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Volume XI, Issue 03, March 2015

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

Identifying NAVIGATION current challenges

"The multisensory approach is likely to be the future"

"Divide between Vulnerability and Autonomy"

"GPS is Too Good"

"Today's challenge is to develop a Robust PNT package"

"As requirements and performance standards are constantly on the rise, navigation faces new challenges"

"Current challenges in navigation are increasingly driven by applications"

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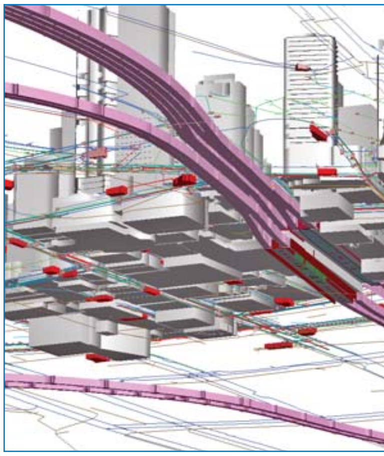

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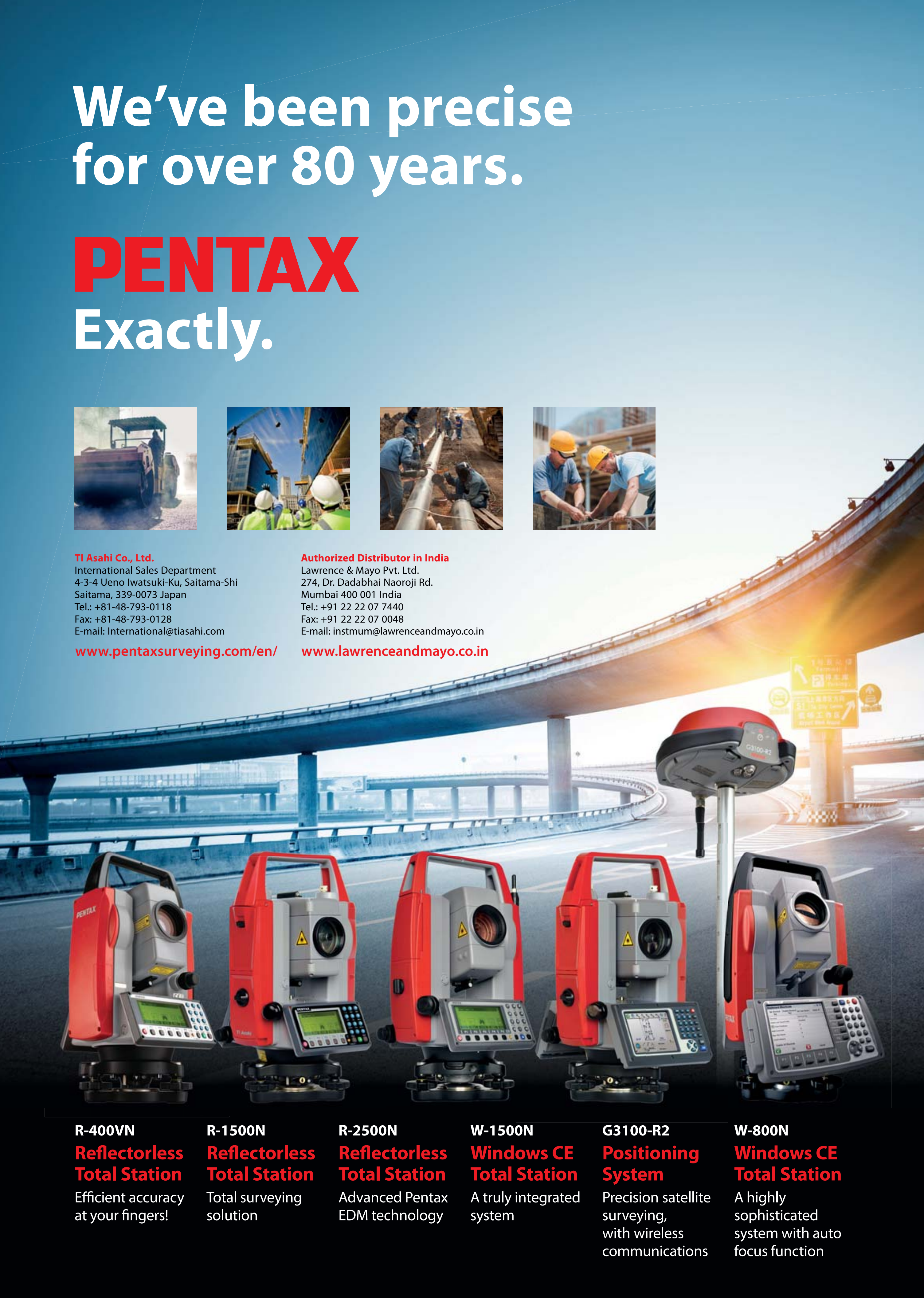
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towards the mother earth,

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of her resources

Bal Krishna, Editor
bal@mycoordinates.org

Navigation – Current Challenges

Experts across the globe discussed current challenges before navigation at International Navigation Conference held at Manchester, UK during February 24 - 26, 2015. We present here some of the views

Divide between Vulnerability and Autonomy

Professor David Last
Consultant Engineer and Expert Witness specialising in Radio Navigation and Communications Systems. Professor Emeritus at the University of Bangor, Wales and Past-President of the Royal Institute of Navigation

The International Navigation Conference 2015 marked the return of the Royal Institute of Navigation to the business of organising major navigation meetings. For some years they have waited on the sidelines as too many conferences competed for a declining number of delegates. This gathering, despite its being scheduled for Manchester in February, attracted 200 attendees. It was small enough to be collegiate and informal while large enough to pull in the great speakers: just imagine, Dana Goward and Todd Humphreys on one bill! RIN conferences have always been informal, welcoming of debate, very open to differences of opinion. And in Manchester those differences were so great, and the shifts of attitude so substantial, that I suspect we will look back on INC2015 as a moment of change.

RIN conferences are different, too, in being about navigation, not just satellite technology. Here we had papers on marine developments including the ACCSEAS studies of eNavigation (Alwyn Williams), decision support systems (Zbigniew Pietrzykowsk) and even flashing lights (Malcolm Nicholson). There was Quantum Technology (Leon Lobo) and a raft of indoor systems. The breadth was outstanding.

The conference opened in the traditional manner of navigation conferences in Europe. A US speaker (Ray Clore) gave an update on the status of GPS and a Brussels chap (Gian Gherado Calini) countered with Galileo. They spoke of separate competing systems, each vertically-integrated - with satellites, receivers, applications and users - overseen by an administration. GPS markets and Galileo markets were assessed. Underlying the subsequent discussions were concerns about the threat of Galileo's being mandated in Europe and the recent "bombshell": that the reception of "foreign" GNSS in the US might be illegal, inappropriate for public services, and even un-American!

The "Vulnerablists" declared that GNSS is fallible and dependent on weak signals, easily disrupted by noise and interference, some natural, some accidental and some - jamming and spoofing - malicious

RIN Past-President Colin Beatty then gave a contrary world-view. Galileo will soon be merely 30 satellites among maybe 150. Receiver chips already accommodate all these systems plus multiple augmentations; the receiver designers are well ahead of the satellite launchers. Receivers now use these many signals to deliver the best possible PNT. And their users neither know nor care about GPS or Galileo any more; they don't even realise their iPhones are using GLONASS. Mandating systems will mean denying users the benefits of multiple GNSS! Which world-view will prevail?

Then another division opened up: between Vulnerability and Autonomy. The "Vulnerablists" declared that GNSS is fallible and dependent on weak signals, easily disrupted by noise and interference, some natural, some accidental and some - jamming and spoofing - malicious. You should not rely on GNSS but back it up with a different but complementary system. The clear leader here was eLoran which the UK General Lighthouse Authorities now had up and running, serving mariners (Gerard Offermans) and precise timing users (Charles Curry).

The "Autonomists" explored the contrary view. All is well. The combination of GNSS with mode-specific sensors and advanced computer systems is now sufficient to support autonomous cars (Neda Navidi), autonomous ships (Andy Higgins) and even pilotless passenger aircraft (Lambert Dopping-Hepenstal). Given the conflict between these two world-views, it was probably wise of the RIN to schedule them into parallel sessions, so physically separating the protagonists!

Two yawning divides: the first between those who believe in rival satellite systems, centrally organised, and those for whom systems are now just components of GNSS with the receiver makers determining the mix. The second divide, between the Vulnerablists and the Autonomists, is turning into a sort of Global Warming of the navigation world, with proponents and deniers locking horns! I predict that after Manchester these two conflicts will dominate navigation conferences for quite some time.

Today's challenge is to develop a Robust PNT package

Colin Beatty
Fellow and Immediate Past President, of the Royal Institute of Navigation, Managing Director of CBi Ltd

For has long as mankind has roamed the earth there have been those among them who became specialists in the art of knowing where they were and how they were going to get to their destination. Various devices were developed to help them in their journeys including the magnetic compass and methods of measuring the angles of heavenly bodies above the horizon. The greatest challenge was the determination of accurate time to allow Longitude to be deduced. It was Harrison who solved the problem of building a clock that could withstand the rigors of ships' motion. Navigation on long ocean voyages out of sight of land, became much more reliable.

In the early 20th Century, Elmer Sperry and Sydney Brown each developed gyroscopic compasses that provided much more reliable and accurate determination of North direction. Radio Direction finders were used at sea and in the air to provide bearings to radio transmitters whose positions were known. During World War II radio hyperbolic and ranging systems were developed for ships and aircraft. It was really after WWII that electronic radio navigation became available to the civilian navigator. Loran , Decca Navigator and Omega were the navigation systems of the 50's, 60's and early 1970's.

As demands for accuracy increased various local area navigation systems were developed.

A key breakthrough came with the introduction of the US Navy Navigation Satellite System, TRANSIT. This provided between 35 and 150metres accuracy with fixes occurring every 1-4 hours depending on the user's latitude.

Development of yet another satellite-based system, the Global Positioning Sytem (GPS), started in the 1960's with the first satellites being launched towards the end of the 1970's.

Even before GPS became fully operational, there was an unseemly rush to shut down the old radio navigation systems. We were told that GPS would solve all of our positioning and navigational problems. The accuracy obtainable with GPS was amazing to the point where the US Military applied a Denial of Accuracy (Selective Availability - SA) to the civilian code. It took but a couple of weeks before the effects of SA were largely circumvented by the development of Differential GPS. Thus, the civil community could now navigate at the 5-10 metre level of accuracy.

Up until the arrival of the in-car satellite navigation systems (satnav) and Smart phones, navigation had, very largely, been the preserve of specialist navigators. These were the people able to use sextants and radio-navigation systems to determine their location. It was necessary to study and to take examinations for to get your navigators "ticket".

For a number of years it really looked as if GPS and similar systems, the Russian GLONASS, the European Galileo and the Chinese Bidou would be all that was needed for reliable navigation. Unfortunately, due to the nature of these satellite-based systems, their signals, as received on Earth, are very weak. This makes all of the satellite-based navigation systems vulnerable to both accidental and purposeful jamming. It is possible to purchase, off the Internet, low cost jamming devices that effectively swamp the radio signal coming from the satellites. Just a few Dollars is all that it takes. In the past couple of years, the vulnerability of Global Navigation Satellite Systems (GNSS) has come to the forefront.

At the recent Royal Institute of Navigation's International Navigation Conference, held in Manchester, UK, a number of the presentations addressed the issues of the vulnerability of GNSS. Papers were presented that highlighted the need for much more robust GNSS to cover the three areas for which GNSS is now used, Position – Navigation and Time PNT. Several eminent specialists, among whom is Professor Brad Parkinson, have called for the adoption of RPNT - Robust Position, Navigation and Timing.

RPNT requires a number of areas of research and development to refine the design of GNSS receivers. Certain of these solutions integrate other navigation sensors to aid the GNSS and thus help tackle the effects of jamming. Devices such as Inertial Measurement Units (IMU) and other radio-navigation systems, such as eLORAN, have been suggested. eLORAN is an enhanced version of the old LORAN system that served a number of local areas, around the world, for many years. Only within the last year has the USA been decommissioning their old LORAN stations, a move that has recently been halted. eLORAN, being a terrestrially based system has a much higher power level making jamming somewhat more difficult. Whereas the GNSS signals have frequencies in the 1.5 – 1.6 GHz bands, eLORAN is down at 100KHz, a totally different area of the radio-frequency spectrum.

Today's challenge is to develop an RPNT package that will be resilient under the threat of jamming. Also to be considered is the requirement to make these new navigation systems able to resist spoofing. With fairly sophisticated equipment, it is possible to spoof a GNSS receiver to put it into an erroneous position, in error by many miles. This is particularly serious when GNSS is used to determine the altitude of aircraft in its final approach to an airfield. Multi constellation receivers make such spoofing more difficult – but not impossible. There is much work to be done.

The multisensory approach is likely to be the future of the navigation systems

Dorota A Grejner-Brzezinska
Professor and Chair, Department of Civil, Environmental and Geodetic Engineering, The Ohio State University

The demand for accurate, reliable and resilient navigation and positioning information, not only in the traditional open-sky environments, but predominantly in confined and transition environments, where the availability of GNSS signals is compromised, has been the primary innovation driver in the positioning, navigation and timing (PNT) industry in recent years. The designers and manufacturers of the navigation equipment as well as the policy makers face formidable challenges, as they must accommodate many, at times seemingly contradicting objectives. A fundamental challenge that GNSS, a backbone of the majority of the contemporary navigation systems, is facing, is the fiscal challenge: how much governments are willing to spend on GNSS, and will the budgetary support be assured, continuous and sufficient? Directly connected is the challenge to internationally manage GNSS in a transparent, coordinated, comprehensive and equitable way. While the cooperation established via the International Committee on GNSS is an excellent start towards addressing this challenge, more needs to be done by the governments and professional organizations to assure sustainability of the constellation and protection of the GNSS spectrum against interference, jamming and cyber attacks. To assure that GNSS and related industries continue investing in the location and navigation markets, GNSS legislators, regulatory agencies and professional communities, as well as the industry must work together to address these challenges. A closely connected challenge is the lack of a GNSS back-up system, a topic of an ongoing debate among professional organizations, the governments and the users.

Consumer demand is driving a surge of innovation, and since GNSS cannot fully cover all of the users' demands, the last decade or so has witnessed substantial intellectual and monetary investments in multisensor integrated navigation systems. As obvious as the mutisensor approach might appear, it introduces a number of new challenges, focused primarily on how to integrate different technologies in the cost effective manner, without compromising the integrity and design principles of the contributing technologies, and avoiding high complexity of the resulting system. A substantial body of research has been generated in recent years, towards the design and implementation of multisensor navigation systems, where initially the sensors were loosely integrated, and recently, with a more coordinated effort of the contributing manufacturers, the systems are becoming more tightly integrated, offering a clear benefit of better information sharing and improved exploitation of complementarity and redundancy features. The prime example is the evolution of the GNSS/inertial integration from a loosely coupled system, to the ultra-tightly coupled approach, where GNSS receiver is implemented as a software-defined radio, whose tracking loops are aided by the inertial system.

The multisensory approach is likely to be the future of the navigation systems, with more sensors, increasingly unconventional (i.e., not designed for navigation, such as imaging systems), coalescing into a multifaceted system. Different types and varying numbers of sensors integrated together contribute to the complexity of the system, and, consequently, the current challenge becomes the effective system design. The target of this challenge is modularity. In modular designs sub-system functionalities are separated into discrete, scalable and reusable components. The concept of *plug-and-play* is a perfect example of a high-level, flexible modular design, where an obvious benefit is the augmentation achieved by adding a new solution by plugging in a new or updated module. This approach, however, requires the use of not only advanced integration algorithms and well-defined modular interfaces, but also a rigorous use of industry standards for interfaces. In addition to the need to address the modularity, miniaturization and portability, combined with the requirement for high accuracy and low cost, and the adaptability to different requirements of various user communities is yet another challenge that the navigation and location industries are presently facing.

New technologies drive new applications and new applications create new challenges. With challenges come opportunities. One example - the Location Based Services (LBS) - the fastest growing sector of PNT applications. Aside from the location privacy challenge that comes with LBS, tremendous opportunities are being generated for many markets, with Asia leading the pack. According to the 2013 GNSS Market Report, the global GNSS market growth in terms of CAGR is expected to reach ~21% over the period 2012-2016, with the LBS only revenues expected to reach over 80 billion Euro by 2020. Autonomous vehicles

> The navigation industry has been a game-changer by driving the innovation and working towards affordable, accurate, resilient and ubiquitous navigation information, and enabling new and emerging applications

The manufacturers of the navigation equipment as well as the policy makers face formidable challenges

are the perfect example of an upcoming application that requires not only reliable and high accuracy navigation information, but must also assure that the vehicles will sense their environment using a suite of active and passive imaging sensors. Once the regulatory policies are in place for safe introduction of these vehicles to our roads and airspace, navigation industry must be ready to deliver suitable multisensory navigation and imaging systems that are not only lightweight but also low-cost and more accurate than most of the currently available portable devices.

The navigation industry has been a game-changer by driving the innovation and working towards affordable, accurate, resilient and ubiquitous navigation information, and enabling new and emerging applications, such as autonomous vehicles, pedestrian and asset tracking, emergency response and rescue operations, fast detection of catastrophic events, LBS, precision farming, just to name a few. PNT is delivered via dedicated and ad hoc infrastructure, such as the GNSS constellation, ground and space augmentation, other RF-based systems, signals of opportunity, imagery, digital elevation models, etc. The primary challenge to delivering ubiquitous PNT is in the areas with no infrastructure, where only the sensors carried by the user or a group of users (collaborative navigation) can be used.

In summary, no single sensor currently available is able to provide the required level of accuracy, continuity, portability and security of PNT in all environments. Thus, integrated systems are the likely future of navigation, with multi-system and multisensor generalizations decreasing vulnerability against system failure and attack.

As requirements and performance standards are constantly on the rise, navigation faces new challenges

Zbigniew Pietrzykowski
Professor, Deputy Dean of Science, Faculty of Navigation, Maritime University of Szczecin, Poland

The perception of navigation has changed over the last decade. The factors responsible for this change are modern technologies, including information and communication technologies (IT, ICT), and new areas of application. Navigational systems and equipment have become easily available, and are used by small groups of specialists and innumerable individual users. As requirements and performance standards are constantly on the rise, navigation faces new challenges.

The primary function of navigation is positioning and indicating the direction from one specific point to another. Although from the viewpoint of services offered, navigation performs mainly information functions, decision support is another function of gradually extended scope. Both functions are also applicable to autonomous, unmanned vehicles.

The starting point for defining challenges for navigation are basic tasks concerning resilient PNT – Positioning, Navigation and Timing. These tasks are determined by technological capabilities as well as needs resulting from human activities. In reality we seek new applications for state-of the-art technologies on the one hand, and attempt to develop new technologies to satisfy users' demands on the other.

Technologies

It seems that at present IT, ICT and nanotechnologies are of key importance. IT and ICT spur the development of GNSS and other alternative positioning systems, and contribute to the enhancement of information systems (gathering, processing, retrieval and presentation of navigational information) as well as decision support systems. Micro- and nanotechnologies increasingly miniaturize sensors, navigational equipment and entire systems.

Areas of use

Navigational systems are used in various sectors of economy, including transport (marine, air, car, pedestrian), industry, commerce. More and more attention is paid to pedestrian navigation (sport and tourism), indoor, offshore and underwater (exploitation of the sea and ocean resources) as well as space navigation (space transport, space tourism). Most of the above cases involve access to information and decision support, including autonomous systems for unmanned vehicles, some of which have important military applications.

Requirements

Regarding information, requirements mainly comprise accuracy, validity and credibility. Requirements for real time systems and devices include safety, availability, reliability and security. On this basis, we can attempt to define current challenges for navigation in terms of Positioning, Navigation and Timing.

Positioning

The relevant challenges are aimed to assure high accuracy, validity and credibility of information to raise system availability, reliability and security. These goals entail the use of various navigational systems and devices to provide for system diversity and redundancy. For the former, we have to provide the same functionality in different ways, e.g. apart from the primary positioning system, alternatives should be used. The latter, i.e. system redundancy, requires a critical component to be doubled so that if one component fails, a backup is available.

In both cases the amount of information increases and necessitates data integration and fusion. As the number of sensors is growing, so is the need for data fusion solutions, which allow the system to present more accurate and reliable data on vehicle position and movement parameters. Improvement of the existing and seeking new positioning methods are essential in areas where the known systems prove to perform poorly, e.g. indoor or underwater navigation. One interesting research direction is the study of human and animal abilities to navigate as well as research on cognitive skills (cognitive science).

Threats of external attacks (jamming, spoofing) call for developing methods and tools assuring the availability and/or accuracy of positioning data.

Navigation

Growing amount of information available in navigational systems on the one hand permit the operator to fully assess the situation, on the other hand information excess may cause human errors in situation analysis and assessment. That is why information systems evolve towards decision support systems. These, in addition to information functions, are capable of analyzing and assessing a current situation and working out a recommended solution. Knowledge engineering, including artificial intelligence methods and tools are used to equip the system with characteristics normally attributed to humans, such as adaptation, learning, autonomy and complexity. The implementation of decision support systems can significantly reduce the number of human errors, which translates into the reduction of accidents at sea and their adverse consequences. Due to their functions, decision support systems are an essential, often necessary component of autonomous systems for unmanned vehicles: aircraft, sea-going vessels or cars.

Timing

Challenges concerning timing are aimed to improve the precision of atomic clocks, enabling more accurate time and frequency synchronization over large distances.

This review of challenges is not complete. It will vary in types and scope depending on further technological advancements, widening range of applications and evolution of user needs.

Current challenges in navigation are increasingly driven by applications and are less technologically determined

Dr Guenter Heinrichs
Head of Customer Applications Business Development, IFEN GmbH, Germany

With respect to the navigation market, today we are living in exciting and challenging times. The key drivers for the current navigation market and in future, in our opinion, are still twofold. They are application based on one hand and technology driven on the other. It appears, however, that the current challenges in navigation are increasingly driven by applications and are less technologically determined.

From a technology point of view, the navigation market has already changed from the usage of a single satellite navigation system, primarily GPS, towards the usage of multiple satellite navigation systems, called multi-GNSSs (Global Navigation Satellite Systems). Examples are the combined use of GPS and GLONASS that are present in the consumer market (e.g. in smartphones and for car navigation) and the usage of multi-GNSS (e.g. GPS + GLONASS + Galileo + BeiDou + SBAS + QZSS + IRNSS), combined with multi-frequency in the professional and safety-of-live market.

Current challenges in navigation, from a technology point of view, are more driven by the demand of high-sensitivity capability in combination with external sensors on one hand; and high position accuracy in combination with high reliability and integrity on the other. In this context, in future, it is foreseeable that the use of dual-frequency equipment in the consumer market will also be in demand.

Application based means that the number of applications relying on position, velocity and timing (PVT) information will grow permanently in future, as it has already in the past. Many applications are already using this information today, predominantly derived from worldwide available satellite navigation systems. The growing number of applications demanding such PVT information even under challenging environmental conditions, such as in inner cities, in urban canyons or indoors, will in future also affect and most likely change the technical requirements of the user equipment (GNSS receivers or more generally GNSS positioning sensors). Furthermore, this will influence the usage requirements of the global satellite navigation systems.

From our point of view, current challenges in navigation regarding applications are most likely coming from the foreseeable trend, that safety in combination with security will play a greater role in upcoming applications. Examples of such applications are Autonomous Driver Assistance Systems (ADAS) and Unmanned Autonomous Systems (UAS), such as robots or UAVs (Unmanned Autonomous Vehicles). Besides high position accuracy, these applications require reliable and secure operations of the system. Thus, safety and security aspects will be one of the key requirements for such applications. In addition, the wish of seamless indoor-outdoor navigation is still another driver of current challenges in navigation demanded by several applications.

Last but not the least, all these current and future challenges in navigation will also affect the testing requirements for GNSS receivers and positioning sensors, and finally the testing needs for GNSS-based applications. IFEN will be prepared for this current and future challenge in navigation by providing a complete portfolio of leading-edge GNSS test solutions.

"GPS is Too Good"

Dana A. Goward
President, Resilient Navigation and Timing Foundation

"The U.S. military has become increasingly dependent upon the Global Positioning System (GPS) for accurate and precise positioning, navigation, and timing in a wide variety of operational environments. However, as U.S. military operations are increasingly carried out in areas where GPS is denied, unreliable, or not accessible, military use of GPS has evolved from strategic advantage to vulnerability. GPS access can now be readily blocked by jamming or environmental conditions… Current system solutions for providing accurate and precise positioning, navigation and timing in GPS-denied environments are costly, inflexible and often need an external fix that requires intermittent access to GPS…"

– United States Defense Advanced Research Project Agency (DARPA)
(http://www.darpa.mil/Our_Work/STO/Focus_Areas/Positioning_Navigation_and_Timing_%28PNT%29.aspx)

While the DARPA website quoted above was, of course, concerned with military operations, much the same could be said of the civil community as well.

Highly precise and free for use anywhere with a view of the sky, the Global Positioning System (GPS) has been superbly maintained and operated. It has been so reliable and useful that it has made us complacent to the point where navigation-as-we-know-it is no longer possible without GPS. If GPS service were to be disrupted, our current air, maritime, and land transportation systems would be unsustainable. All modes of transportation would slow down and be able to carry less traffic. GPS has become a single point of failure for transportation around the globe.

This isn't because the superb reliability and accuracy of GPS-based electronic navigation systems has resulted in the loss of other navigational skills, although that is indeed true. But even if mariners were to relearn how to use a sextant and drivers were to buy and figure out how to use road maps (both of which are good ideas), these methods of navigation could not sustain the our current system speeds and efficiencies.

Our real complacency isn't shown when someone mindlessly goes off the road because their car's "GPS" tells them "turn right." Rather it is the fact that there are no non-space electronic navigation sources to fall back that are able to sustain current transportation service levels during a GPS disruption. (Many may argue that this is not true in aviation, and the author agrees that aviation would be less impacted because of legacy navigation aids such as VOR, DME and ILS. However, integration of GPS into on-board and ground systems for both navigation and support services means that a GPS service disruption would degrade the aviation system as well.)

The solution to this complacency, to the problem that "GPS is too good," is a sensible agenda to protect, toughen and augment our Global Navigation Satellite Systems (GNSS).

Originally proposed by Dr. Brad Parkinson, the man most responsible for development and deployment of GPS, the "Protect, Toughen and Augment" scheme has been adopted by our non-profit. It incorporates recommendations from Dr. Parkinson, the US Positioning, Navigation and Timing Advisory Board, and best practices from around the navigation community.

These recommendations are given in the box on this page, and are also available at the foundation's website: www.RNTFnd.org.

Protect, Toughen, Augment

Policy Recommendations for Global Navigation Satellite Systems*

Protect GPS/GNSS

- Recognize PNT as critical infrastructure
- Designate and empower a lead federal official
- Protect the adjacent bands to GNSS as "quiet" neighborhoods
- Make ownership of jammers a misdemeanor
- Make use of jammers a felony
- Make anti-jamming and anti-spoofing laws enforceable at all levels of government
- Establish a national system to detect & rapidly locate jamming
- Ensure sufficient enforcement personnel to detect, prevent, respond to and prosecute jamming

Toughen Receivers & Users

- Develop standards for jam-resistant receivers to include ARAIM and RAIM
- Establish as an industry best practice having more than one source of precise Position, Navigation and Timing (PNT) for critical infrastructure
- For critical infrastructure that uses space-based PNT, establish as an industry best practice being able to continue normal operations in the event of an extended GNSS service disruption.

Augment GPS/GNSS Services

- Provide a wide-area, difficult to disrupt, diverse non-space PNT service (GPS-Earth/eLoran)
- Develop standards for seamless use with space-based PNT.
- Encourage development of numerous, complementary terrestrial PNT services to increase resilience (integrated radar, local positioning systems, inertial, etc.)

** Adapted from presentations and positions advocated by Dr. Brad Parkinson and discussed at the US government's Position, Navigation and Timing Advisory Board. The Resilient Navigation and Timing Foundation heartily supports these policies and initiatives.*

A look into the future of positioning, navigation and timing

The world urgently needs an even stronger, more resilient and more versatile PNT infrastructure

Dr Ing Marco Lisi
European Space Agency
ESTEC, Noordwijk,
The Netherlands

The present Position, Navigation and Timing (PNT) world infrastructure is mainly based on the American Global Positioning System (GPS), complemented by other Global Navigation Satellite Systems, such as the Russian GLONASS and the forthcoming European Galileo and Chinese Beidou.

Regional navigation satellite systems, such as The Indian Regional Navigational Satellite System (IRNSS) and the Japanese Quasi-Zenith Satellite System (QZSS), are also important components of the present worldwide scenario.

The multi-constellation has already proved to be a safeguard against massive outages of one constellation. However, present GNSSs and GPS "in primis", are very vulnerable to jamming and spoofing attacks.

These are the reasons why alternative non-GNSS PNT systems and technologies are being developed worldwide.

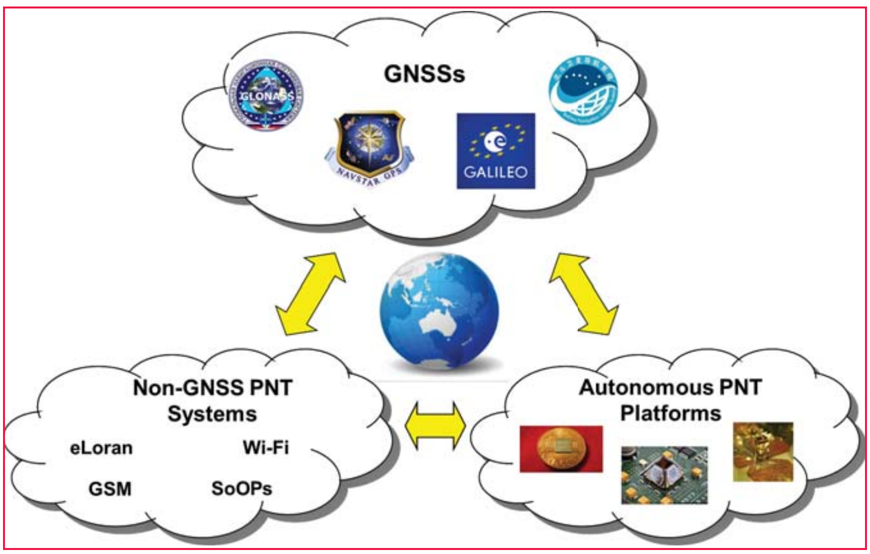

Figure 1: Possible future PNT system of systems scenario

In the not so far future, a PNT system of systems, including GNSS and non-GNSS infrastructures, is likely to take place; while, at user receiver level, a fusion of data from GNSS and other sensors (such as inertial platforms, Wi-Fi, GSM, signals of opportunity, etc.) will become normal practice (figure 1).

Introduction

On April 1, 2014, GLONASS, the Russian GNSS, experienced a system-wide 12-hour blackout, apparently due to the uploading of wrong ephemeris data from the ground segment to the satellites in orbit.

The accident demonstrated that complex systems such as GNSS' need to be supported and operated by dedicated organizations responsible for their operations, use and ultimately, quality of service.

Large and complex systems are otherwise vulnerable: state-of-the-art technologies and well-conceived system architectures can hardly compensate for weaknesses in operational and service provision processes and procedures.

On the other hand, the GLONASS blackout also confirmed that the multi-GNSS approach, presently being adopted in most civilian and mass-market applications, is very resilient against even total failures of one constellation. Presently, there are no mass-market devices, even in Russia, that use exclusively GLONASS, so that no major consequences were suffered from the black-out.

However, each individual GNSS is intrinsically affected by many vulnerabilities and limitations.

Because of the weakness of their radio signals, GNSSs can be easily jammed and spoofed. This problem is becoming terribly serious, also due to the proliferation of commercially available jamming equipment that are relatively inexpensive yet very sophisticated.

Weak radio signals also make GNSSs incapable to work indoors, underground and underwater.

GNSS Multi-Constellation Scenario

At present, the world is experiencing a proliferation of GNSS constellations: two fully fledged and operational constellations (GPS and GLONASS), along with two more (Galileo and Beidou) under development (Beidou is actually already operational over the Asian region). In addition, regional constellations are in highly inclined or geostationary orbits, such as the Japanese QZSS and the Indian IRNSS (figure 2).

The situation in space would seem to be rather crowded and this is no exaggeration.

Then all of a sudden, GLONASS' massive and worldwide system outages in April in 2014 made everybody understand that the world's dependence on GNSS was so high that one could not risk to get anything less than well-functioning navigation satellites in orbit.

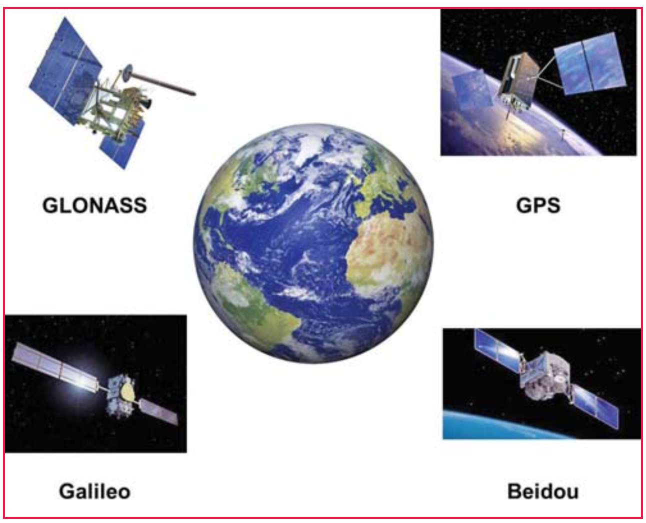

Figure 2: Present GNSS multi-constellation scenario

Then all of a sudden, GLONASS' massive and worldwide system outages in April in 2014 made everybody understands that the world's dependence on GNSS was so high that one could not risk to get anything less than well-functioning navigation satellites in orbit.

Moreover, the world sometimes faces critical political situations that force others to start doubting the repeatedly stated full interoperability and compatibility among all GNSSs.

A closer look at the problems would suggest that the solution should be qualitative rather than quantitative. We need well operated systems supported by effective management organization, with fool-proof processes able to compensate for the inevitable bugs of the technology and guarantee vis-à-vis the users continuity and quality of the service provided.

This service-oriented approach is well presented in the genetic code of the Galileo system.

European Commission, European GNSS Agency (GSA) and European Space Agency are all together spending a substantial effort to set the path towards the forthcoming Galileo service exploitation phase.

A focal role will be played in this perspective by the GSA based in Prague, which in its role of Core Service Provider will have the responsibility to guarantee performance, continuity and availability of the Galileo signals to users, customers and stakeholders in Europe and worldwide.

Today, more than ever before, Galileo, a system conceived from the beginning to be compatible and interoperable with GPS and with a strong focus on civilian services, could play a strategic role in the future GNSSs scenario.

GNSS Limitations, Threats and Vulnerabilities

GPS or, more generally, the GNSS concept, suffers from some well-known intrinsic system limitations. They mainly derive from the poor quality of signal reception. GNSS signals, propagating from the satellites to the user receiver, are weak and cannot penetrate well liquid and solid obstacles, such as sea water, soil, concrete buildings, etc.

Therefore, weak radio signals make GNSSs incapable of working indoors, underground and underwater. On the other hand, a reliable and accurate PNT would be mostly useful just in the above situations.

Indoor navigation would have many important applications both in commercial (eg., assets management) and emergency environments (fires, natural disasters, etc.).

Similarly, subsurface marine navigation (submarines) and underground positioning and surveying (tunnels, mines) would benefit greatly from a suitable PNT infrastructure.

It is also often forgotten that the weak GNSS signals can be swamped by solar flares and storms, as already experienced in the past.

Finally, the recent GLONASS system wide outage confirmed something well known: large and complex systems can fail.

Figure 3: Commercially available GNSS jamming devices

Apart from its limitations, GNSSs are vulnerable systems, at least as far as civilian applications are concerned.

In 2013, 'The Economist' reported in an article titled 'Out of sight', about the daily 10-minute jamming of GPS signals near the London Stock Exchange. Most likely, the problem was unintentionally but still culpably caused by a delivery driver dodging his bosses' attempts to track him.

The main threat to the integrity of GPS and, in general, GNSS signals are posed by a growing number of jamming and spoofing devices that are commercially available and that can be purchased even online (figure 3).

To understand the potential risk derived from jamming, one should realize how tightly linked are our society critical infrastructures to GNSS (mainly GPS). As a matter of examples, cell phones towers and electrical grid systems use GNSS signals for time synchronization: jamming can throw them off and cause outages. Not to mention the potentially disastrous effects of GNSS jamming onto air traffic management inflight and at airports (although, airplanes still rely on non-GNSS, autonomous navigation systems).

Intentional jamming is also possible. North Korea for instance, has already experimented with this technology, reportedly blocking GPS signals in South Korea on several occasions.

North Korea used big lorry-mounted jammers to block GPS signals in South Korea up to 100 km away. Starting with a four-day burst in August 2010, the attacks which come from three positions inside North Korea, have lengthened. In early 2012, they ran for 16 days causing 1,016 aircraft and 254 ships to report disruption.

Spoofing is a more subtle and slightly more difficult way to harm and attack the GNSS infrastructure.

The threat is based on the possibility to generate, through relatively inexpensive and technologically simple equipment, fake replicas of GNSS signals. In this way, it is possible to provide to the attacked user or infrastructure, inaccurate information about both location and time.

The reality of this type of threat was glamorously proven last year by a team of researchers from the University of Texas. They boarded a 65-meter, $80 million luxury yacht named 'White Rose of the Drachs', sailing from Monaco to the island of Rhodes in the Mediterranean (figure 4).

While in international waters some 50 km off the coast of Italy, the team, using just a laptop, an antenna and a 'spoofing' device (a total investment of about USD 3,000), managed to overpower the authentic GPS signals with fake ones and gain control over the yacht's navigation system, deviating its course from the original one.

The same approach could be used to hijack commercial airliners, although these are still somehow less dependent on GNSS navigation.

The general feeling is that in order to circumvent the present limitations and vulnerabilities of GNSS, alternative and/or complementary PNT approaches have to be adopted. The ultimate goal is that of a truly resilient PNT infrastructure,

Figure 4: The yacht "White Rose", target of a simulated spoofing attack

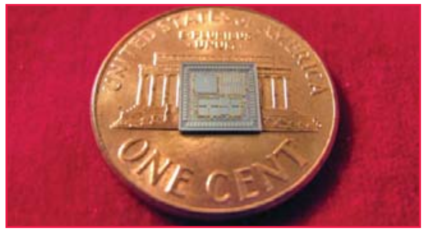

Figure 5: DARPA and University of Michigan Timing and Inertial Measurement Unit (TIMU)

based not on a single system or family of systems, but on complementary and dissimilar systems. As Dana Goward of the Resilient Navigation and Timing Foundation stated at this year's European Navigation Conference (ENC 2014) in Rotterdam, "GNSS vulnerability is a massive mudslide waiting to happen."

Non-GNSS PNT Alternatives

The US Defense Advanced Research Projects Agency (DARPA) launched the 'All Source Positioning and Navigation (ASPN)' program, aiming at the development of a multi-sensor fusion system that is able to offer low cost navigation on any operational platform and in any environment, with or without GPS.

The concept is based on a swift integration of various possible sensors with a sort of 'plug-and-play' open architecture approach.

Besides a multi-GNSS receiver, the core of the system will be an Inertial Measurement Unit (IMU) associated with an atomic clock, allowing the so-called 'dead-reckoning' navigation. Other sensors could also be integrated such as electronic compasses, 3D imagers, LiDAR, laser rangers, radio

> Personal Digital Assistant (PDA) devices such as smartphones, will further develop their location capabilities based on Wi-Fi, GMS and other 'signals of opportunity' through the so-called Wireless Local Positioning Systems (WLPSs).

receivers (to take advantage of the so-called signals of opportunity, SoOPs) and even stellar sensors.

An affordable, low-cost and low-mass realization of the multi-sensor platform is made possible by advanced microelectronic technologies together with powerful processing algorithms.

The present state-of-the-art is a single chip Timing and Inertial Measurement Unit (TIMU), containing a six axis IMU (three gyroscopes and three accelerometers) and integrating a highly accurate master clock into a single miniature system, smaller than the size of a penny (figure 5).

Chip scale atomic clocks (CSACs) are also available and will be soon integrated in future generation TIMU's (figure 6). They can already achieve stabilities in the order of 1 microsecond per day with associated power consumptions compatible with battery operation.

It is very likely that in the future, both for civilian and military applications, a single chip with powerful data fusion capabilities will integrate a multi-GNSS receiver and a TIMU.

Moreover, Personal Digital Assistant (PDA) devices such as smartphones, will further develop their location capabilities based on Wi-Fi, GMS and other 'signals of opportunity' through the so-called Wireless Local Positioning Systems (WLPSs).

Unlike GPS or other global navigation satellite systems, local positioning systems do not provide global coverage. They use RF beacons with a limited range, including cellular base stations, Wi-Fi access points and radio or TV broadcast towers.

Among the non-GNSS PNT systems, a raising attention is gained by eLoran (Enhanced Loran).

eLoran is an internationally-standardized positioning, navigation, and timing (PNT) system concept which can be considered the last and modernized version in the long-standing and proven

Figure 6: Symmetricom CSAC (left); NIST CSAC (right)

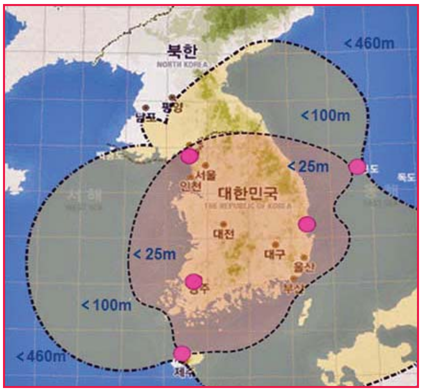

Figure 7: Projected accuracy and coverage of Korea's eLoran network.

series of low-frequency, LOng-RAnge Navigation (LORAN) systems.

eLoran meets the accuracy, availability, integrity, and continuity performance requirements for aviation non-precision instrument approaches, maritime harbor entrance and approach maneuvers, land-mobile vehicle navigation, and location-based services. It is also a precise source of time and frequency for applications such as telecommunications.

The increasing interest in this PNT system, however, does not derive from its performance, although comparable in terms of accuracy, availability, continuity and integrity with that of GNSS.

The attractiveness of eLoran relies mostly on being independent, dissimilar and yet complementary to the existing Global Navigation Satellite Systems presently in use.

After the already mentioned North Korean GPS jamming attacks, exploiting the vulnerability of the very low-powered GPS signals, South Korea announced in 2013 a nationwide eLoran navigation project under which the entire country will be covered by the new system in 2016, with 20-meter position accuracy (figure 7).

A PNT System of Systems

A likely future scenario starts appearing: that of an integrated PNT world infrastructure, a system of systems including present and future GNSSs (with all the associated local and wide area augmentation networks, such as EGNOS), non-GNSS systems (e.g., eLoran, WLPSs) and autonomous navigation platforms at user level.

Data deriving from different systems and platforms will be seamlessly 'fused' at user receiver level, guaranteeing a high degree of availability and continuity.

The integrity of time and position data will be more easily assessed by the user himself, comparing different sources and spotting discrepancies.

Jamming and spoofing will be more difficult to exercise and more easily detected as the user will no longer rely on a single source of information.

The above scenario is a natural evolution of the multi-constellation GNSS approach that has already demonstrated its effectiveness during the GLONASS outages, as well as in harsh environments (e.g., urban canyons).

However, in order for this vision to materialize, three conditions need to be verified;

a. To proceed along the path of compatibility and interoperability among GNSSs to the maximum possible extent;
b. To assure that each GNSS be supported by very effective, service-centered organizations monitoring their performance through a severe KPIs process and aiming at continuously improving it;
c. To further develop technologies and platforms allowing a seamless data fusion of PNT information at user level.

Conclusion

Whether we like it or not, our society has become essentially dependent on the world Positioning, Navigation and Timing infrastructure today, mainly based on GNSSs and more specifically on GPS.

The advent of GNSS has made possible numerous advances in all area of our manufacturing and service economies and many critical infrastructures of our society would literally collapse in case of a total, worldwide GNSS failure.

The world urgently needs an even stronger, more resilient and more versatile PNT infrastructure.

The answer to this need should come from a consolidation of the GNSS system of systems, pursuing the objectives of compatibility and interoperability among the systems.

In this respect, the European GNSS Galileo could play a vital role, being the most compatible and interoperable with GPS and because of its strong service orientation.

In parallel, the development of non-GNSS solutions and of autonomous platforms and technologies will go in the direction of a worldwide, totally integrated PNT system of systems that are able to resolve to a large extent all present limitations and vulnerabilities.

All views expressed in this article are those of the author and do not necessarily represent the views of, and should not be attributed to, the European Space Agency.

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The impact of the high ionospheric activity in the EGNOS performance

This article provides a summary of the different analyses performed by ESSP relative to the existing correlation between the EGNOS performance measured over the north region of the EGNOS service area, some ionospheric indicators and some solar events.

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From the beginning of 2008, we have been facing a period of high solar activity linked to solar cycle #24. Taking into account a typical duration of eleven years, solar cycle 24 would have just reached halfway point. Figure 1 shows the evolution and prediction of different parameters used to measure the solar activity, number of sunspots (SSN) and the planetary geomagnetic indicator (Ap) that reflects the existence of a high geomagnetic activity in the ionosphere. From Figure 1, it can be deduced the smoothed monthly value of the number of sunspots reached a first maximum in February 2012. A second relative maximum, higher than the first one, was attained in August 2013. The increase in solar activity affects the geomagnetic behavior of the ionosphere.

As it can be seen in Figure 1, the evolution of the Ap index, which provides an indication of the geomagnetic activity as measured by different magnetometers over Earth, does not present a link with the solar cycle as evident for other parameters. This is because a slight increase of the number is observed when a period of geomagnetic storms arrives.

The dependence of EGNOS performance with the variations observed in the ionospheric behavior is known (Billot et al., 2013), and has been relevant since the beginning of the solar activity increase linked to the current solar cycle. Such events affect not only EGNOS, but also other SBAS systems under geomagnetic storm conditions. This is considered as an intrinsic limitation in single frequency SBAS systems. The reason for this is that SBAS systems estimate ionospheric delays assuming a bi-dimensional behaviour of the ionosphere (no height). This is true in a nominal situation, but is not accurate in case of high geomagnetic activity or ionospheric storms, when the ionosphere behaves as a 3-dimensional body whose properties change with height.

In the past, some areas of Europe were more sensitive to the variations in the behaviour of the ionosphere. An improved level of stability has been

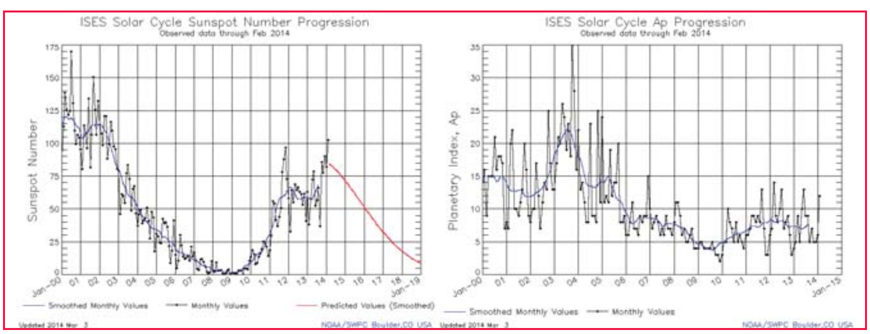

Figure 1: SSN (left) and Ap (right) progression from NOAA/SWPC

currently achieved after the deployment of the EGNOS2.3.1i in August 2012. A new EGNOS release (2.3.2), deployed in October 2013, has increased the robustness of EGNOS against this kind of events, correcting some issues which were observed during autumn of 2012. However, even if this new release provides a high stability to ionospheric disturbances, some degradation can still be expected during periods with very high geomagnetic activity. Dual-frequency is expected to solve this issue, although scintillation may still be a concern in equatorial areas (Walter, 2012). Another important aspect, of the iono related SBAS performance degradations, is that they are highly location-dependent and the service status may vary for neighboring locations (FAA, 2013).

Several indicators can be used to measure the status of the ionosphere such as the K and A indexes or the SSN. The dependence of EGNOS performance with the indicators is known (Suard et al., 2013), and has been relevant since the increase of the solar activity in 2011. Other indicators, such as the disturbance storm time (Dst), are currently being investigated as an alternative mean to detect ionospheric events. The preliminary analyses of this indicator have demonstrated the presence of a high degree of reliability to detect ionospheric-related events affecting SBAS systems.

Impact of ionospheric events in EGNOS performance

The evolution of the observed EGNOS performance since the beginning of this solar cycle has demonstrated that a close link exists between some of these parameters and the behavior of the ionospheric corrections provided by the system. This link is particularly clear in the case of performance degradations observed in the North of Europe, during periods with very high geomagnetic activity. In fact, this issue and its impact on the performance are well known since the beginning of the solar cycle for EGNOS and other SBAS systems.

The month of February in the year 2014 represents a very clear case of a period with a high number of ionospheric events impacting the performance of EGNOS and other SBAS. As an example, Figure 2 presents the daily LPV performance achieved by EGNOS and WAAS during two particular degraded days, February 19th and 27th. Note that EGNOS LPV availability is measured as the percentage of time the Horizontal Protection Level (HPL) and VPL (Vertical Protection Level) are below the Horizontal Alarm Limit (HAL) and Vertical Alarm Limit (VAL). HAL is 40 m and VAL is 50 m for LPV. The International Civil Aviation Organization (ICAO) requirement specifies that availability must be over 99%.

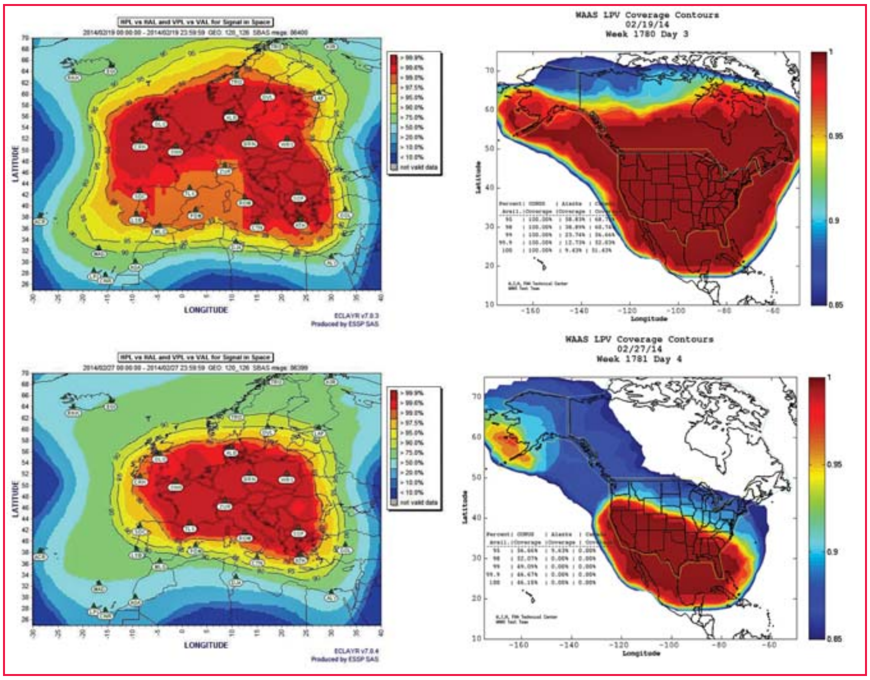

Figure 2: EGNOS (left) and WAAS (right) LPV performance results on 19th (top) and 27th February 2014 (bottom) from ESSP and FAA websites

As it can be observed, several regions in the North of Europe (EGNOS) and Canada (WAAS) were affected on February 19th. The case that occurred on February 27th is significant. During this day, the LPV coverage area obtained with both SBAS systems represents a small portion of the corresponding service areas (ECAC and CONUS respectively). Note that the observed impact during those days is relevant because ionospheric events cannot be notified to users (Pintor et al., 2013) in advance. Even if the possibility of predicting such a kind of phenomenon using space weather forecasts is still under investigation, the high impact for SBAS users show the clear need of understanding the mechanisms involved in this process.

The following section provides some information about the use of some public indicators to measure the ionospheric activity.

Ionospheric indicators to monitor EGNOS performance degradations

In this section, several geomagnetic indexes are presented and their correlation to EGNOS performance. Indexes used for monitoring the behavior of the ionosphere are:

- **K/Kp index:** The K index provides a representation of disturbances in the horizontal component of magnetic field, as observed on a magnetometer during a 3-hour interval. It is represented by an integer scale in the range 0-9: a value of 0 indicates absence of any disturbance. A value of 5 or above indicates geomagnetic storm. The planetary Kp index is obtained by averaging the K-indices from a set of geomagnetic stations.
- **A/Ap index:** The A index represents a daily average value of the geomagnetic

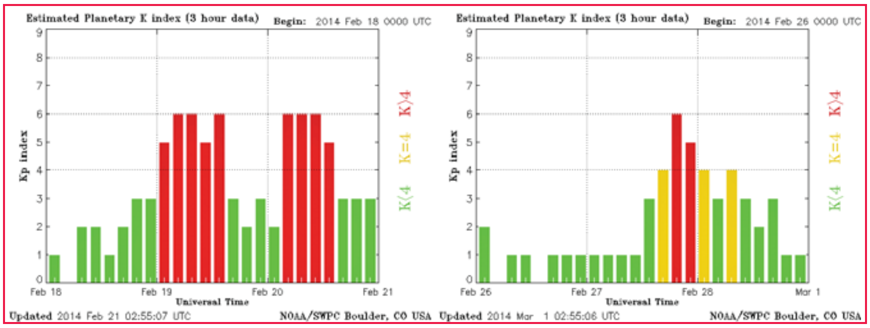

Figure 4: 3-hour Kp indexes during the 19th (left) and 27th (right) February 2014 from NOAA/SWPC

activity measured at a specific station. It can be derived from the 3-hourly Kp indexes, following a transformation from a logarithmic to a linear scale. The Ap index is the averaged planetary A-index obtained using a set of stations over the whole planet.

- **Dst index:** Index of magnetic activity representing the intensity of the equatorial electrojet. It is obtained from a network of near-equatorial geomagnetic observatories.
- **TEC maps:** These are global maps of ionospheric Total Electron Content (TEC) obtained from observables from ground stations. This information is usually distributed using IONEX format files.
- **Solar indexes:** Some additional indexes are used to monitor the solar activity. Some of them are the Sun Spot Number (SSN), 10cm solar radio flux, proton flux, etc.

In particular, A/Ap and K/Kp provide a direct indication of the level of geomagnetic activity that can be used to analyze a potential correlation with the behavior of the Protection Levels obtained using the information provided by SBAS.

As already mentioned in the previous section, the month of February in 2014 presented some events with a high level of geomagnetic activity. This is visible in the Ap series evolution which shows several days with daily values of Ap above 20 (Figure 3). Note that an Ap index of 30 or greater indicates local geomagnetic storm conditions.

In Figure 4, two peaks in the Kp index are clearly identified to present high value corresponding to the dates presented in Figure 2.

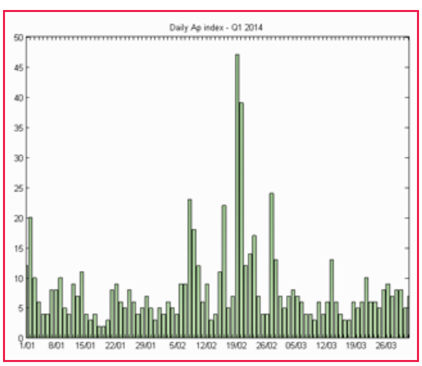

Figure 3: Evolution of daily Ap index from January 2014

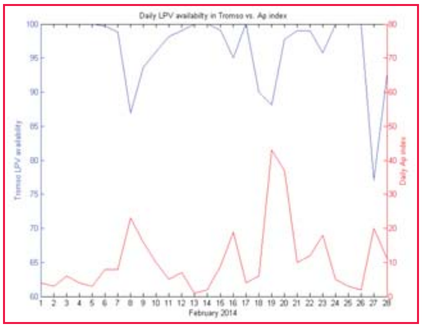

Figure 5: Correlation of Ap index and EGNOS LPV Availability at RIMS Tromso (Norway)

These values confirm that during those days a high geomagnetic activity took place that explains the results observed in the LPV performance of both SBAS systems. The link with the behavior of EGNOS performance is clear if we fix the attention in the results measured at high latitudes. As an example, Figure 5 shows the dependence between the LPV availability measured in RIMS Tromso (located in Norway) and the daily Ap index, during February 2014.

This case shows that a high correlation exists between the value observed in this Ap index and the results obtained in this station. Note, however, that the size of the impact is not always the same: some events are observed with a lower level of activity but a higher impact in terms of performance. Figure 6 presents an example, corresponding to the case on March 5, 2014, wherein the EGNOS performance degradation in the north of Europe is not linked to a high value of the Kp indicators.

However, the use of these indicators also presents some limitations:

- Temporal resolution: As the A/Ap is a daily index, its use for the detection of geomagnetic events of short duration is not always the best option. This problem could partially be solved by using the 3-hourly K/Kp indexes. But even in this case, the estimation of a geomagnetic storm is limited to an interval of 3 hours, that doesn't seems adequate to identify any potential correlation with the instantaneous values of the Protection Levels obtained using EGNOS (calculated at 1Hz).
- Geographical applicability: The second limitation is linked to the fact that the Ap or Kp indexes correspond to global

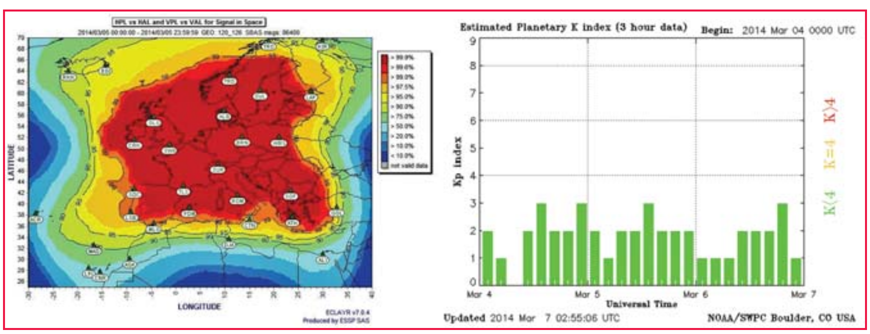

Figure 6: EGNOS LPV performance availability (left) and 3-hour Kp indexes (right) on 5th March 2014 from ESSP website and NOAA/SWPC

planetary values. This means that the values are obtained by averaging the values measured at different stations, which could be located at different longitudes and latitudes. If a geomagnetic storm occurs over the American continent, a decreased effect over Europe is likely; whereas the planetary indexes would be affected. As EGNOS is a local system limited to Europe, it would be necessary that this value be computed for a certain set of stations located over the ionospheric region supported by EGNOS.

- Level of correlation: Finally, as commented above, even if the level of correlation is high when the results are observed, the link is not always so evident. Several cases are known in which the values of the Ap/Kp indexes present low values, even if the SBAS performance are disturbed. In the same way, several geomagnetic storms have a limited impact in the performance levels.

All these limitations show that the information provided by these indexes needs to be used carefully in order to understand the impact of the ionospheric behavior in the performance of SBAS.

The following sections present a detailed analysis of additional parameters and indicators which could be used in order to understand the close link existing between the ionospheric behavior and the performance observed by SBAS users.

Geomagnetic effects on EGNOS in the north of Europe

Horizontal error is bound by HPL and HPL is calculated with the EGNOS information broadcast according to MOPS 229D (RTCA, 2006). The EGNOS performance appeared to be degraded due to geomagnetic conditions during several periods in February 2014, with values of HPL well above the 40 m HAL. It is of great importance to emphasize that although availability was degraded in the North, EGNOS integrity was always guaranteed with every single epoch for the whole service area.

Approach to EGNOS degraded performance in the North in February 2014

As explained earlier, geomagnetic indicators show a relation between geomagnetic activity and SBAS performance (HPL). From (RTCA, 2006), it is known SBAS systems model its ionospheric corrections and integrity information from TEC estimated by its algorithms. TEC disturbances are known to also be correlated to geomagnetic storms (Mendillo, 2007) and local time (Biquiang et al., 2007). These storms at the same time can be traced to exchanges between the Earth's magnetosphere and the interplanetary conditions originated by the Sun (Zhang et al., 2007). Space weather research is bent on understanding a series of phenomena that originated when the Sun liberates matter into the Solar System. These phenomena, whose description is out of the scope of this paper, include: coronal mass ejections (Webb, et al, 2012), solar flares (that can be B, C, M and X flares according to their brightness) (Hudson, 2011), coronal holes (Cranmer, 2002) and solar prominences and filaments (Van Ballegooijen et al., 1989). Moreover, the matter blown out from the Sun moves away from it in a continuous but varying flow and is called the solar wind. Finally, the magnetic field of the solar system, arising from the magnetic activity of the Sun is called the interplanetary magnetic field (IMF).

In order to analyze the geomagnetic conditions in February, the method of analysis focuses on the negative variations of interplanetary magnetic field z component (Bz), and the solar wind speed sudden increases. More information on this method can be found on (Zhang et al., 2007). We have tried to identify the correlation with EGNOS HPL in Tromso, ROTI in the North of Norway and Earth's magnetic field in Tromso. All these five variables were retrieved from the following data sources:

- **EGNOS data source:** Apart from the fault-free monitoring method, EGNOS user performance (Integrity, Accuracy, Availability and Continuity) is monitored daily by the ESSP EGNOS Mission Performance Team (Roldan et al., 2014) for a list of EGNOS RIMS (Ranging and Integrity Monitoring Station) that provide observation data with a frequency of 1Hz. Several RIMS within the service area are located in Northern Europe (Egilsstadir, Kirkenes, Gävle, Lappeenranta, Reykjavik, Trondheim and Tromso) whose data is available at EDAS FTP (EC, 2013). For this study, RINEX data from Tromso (69.65°N) in Norway have been selected in order to compare with other available ground data sources. For this analysis, it has computed the value of the HPL obtained at this station using the information provided by EGNOS. Horizontal error is bound by HPL and HPL is calculated according to MOPS DO-229D.
- **Rate of TEC index at ground (ROTI) data source:** Norwegian Mapping Authority (NMA) operates a network of permanent GNSS stations. Based on the data collected from these stations (Jacobsen et al. 2012), the NMA Real-Time Ionosphere Monitor (RTIM) estimates the state of the ionosphere providing, among others, online ROTI and TEC graphs in Norway. ROTI data for this study has been provided on demand by NMA.
- **Earth's Magnetic field data source:** Tromso Geophysical Observatory (TGO) (Johnsen, 2013) operates the Tromso magnetometer and several others along the Norwegian coast and on Svalbard. TGO provides graphical, historic and real-time data on their website. On demand, they can provide numerical data as they have done for the present study.
- **IMF and solar wind speed data source:** Advanced Composition Explorer (ACE) spacecraft (Stone, 1998) observes particles of solar, interplanetary, interstellar, and galactic origins, spanning the energy range from solar wind ions to galactic cosmic ray nuclei. From a vantage point of approximately 1/100 of the distance from the Earth to the Sun, ACE performs measurements over a wide range of energy and nuclear mass under solar wind flow conditions, and during both large and small particle events including solar flares. ACE provides near-real-time solar wind information over short time periods. ACE data can provide an advance warning (about one hour) of geomagnetic storms. For the present study, solar wind speed in GSM coordinates and interplanetary magnetic field data have been retrieved from NOAA FTP.

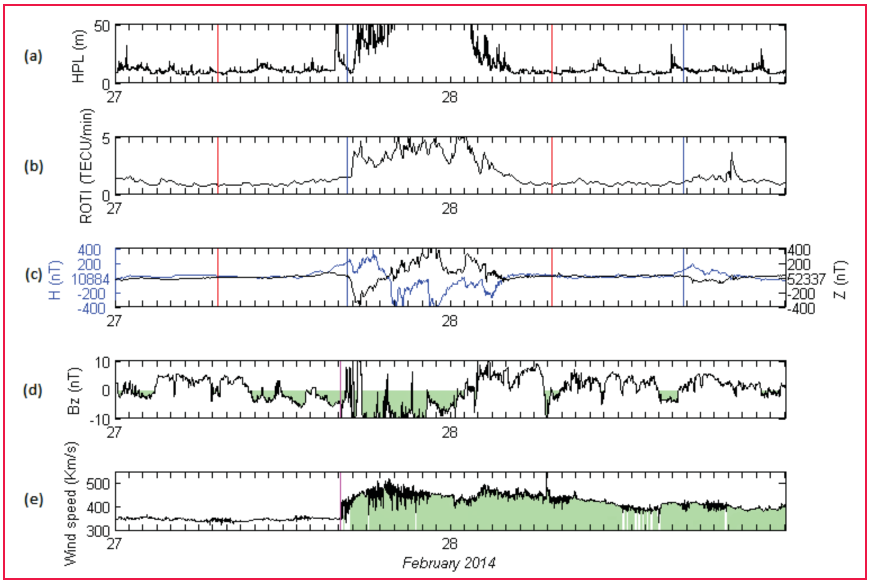

Figure 7: Data related to the geomagnetic storm on February 27, 2014, showing temporal profiles of (a) the EGNOS LPV HPL in Tromso, (b) ROTI for Northern Norway (67º–72º) (c) H and Z components of the geomagnetic field in Tromso, (d) interplanetary magnetic field Bz component, and (e) solar wind speed. The vertical red and blue lines respectively indicate sunrise and sunset in Tromso. The magenta line indicates the arrival time of a shock at ACE spacecraft.

Detailed analysis of EGNOS performance

In February 2014, the EGNOS performance presented several periods that can be considered highly degraded. For detailed analysis, three time periods have been selected: 7^{th} to 13^{th}, 18^{th} to 20^{th}, and 27^{th} to 28^{th}. When analyzing the events, it has been decided to sort them according to the HPL degradation they produced becoming Event #2, Event #3 and Event #1, respectively.

Event #1: February 27^{th} to 28^{th}

The first period of analysis starts at 1700 UTC on February 27, when EGNOS performance degraded in the North of Europe. At that time, geomagnetic indexes did not react immediately since Kp index was 4 at the next calculation slot (1800UTC) and only jumped to 6 (major storm) at 2100 UTC. Dst was only slightly negative at the next calculation

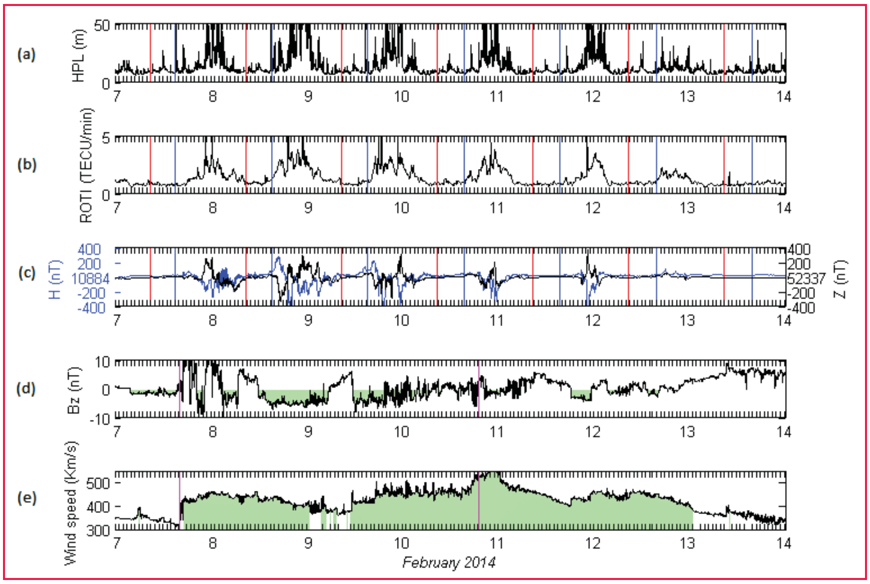

Figure 8: Data related to the geomagnetic disturbed conditions from 7th to 13th February 2014, showing temporal profiles of (a) the EGNOS LPV HPL in Tromso, (b) ROTI for Northern Norway (67º–72º) (c) H and Z components of the geomagnetic field in Tromso (d) interplanetary magnetic field Bz component (e) solar wind speed. The vertical red and blue lines respectively indicate sunrise and sunset in Tromso. Magenta lines indicate the arrival time of a shock at ACE spacecraft.

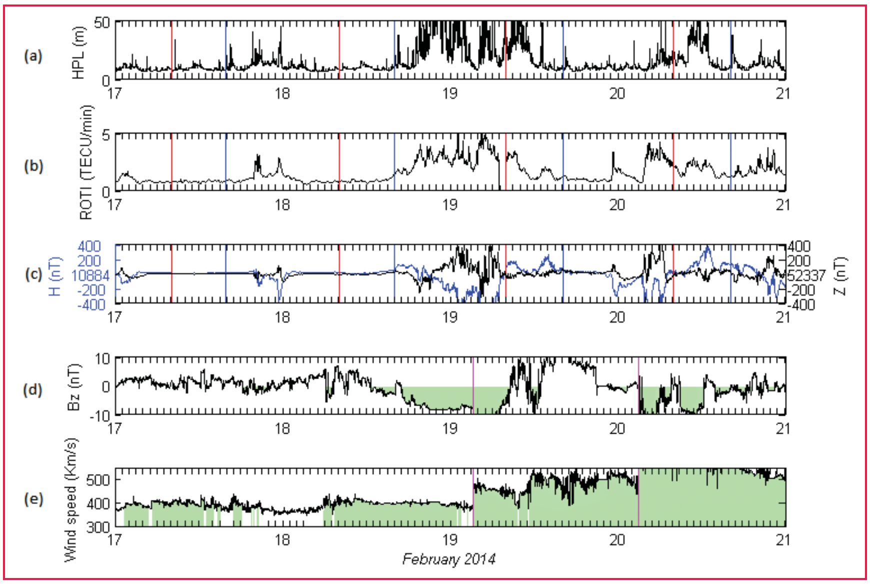

Figure 9: Data related to the geomagnetic storm from 17th to 20th February 2014, showing temporal profiles of (a) the EGNOS LPV HPL in Tromso, (b) ROTI for Northern Norway (67º–72º) (c) H and Z components of the geomagnetic field in Tromso (d) interplanetary magnetic field Bz component (e) solar wind speed. The vertical red and blue lines respectively indicate sunrise and sunset in Tromso. The magenta line indicates the arrival time of a shock at ACE spacecraft.

epoch (-8nT at 1800UTC) and then dropped to -99 nT at 2300 UTC.

Figure 7a shows how EGNOS LPV HPL in Tromso rose on the 27th from 1715 UTC to 28th 0200 UTC, exceeding the HAL. Figures 7b and 7c show time profiles of ROTI in Northern Norway and the variation of the horizontal (H) and vertical (Z) Earth's magnetic field measured in Tromso. Both HPL and ROTI showed clear high (disturbed) values from approximately the same time (1700 UTC). Earth's magnetic field variations seem to start even before (1500 UTC).

On taking a look at the interplanetary information measured by ACE, the solar wind speed is illustrated in Figure 7d and the IMF north-south (Bz) component in Figure 7e. In Figure 7d and Figure 7e, light green shading means that Bz is negative and solar wind speed is above 380 km/s respectively. When it comes to the data, in Figure 7d, a sudden jump in the solar wind speed (from 350 km/s to a maximum 520 km/s at 1930 UTC) is detected by ACE at 1609 UTC marked by a vertical magenta line. Moreover, IMF north-south (Bz), which was already mainly negative during the previous six hours, started flickering at 1600 UTC and finally dropped to almost -20nT at 1800 UTC. It remained negative until 0200 UTC.

From the analysis above, it seems clear that the disturbed conditions started one hour after the arrival of the shock detected by ACE at 1609 UTC, which by its locations must receive the shock one hour before Earth. According to (NOAA, 2014a), this shock on February 27th is a consequence of the coronal mass ejection associated to a X4.9 flare erupted from the Sun at 0049 UTC on February 25th.

Event #2: February 7th to 13th

A second period of interest was identified from February 7th to 13th where a series of degradations affected EGNOS user's during night-time from 7th to 12th. The case of February 13, considered a day with EGNOS nominal performance, is also included in the analysis as a nominal reference.

Figure 8a shows different levels of EGNOS performance degradations during the nights from 7th to 12th. Periods of higher and more degraded HPL are presented on the 9th and 10th. These periods become shorter on the 12th. Figure 8b shows a similar trend for ROTI in Northern Norway and in Figure 8c, it can be seen as Earth's magnetic field is also affected in a similar manner. This confirms the Figure 7 analysis.

For this week, Kp index reached 5 (minor storm) at 2100 UTC on the 9th and then stayed between 2 to 4 during the rest of the period. In (NOAA, 2014b), it identified the arrival of two shocks at ACE, one at 1616 UTC on the 7th (due to the arrival of the coronal mass ejection associated to M3.8 flare) and the second one at 1900 UTC on the 10th, due to the arrival of coronal hole high speed stream (Kavanagh et al., 2007) according to (NOAA, 2014c). Both shocks are marked by a vertical magenta line. From Figure 8d, other two situations where solar wind speed jumps took place at 1100 UTC on the 9th and 1800 UTC on the 11th. At the same time, the IMF Bz turns negative (Figure 8e). In Figure 8d and 8e during the night of the 8th to the 9th, the effects over HPL, ROTI and Earth's magnetic field of a relatively not-so-high solar wind (400Km/s) and a persistent negative Bz (lasting 17h) can be seen.

It is also interesting that the effects of a higher solar wind speed (maximum of 570 km/s) on the night of the 9th to 10th did not produce such high HPL or ROTI values. The different effects over HPL and ROTI seem to be related to the strength of the combination of solar wind speed, and either the flickering Bz (lower effects) or full negative Bz (greater effects) peaking at midnight.

Event #3: February 18th to 20th

Finally, on February 18th, Figure 9d shows an increasing negative component of the IMF Bz since 1300 UTC. Bz stabilizes at -9nT at 2100 UTC. For the same period, the solar wind speed is above 400 km/s.

The effect of this combination is clear in HPL (Figure 9a), ROTI (Figure 9b) and Earth's magnetic field (Figure 9c). According to the previous cases, this should have produced an increase HPL and ROTI during the nighttime at Tromso, but when daylight arrived, HPL should have come down to a much lower value. However, at 0309 UTC, a shock, probably because of a coronal mass ejection on the 16th (NOAA, 2014d), arrived at ACE making the solar wind speed rise to 500 km/s with a maximum of 550 km/s. The solar wind speed stays over 400 km/s until the end of the plotted period. The IMF Bz, already quite negative, plummeted and reached a minimum of -15nT. Bz stayed negative until 0800 UTC. Bz finally started flickering until 1300 UTC. This storm made Kp index reach 6 (major storm) for several intervals on the 19th, and Dst decreased to a minimum of -112nT at 1200 UTC that day.

What makes the effects of this storm different from previous cases is that the disturbed HPL, ROTI and Earth's magnetic field continued during daylight on the 19th. So it seems that the combination of more disturbed values of solar wind speed and negative Bz can extend the effects over HPL and ROTI to daylight. A similar situation happened on the 20th, when ACE spacecraft detected a sudden increase of solar wind speed from 500 km/s to 650 km/s with a peak of 750 km/s, probably due to a filament eruption on the 18th (NOAA, 2014d), at 0251 UTC. IMF Bz again plummeted and the effects could be appreciated during daylight in Tromso.

Conclusion

A summary of the different analyses performed by ESSP relative to the existing correlation between EGNOS performance measured over different regions of the EGNOS service area and some of those ionospheric indexes (Kp, Ap, etc…) is presented in the article. Even if the use of those basic indicators provides good results in general, the correlation between those parameters and EGNOS LPV performance is not always direct. The existence of some limitations justifies the search of additional sources of data that could provide a better match with the observed results.

With this objective in mind, ESSP is advancing towards a deeper understanding of the effects of ionosphere at user performance level. In the present study, limited to some events in February 2014, ESSP Mission performance team has identified the existing link between EGNOS LPV performance outliers and variations in the ROTI, Earth's magnetic field, solar wind speed and IMF Bz component. As a result of this analysis, the existence of a joint effect of the high solar wind speed plus a negative (or even disturbed) IMF Bz over degraded EGNOS LPV HPL has been identified. This same joint effect is used in literature to confirm the effects of geomagnetic storms. Also, it is shown, that ROTI, HPL and Earth's magnetic field are mainly disturbed simultaneously.

More analysis must be done to confirm early conclusions, but the variations in these parameters seem to be correlated to EGNOS LPV performance in a promising way. Shock detection at the ACE spacecraft, where typically disturbed conditions arrive at about 1 hour before the Earth, and other sources of information (i.e. SOHO/LASCO) must be assessed as an early warning of performance degradation in the North of Europe

Acknowledgments

The authors wish to thank the providers of data used in the present study. We thank Dr. Knut Stanley Jacobsen from the NMA for the ROTI data. We also thank Dr. Magnar G. Johnsen from Tromso Geophysical Observatory for the Tromso magnetic field data. ACE IMF data, solar wind speed data, Kp index and Weeky reports were obtained from the NOAA Space weather prediction center. Dst index was retrieved from the World Data Center for Geomagnetism (Kyoto).

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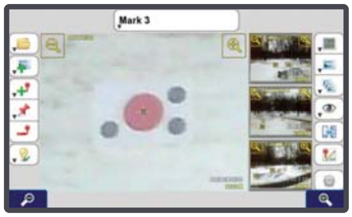
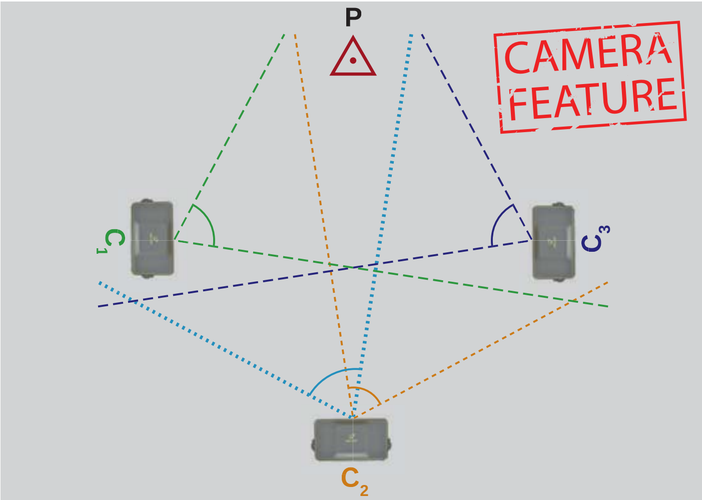
Offset Survey with built in camera

You can survey points with internal TRIUMPH-LS camera with accuracy of about 2 cm. Take pictures from at least three points. Leave a flag on points that you take pictures from, otherwise accuracy will be about 10 cm.



Point	#	Δ,m	σ,m	RE,px
Check14	4	0.044	0.052	0.214
Check15	2	0.041	0.055	0.722
Check16	3	0.230	0.154	0.170
Mark1	5		0.095	0.500
Mark2	5		0.093	0.336
Mark3	5		0.067	0.207

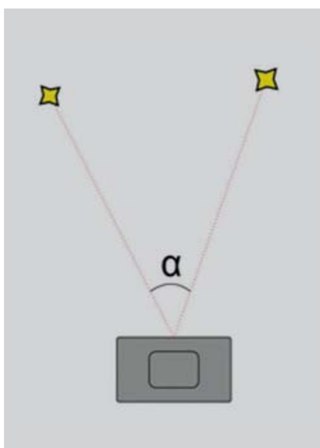


Visual Angle Measurement with Triumph LS

The new Visual Angle Measurement function of the TRIUMPH-LS allows measuring angles between points by using photos taken by the TRIUMPH-LS camera and use in CoGo tasks with the Accuracy of about 10 angular minutes.

To measure an angle:

- just take an image containing both objects of interest and open it in the Measure Angle screen
- select first and second point (using zoom to focus on necessary features)
- The angle between points is immediately displayed on the screen.



From:
V. Kelly Bellis, PLS
Horizon Surveying Co., Inc.
Ellsworth, Maine 04605
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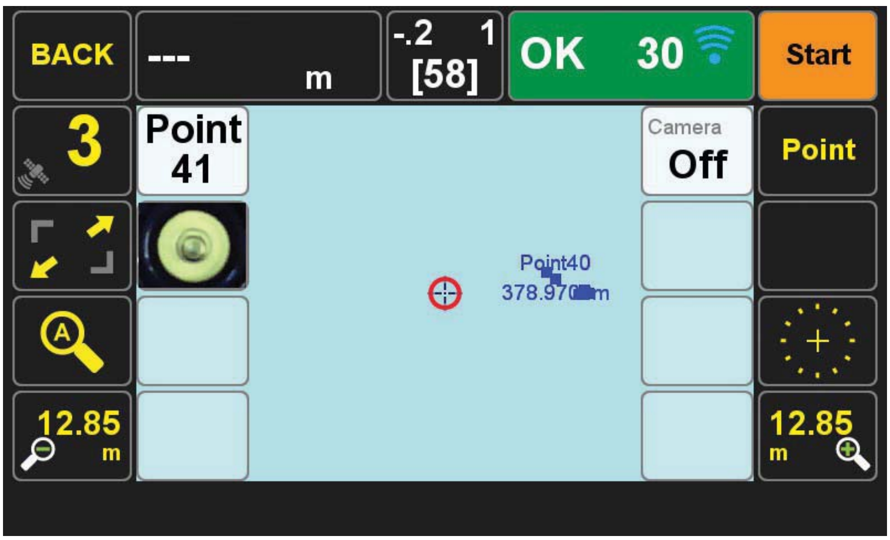
Without question, the Triumph-LS is the most mind-blowing piece of technology that I have ever held in my hands and being able to work with it is the highlight of my 40-year career in land surveying. Intertwined and commensurate with that highlight has also been the incredible honor and privilege in working with Javad Ashjaee, his amazing Moscow-based team of scientists and engineers, as well as some of the brightest surveyors in the United States, all in the shaping of the Triumph-LS and its graphical user interface, J-Field.

There are so many features of the Triumph-LS worth highlighting, it's difficult to know where to start; from the built-in frequency scanners for both UHF interference and GNSS interference, the automated shifting of project coordinates after the base file has been submitted to DPOS (Javad's own version of OPUS for .jps files) and its adjustment received – all being done by J-Field, or to start by mentioning Visual Stakeout using J-Field's unique and way cool Guide feature. The ability to locate objects using photogrammetric methods is another exciting tool included in J-Field's extensive tool-set.

Being a person that has always gravitated to understanding things visually, J-Field's approach and graphical displays has aided my transition from strictly being an L1 guy for more than a dozen years; (6) ProMark2 Ashtech[1] receivers, to finally get with today's surveying using RTK. Of course, the Triumph-LS's very competitive price point also made this transition possible.



Shown here is just one example of the visual presentation of information given the surveyor. It includes being able to see at a glance the image of the rod bubble beneath the instrument's second camera and the textual display of Triumph-LS's internal pitch and roll values.

If I was limited to saying only one thing about the Triumph-LS that has impressed me the most, I'd have to say that it doesn't have anything to do with technology whatsoever. It has to do with a GNSS manufacturer that has so openly embraced the surveying profession during the development of a specific product, and most notably, professional land surveyors in the United States. As a matter of policy, Javad GNSS users are encouraged to suggest improvements and new features to all Javad GNSS products. And nowhere is that policy reflected more clearly than in J-Field.

The Javad PLS Support Network is an other reflection of Javad GNSS's commitment to supporting the U.S. Professional Land Surveyor and their use of Javad equipment. Composed of a core group of licensed professional land surveyors scattered across the United States, the so-called 5PLS members stand ready to assist by phone or email. The best method of support is actually using the website's support forum (https://support.javad.com/index.php) which serves not only as a portal to quickly getting answers to questions from all of the licensed land surveyors, Javad GNSS geodesists, scientists, engineers and even Javad Ashjaee himself, but also ever increasingly the support forum serves as a reference source and suggestion box.

1 Ashtech was the first GNSS company that was founded by Javad Ashjaee.

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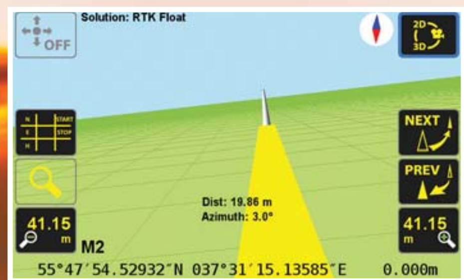

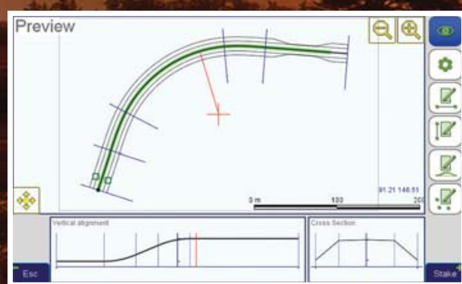

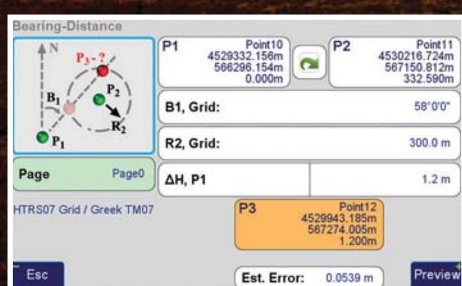

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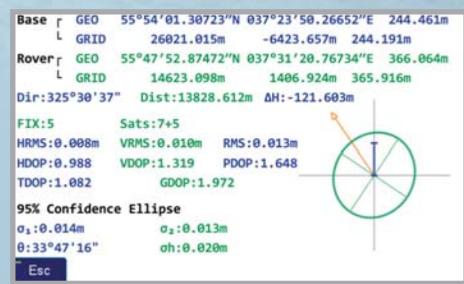

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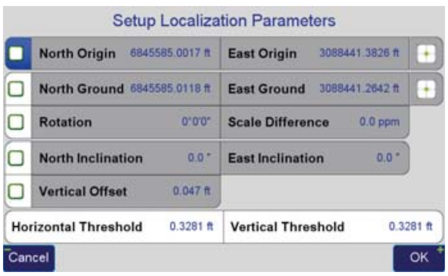
Precision with TRIUMPH-LS

Case study for Transformation with Localization

We have a city wide control network of 30 monuments, determined by excellent GPS procedures done by another surveying company in 2000. The monuments are dispersed over an area of approximately 25 square miles (5 miles by 5 miles). POST is on the far East side of this network. I set a Triumph-1 on POST with NAD83_2011 coordinates broadcasting over TCP. Dad drove me around to the five main control points established in 2000. I observed them for 120 seconds each, except for one which I observed for 90 seconds. The results were nothing short of incredible:

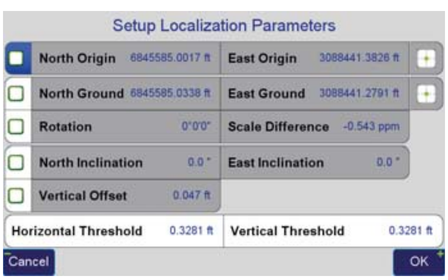
This is the first calculation by localization. I started with a minimally constrained localization. I picked the central point (point 11). Notice the other four points are gray, as they are check points. Point 17 immediately shows signs of some trouble.

The parameters from this localization



Then I add more points. In this localization, I added all but point 17 horizontally, but left the single constraint point for vertical (point 11). Are those residuals for real?!?!

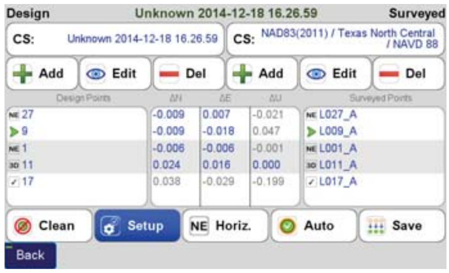
Let's check what the parameters are for this calculation...



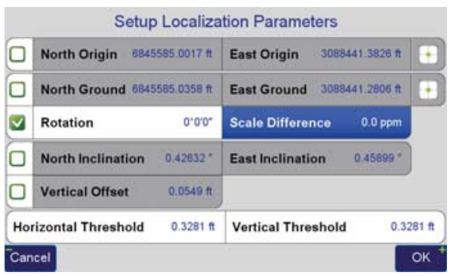
Rotation calculated to be 0°00'00". Scale was only 0.5ppm! I imported these points as State Plane and surveyed them as State Plane so that (theoretically) scale and rotation would be identical.

Because I don't like the idea of redefining the foot, I set the scale to 0ppm. I also manually set the rotation to 0 (just in case the 0 showing was actually some fractional part of a second).

Finally I made the four points fixed in 3D



The inclination values are very low (0.5 arc second). Because the original control was done using Geoid99, and today's survey was with Geoid12A, I think (in theory) that it's appropriate to let Vladimir calculate the inclination values here. I might have zeroed these, but in reality, it probably wouldn't have made much practical difference. Notice that the difference deltas are N 0.0341, E -0.102, U -0.0549. What we had observed for the difference between HARN and NAD83_2011 is N 0.054, E -0.088, U -0.018.

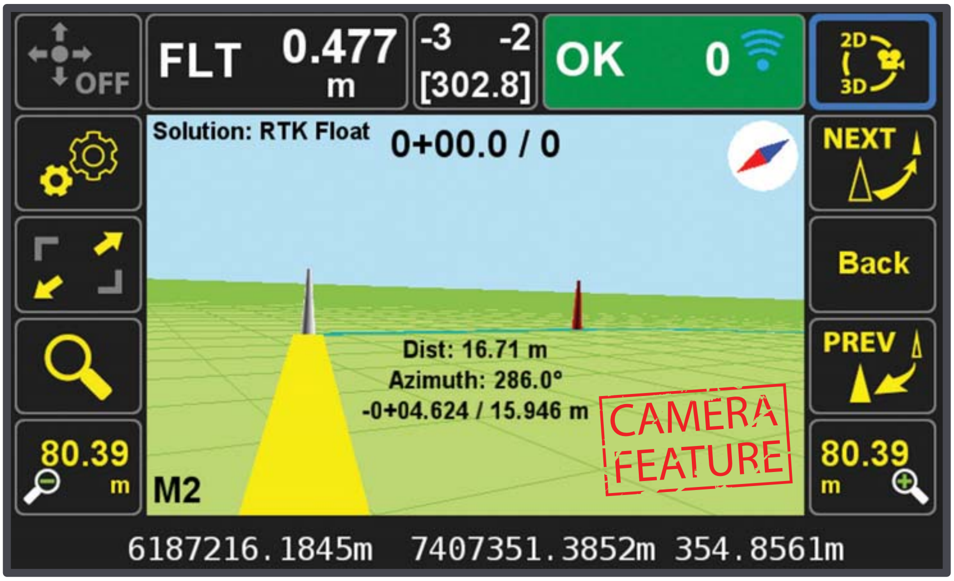


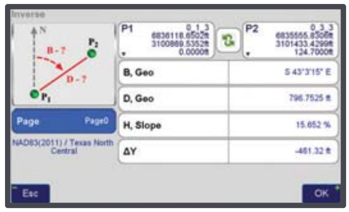
It took 1.5 hours to drive around and observe these five points. It took ten minutes to do the analysis I described above. Saving this localization, I could then import coordinates from city based State Plane Coordinates into the resulting coordinate system and be properly related. Or, I could be using a NAD83_2011 correction source and work in the city coordinate system.

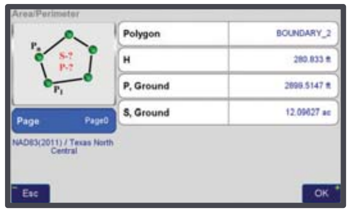
What happened to point 17? Was it a bad RTK observation? I don't believe so. This point is on the side of the highway and has probably been displaced by heavy machinery driving over it over the years. I may reobserve it in the next few days, but I am pleased that localization was able to identify it. This is a tremendous side benefit of localization.

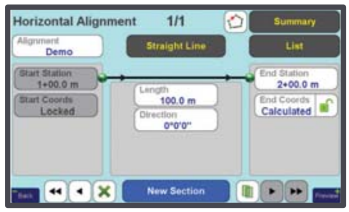
Ultimately I am shocked by the accuracy of the LS over these baseline distances in such short observations.

Shawn Billings, PLS









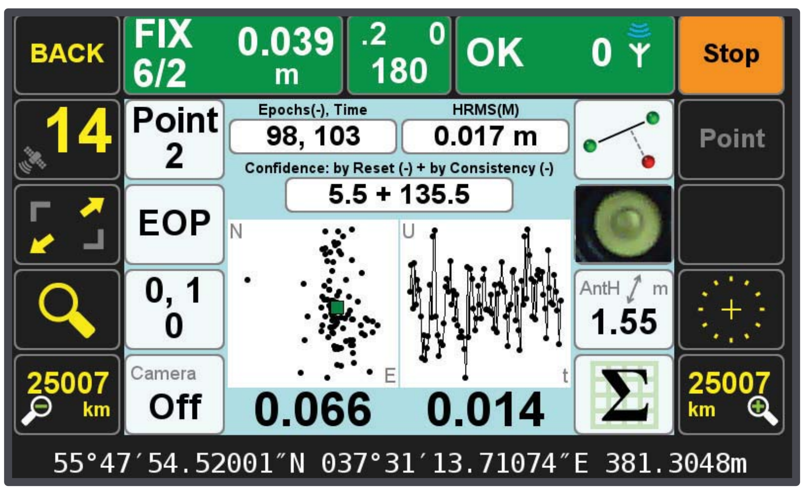
Store and Stake

Introducing GUIDE data collection in the TRIUMPH-LS. Visual Stake-out, navigation, six parallel RTK engines, over 3,000 coordinate conversions, advanced CoGo features, rich attribute tagging on a high resolution, large, bright 800x480 pixel display.
Versatile attribute tagging, feature coding and automatic photo and voice documentation.
The TRIUMPH-LS automatically updates all firmware when connected to a Wi-Fi internet connection.

View and Document your level

The downward camera of TRIUMPH-LS scans and finds the liquid bubble level mounted on the pole. Then focuses on the circular bubble automatically and shows its image on one of the eight white buttons of the Action Screen. You can:

- View the liquid bubble level on the screen.
- Document survey details including the leveling by taking automatic screen shots of the Action Screen, as shown here.
- Calibrate the electronic level of TRIUMPH-LS with the liquid bubble level for use in Lift and Tilt and automatic tilt corrections.



All these camera features are possible only in TRIUMPH-LS where camera, and GNSS antenna are co-located and all other modules integrated.

Managing inaccurate historical survey records in a future accurate digital world

We start a series of two papers, first being the underlying survey database technology and workflows and the second being how the process is facilitating the representation of the survey plan in a machine readable file that is allowing automation of manual plan examination processes and transactions. We present here the first paper. The second paper would be published in next issue

Ian Harper
Director, Geodata Australia, Australia

Spatial definition of land ownership

The physical extents of land ownership have been defined by many methods over the years ranging from verbal agreements between adjoining owners to formats of written descriptions, maps or survey records. These informal and formal tenure definitions have then been managed at various local, regional or State levels of registries by manual methods. Technology is driving the agenda to digital land administration systems.

The starting spatial representation will usually be digitised from indicative maps of ownership. These are adequate where resources are limited but where survey records of property ownership existed, those digital maps will gain a higher level of acceptance where there is a recognisable link in the system to the historical survey measurement and cadastral intelligence.

The challenge is to represent the intent of those inaccurate historical records in a future digital administration that demands specific structure in digital data formats.

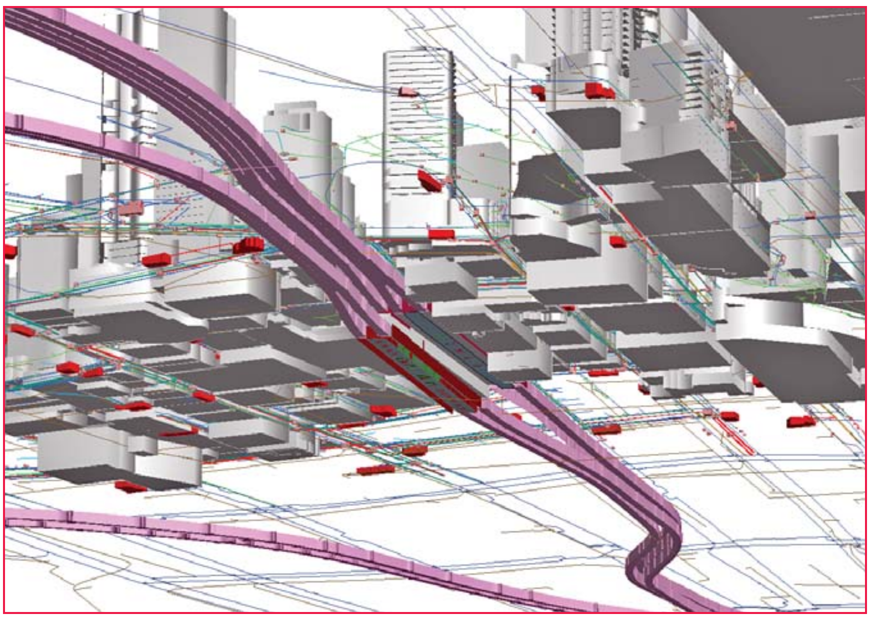


Diagram 1 – Sydney CBD model from below
Courtesy – Tony Sleigh – Emergency Information Coordination Unit Department of Lands NSW

Future digital efficiencies

The digital database world offers powerful tools that can require significant technical and commercial resources. The 'big picture' type of outcome indicated (Diagram 1) belies the amount of data, governance and management resources required for their creation.

Technology is providing greater capabilities in measurement tools – GNSS, Scanning, Lidar, terrestrial and aerial imagery, Unmanned Aerial Vehicles (UAV) or drones. These tools also raise the level of expectation in outcomes.

Some of these technologies could assist in providing cost effective mapping solutions but others require considerable commercial and technical resources to manage the data.

Computing technologies have also advanced with significant increases in computational and data storage capacity. Those advances underpin the automation of existing manual processes that allow efficiency in accessing, manipulation and examining data. These processes have rigid governance systems with standard data formats but do provide significant efficiencies.

If digital cadastral definition was straight forward, it would have been implemented by now. To get to a future simplified outcome, the spatial and legal issues are considerable. We are moving towards it and other aspirations like 3D cadastral modelling and boundary definition by coordinates are on the agenda. The concept is achievable but the devil is in the detail and a starting agenda would be to get a cadastral management process in place at a local level that replicates a State system. Where the spatial component is managed is then optional.

A big issue is the perception and expectation that technology will solve all the problems. The tools of the future will probably do that, but we have a unique set of circumstances in the cadastral definition domain to manage as part of the transition. It will also be important to recognise there may be better ways of doing things that are difficult to grasp in our minds that have been moulded in a manual world.

The technology transitions

When digital systems are being implemented there are two main transitions that can occur in representing boundaries. The manual to digital transition is the initial one, as any system needs to create a spatial representation of the cadastral boundaries in a digital format. All types of agreements, descriptive documents, maps and surveys need to be identified and represented for transaction requirements.

Accuracy is not critical in the first transition but as systems develop in complexity and look to represent and manage other information (political, environmental, infrastructure, assets etc) it increasingly becomes a necessity. Thus there is a need for a second transition from a mapping solution to a survey solution. Higher accuracy also invokes a new level of consideration of issues associated with measurements and coordinates in a dynamic geodetic system.

Manual to digital transition

Where no documented records exist such as verbal agreements between owners or areas of previously State owned property, decisions on boundary locations must be determined. Ideally, monuments are physically placed in agreed locations and then surveyed. Those survey records then allow accurate reinstatement at any time. Broader scale indicative maps of ownership can be scanned to provide a digital representation for administration purposes and can be linked to aerial imagery to enhance location accuracy.

These methods service strategic land administration and are useful when resources are limited but reinstatement may face disputes.

Historical survey records represent the local relationships between adjoining properties and are interpreted by Licensed Surveyors to determine an accurate boundary location on the ground. Those records can be difficult to represent accurately in a large database and can require significant resources to consider them on their exact spatial intent. This is not justified in initial land administration databases.

Diagram 2 outlines the processes in the Manual to Digital transition. Technology now provides the tools to generate a useful mapping boundary database and even though survey records exist, a representative database can be created without reference to the detail on those records. Survey field work or computations may be useful but not vital.

Mapping to survey transition

The mapping to survey transition is a consideration when stakeholders are finding that the spatial precision of an

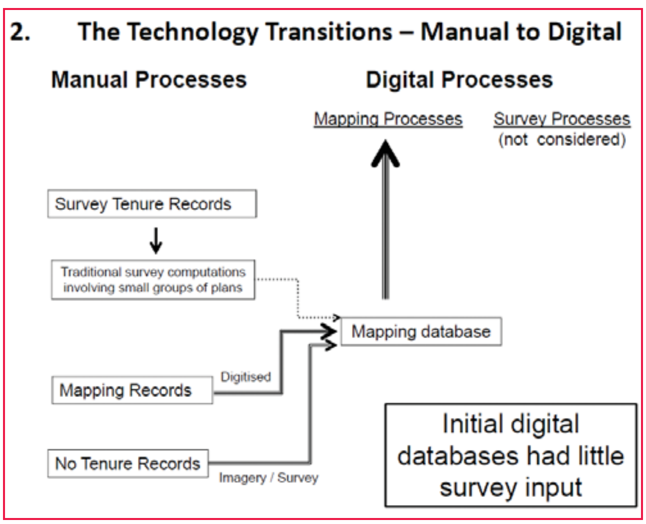


Diagram 2: Database management was initially managed by mapping systems

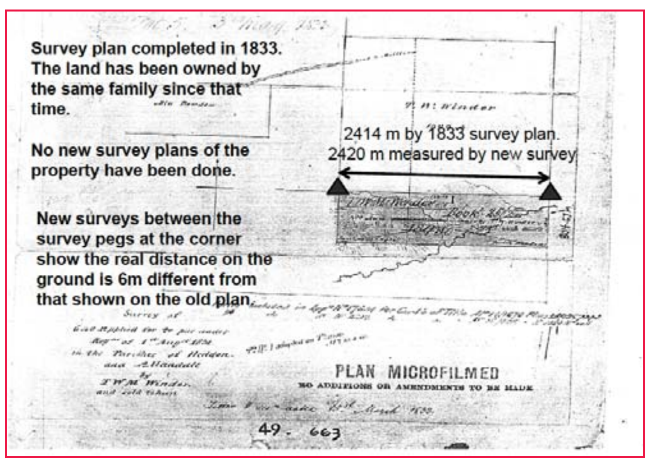


Diagram 3

initial mapping land administration database is not meeting their business needs. This has been happening for some time as Geographic Information Systems (GIS) database technology now provide powerful tools to manage governance and infrastructure.

The complexity has grown in those tools but the outcomes are still dependent on the quality of the information within them and there has been increasing investment in upgrading the accuracy of the cadastral database to overcome those inadequacies. A combination of accurate survey data and survey data management tools are required.

Existing survey measurement records do not 'fit' easily into a structured digital environment that represents the real world cadastre. Diagram 3 is an example from Australia that indicates how poorly an historical survey record that depicts a current legal land title represents the true 'on ground' dimensions of the property. Simply adopting all the legal survey records and joining them together is not an effective solution.

Three Plenary Speakers at the Map Asia Conference - August 2008 spoke about the future and those comments are noted in Diagram 4. The points they make are the importance of the cadastre and accuracy, and that the rigour of survey processes to check and validate data is needed rather than GIS or mapping processes that generate indicative maps with a minimum of effort. These digital maps are only suitable for 'big picture' jurisdictional governance.

Systems for the future

Technology now provides the capacity for accuracy in land administration spatial systems but there are issues in pursuing that goal:

- A significant investment if pursuing spatial quality in the short term
- Implementation strategies – Governance & Integration of data and resources
- Stakeholder perceptions and expectations
- A high level of detail required across a significant dataset

Even in developed countries with extensive systems in place, these issues make it difficult for large scale SDI mapping systems to be spatially accurate at a local level, so many local authorities or utilities create their own systems to meet their operational needs, even though it is duplicating the same database managed by the State.

The Survey Database (SD) technology outlined below provides the same workflows and processes at both local and State level so with good management, similar duplication of resources and databases can be avoided.

The SD is a survey database of dimensions. Representing and computing boundaries in the past has always been measurement based, but with digital technology, storage of spatial information is coordinate based.

Whilst the general acceptance of coordinate point definition is increasing, most users outside the survey and GIS worlds relate to measurements, so cadastral boundaries are best represented by measurements, but must be digitally stored as coordinates in the database.

The survey database technology

The Survey Database (SD) technology was developed in Australia to facilitate the transition to a survey database to generate a higher level of accuracy and functionality underpinning the cadastral database. The initial mapping databases had been generated by digitising administrative maps and as greater accuracy in those administrative databases was being pursued, the process was developed to integrate the historical survey records with new accurate survey data, partly automating the intuitive processes that a Licensed/Registered Land Surveyor would follow in determining the location of a boundary.

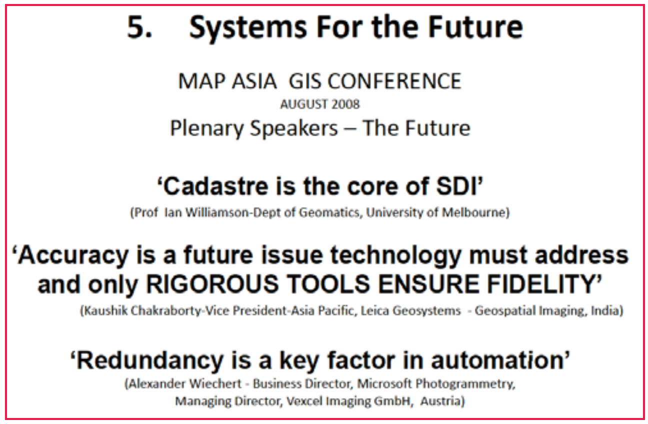


Diagram 4

The SD Solution at a State level is available around the world as the ESRI Parcel Editor tool in the ArcGIS enterprise system and at a local level, the GeoCadastre (GC) technology is a stand-alone software solution capable of being used in the field or remote locations with the most basic computer resources.

The SD format is standard at all levels and ground measurements are the common unit used in computations, so all measurement data (compass traverse/pacing, theodolites/band/chain & EDM) can be utilised with GNSS or other modern position based technology. It means the most basic field survey information as well as modern survey data contributes to a geodetic or planar spatial outcome on the spatial merits of the information.

Measurement data can be sourced from manual and digital systems that could include:

- Manually entering the measurements from record documents
- Importing new digital survey data outcomes from survey cogo software.
- Creating parcel measurements from existing mapping database coordinates
- Generating measurements from sets of GNSS coordinates.

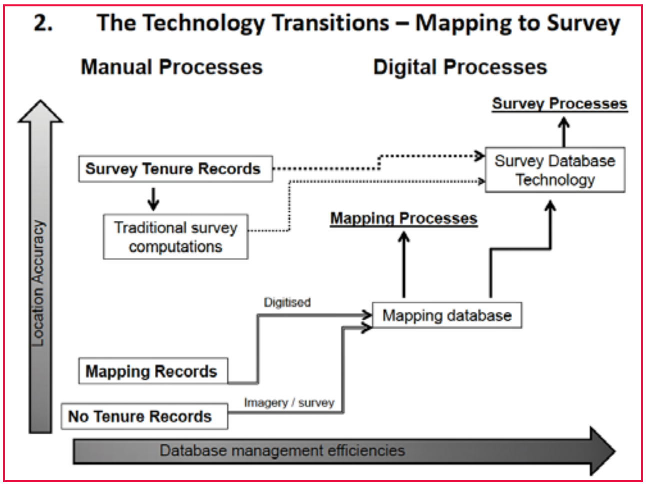


Diagram 5

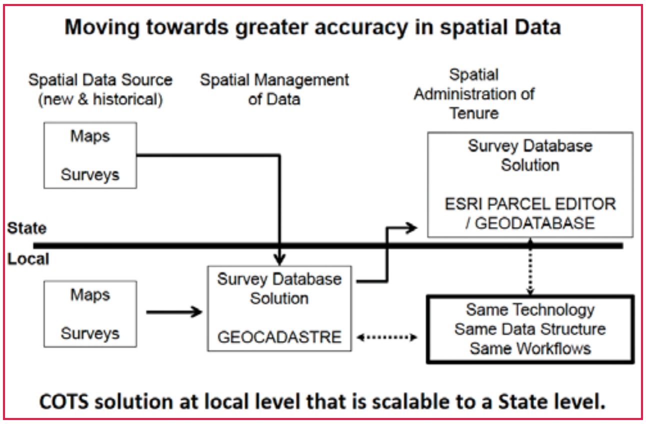


Diagram 6: Cadastral Upgrade Workflows

When joined, the geometry of all the property parcels in the database creates a mesh or continuous 'fabric' that is adjusted to nominated Survey Control points. All the original survey dimensions and control points are stored in the main SD.

Diagram 5 extends the database creation workflows to now include the progression from Mapping Processes to Survey Processes. The measurements from the survey records are input directly into the SD technology and issues such as poor quality plans and the topology or 'fit' of the cadastral fabric area are managed and adjusted to achieve the highest spatial outcomes without considerable field survey that would normally be required.

The diagram identifies that the SD processes provide greater location accuracy and database management efficiencies and if field survey is utilised to increase accuracy, those costs would be considerably greater without the SD technology.

In traditional databases, the coordinates of boundary corners are the defining spatial attributes of a parcel. In the SD, the original measurements (irrespective of accuracy) as noted on the legal survey document are be the defining attributes. The coordinates of a parcel in a dynamic SD model are an informed (or otherwise) estimate of the spatial location of a corner at a specific time.

Survey database workflows

Data Entry

Measurement data can be sourced by various methods as outlined above. The manual data entry of measurements from survey records achieves the highest outcome but is the most labour intensive. Once that entry is complete it is stored in the SD and no further manual data entry is required.

Miscloses remain in the parcels as basic adjustments (Bowditch, etc) distribute an error across all lines where it may only be in one line. Redundancies in the SD Least Squares Adjustment (LSA) can identify the specific line. Variation in azimuths between survey plans or scale corrections are also automatically managed in the SD process.

Parcel Joining or Topology Management

The parcels are joined to a fabric ensuring the correct topology with no overlaps or gaps. As the adjustment is a survey based process across a geometry mesh, survey measurement connectivity is required throughout any dataset. The topology or 'fit' of the cadastre parcels is important to ensuring the adjustment will operate.

Adjusting the database

Weighting based on the estimates of measurement quality is applied to each measurement on a per plan/survey basis (i.e. all lines on a specific plan are usually equally weighted). The adjustment is designed for cadastral survey data which is quite different to the type of rigorous measurements found in a geodetic survey adjustment. Error ellipses are valuable in geodetic adjustments but in the SD LSA, they are generally not a true indicator of precision. The only true test of the spatial precision of a point is a comparison between the SD coordinate and the coordinate of a boundary location determined in the field by a Licensed Surveyor after consideration of all the evidence.

Survey database resource allocations

Basic data entry requires the least amount of experience and the level of comparative resources required diminishes through stages 2 and 3 but the level of experience required grows as the need to troubleshoot and resolve survey data issues grows. Field survey greatly assists the quality of the outcome in the adjustment and the adjustment is used as a tool to direct operators to areas of problem data where field survey can be focused.

The various stages can be assigned to different levels of experience, but they can all be managed at a local jurisdiction. Each stage has levels of data checking and validation that can be invoked if a higher spatial outcome is being sought. The local SD output can then be incorporated into a central SDI and should not require further adjustment.

Diagram 6 highlights a cadastral upgrade business model where there is a differentiation of data management tasks between the Local and State jurisdictions and identifies the SD tools for each jurisdiction.

There is a significant difference in the application of the technology between the State and Local Jurisdictions. At a State level, the business needs and outcomes are strategic and the level of detail and accuracy is not critical. At a local level, the detail and accuracy becomes more important as a database map becomes a tool that provides information as to the **approximate** location of property boundaries on the ground and flows through to the representation of above and below ground assets or identifying political, environmental or other constraints.

The SD is firstly the repository of survey measurement data, survey connectivity and control surveys but then becomes the computational tool in modelling the complete cadastre. Once local computations are undertaken, the output to the GIS Land Administration database is only the model of the cadastre boundaries. All the original survey data remains in the SD where it can only be accessed by authorised resources when further upgrading is required.

Survey Database – Business Case

There are only a few States (or Countries) where coordinates are the point of legal truth in defining property boundaries, thus in most developed countries, historical survey records are still the prima facie evidence to determining the location of cadastral boundaries.

There are two ends of the business strategy in creating a SD to expedite the mapping to survey database transition:

1. Reverse engineering existing mapping databases to the SD data structure. This retains the existing spatial quality of the model by adopting the original measurements from the mapping database, but facilitates efficient upgrading with survey plan data as required. There is limited initial migration costs and spatial upgrading can undertaken as needs and budgets allow. However, as this method progresses, the rationalisation of new survey data and original poor quality digitised data can be a timely process
2. Entering and joining all the survey measurement and other cadastral intelligence available from current and historical survey records and applying all the rigour of the process in conjunction with a GNSS field survey of some cadastral monuments – this strategy involves a reasonable cost 'up-front', but those costs are amortised rapidly due to the savings in general efficiencies and having one accurate system (i.e. not duplicated).

Over time the cost of Option 1 will be significantly greater than Option 2. The difficult part is to identify the real cost burdens of how an inaccurate cadastral database can affect the efficiency and quality of operation. The accidental severing of an optic fibre cable can cost millions of dollars per minute in down time. If there is a high level of uncertainty in the State based cadastral model, it may be initially be part of the problem or it may put in doubt any opportunity to apportion liability to the perpetrator.

There is a considerable amount of scope between the two strategies outlined above. Our experience in creating SDs has proven that a flexible strategy with consideration of survey data quality and stakeholder needs being the determining factors in a practical and cost effective solution. This may involve applying Option 2 in urban areas or where specific infrastructure projects are being undertaken and applying Option 1 in rural or remote areas where the quality of survey data is poor. One strategy across a whole jurisdiction is usually not an effective solution.

Survey database outcomes – Technical

There should be a State approach to statutory governance, standard data structures and workflow guidelines however local management will have a greater understanding of the survey and mapping data and should find it easier to resolve boundary or survey uncertainties.

The basic workflows of data collection & compilation can be undertaken at a local level. The full rigour of the process is available in the local tools but limited experienced resources at that level may mean that the complete checking and validation of survey data may not occur, however, as that experience grows a higher level of data validation can be done locally.

Local Authorities will be micro managing the data that feeds into a macro State Land Administration system. Local data management systems can be initially set up independently so that they have the capacity to feed into a State system that still may be in its formative stages.

Survey database outcomes – Social / Professional

A high level of local SD management will flow through to a greater sense of ownership and pride in the data.

In Developing States, up-skilling local resources in basic measurement and computations will also boost employment in areas away from capital Cities and other main Government Departments. In those jurisdictions local manpower resources are usually much more accessible than commercial technology solutions.

If government resources permit, engaging the local survey profession has a considerable upside. It would firstly provide skilled resources and secondly provide a strong connection between the two sectors. This was evident in the Northern Territory (Australia) where the wide involvement of the private survey practitioners meant they better understood the new (and different) digital workflows and thus supported the government department in its digital initiatives.

Survey Database versus Survey Definition

The SD is the dynamic integration of many individual surveys, possibly thousands and will not produce the same outcome as a survey definition outcome represented by a survey plan.

An individual survey identifies the immediate relationship between monuments and other survey information. New surveys have a stronger weighting than older surveys and the adjustment will endeavour to maintain the geometry relationship identified in the newer survey, however the constraints of a significant number of adjoining surveys will generally slightly vary the new survey.

The only way to hold a specific survey fixed in the adjustment is to nominate a significant number of the points in the survey as control points and hold the coordinates of those points 'fixed' in the adjustment.

In the same way a surveyor makes an intuitive decision to adopt certain monuments and measurements, the surveyor will identify the points to hold fixed and the coordinates to adopt.

As modern surveys are gradually added to an SD, the number of points accurately surveyed on the ground will increase and the model representation will become closer to the true location of the boundary.

This is the progression that will eventually lead to consideration of the SD as having a higher weighting in the chain of evidence in survey definition and when parts of the SD are deemed to be of the highest spatial precision, the coordinates representing boundaries could be considered for legal definition. There are many aspects of governance to be considered before this will occur.

Alignment definition in a Digital Environment.

Representing the definition of a road or other alignments defined in historical survey plans is something that also needs care in the transition to a digital database. A distant occupation or alignment stone provides evidence of a straight alignment extending beyond the immediate surveyed parcels but that alignment point must be referenced by a coordinated point in a database.

This can be misleading in that the coordinated point only represents a direction rather than a specific point in the cadastre. The true digital representations of alignments should only be utilised when two alignments can intersect to identify an angle or corner in the cadastre.

The SD accommodates this by having a unique data feature called a LINE POINT that lies along a boundary or alignment. The line point is not classed as a node in the adjustment so that boundary or alignment is kept as a straight line and in the adjustment does not generate a slight angle at that point.

Adjustment of Associated Feature Datasets.

As a Land Administration SDI moves toward greater accuracy, greater importance is placed on the spatial accuracy of all data. The relationship between infrastructure and other layers was historically referenced to the cadastral layer and by spatially upgrading only the cadastre, that relationship changed. This can be a major issue as stakeholders become more dependent on the Land Administration database.

At the regional and State Level the ESRI Parcel Editor SD tool has the functionality to automatically re-align associated feature datasets as adjustments are made to the cadastral layer, however at some point in the creation of the SD the true relationship must be generated to start that automation process.

That initial synchronization of the cadastre and associated layers requires a strategy involving resources that understand the data and the history as to how it was entered into the system.

Case studies

Several States and many local authorities in Australia use the GeoCadastre tool as a data compilation tool to feed historical survey plan data into their ESRI Parcel Fabric Spatial Data Infrastructure or other industry standard database technologies.

In NSW the technology underpins the automation of the lodgement and quality examination of digital survey plan files creating new titles. A LandXML survey plan file is lodged at the titles office portal and it immediately undergoes many tests of the plan's jurisdictional information and internal geometry quality. This is followed by an automated spatial precision validation process.

In some cases this has resulted in a reduction of the time taken to register a new survey plan from 1-2 months under the existing manual workflows to 3-5 days. Economic benefits then apply to all stakeholders, the state requires less staff resources, receives property based revenue sooner and those looking to create new titles have their development holding costs reduced and their revenue returns are also faster.

In the Northern Territory an operational SD is close to being completely populated with historical survey records. Legislation is in place to allow coordinates to be the prima face survey evidence to legally define Land Titles. This will only happen in areas where the Surveyor General is satisfied that the SD coordinates are of sufficient spatial precision for that purpose.

The Hunter Water Corporation is a local Water & Sewer utility that has been manually entering survey plans into GC for over 15 years. They now have an expansive accurate SD cadastre aligning with accurate location of all their assets. They have recently implemented an ESRI based SDI to allow a higher level of management of their assets and cadastral database.

References

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Tony Sleigh Emergency Information Coordination Unit Department of Lands NSW

Operational benefits of Multi Constellation Dual Frequency GNSS for aviation

This paper summarises recent discussions of the 12th ICAO Air Navigation Conference and ICAO Navigation Systems Panel, and the work done within the SESAR project

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GNSS is a key technology of the communications, navigation, and surveillance (CNS) infrastructure, essential for the introduction of Performance Based Navigation (PBN) and Automatic Dependent Surveillance-Broadcast (ADS-B). It is used in safety related systems such as GPWS (Ground Proximity Warning Systems), and provides the time reference that is used to synchronise many systems and operations in ATM.

Many navigation and surveillance applications (e.g. RNAV 5, RNP APCH or ADS-B) are already deployed on the basis of the excellent GPS service provided free of charge by the US. Around 90 % of the fleet operating in Europe is already equipped with GPS receivers and it is expected to reach 100% before 2020.

The ICAO ANC (Air Navigation Conference) 12th held in Montreal in November 2012 highlighted that as new constellations are deployed, and existing constellations are enhanced, signals from multiple constellations broadcasting in multiple frequency bands are becoming available to aviation. These developments lead to technical performance improvements, which create the potential for achieving significant operational benefits.

Recommendation 6/5 b) from the ICAO ANC 12th highlights the need that the ICAO work programme should address the *"identification of operational benefits to enable air navigation service providers and aircraft operators to quantify these benefits for their specific operational environment "*. At the same time, this Conference noted that the introduction of multi-constellation, dual frequency GNSS entailed a number of new technical and regulatory challenges beyond those already associated with current GNSS implementation.

The European roadmaps for Navigation and Surveillance show the plans for introducing more demanding applications based on GNSS. Taking into account the progressive dependency on GNSS for ATM/CNS applications and the operational benefits that MCDF GNSS will bring, EUROCONTROL policy on GNSS and the European ATM Master plan set a vision based on the combined use of signals coming from at least two constellations in diverse frequency bands that will provide technical capabilities to improve performance, robustness and coverage.

Technical capabilities of MCDF GNSS

The SESAR project 15.3.4 made a technical assessment of the MCDF GNSS capabilities based on performance simulations and the analysis of robustness against identified vulnerabilities (ionosphere and interference). The project also assessed the benefits of integrating GNSS sensors with inertial systems. This assessment identified the following technical capabilities resulting from having additional GNSS satellites from different constellations offering new and better signals in diverse frequency bands:

a) Increased availability and continuity in nominal conditions and in degraded degraded conditions (increased robustness).

Next generation of GNSS avionics will be robust against GPS constellation degradation or unavailability (RAIM holes). They will be able to calculate ionosphere delay in real-time, (due to dual frequency), effectively eliminating this major error source. Additionally it will be less likely that scintillation would result in loss of GNSS service due to the extra ranging sources available in multi constellation scenario. Additionally it will be less likely that un-intentional interference would result in loss of GNSS service.

New GNSS signals will be more resistant to interference due to higher power and improved signal designs. Better and more signals will be available in mountainous terrain/high latitude, making less likely that high terrain or lack of satellites in view would result in loss of GNSS service.

Dual-frequency and Multi Constellation capability will add robustness thanks to backup modes available in degraded modes (alternative frequency and additional satellites from different constellation).

b) Extended service area

For example, EGNOS v3 that is the evolution of EGNOS that will augment GPS L1/L5 and Galileo will enable to extend some services to all ECAC and even to Africa.

c) Supporting more demanding system performance levels

MCDF GNSS will support more demanding system performances that will support new applications or advanced operations that are expected to be developed over time. For example EGNOS V3 is being designed to support system performance levels with a Vertical Alert Limit of 10 meters that could be used to certify CAT I auto-land systems.

d) Independent time reference system

MCDF GNSS will improve availability and continuity of GNSS timing service making aviation less dependent on GPS for time distribution and synchronisation for an increasing number of CNS/ATM systems and applications (e.g. data link, ADS-B, terrestrial communication systems, WAM, 4D NAV,..).

As a conclusion, it can be said that MCDF GNSS will improve performance and enhance robustness to mitigate all the identified vulnerabilities with the exception of intentional interferences. The integration of GNSS with inertial systems as an on board augmentation (ABAS) would be mitigate the impact of interferences but during a limited time duration due to the drift of the inertial systems over time.

Operational benefits assessmemt

A generic assessment has been made to study how the technical capabilities identified in the previous section would result on operational benefits in terms of safety, cost efficiency, capacity and environment. This generic assessment has been customised by representatives of different aviation stakeholders: ANSPs (Aena and Avinor) and Airspace Users (Turkish Airlines, Ryanair, European Business Aviation Association, European Helicopters Association and International Council of Aircraft Owner and Pilot Association) to their individual operational needs. The main operational benefits that have been identified are summarised hereto:

- Improved availability, continuity and robustness for existing CNS applications based on GPS.
  - En-route/TMA: Reduce likelihood of having to revert to DME/DME and/or INS supporting only RNAV not RNP
  - Final Approach: Reduce missed approach rates and likelihood to revert to conventional navaids
- Enable services at remote/oceanic/high latitude areas lacking navaids and/or radar coverage.
- Improved performances to support advances concepts
- Extend service area coverage
- Enable further rationalisation of navaids
- Dual source for time distribution for CNS/ATM systems and applications.
- Possibility to relax airborne requirements (e.g. the possibility of not having to equip with INS to support RNP AR needs to be discussed with EASA position)

"During recent discussions within RTCA,EUROCAE, ICAO NSP on the subject the following additional benefits have been identified for aircraft equipped with MCDF GNSS:

1. No need for aircraft operators to run a RAIM prediction tool that is required today.
2. Possibility to remove the need to equip with sensors for some conventional navaids (e.g. NDB and VOR).
3. Possibility to comply with most stringent ADS-B requirements worldwide (in particular with FAA/US mandate on ADS-B).
4. Potential to benefit from LPV approaches in equatorial areas (e.g. EGNOS v3 could be expanded to Africa providing a LPV service that is not possible with EGNOS v2).
5. Aircraft that are not equipped with SBAS (most Airbus and Boeing) would benefit from a lower minima (LPV) and would avoid QNH setting issues. This would also enable new applications that today we just can imagine e.g. Geometric Vertical navigation in TMAs or use of geometric vertical positioning to support RVSM in the long term"

Conclusions: A cost efficient transition to MCDF GNSS

European aviation is transitioning to use multi-constellation dual-frequency GNSS with augmentations (ABAS, SBAS and GBAS) depending on the phase of flight. It is recommended that standardisation bodies (RTCA, EUROCAE and ICAO NSP) and industry work together to develop an architecture of future receivers integrating all GNSS capabilities (e.g. GPS L5, Galileo and possibly other constellations, new SBAS and RAIM standards) into one box (meaning one MOPS) in order to reduce costs for airspace users when upgrading to MCDF GNSS avionics.

It is also expected that most of the aircraft will be equipped with INS/IRS systems (e.g. assuming costs will become more affordable in particular for GA aircraft). It is recognised that one size does not fit all and this generic baseline has to be considered as a "common denominator" for all aviation stakeholders that will need to be tailored to specific stakeholders depending on individual business and operational needs.

Taking into account the fact that business case for retrofit is negative for airspace users, due to tangible benefits being small and costs associated with the equipment, installation and certification of future GNSS avionics being high, airspace users prefer to upgrade to next generation of GNSS receivers adopting a forward-fit approach. This, however, still assumes that incremental costs of future GNSS avionics when forward-fitting will be reasonable. When applying this forward-fit approach transition, it has to be considered that orders for new aircraft are typically made several years in advance. New generation of avionics/receivers can only be included in these orders when will be ready in terms of availability of approved MOPS, and EASA regulations and certification rules.

A forward fit approach is a cost efficient approach however it implies a long transition period until having the fleet operating in Europe equipped with MCDF GNSS avionics. There is a need that during the transition period GNSS systems offer a service backwards compatible with the current GNSS baseline (GPS L1 and ABAS, SBAS and GBAS augmentations) to provide a service to legacy users.

As a lesson learnt from the past and in order to reduce costs for airspace users these two recommendations are proposed for mandates to be issued in the next decade:

a) Considering that airlines operating outside Europe have to be compliant with mandates from other regions it is recommended that dates and requirements of European mandates are harmonised with other national/regional mandates (e.g. FAA rulemakings).
b) In Europe we have had several regulatory actions (e.g. Datalink, ADS-B and the PBN implementing rule that is under development) that were a de factor GPS mandate but had different requirements and different retrofitting dates. It is proposed that future mandates will take into account all CNS requirements (e.g. 4D NAV with required time of arrival, advanced ADS B applications,..) and will indicate a single retrofitting date.

To take full advantage of the GNSS capabilities, a cost effective transition towards GNSS shall be pursued driven by operational needs with due consideration to safety, technical, security, economic and legal factors. GNSS implementation shall be based on cohesive benefit-driven technical choices backed by realistic system development plans and political commitments.

Considering that there is an effective navigation infrastructure in Europe (e.g. DMEs), the fleet operating in Europe is well equipped with navigation systems and the costs to airspace users of transitioning to a new system are high, it is anticipated that a cost effective transition towards a Multi Constellation Dual Frequency GNSS will be long. However, the positioning and timing performance requirements from different CNS systems/ applications may require mandating retrofitting to MCDF GNSS equipment in the 2030+ timeframe if justified from a performance based perspective.

The transition to MCDF GNSS should adopt a performance based approach and consider the following aspects:

- The operational impact of losing GPS in the 2020 timeframe (after PBN implementation) taking into account the capabilities of Alternative navigation systems (e.g. DME/DME and-or INS).
- Likelihood of having GPS L1 loss taking into account identified vulnerabilities.

Acknowledgements

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For further reference visit http:// www.eurocontrol.int/ and http:// www.sesarju.eu/

Geospatial techniques for modelling the environmental niche of the species

Geospatial tools helped confirm Indian Giant Squirrel presence in the Kanha Tiger Reserve

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A protected area network like Kanha Tiger Reserve, in general, protects and manages a vast spectrum of wildlife. However, the conservation of charismatic large mammals and wildlife of high conservation value tends to overshadow all other wild animals and birds. The perceived ordinariness of these wildlife species in protected areas have also become one of the main causes of their not receiving due attention for detailed systematic studies therein, and rapid decline outside in managed forests. The fauna of Kanha Tiger Reserve (KTR) supports the endangered tiger (*Panthera tigris tigris*) and vulnerable hard ground *barasingha* (*Cervus duvauceli branderi*) and a wide range of larger mammal species and birds. The fauna also includes an amazing arboreal mammal species - Indian giant squirrel (*Ratufa indica* Erxleben). The species belongs to the family *Sciuridae* of order *Rodentia*. The significance of the conservation of Indian giant squirrel in the tiger reserve lies in the endemicity of this mammal species to India and its consequent implications for conservation in managed forests still supporting small populations of this species.

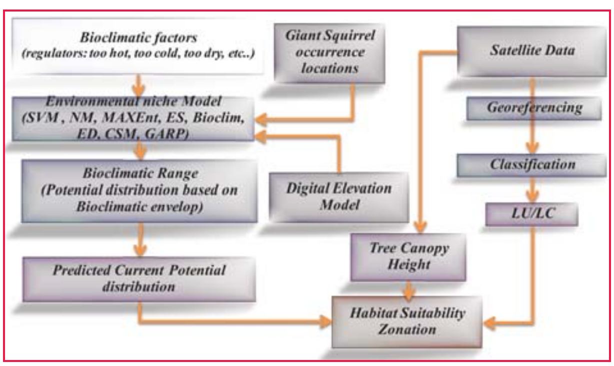

Figure 1: Methodology flowchart

An endemic species to India, it commands a wide distribution in Peninsular India, from evergreen forests to moist and dry deciduous forests of eastern and western ghats to central India (Baskaran *et al*. 2011). The Indian Giant squirrel has been categorised as of Least Concern with decreasing population trend in the Red List of IUCN (Rajamani et al. 2014). It has been placed under Schedule II in the Indian Wildlife (Protection) Act, 1972 (as amended). Ghosh and Bhattacharyya, 1995 described the occurrence of this species in KTR. They, however, recorded only one animal near the Banjar River in the Mukki forest range. Some forest guards and visitors reported its sighting at a few sites in the Supkhar forest range.

Methodology

A systematic procedure was followed for this rapid study of its occurrence. Space Applications Centre, ISRO used the presence record of Mukki and Supkhar forest range sites and Pachmarhi area, along with occurrence records in Western Ghats using global biodiversity information facility (GBIF) repository for training eight different environmental niche models (Bioclim, climate pace model (CSM), environmental distance (ED), Envelope Score, genetic algorithm for rule set production (GARP), maximum entropy (MaxEnt), Niche Mosaic and support vector machine (SVM)). These environmental niche models are aimed at providing a detailed prediction of distribution by relating presence of species to environmental predictors (Araüjo and Williams 2000, Scotts and Drielsma 2003, Mac Nally and Fleishman 2004, Singh *et al.* 2013).

The landuse/ landcover (LU/LC), digital elevation model and tree canopy height were also incorporated with 19 spatial bioclimatic indices (representing hotness, coldness and wetness in the region), to identify potential niche of Giant squirrel with similar climatic and LU/LC preferences (Figure 1). The canopy height information was taken from ICESAT-GLAS LIDAR product as this is an arboreal animal that prefers to live on tall trees. The niche model results were combined in GIS domain, suitably weighted with LU/LC and tree canopy height data to minimize uncertainty and bias in the predictions.

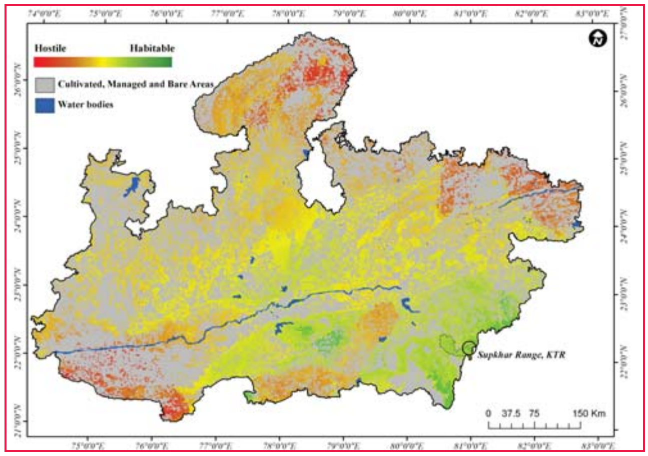

Figure 2: Habitat suitability map of Giant squirrel in Madhya Pradesh

Findings and Action

The model outputs suggest that the fundamental niche of this species could reach as far north as the Satpura hill range of Madhya Pradesh (approx. 22° N) and Dindori Range (approx. 23° N) in Madhya Pradesh. The result supported that parts of the Supkhar range has high habitat suitability for the species (Figure 2). Kanha Tiger Reserve and Space Applications Centre, ISRO, Ahmedabad in a joint campaign on May 20, 2013, recorded presence of three individuals of the Giant squirrel (one being in pair and other in solitary) and many dreys. The map showing Supkhar as one of the most suitable zone in KTR, was used for field verification and opportunistic sightings of the mammal (Figure 3) and *ad libitum* identification of trees within the most habitable zones were recorded. Close observations of the movements of this arboreal mammal for long hours revealed the presence of 20 dreys in several trees species. The GPS coordinates of each of the trees with dreys, along with its species, within one hectare were recorded. Total 50 tree species out of 900 species (Negi and Shukla 2010) in KTR were found in its habitat. Drey presence was recorded on *Ficus racemosa*, *Shorea robusta*, *Syzygium cumini*, *Ougeinia oojenensis*, *Kydia calycina*, *Bauhinia retusa*, *Terminalia tomentosa*, *Mangifera indica*, *Adina cardifolia and Buchanania lanzan*.

In this study, four forest beats were found supporting the nesting sites of the Indian giant squirrel in the Supkhar range. The mammal (Figure 4) was observed to feed on a wide range of plant parts, including fruits, flowers, seeds, young leaves and bark of *Cassia*

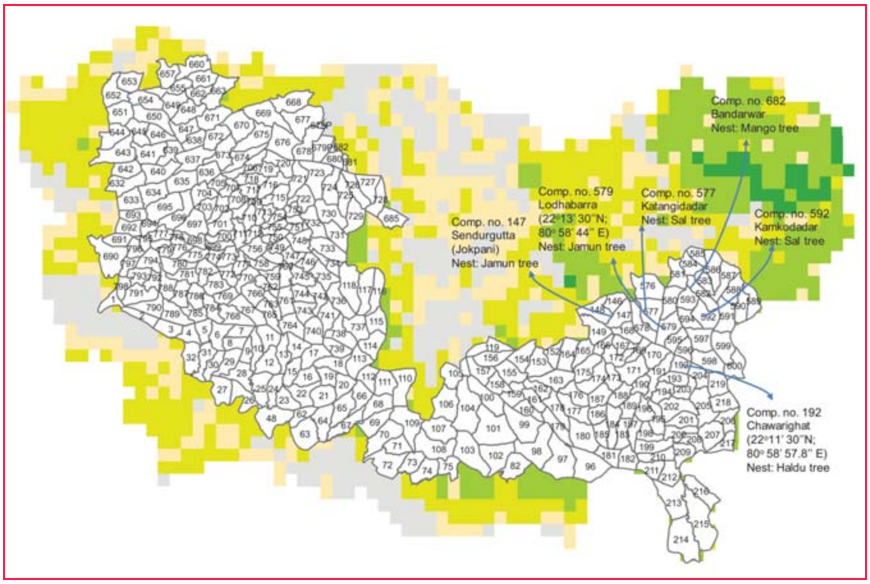

Figure 3: Habitat suitability map of Giant squirrel in KTR with some points of sighting of nests (most suitable area in dark green falling in Supkhar range)

fistula (Amaltas), *Diospyros melanoxylon* (Tendu), *Emblica officinalis* (Aonla), *Ficus bengalensis* (Bargad), *Ficus racemosa* (Umar), *Grewia tiliaefolia* (Dhamin), *Mallotus philippensis* (Sendur), *Mitragyna parvifolra* (Mundi), *Ougeinia oojenensis* (Tinsa), *Schleichera oleosa* (Kosum), *Syzygium cumini* (Jamun), *Terminalia tomentosa* (Saja), *Terminalia chebula* (Harra), *Terminalia belerica* (Bahera) and *Ventilago denticulata* (Keotibel).

Conclusion

The Supkhar forest range of KTR is one of the six forest ranges of the core zone or Critical Tiger Habitat. The forest range typically represents the floral and faunal attributes of the Kanha core zone, with sal (*Shorea robusta*) and miscellaneous forests. The climate of the study site is typical monsoonal, with average annual rainfall around 1,300 mm. Temperature soars to 45°C in summer and may drop to even -2°C for a few days in winter. This bio-climatically unique forest range of KTR showed the maximum value of the fundamental niche indicating potential climatic conditions for Giant squirrel. More such efforts will be required within this fundamental environmental niche to understand its current status and abundance in the area to save it from local extinction. The squirrel is mainly hunted for meat and trade therefore; its habitats need to be specially protected through regular monitoring of all nesting sites.

Acknowledgements

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Figure 4: Giant squirrel on branch of *Mangifera indica* near Bandarwar camp (Lat: 22°15′57″, Long: 81°00′10″)

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Relevance of information technology and urban planning in India: An innovative approach

The extensive usage of ICT technologies are continously transforming our cities and making them more advanced, habitable and livable

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In the mid 1980s, cities around the world had experienced unparalleled changes in their economy, society and environment due to globlization, modernization and urbanization. The process of urbanization is growing rapidly in Indian cities, and it happened for the first time in history that India will have five large states like Tamil Nadu, Gujarat, Maharashtra, Karnataka and Punjab in terms of urban population.

Consequently, these five states undoubtedly enlightened the growth trend of the country's urban population statistics. According to the census, urban population in India increased from about 19% in 1951 to 30% in 2008, and it is expected to increase upto 40% by 2030.

It has been envisaged that the scale of India's urbanization and modernization will be massive in the coming years. India will have 68 cities with a population of more than 1 million, 13 cities with more than 4 million people and 6 megacities with population of 10 million, in which Delhi and Mumbai will be among the five largest cities in the world by 2030. In addition, cities will account for nearly 70% of India's GDP by 2030.

After observing figure 3, it is observed that the gap is continuously widened between the infrastructure services and population growth and its mismatch will lead unendurable development for the future prospects. Presently, Indian cities are facing economic, environmental, social and mobility challenges such as unemployment, improper tax collection, lack of coordination among different agencies, excessive use of energy, inefficient buildings, pollution, natural hazard & risks, solid waste, traffic congestion, parking, increasing number of private vehicles and so on. The current performance of India's cities is poor across key indicators of quality of human life.

After visualizing the above current trends, it is obvious that quality of urban services will deteriorate quite sharply by 2030 and this depreciation of the

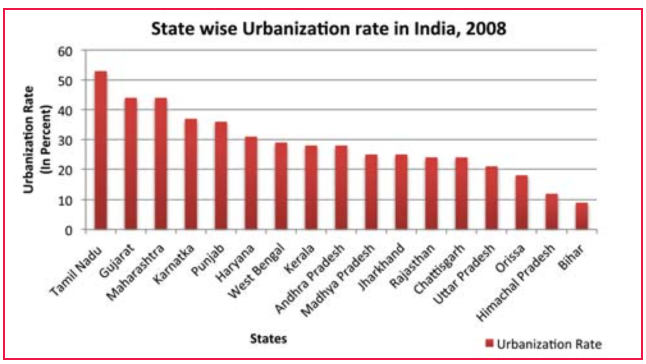

Figure 1: State wise Urbanization rate in India, 2008
Source: Mckinsey Global Institute Analysis

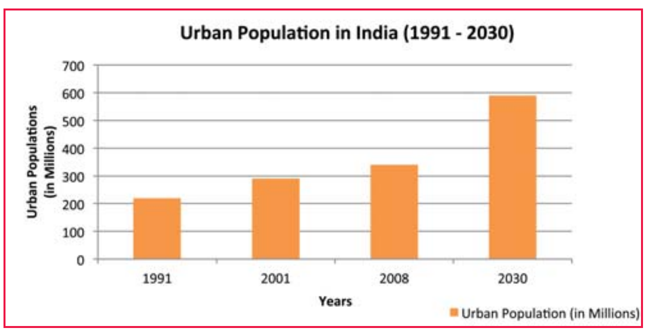

Figure 2: Urban Population in India (1991-2030)
Source: India Urbanization Econometric Model

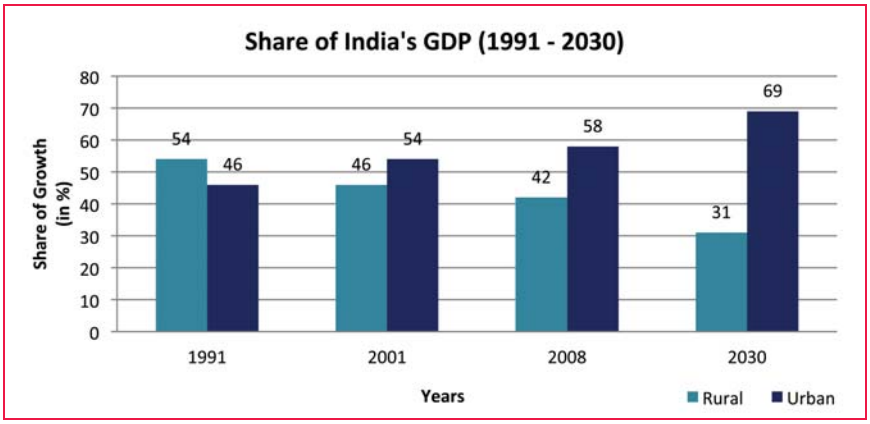

Figure 3: Share of India's GDP (1991–2030)
Source: India Urbanization Econometric Model

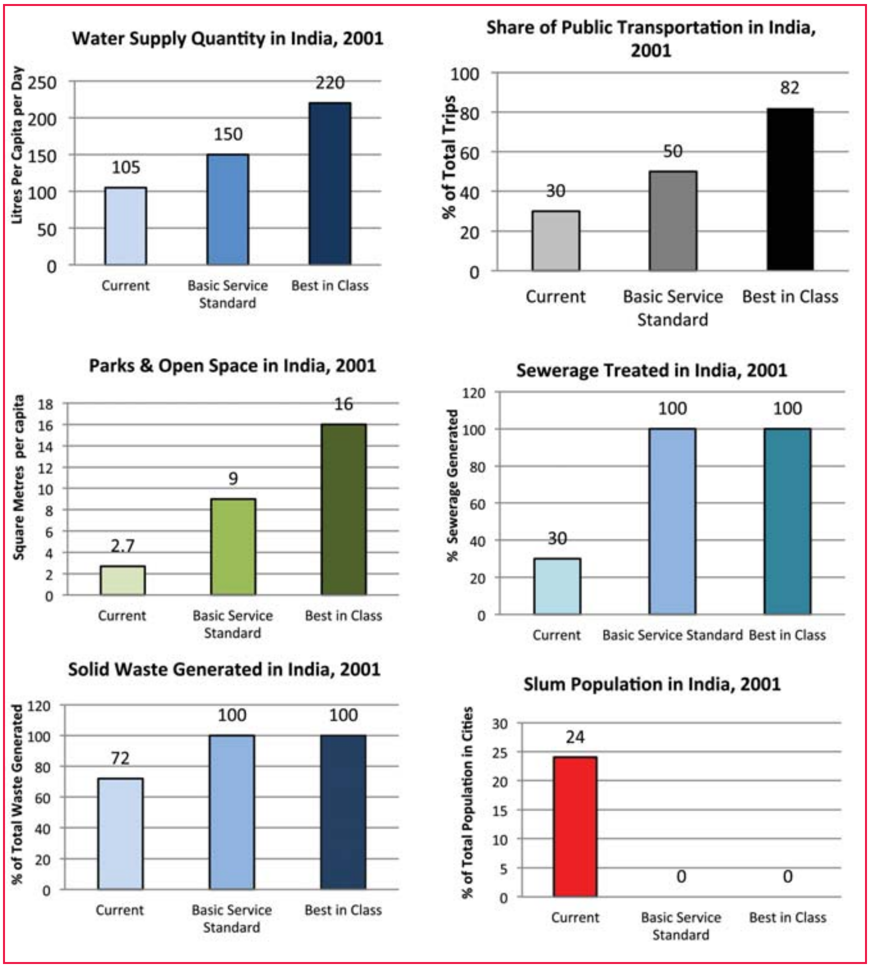

Figure 4: Performance of Indian Cities at different indicators of Quality of Human Life, 2001
Source: India Urbanization Econometric Model

condition of cities will raise several questions before economists, planners, architects, and policy makers, such as how can a city accommodate such a huge population with its limited land resources. Who will be accountable? Where will resources come from? What will be the sector policies regarding economical growth, affordable housing, environment sustainability and infrastructure services, etc. Accordingly, two important changes within the city government is required in order to tackle the above questions. The first shift recommends that cities must become smarter using ICT as both an enabler and provider of city services, the while second important shift lays emphasis on the fact that cities should become more agile or lively, faster and more flexible in identifying challenges, sourcing and implementing new solutions by adopting new faster technologies.

Existing planning mechanisms and tools

Presently, the concept of urban management became a key issue in front of the Indian planner which lays emphasis on rational utilization of resources and sustained growth of urban areas. Although, planners have always offered their best in order to improve the current situation of cities and make them habitable, cities are still growing faster. Planners always promote planned development but in actual, the situation is different on ground, where cities and towns are developing in a haphazard and unplanned way. Similarly, planners always insist on housing to all but the number of people who do not have a shelter keeps on increasing day by day. Consequently, a huge gap has been observed between what the planners had supposed and what happened in reality, and this gap creates a hurdle in the planned development of cities and keeps adding onto the existing challenges instead of resolving them.

For instance, the informal sector is the only key sector that helps in improving the city's wealth and provides livelihood opportunities to the poor. The workers of this sector are mostly employed in construction, manufacturing, trade and other activities. However, the informal sector has a predominant place in the Indian economy in terms of its contribution to the Gross Domestic Product (GDP) and employment. According to the National Sample Survey (NSS) in 2004-05, out of the total workers about 82% in rural areas and approx 72% in urban areas were engaged in the informal sector. Despite such a huge contribution in GDP and employment, this sector has always been abandoned by the policy makers. As a result, it constantly keeps adding to the burden of the urban dilemma over the years. Thus, in order to make a city's development more vibrant and productive, it becomes essential to cater to this sector in the process of planning and decision-making.

The other important aspect is the master plan that is regarded as a tool promoting planned development of a city. Currently, cities are transforming swiftly because of growing concern towards environment and the use of information technologies that made Indian cities more progressive. But in this progressive phase, the master plan seems helpless due to its inflexibility and limited scope. Additionally, it also gives importance to preparation of land use plan rather than addressing the economic, social and environmental issues of the cities. Apart from the above instances, there are several other negative aspects of planning such as lack of people's participation, ineffectiveness of urban governance in terms of financial and technical, urban poverty and slums that need to be considered before preparing a plan. So it is necessary to re-examine the existing planning mechanism and tool in order to check the current as well as future challenges of urban areas.

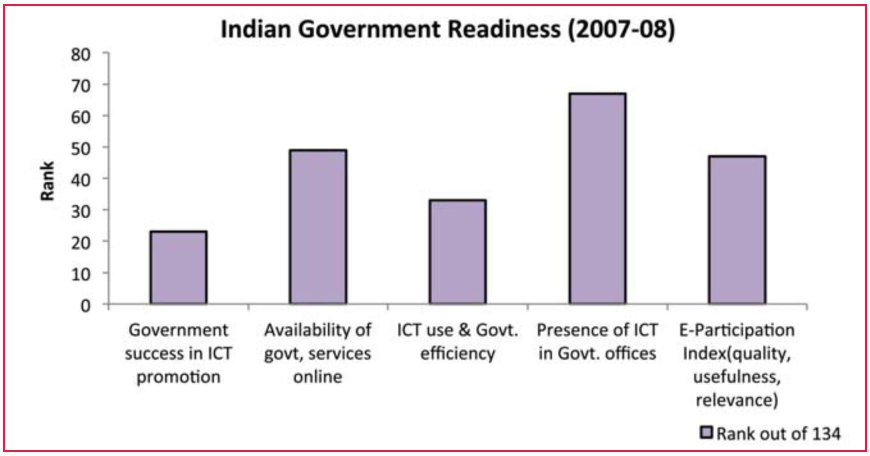

Figure 5: Indian Government Readiness (2007-08)
Source: World Economic Forum & Executive Opinion Survey, 2007-08

Information technology led sustainable urban development

Sustainable urban development means to attain a balance between the development of urban area and protection of environment with equal distribution of employment, shelter, basic infrastructure services, social infrastructure and transportation in urban areas. Presently, cities became known for the hub of environment degradation, depletion of natural resources and the main reason behind this depletion is high densities of Indian cities due to high migration process and natural growth. Thus, in order for an urban area to be sustainable it needs to manage basic infrastructure services in a better and smarter way. Even the basic objectives of the 12th Five Year plans also appeal for a faster growth, inclusive and sustainable development. The whole attention in the plan has been given towards the problem of sustainability and assured that environmental concern is a must in the development process. To attain sustainable growth, the plan has laid down a number of targets such as affordable housing, sustainable livelihood & enterprise, universal access to water and sanitation, affordable public transport, and clean & healthy environment.

Moreover, some strategies have also been given in order to achieve the above target such as strengthen local governance systems, integrate planning organization & process, build capacity across all levels, empower Urban Local Bodies financially, and encourage innovation and technology in urban management. Undoubtedly, the last strategy that promotes innovation has been more effective in transforming the Indian cities for the past few decades.

At present, cities are evolving into such a place where institutions, civil societies and citizens are supported by information and communication technologies. This innovative approach has altered physical communities into the connected ones that will contribute in establishing economic, social and environment sustainability. Thus, it is clearly evident that Information and Communication Technology based techniques have become the key drivers in order to nurture a city's progress towards sustainability.

ICT in Indian context

A shift has been observed in the country's economy from industrial based to knowledge based over the past decades. New strategies for economic and social development are emerging rapidly due to increasing urban growth and introduction of new innovative approach, such as concept of green building, stress on the use of renewable energy & alternative fuels, apply information and communications technologies, low carbon city and so on. Information and communication technologies have provided a stable platform where local authorities can supply better services to citizens by monitoring sensible use of resources across cities. India has been ranked 121st among 157 countries in terms of progress in the area of information and communication technology. This ranking is based on ICT development index which in turn based on three sub indexes which relate to access, skills and use.

The best example of usage of ICT in India is the agenda of E-governance which is considered as the only means of taking IT to the common man. E-governance offers a new style of leadership, new ways of debating, deciding policy, accessing education, listening to citizens, organizing & delivering information and services in order to provide transparent, effective, responsive, efficient and accountable governance to the community. This innovative move demands to incorporate inclusive approach by taking into account the voices of the most vulnerable group of society in the decision-making process. Although, the e-governance initiative has commenced in every state, some of the states have implemented this project successfully and sets an example in front of the other states.

E-Governance projects implemented by various states in India

Green buildings

The construction industry in India is one of the largest economic activities growing at an average rate of 9.5% as compared to global average of 5%. Buildings made under this industry are predominantly influenced by green building movement has gained immense popularity in the world over the last decade. According to the Indian Green Building Council, India has 1.2 billion sq ft of green buildings being built right now, and it is expected to increase up to about 80 billion sq ft by 2030. The reason behind this boom of green buildings is due to the upcoming India's largest infrastructure project, i.e., DMIC which emphasises on maximum use of energy efficient technology and installation of related equipment in the buildings in a smarter way. Mumbai city has India's maximum number of environment-friendly buildings as per a list released by the Indian Green Building Council. The city has more than 60% green building projects compared to Delhi and Bengaluru. With the help of ICT, green building design focuses on maximum use of renewable energy which in turn reduces fossil fuel energy consumption. ICT also helps in building orientation in order to utilize more natural conditions, including sunlight for lighting and heating, and wind for cooling. Once the buildings are completed, ICT will support the maintenance with features like sensors to control design efficiency and energy use.

Smart Grid

Smart grid is emerging as one of the most efficient and reliable technology in the power sector. It works with the grid to respond digitally to the consumer's dynamic electricity demand. ICT-enabled smart grids increase the efficiency of existing power grids by collection, storage and distribution of energy. Smart grid can act together with building control system to provide efficient building heating, cooling and lighting.

Table 1: E-Governance Projects implemented by various States in India
Source: Dwivedi & Bharti, 2005

State	Project	Features	Benefits	Reason behind success
Karnatka	*Bhoomi:* Provides computerized record of rights; Tenancy & crops to farmers in order to obtain bank loans & settle land disputes.	• Computerization of entire 20 million records of land ownership of 6.7 million farmers. • Regional language dominance, i.e., Kannada. • Near 177 taluks and 203 kiosks are developed for supporting the Bhoomi project.	• Kiosks (Bhoomi Center) provide RTC online at a very nominal cost of Rs 15/- only. • Efficiency for getting records of right is very high. • Mutation will takes place within 35 days, whereas in old manual system it will take minimum of 200 days.	• Easy & Fast access of land records. • Efficiency and reliability of record of rights. • Allow citizens to participate and access information with a very nominal cost.
Andhra Pradesh	*CARD* (Computer-Aided Administration of Registration Department)	• Aimed to complete computerization of the land registration process in AP • Ensures transparency in valuation of property and efficient document management system. • Similar initiative found in other states with a different name.	• Almost 90% of registration transactions were performed electronically in Andhra Pradesh.	• Well accepted by the citizens because of its quality and less time for the registration process.
Madhya Pradesh	*Gyandoot:* Intranet in Tribal District of Dhar	• Offers e-governance services, including online registration of applications, rural e-mail facility, village auction site, etc. • Provides services such as Information on Mandi (farm products market) rates, online public grievance redressal, caste & income certificates and Rural Market (Gaon ka Bazaar). • Provides data regarding the families below poverty line.	• Villagers can participate in the decision-making process by using this.	• Citizens can access number of facilities and information on this one-stop-shop at a very nominal cost.
Tamil Nadu	*Vahan & Sarathi*	• Vahan is for processing all transactions related to vehicles and Sarathi is for processing Driving License and related activities.	• Online availability of vehicle information, selling and purchasing of vehicle, transfer of vehicle & address modification, etc., becomes very fast and easy.	• Collection of fees and taxes of registration, license, and permits are fast and efficient also minimizes corruption.

The Uttar Gujarat Vij Company Limited will initiate India's first modernized electrical grid or the smart grid in Naroda and Deesa in North Gujarat. The aforesaid project will study consumer behavior of electricity usage and propose a tariff structure based on usage and load on the power utility. New meters along with sim card will be installed in about 20,000 residential and industrial units in Naroda in order to monitor data within every 15 minutes, or get to know how a particular consumer uses power.

Smart City

In the Shanghai declaration on better cities and better life, it was emphasized that cities should distinguish that information and communication are a must for the vibrant social, economic and cultural life of the city. Every city should link information and communication sector with other multiple sectors to build a strong digital data system for smooth running of urban operations. For instance, Rio De Janeiro city was facing the problem of landslide and flooding due to intense rainfall every summer. In order to get rid of these regular incidents, the city implemented strong ICT-based system to manage disasters and emergencies in a better way. This system prepares the city to respond to flood related incidents while coordinating with multiple agencies on the basis of dynamic data generated from weather sensors, video surveillance and field personnel. Another example of a smart city is Dubuque that led to one of the fastest urban economics turnaround in the US. In 2006, the city introduced a sustainability model with three important premises namely Economic Prosperity, Socio-cultural Vibrancy and Environment Integrity. The 11 principles of this model were smart use of energy, water, power, mobility and other resources, green buildings, etc. Similarly, for the first time in the history of any Indian city, seven smart cities have been proposed in different states with varied locations along the Delhi Mumbai Industrial Corridor and application of ICT has been highly recommended in their evolution process.

Conclusions

Thus, ICT gives new revolutionary ways to our cities in the form of green buildings, intelligent traffic management, new efficiencies in energy consumption, waste management, exchanging information & knowledge and establish communication link among the people. ICT can provide simulation software that can help planners and architects to set up the optimal locations of buildings, schools, health services and public transportation routes to reduce mobility needs and eventually support low-carbon lifestyles. The use of ICT by planners in the field of planning are known as E-planning which presents a platform for using easily accessible public portals in amalgamation with Geographic Information System (GIS) and also facilitates the citizens with the opportunity to participate in urban planning processes.

E-governance is considered as another approach of ICT which allows access to information, time-saving convenience for citizens, and conveys efficiency and transparency in the system. ICT technologies permit cities to save capital expenditures while transforming government employees and citizen behavior to become more sustainable over time. Through E-governance, local governments can become more efficient both in terms of internal operations as well as through their relationships and transactions with citizens, businesses and other levels of government.

Presently, ICT has changed a city's image from being a common city to a virtual city due to the extensive use of Internet. A good website with meaningful content can be a powerful tool to attract business, residents, educational institutions and tourists. At this time, cities are moving towards adoption of new technology, while protecting and preserving the environment, and these technologies have made the city more vibrant and lively. For instance in Spain, a *phytokinetic bus* has been designed that will have a green roof; plants on the roof of the bus will absorb carbon dioxide, produce oxygen and will also increase the efficiency of buses by reducing use of air conditioning.

In the same way, *Waka Waka* foundation has initiated mobile phone charger powered by solar energy for the power crisis area, especially rural areas. This device can easily be carried in a pocket. A number of smartphone apps came into view as an eco-driver in the market to monitor fuel consumption, reduce carbon footprints and check speed, etc. A network of smartphones powered earthquake detectors can be used in urban areas to identify the worst hit areas. Thus, the extensive usage of ICT technologies are continously transforming our cities and making them more advanced, habitable and livable in terms of economically, socio-culturally and environmentally as compared to earlier cities.

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Galileo update

Successful re-certification of German Galileo Test and Development Environment GATE from TÜV SÜD

IFEN GmbH has announced that the German Galileo test and development infrastructure GATE has recently been re- certificated by TÜV SÜD stating the conformance to ISO 17025 as Galileo open-air test laboratory, to receiver integrity testing (RAIM) for Safety-of-Life (SoL) applications and Galileo SIS ICD conformance of signal characteristics and signal quality.

For application tests it is essential for the Galileo Test and Development Environment GATE to provide constant Galileo specifications for tests (like position accuracy, signal spectrum and navigation data). This is essential for both test types: tests with the eight 'GATE satellites' only and tests with simultaneously usage of the already existing Galileo satellites in orbit. The compliance to the specification was recently verified by the company NavCert GmbH from Braunschweig, Germany in a so called re-certification of the GATE test bed. Compared to a full certification, taking part every three years, a re-certification only verifies the compliance to the specification by the use of random inspections though tests in GATE.

Third, fourth Galileo FOC Satellites confirmed fit for Soyuz Launch

The third and fourth Galileo Full Operational Capability (FOC) satellites are a confirmed "fit" for their Arianespace Soyuz launch March 27, having made initial contact with the mission's dual-payload dispenser in French Guiana, according to Arianespace.

The fit check was completed over a two-day period inside the Spaceport's S1A payload preparation building. The two satellites were installed separately, with the Flight Model #3 (FM3) spacecraft integrated on — and subsequently removed from — the dispenser on Feb. 9. Flight Model #4 (FM4) underwent the same process the following day.

The payload dispenser for Galileo was developed by RUAG Space Sweden for Arianespace, and carries one satellite on each side. It will deploy the spacecraft during the Soyuz launch by firing a pyrotechnic separation system to release them in opposite directions at the orbital insertion point.

Final integration on the dispenser is to be performed during upcoming processing at the spaceport, and will be followed by the completed unit's installation on Soyuz.

The March 27 mission — designated Flight VS11 in Arianespace's numbering system — will be the company's fourth launch carrying spacecraft for the Galileo constellation. FM3 and FM4 were built by OHB System, with Surrey Satellite Technology Ltd. supplying their navigation payloads.

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Beidou gets infrastructure boost

Infrastructure that boosts precision navigation and positioning for China's Beidou Navigation Satellite System will be built on Qinghai's Xining and Haidong City. According to the First Institute of Surveying and Mapping of Qinghai, the infrastructure includes base station networks, data processing, broadcasting systems and user terminals. *http://en.yibada.com/*

BeiDou Precision Nav will receive GPS, GLONASS, Galileo Signals

A senior Chinese government space official recently said that precision-navigation user receivers in China will be fitted with chipsets receiving satellite signals from BeiDou, GPS, GLONASS, and Galileo. The move could accelerate the trend among navigation chipset and receiver makers to build gear for multi-constellation reception, and at the same time undermine regional measures to promote one system over others.

Chen Zhi, deputy chief designer of the China Aerospace Science and Industry Corp., said China's early deployment of satellite navigation receivers for precision agriculture already feature multi-constellation GPS-Beidou receivers.

The United States and European Union have signed World Trade Organization agreements for their constellations, GPS and Galileo. China and Russia are not part of the agreements.

NASA study looks to the ionosphere to improve GPS communications

A new NASA study focusing on irregularities in Earth's upper atmosphere may help scientists overcome disruptions in GPS communication. The findings provide an insight into the causes of the disruptive regions, and represent the first time that such observations have been made from space.

The NASA observations, carried out by the Canadian Space Agency's Cascade Smallsat and Ionospheric Polar Explorer (CASSIOPE) satellite, focused on the Northern Hemisphere. They compared turbulence in the auroral regions with that observed at higher latitudes, above the Arctic polar cap.

It was found that irregularities tend to be larger in the auroral region – where they were measured to be between 1 and 40 km (0.62 to 25 miles) – than at higher latitudes, where they measured between 1 and 8 km (0.62 to 5 miles).

The study surmised that the variation between the two regions can be attributed to outside factors, with the auroral regions being exposed to energetic particles from the magnetosphere, while the polar cap region is affected by solar wind particles and electric fields in interplanetary space. This is important information in understanding and mitigating the effects of the irregularities. *NASA*

ICAO recommends new flight-tracking performance standard

Member states of the International Civil Aviation Organization (ICAO) recommended the adoption of a new 15-minute aircraft tracking standard recently. The recommended standard is performance-based and not prescriptive, meaning that global airlines would be able to meet it using the available and planned technologies and procedures they deem suitable.

The concept of operations for the GADSS was developed by ICAO over the course of 2014, following the disappearance of Malaysia Airlines flight MH370 and the special Multidisciplinary Meeting on Global Flight Tracking that ICAO convened soon after. The GADSS concept calls for a three-tiered approach for global aircraft tracking over the long-term, covering normal, abnormal, and distress conditions.

Raytheon GPS ground program passes review, delays still possible

A $1.6 billion ground control system being developed by Raytheon Co for GPS satellites passed a Pentagon review, but will be monitored to ensure it stays on track.

Recently, Raytheon CEO, Tom Kennedy told analysts that problems with the program had been resolved, and he did not expect an 80 percent cost increase to affect the company's financial results.

Michael Gilmore, the Pentagon's chief weapons tester, warned in a report to Congress last month that delays in delivery of the Operational Ground Control System (OCX) posed risks to the Air Force's ability to operate GPS satellites. *http://wtaq.com/*

Russia, China discuss technological compatibility of satellite systems© Sputnik/ Maksim Bogodvid

Russia and China are discussing the compatibility of their satellite navigation systems, Glonass and BeiDou, Glonass' Vice-President of Strategic Development Evgeniy Belyanko.

"At the moment we are discussing the question of technological compatibility of BeiDou and Glonass. This, essentially, will form a unified compatible security system along the China-Europe transport corridor," Belyanko said.

He said that the systems did not have to be identical but it was important that they adhered to the same technical standards, while many elements of the systems could be specific to a particular country. He said that the precise number of joint monitoring stations for the systems is currently being discussed and will be determined on technical grounds, but the number of these stations had to be sufficient to expand the areas of monitoring in both Russia and China. *http://sputniknews.com*

One GLONASS satellite withdrawn for maintenance

Satellite No 732 of GLONASS has been withdrawn for maintenance, the information and analytical center of the Federal Space Agency (Roscosmos) said on its website. In early December 2014, experts registered the satellite's malfunction. The "unhealthy" signs were recorded during an hour in the ephemerides (coordinates) of the Glonass-M satellite No 732, located at the 23rd orbital slot of the GLONASS system's third orbital plane. However, the satellite became operational again within a day. *http://in.rbth.com/*

India Interested in Russia's Glonass Satellite Navigation System

According to Glonass Union president, Russian satellite navigation technologies will be widely used in India in toll paying systems, rapid response emergency systems and asset management.

"At the moment, India is actively developing the market of telematics services… Governmental organizations, including police service, express interest in navigation technologies," the spokesperson told RIA Novosti. *http://sputniknews.com*

FCC shot down the proposal to add GLONASS to GPS system

The US Federal Communications Commission (FCC) doesn't allow the use of non-US satellites, according to Chief of the FCC's Public Safety and Homeland Security Bureau David Simpson. referring to the FCC order, requiring wireless providers to be able to transmit emergency indoor cellphone calls to 911 call centers.

FCC reviewed proposal to add Russia's GLONASS satellite system to the US satellite GPS system to double the coverage of satellites, thereby increasing the probability and accuracy of finding someone making a 911 call. *http://sputniknews.com*

Funding Proceeds for More GLONASS-K1 Satellites

According to its in-house newspaper, *Siberian Satellite*, the joint-stock company "Information Satellite Systems – Academician M.F. Reshetnev" has signed two loan agreements with the Russian VTB Bank (formerly Vneshtorgbank) worth 2.5 billion rubles ($38 million) to finance the production of GLONASS-K navigation satellites. Presumably, this refers to the decision to produce more GLONASS-K1 satellites as recently announced.

Public transport in Krasnodar to use GLONASS

Krasnodar Mayor Vladimir Yevlanov has ordered executives to equip public transport of the city with GLONASS navigation systems. 10 observers monitor public transport on city streets: 3 monitor the Krasnodar Tram and Trolleybus Department (trams, trolleybuses, buses), 4 monitor bus routes of commercial transport, one monitors the hotline, two consult evacuators of private vehicles parked against the law, Yuga.ru reports. Over 90% of the public transport has been equipped with GLONASS systems. The systems will be compulsory for private passenger transport too. *http://vestnikkavkaza.net/news/*

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

March 1, 2015 Signature of publisher

At a Glance

- Global Mapper V16.1 Release
- Tallysman™ Announces Availability of Armoured Cable
- Phase One Industrial Signs Dealership Agreement with C.R. Kennedy, Australia
- Raytheon acquires remote sensing, UAS tech company
- DigPilot relies on Septentrio GNSS RTK OEM Receiver Boards for 3D Machine Guidance System
- Fugro launches G4 positioning system
- The Latin America LBS market is estimated to reach $4123.4 million by 2019
- Bentley acquires Acute3D to Advance Reality Modeling
- Helios opens new office in Slovakia
- European Commission launched EU survey on Earth observation
- 1Spatial Australia launches FME interactive online training
- DigitalGlobe to offer 30cm imagery for commercial use
- Hungary to become ESA member state
- MineSpace, Hexagon partner for SAAS market
- Harris Corporation to acquire Exelis in a $4.75 bn deal
- Xactware Introduces Remote Sensing Lab
- QuickBird satellite mission ends

Porsche offering retrofit navigation system for classic cars

Porsche is offering navigation for its classic cars, with a system designed to maintain the classic aesthetic of its old dashboards. Porsche has decided that owners of its classic cars deserve some of this high-tech help, and has designed a sat-nav system to fit into the dash of cars dating back to the 1960's.

Central to Porsche Classic's new navigation unit is carefully-designed retro looks. These retro-designed elements frame a 3.5-inch touchscreen, which can be used to display maps or, as with most other modern infotainment systems, control a phone connected via Bluetooth. *Porsche*

NTT to roll out indoor navigation using smartphone sensors

Japanese mobile carrier NTT DoCoMo wants to go beyond GPS with a more granular smartphone navigation system for complex indoor spaces.

DoCoMo has partnered with mapping company Zenrin DataCom to develop the navigation system that makes use of sensors in smartphones. It's designed to help users find their way through Japan's dense indoor spaces such as subway complexes or underground malls where GPS signals may not reach.

The new platform uses smartphone motion sensors to track direction when a user walks around. The data is plotted against preloaded maps from Zenrin, which supplies mapping apps for all DoCoMo mobile phones.

Atmospheric pressure sensors, or barometers, in some smartphones can also be used to detect when users of the navigation service climb or descend stairs or use elevators, according to DoCoMo. When that happens, the appropriate map for the floor or outdoor environment is automatically called up. *www.pcworld.com*

Report Card on the U.S. NSD

The Coalition of Geospatial Organizations (COGO) released its Report Card on the U.S. National Spatial Data Infrastructure (NSDI) that depicts the condition and performance of the nation's geospatial "infrastructure" which includes surveyed, mapped and remotely-sensed information. The NSDI Report Card is in the familiar form of a school report card—assigning letter grades that are based on physical condition and needed investments for improvement.

The report card was developed by an expert panel chaired by The Honorable James E. Geringer, former Governor of Wyoming, with Dr. David J. Cowen, John J. Moeller, Dr. John D. Bossler, Susan Carson Lambert, The Honorable Tom D. Rust, and The Honorable Robert T. Welch. *www.cogo.pro*

Western Australian Whole of Government Open Data Policy

The Western Australian Whole of Government Open Data Policy (the Policy) aims to facilitate greater release of government data to the public in appropriate and useful ways to generate value and productivity. A draft of the Policy, which ultimately will be implemented and maintained by the Western Australian Land Information Authority (Landgate) with progress reports to the Minister for Lands, has been released for consultation. As currently written, the Policy would require the "proactive" release of datasets under creative commons licensing, while still reserving the ability of some agencies to charge for "higher value datasets or information that comes with a cost of publication.

Defeating dengue the smart way

Pakistan's Sindh province is working on a dengue prediction system based on surveillance data gathered in real time using a smartphone app and fed into a spatial or geographical model.

The dengue surveillance model using spatial technology was designed by the Pakistan Space and Upper Atmosphere Research Commission (SUPARCO). *http://www.scidev.net/*

Summit Evolution compatible with Global Mapper

The new Global Mapper Extension from DAT/EM Systems International connects Global Mapper® from Blue Marble Geographics® with any edition (Professional, Feature Collection or Lite) of DAT/EM's famous Summit Evolution™ stereoplotter. The extension is provided at no additional cost with any purchased or supported Summit Evolution license. It enables Summit Evolution to be a 3D digitizing device for Global Mapper and allows Global Mapper projects to utilize the tools of Summit Evolution. *www.bluemarblegeo.com/*

CompassData granted ISO 9001:2008 Certification

CompassData has announced that they have received ISO 9001:2008 Certification for Quality Management Systems from Orion Registrar, Inc. It has completed a rigorous audit in which Orion Registrar, Inc. reviewed each step in the firm's quality management methodologies used during the creation of GPS-surveyed ground control and other geospatial products such as orthorectified imagery, DEM, sensor calibrations and GIS map products. *www.compassdatainc.com*

Bluesky Partnership launches air pollution monitoring rocket

A rocket equipped with air pollution monitoring equipment has been launched recently. As part of a wider air pollution mapping project supported by aerial survey company Bluesky, a pollution monitoring system, developed by scientists at the University of Leicester, aims to record how dangerous gases, such as nitrogen dioxide, dissipate with vertical distance from the earth. The micro sensors will be integrated with other technologies and launched into the atmosphere using Starchaser Industries' Tempest Research Rocket. The launch follows previous work mapping air pollution across entire cities from planes, cars and ground sensors. *www.bluesky-world.com*

Mapping illegal colonies in Delhi

The Delhi government has started the process for fixing boundaries of unauthorized colonies to give shape to the promise of regularization. Delhi government has decided to begin the process of regularization with a ground mapping survey which could last a year. Old list of 1,639 unauthorized colonies is now expected to become longer. A notification has already been issued to this effect by the Union urban development ministry. *http://timesofindia.indiatimes.com/*

Romanian New Geoportal

The Romanian government's Topographic Military Directorate (DTM) recently implemented a portal for geospatial data based on Esri technology. The DTM Geoportal is compliant with the established standards of Romania's spatial data infrastructure (SDI) and joins the country's other geospatial data portals including the Infrastructure for Spatial Information in Europe (INSPIRE) Geoportal and the INIS Geoportal. The new geoportal provides quicker access to critical geospatial data and greater collaboration among the agencies the DTM serves, such as the Romanian Ministry of Defense (MoD). *www.esri.com*

White Paper on smart cities spatial information framework by OGC

The Open Geospatial Consortium (OGC) has released a White Paper on smart cities spatial information framework. The paper provides critical guidance on how to plan and implement open spatial standards architectures that guide deployment of interoperable information system components.

It discusses open standards for mobile location communication, 3D urban models, building information models, indoor navigation, augmented reality, and sensor webs. It also gives Smart City system architects insight into how changing computing paradigms, particularly the widespread use of XML and the rise of RESTful programming, figure into Smart City planning. In the paper OGC has discussed the primary steps for developing a spatial information framework for urban spatial intelligence based on open standards such as OGC CityGML, IndoorGML, Moving Features, and Augmented Reality Markup Language 2.0 (ARML 2.0).

Statistics Agency plans Br1.7 billion budget for next census in Ethiopia

The Central Statistics Agency (CSA), Ethiopia has prepared a proposal that includes costs and various work plans to fully carry out the 2016/17 population and housing census of Ethiopia.

The proposal was prepared in June 2014, drawing lessons from the previous population and housing census; it will be submitted to parliament in 2015/16 through Population Census Commission, which is yet to be established by the end of this budget year.

The Commission will have the responsibility of processing, evaluating and analyzing the data collected during the census. It will be chaired by the Deputy Prime Minister and the members of the commission who will be drawn from various Ministries, regional state representatives, the House of Federation, the National Electoral Board of Ethiopia and the CSA, the entire group serving as the Office of the Census Commission (Secretariat).

The cartographic work, which is used to sub-divide regions into enumeration areas to avoid omission or repetition, will be carried out through GIS. *http://allafrica.com/*

Ghana to develop Lands Bill

Nii Osah Mills, the Minister of Lands and Natural Resources, has inaugurated a 17-member special working group to oversee and guide the development of a Lands Bill and associated legislative instruments. The working group forms part of the Lands Administration Project which focuses on facilitating access to land, ensuring security of title to land and enhancing institutional capacity for efficient and effective land administration. Nii Mills said for the past 13 years, Government had been grappling with the drafting and passage of a Lands Bill to consolidate and update the legal framework for an efficient, transparent and sustainable land administration in the country. He said the only way to ensure viable land administration was to reinforce the policy, legal and regulatory framework. *www.businessghana.com/*

High Accuracy and Advanced Field Work with Latest SuperSurv

Supergeo has announced the latest SuperSurv (Android), the GIS mapping app, which not only allows users to connect with and operate external Bluetooth GNSS devices, but also elevates field work efficiency with new averaging algorithms. It is an efficient mobile GIS App designed for field data collection on Android and iOS-powered devices. *www.supergeotek.com*

Agency9 brings WebGL streaming of 3D cities to iOS and Android

Agency9 has extended its 3DMaps WebGL support to iOS and Android devices. Large highly detailed 3D city models can now be streamed to web browsers on both tablets and smartphones with both high performance and visual quality. Mobile support substantially improves reach in GIS and planning applications. *www.agency9.com*

EMU researcher awarded $1.5 million grant

Yichun Xie ,director of Eastern Michigan University's Institute for Geospatial Research and Education, recently won a $1.5 million grant from the National Science Foundation to work with 120 Michigan teachers to integrate GIS applications into their curricula and thus enhance career possibilities for their students. Participating teachers will be selected in partnership with the Michigan Math and Science Networks. *www.heritage.com*

FAA grants Pravia Precision Ag UAS exemption

The FAA has posted two grants of exemption for Niceville, Florida-based Pravia to operate the eBee Ag and E384 small unmanned aircraft systems for precision agriculture applications for a domestic agricultural seed company. The proposed operations will include biomass analysis and estimation, yield monitoring, leaf area indexing, and reporting of geographical data and overall crop health.

Sentinel-2A: New eyes of Copernicus ready for space

After six months of intensive testing, the first Sentinel-2 satellite developed and built by Airbus Defence and Space for the European Space Agency (ESA) is getting ready for its mission in space. Sentinel-2A will be the second satellite of the Copernicus programme to be launched. The Copernicus Sentinels supply remote sensing data of the Earth to deliver key operational services related to environment and security. *www.airbusdefenceandspace.com*

DigitalGlobe, UNOOSA to collaborate

DigitalGlobe has signed a MOU with the United Nations Office for Outer Space Affairs (UNOOSA) to combine their expertise in the use of earth observation technologies for economic, social, and scientific development and improved decision-making, particularly in developing countries. Both will work to develop an online platform to provide easy access to imagery catalogues as well as data and analytical services specifically tailored for the needs of the UN. *DigitalGlobe*

Tapan Misra to head Isro's Space Applications Centre

Eminent scientist Tapan Misra has been appointed the chief of Isro's Space Applications Centre (SAC), Ahmedabad, India. Misra, deputy director of the microwave remote sensing area in SAC, succeeds A S Kiran Kumar, who was appointed as the chairman of Isro last month. *http://timesofindia.indiatimes.com*

Base map of Middle East using Landsat 8 imagery released

PlanetObserver has released a new range of country base maps of Middle East processed from fresh Landsat 8 imagery. The PlanetSAT 15 L8 maps offer 15-metre resolution, processed in natural colours from orthorectified Landsat 8 imagery.

PCI Geomatics Implements Support for KazEOSat-1

PCI Geomatics has implemented support for KazEOSat-1, an Earth Observation satellite owned and operated by the Kazakhstan Gharysh Sapary (KGS), a division of Kazcosmos. KazEOSat-1 is capable of producing imagery of up to 1-meter panchromatic and 4-meter multispectral. *www.pcigeomatics.com*

DARPA to monitor Arctic land, sea, and air traffic

Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., released a solicitation for the Future Arctic Sensing Technologies project, which seeks to capitalize on commercially developed technologies to monitor the Arctic region for military activity. For this project DARPA remote sensing experts are asking for proposals for low-cost unmanned air, surface, and subsurface sensing systems for the Arctic, including ways to deliver sensor information to remote sites.

The Arctic increasingly sees military and commercial activity, yet U.S. capabilities to monitor these activities are limited, DARPA researchers say. The Arctic has little fixed infrastructure to support sustained operations, and remote-sensing systems must be rugged and durable enough to operate in the harsh Arctic cold. *www.fbo.gov*

Indian state MP to get national award for remote sensing plan

The Union Government of India has selected Madhya Pradesh for National Award in the category of Best Practices in the remote sensing plan while lauding innovations being adopted for result-oriented implementation of Integrated Watershed Area Management Programme. Watershed projects in the State are being implemented under Integrated Watershed Area Management Programme. It is funded by Land Resources Department of Union Rural Development Ministry. Its main objective is conservation and augmentation of water as well as soil conservation in areas of rain-fed agriculture so that increase in agriculture production and sustainable rural livelihoods can be ensured. Apart from surveys like PRA and Net Plan, planning based on remote sensing and GIS has also been adopted. Android mobile-based application 'WMGO' is being used ensuring quality of watershed works and their constant monitoring. *www.nyoooz.com*

NASA launches groundbreaking soil moisture mapping satellite

NASA successfully launched its first Earth satellite designed to collect global observations of the vital soil moisture hidden just beneath our feet. The Soil Moisture Active Passive (SMAP) observatory, a mission with broad applications for science and society from Vandenberg Air Force Base, California, on a United Launch Alliance Delta II rocket. SMAP now begins a three-year mission that will figuratively scratch below Earth's surface to expand our understanding of a key component of the Earth system that links the water, energy and carbon cycles driving our living planet. SMAP's combined radar and radiometer instruments will peer into the top 2 inches (5 centimeters) of soil, through clouds and moderate vegetation cover, day and night, to produce the highest-resolution, most accurate soil moisture maps ever obtained from space. *www.spacedaily.com*

Agreement between Sagem and HAL

Hindustan Aeronautics Ltd (HAL), India has signed a technology transfer agreement with Sagem (Safran) concerning the manufacture and maintenance in India of Sagem's SIGMA 95 laser gyro navigation systems.

SIGMA 95 is an autonomous, hybrid laser gyro inertial/GPS-Glonass navigation system. It stands up to severe environments, and gives military aircraft a high degree of navigation precision and operational flexibility, thus supporting the success of even the most demanding missions, including in areas without GPS signals. HAL will be able to produce SIGMA 95 units for the Indian air force, and also provide "level 3" front line maintenance. *www.sagem.com*

Dual-Antenna, Dual-Frequency RTK GNSS Receiver by NovAtel®

NovAtel Inc. announced the FlexPak6D™ enclosed GNSS receiver, a flexible dual-antenna solution for application developers seeking a high precision heading-capable positioning engine for space constrained applications. This compact, lightweight receiver tracks GPS, GLONASS, Galileo and BeiDou. Antenna placement is flexible which means the antenna baseline can be set according to space available on the vehicle and the heading accuracy required. In addition, the modular nature of the FlexPak6D's OEM6® firmware provides users with the ability to configure the receiver for their unique application needs. Scalable for sub-metre to centimetre-level positioning, the FlexPak6D delivers NovAtel's ALIGN® precision heading and relative heading firmware, as well as our GLIDE™ firmware for smooth decimetre-level pass-to-pass accuracy, and RAIM for increased GNSS pseudorange integrity. *www.novatel.com/flexpak6d*

Phase One Industrial Releases iX Capture 1.2

Phase One Industrial, a leading manufacturer of medium format aerial photography equipment and software solutions released Phase One iX Capture 1.2, a control, capture and RAW conversion application designed specifically for aerial photography. *http://industrial.phaseone.com/downloads*

Ellipse-D Dual-Antenna mini INS/GNSS

The new Ellipse-D is now available for order. It is a miniature Inertial Navigation System with embedded dual-antenna Survey-grade GNSS receiver for unmatched orientation and position accuracy. This amazing sensor is immune to magnetic disturbances and provides accurate heading even under low dynamics.

xNAV550 dual frequency miniature INS from OxTS

OxTS Ltd. has released the much anticipated xNAV550, the latest in the xNAV series of miniature inertial navigation systems. Adding survey-grade GNSS receivers to the package, it can achieve centimetre-level position accuracy with RTK corrections. It also retains the benefits of the other xNAV models such as dual antennas for stable heading performance, 4 GB internal storage and automatic logging, and a rugged compact enclosure weighing a total of just 465 g.

Settop battery for ADL vantage and TDL450L radio modems

Settop Survey has announced the release of the unique and innovative Settop Battery compatible with Pacific Crest®'s ADL Vantage Radio and Trimble®'s TDL450L. The newly designed carbon fiber battery combined with the latest Lithium Ion technology, revolutionizes the concept of power supply for these radios, this benefits the user by reducing the cables normally required by powering the GPS and Radio from the same battery built into the radio itself. The carbon fiber design allows considerable reduction of the systems weight without sacrificing any of the rugged reliability and durability of the battery when performing at 4 watts of transmit power. *www.settopsurvey.com*

Trimble® SG160-09 SeismoGeodetic system

Trimble India has introduced an integrated GNSS reference receiver, broadband seismic recorder and a force-balance triaxial accelerometer for infrastructure and precise scientific applications—the Trimble® SG160-09 SeismoGeodetic system. It provides real-time GNSS positioning and seismic data for earthquake early warning and volcano monitoring as well as infrastructure monitoring for buildings, bridges, dams as well as other natural and manmade structures.

The system includes both the SG160-09 and utilization of Trimble's CenterPoint™ RTX™ correction service, which provides on-board GNSS point positioning. Based on Trimble RTX technology, the service utilizes satellite clock and orbit information delivered over cellular networks or Internet Protocol (IP), allowing cm-level position displacement tracking in real-time anywhere in the world.

Trimble's R1 GNSS receiver enables high-Accuracy Data Collection

R1 GNSS receiver is a pocket-sized, rugged, standalone receiver that works with iOS, Android or Window® mobile handhelds, smart phones and tablets using Bluetooth® connectivity. When paired with a smart device, the receiver adds professional-grade GNSS geo-location capabilities to transform consumer devices into high-accuracy mobile data collection systems. With the evolution of smartphones and tablets, more field workers now have access to positioning technologies for geospatial data collection. The Trimble® R1 GNSS receiver is an ideal choice to collect data and inspect or manage assets using smart devices without an integrated high-accuracy GNSS receiver. *www.trimble.com*

Apogee Series, MEMS Inertial Navigation System

SBG Systems has released the Apogee Series, the most accurate inertial navigation systems based on the robust and cost-effective MEMS technology. It is also the smallest and lightest inertial navigation system at this level of accuracy. High Accuracy, cost-effective, compact, the Apogee adds extreme versatility and simplicity to its many qualities. *www.sbg-systems.com*

Topcon introduces Android app for LN-100 Layout Navigator

Topcon Positioning Group has announced the release of a new app MAGNET Construct designed to drive the LN-100 Layout Navigator system — MAGNET® Construct. The no-cost app, available for the Android market, is built to provide "out-of-the-box" productivity with LN-100W hardware. MAGNET Construct offers optional connectivity with MAGNET Enterprise for real-time data exchange from active project sites to and from the office within a user's private company account.

Integrated GNSS Master (IGM) solution

Microsemi Corporation is offering a new Integrated GNSS Master (IGM) solution for small-cell synchronization. The IGM is the company's first solution that fully integrates a 1588v2 PTP grandmaster with a GNSS receiver and antenna in a small, fully contained package, designed to mount indoors. It solves the challenge of indoor synchronization, which has been a significant hurdle for cost-effective small cell indoor deployments. According to the Small Cell Forum, 80 percent of small cell needs are for indoor use.

GPS Source's Newest GNSS Antenna can take the extremes

GPS Source released a new GNSS Antenna, which is robust, lightweight, suitable for harsh environments and long-term, high-precision applications worldwide. It features a MIL-STD design allowing the antenna to be used in the most rugged of environments. The signal reception is unaffected by placement of the antenna. *http://satnews.com/*

150 layers of info: GIS to help map Bengaluru's wards

The BS Patil committee on Bengaluru restructuring has initiated the setting up of this Geographic Information System - dubbed BASIC (Bangalore Spatial Info Centre) - at a cost of Rs 43 lakh for the Bengaluru region, in India including the areas covered by the Bengaluru Development Authority . The committee, in partnership with Infrastructure Development Corporation of Karnataka (I-DecK), tendered out the GIS project last month and work on it began last week. The GIS will map about 150 layers of information for each ward. These include both major and minor details like major roads, green cover, drains, hospitals, blood banks, lakes, bus-shelters, manholes, clubs, fire and police stations. *http://articles.economictimes.indiatimes.com*

New L1 L2 GPS GLONASS Active Antenna by Maxtena

Maxtena has launched an L1 L2 GPS/GLONASS active helix antenna for GNSS satellite applications. The new antenna M1227HCT-A2-SMA will replace its predecessor the M1227HCT-A-SMA antenna, which made its debut in 2010. It is packaged in a high-quality, durable IP67/68 sealed radome housing and terminated with a gold-plated SMA connector for RF feed/input and DC bias/power typically powered from the applications' GNSS RF module.

TeeJet launches Precision Ag GNSS receiver

The new RX520 dual-frequency GNSS receiver from TeeJet Technologies brings reliable, upgradable accuracy and performance to precision farming applications. It features an integrated L1/L2 GPS+GLONASS receiver and antenna in a single compact enclosure. Integral magnetic mounting allows for a clean, low-profile installation. All RX520 receivers include ClearPath technology, which ensures smooth, consistent position data even if brief signal losses occur. The standard L1/L2 SBAS receiver offers +/-5-8 in pass-to-pass accuracy for a wide variety of field operations.

Sokkia introduces GCX2 receiver

Sokkia introduces the latest GNSS integrated receiver designed for lightweight and convenient field operation — the GCX2. The multi-constellation and dual frequency receiver is designed to offer affordable high-quality results for traditional applications in the surveying and construction fields — as well as unconventional utilizations such as in landscape architecture, GIS, BIM and forensic mapping. *www.prweb.com*

Airbus Defence and Space to build SES-14 satellite

Airbus Defence and Space has been awarded a contract by SES, one of the world's leading satellite operators, to design and develop SES-14, a highly innovative telecommunications satellite. It will be based on Airbus Defence and Space's ultra-reliable Eurostar platform in its E3000e variant, which exclusively uses electric propulsion for orbit raising (EOR), taking advantage of the reduction in mass that this technology enables with an exceptionally large payload. *www.airbusdefenceandspace.com*

GEOS wins European Commission's €12 mn contract

e-GEOS has been awarded a contract from the European Commission worth €12 million to provide satellite maps for emergency management. The contract, identified as Copernicus Emergency Management Service - Rapid Mapping, will be active in the period 2015-19. This is the operational service of the European Copernicus programme for Earth observation and is unique at a global level in the field of emergency.

MARK YOUR CALENDAR

March 2015

SPAR International
30 March - 2 April
Houston Texas, USA
http://www.sparpointgroup.com/

April 2015

European Navigation Conference 2015
7 – 10 April
Bordeaux, France
http://enc-gnss2015.com/

The World Cadastre Summit, Congress & Exhibition
20-25 April
Istanbul, Turkey
http://wcadastre.org/page/45-en-home

Interexpo GEO-Siberia-2015: Open-Source Geospatial Solutions for Public Benefits
20 – 22 April
Novosibirsk, Russia
http://expo-geo.ru/event/4-Interekspo_GEO-SIBIR/

2015 Pacific PNT Conference
20 – 23 April
Honolulu, HI United States
www.ion.org/

The 9th International Forum on Satellite Navigation & NAVITECH-2015 exhibiton
April 22-23
Moscow, Russia
http://www.glonass-forum.com/

May 2015

AUVSI's Unmanned Systems 2015
4-7 May
Atlanta, USA
http://www.auvsi.org/

RIEGL LiDAR 2015 Conferences
5 – 8 May
Hong Kong and Guangzhou, China
www.riegllidar.com/

MundoGeo Connect
May 5 to 7, 2015
Sao Paulo - Brazil
http://mundogeoconnect.com/2015/en/

Baska GNSS Conference 2015
10 - 12 May
Baska, Krk Island, Croatia
www.baskagnssconference.org

10th National GIS Synposium in Saudi Arabia
11 - 14 May
Dammam, Saudi Arabia
www.saudigis.org

6th China Satellite Navigation Conference
13 - 15 May
Xi'an, China
www.beidou.org

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

UN/Russian Federation Workshop on theApplications of GNSS,
18 - 22 May 2015
Krasnoyarsk, Russian Federation

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

June 2015

HxGN LIVE Las Vegas 2015
1 – 4 June
Las Vegas, Nevada USA
http://hxgnlive.com/las.htm

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

July 2015

IGNSS 2015
14-16 July
Queensland, Australia
www.ignss.org

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

August 2015

UAV-g 2015
30 August - 2 September
Toronto, Canada
www.uav-g-2015.ca

September 2015

ION GNSS+
14-18 September
Tampa, Florida, USA
www.ion.org

INTERGEO 2015
15 – 17 September
Stuttgart, Germany
www.intergeo.de/intergeo-en/

October 2015

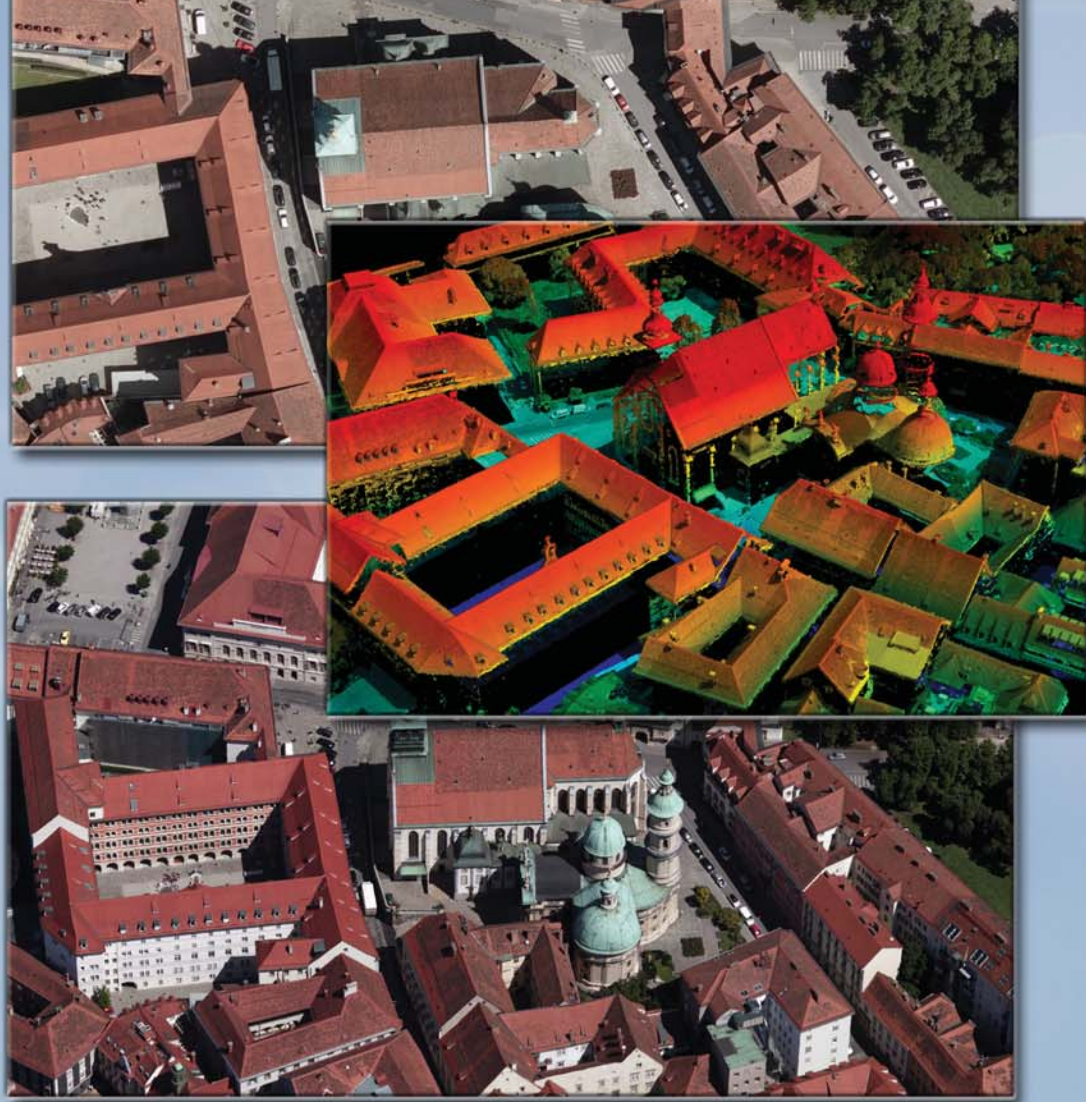
DIGITAL EARTH 2015
October 5-9
Halifax, Canada
www.digitalearth2015.ca

Commercial UAV Expo
5 - 7 October
Las Vegas, Nevada, USA
www.expouav.com

2015 IAIN World Congress
20 – 23 October
Prague, Czech Republic
www.iain2015.org

November 2015

ISGNSS 2015
16 - 19 November
Kyoto, Japan
http://www.isgnss2015.org/



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