an ultra-small 9.6 x 14.0 x 1.95 mm package. The new module requires only a power source for reliable and accurate satellite positioning anywhere in the world. *www.u-blox.com*

Jupiter SL871 by Telit

The Jupiter SL871 is the ideal solution for battery-life sensitive GNSS applications that do not require Dead Reckoning, TRAIM and support of communication ports like USB or CAN bus. The recently introduced companion SL869 V2 module provides these sophisticated features. The SL871 can track GPS + Galileo and GLONASS (or GPS + Galileo and Compass\ Beidou depending on the SW onboard) constellations, while simultaneously providing the positioning data through standard UART. *www.satnews.com*

Northrop Grumman Awarded U.S. Military Contract for Navigation Systems

Northrop Grumman Corporation has been awarded a contract from the U.S. Air Force for purchase and sustainment of its embedded global positioning/ inertial navigation systems (EGI).

Under an indefinite-delivery, indefinite-quantity (IDIQ) contract with a potential value of up to $200 million, Northrop Grumman's suite of fiber-optic gyro-based navigation systems are available for the U.S. Air Force, Army, Coast Guard, Marine Corps and Navy as well as international customers. Northrop Grumman will also provide platform integration, modernization, flight test and technical support, training, depot repair and spares for its EGI. *www.northropgrumman.com*

Summit Evolution Software now processes CartoSat-1 Satellite Imagery

Designed for geo engineering (mapping) applications calling for high resolution panchromatic imagery with high pointing accuracies in India, the CartoSat1 Satellite (IRS P5) was built by the Indian Space Research Organization (ISRO) and produces panchromatic stereoscopic imagery. ISRO recently released the CartoSat sensor models and the rational polynomial coefficients necessary to geolocate the imagery. By combining these parameters with measured ground control points, Summit Evolution by DAT/EM Systems can efficiently orient CartoSat imagery and enable the imagery for stereo viewing, 3D feature collection, and terrain processing. *www.datem.com*

DigitalGlobe acquires Spatial Energy

DigitalGlobe, Inc. has acquired Spatial Energy, a leading source for digital imagery and related services to the energy industry. Spatial Energy helps energy companies reduce the cost, time and effort associated with acquiring and analyzing complex geospatial information. *www.digitalgloble.com*

Garmin recognizes a GPS milestone in aviation

Garmin International Inc has commemorates the twentieth anniversary of the Garmin GPS 155 receiving FAA Technical Standard Order (TSO) authorization, the industry's first FAA TSO-C129 approach approved IFR GPS receiver. The GPS 155 TSO received FAA TSO approval on February 16, 1994, which set the bar for future technological GPS advancements in aviation. The GPS 155 TSO was the world's first GPS navigation product to be fully certified to FAA TSO-C129, Class A1 standards for non-precision approach use. For the first time, pilots could fly in instrument meteorological conditions (IMC) throughout the departure, enroute, and approach phases of flight using GPS as their primary navigation source. *www.garmin.com*

Hexagon News

Aibotix acquired

The Hexagon Group from Sweden acquires the Kassel manufacturer of flying robots as of now. Hexagon Technologies measures with precision and quickness large amounts of complex data that are visualized via engineering and geospatial software. The products of Aibotix are ideal for delivering highly accurate geo-information, which is an excellent complement to the Hexagon products. *www.aibotix.com*

Chiroptera II

Leica Geosystems and Airborne Hydrography AB announced the availability of CHIROPTERA II LiDAR solution for topographic mapping and shallow water surveying in depths of up to 15 metres. The system simultaneously captures the full waveform in both the 35 kHz bathymetric channel and the 500 kHz topographic channel to provide high-detail maps for environmental and coastal monitoring, infrastructure planning, and other near-shore applications. It incorporates *www.leica-geosystems.com*

Satellite navigation, positioning system acquisition

Hexagon AB said its cash offer for shares of Veripos Inc., a manufacturer of satellite navigation and positioning systems for offshore oil companies, has now earned it a 95.8 percent stake. As part of the planned acquisition, Hexagon announced a deal Topcon, Japan to be a reseller of the satellite broadcast correction signal offered by Veripos subsidiary TerraStar GNSS Ltd. The deal also calls for Hexagon and Topcon to create a joint venture to grow the TerraStar business.

MARK YOUR CALENDAR

April 2014

ENC-GNSS 2014
14 – 17 April
Rotterdam, The Netherlands
www.enc-gnss2014.com

SPAR International
14-17 April
Colorado Springs, CO, USA
http://www.sparpointgroup.com/international/

Interexpo GEO-Siberia 2014
16 - 18 April
Novosibirsk, Russia
http://expo-geo.ru/event/27_Interexpo-GEO-Siberia-2013

IGRSM 2014
21 - 22 April
Kuala Lumpur, Malaysia
http://www.igrsm.com/igrsm2014/

2014 International Satellite Navigation Forum
23 – 24 April
Moscow, Russia
http://eng.glonass-forum.ru

Intergeo Eurasia
28-29 April
Istanbul, Turkey
http://www.intergeo-eurasia.net/index.html

9th National GIS Symposium in Saudi Arabia
28 - 30 April
Dammam, Saudi Arabia
http://www.saudigis.org/default.aspx

May 2014

IEEE/ION Position Location and Navigation Symposium
5 – 8 May
Monterey, CA
www.ion.org

Esri Africa User Conference
6 – 8, May
Cape Town, South Africa
www.esri.com/events/auc

Annual Baska GNSS Conference
7 – 9 May
Baska, Krk Island, Croatia
renato.filjar@rin.org.uk

MundoGEO Connect 2014
7 – 9 May
Sao Paulo, Brazil
http://mundogeoconnect.com/2014/en/

GNSS: Principles, Augmentations and Evolutions of EGNOS
12-23 May
Toulouse, France
sandrine.castiglioni@enac.fr

The 5th China Satellite Navigation Conference
21-23 May
Nanjing, China
http://www.beidou.org/english/index.asp

GEO Business
28 – 29 May
London, UK
www.geobusinessshow.com

June 2014

Hexagon Conference 2014
2 – 5 June
Las Vegas USA
http://hxgnlive.com/

5th International Conference on Cartography and GIS
15 – 21 June 2014
Riviera, Bulgari
http://iccgis2014.cartography-gis.com/Home.html

ION Joint Navigation Conference 2014
16 – 19 June
Orlando, United States
www.ion.org/jnc

INSPIRE Conference
16-20 June 2014
Aalborg, Denmark
http://inspire.jrc.ec.europa.eu/events/conferences/inspire_2014/

XXV FIG Congress
16 – 21 June
Kuala Lumpur, Malaysia
www.fig.net

International Congress on Remote Sensing and GIS
25-27 June 2014
Casablanca, Morocco
http://siggtcasablanca.univcasa.ma/

July 2014

GI Forum 2014
1 – 4 July 2014
Salzburg, Austria
www.gi-forum.org

Esri International User Conference
14 – 18 July 2014
San Diego, USA
www.esri.com

October 2014

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

November 2014

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

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