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

No: DL(E)-01/5079/14-16
Licensed to post without pre-payment U(E) 28/2014-16
Rs.150

ISSN 0973-2136
www.mycoordinates.org

Coordinates

Volume XII, Issue 02, February 2016
THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

International lessons for land administration in Nepal?

Wherever You Are

SP60

The most versatile GNSS solution

Challenging environments will no longer be a nightmare for you or your crew. The Spectra Precision SP60 is a new generation GNSS receiver offering a high level of flexibility to cover any survey demand from simple post-processing, through UHF or Long Range Bluetooth base and rover systems to sophisticated RTK and RTX rover solutions. Combining the unique all-signals-tracking and processing Z-Blade GNSS-centric technology and L-band capability for satellite-delivered CenterPoint® RTX service, the SP60 GNSS receiver provides the most reliable measurements and the highest possible accuracy under any conditions, anywhere in the world.

SP60 : Simply Versatile

Features

- **Extended survey scalability**
- **New 240-channel 6G ASIC**
- **Z-Blade GNSS-centric**
- **CenterPoint® RTX capable**
- **Internal TRx UHF radio**
- **Long Range Bluetooth**
- **Anti-theft protection**

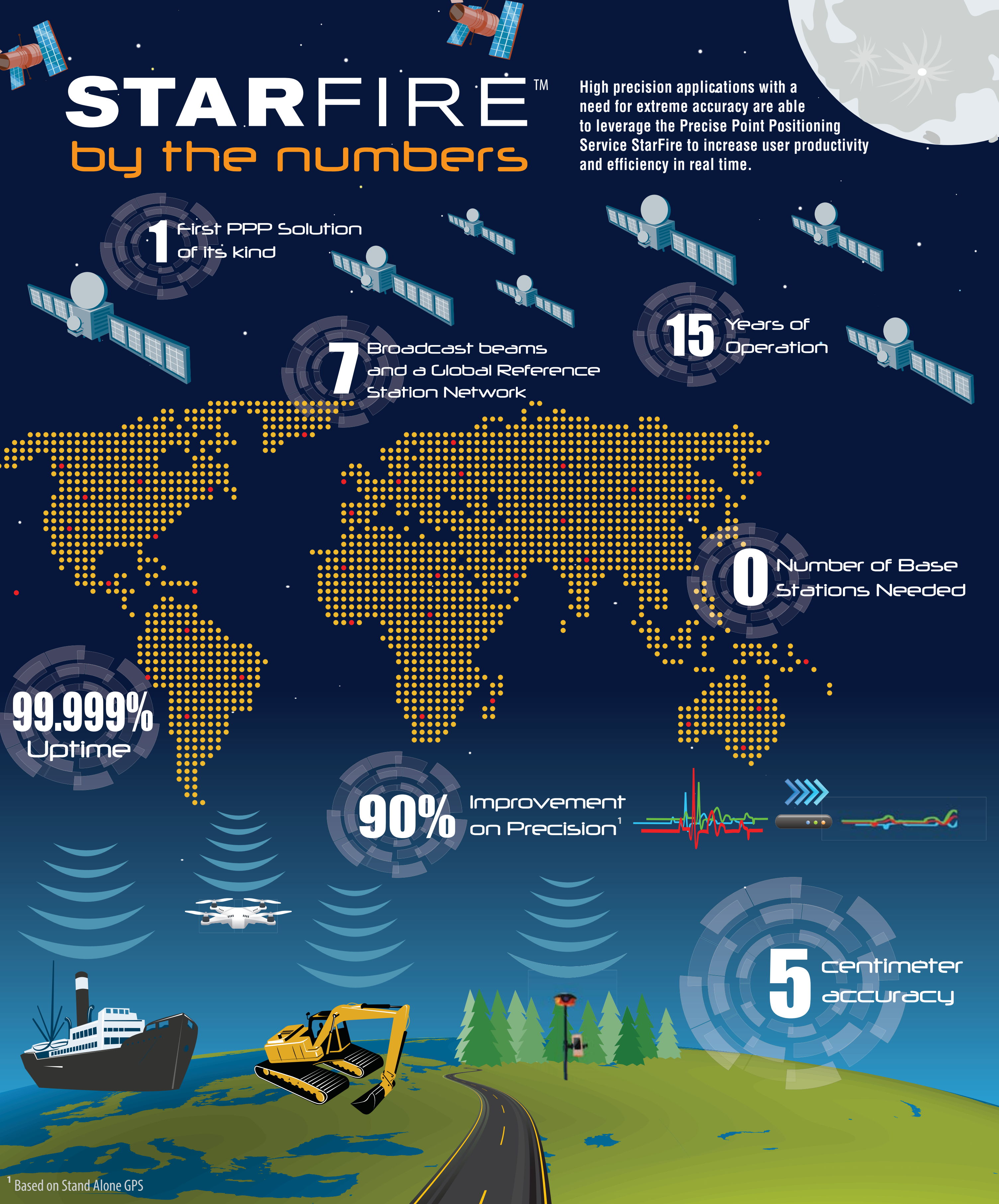
Z BLADE TECHNOLOGY INSIDE

SPECTRA PRECISION

AMERICAS: +1-720-587-4700 or 888-477-7516 (Toll Free in USA)
EUROPE, MIDDLE EAST AND AFRICA: +33-(0)2-28-09-38-00
ASIA-PACIFIC: +65-6348-2212

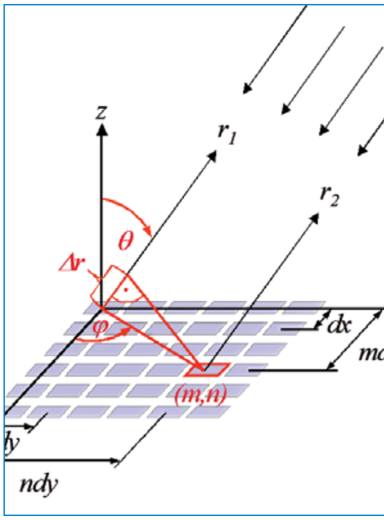
www.spectraprecision.com

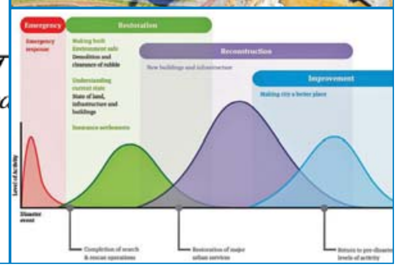
CONTACT YOUR LOCAL SPECTRA PRECISION DEALER



Join others around the globe and learn more at:
www.navcomtech.com/starfire

NAVCOM
A John Deere Company





In this issue

Coordinates Volume 12, Issue 02, February 2016

Articles

Columns

This issue has been made possible by the support and good wishes of the following individuals and companies
Ananda Fowler, Anindya Bose, Bernd Eissfeller, Chris Rizos, David Mitchell, Donald Grant, Fabio Dovis, Günter Heinrichs, Hiroshi Shinohara, Nobuaki Kubo, Raghupati Shukla, Reha Metin Alkan and Thorsten Lück; Effigis, HiTarget, IP Solutions, Javad, Navcom, Microsurvey, Pentax, Riegl, Spectra, and many others.

Mailing Address
A 002, Mansara Apartments
C 9, Vasundhara Enclave
Delhi 110 096, India.
Phones +91 11 22632607, 98102 33422, 98107 24567
Fax +91 11 22632607

Email
[information] talktous@mycoordinates.org
[editorial] bal@mycoordinates.org
[advertising] sam@mycoordinates.org
[subscriptions] iwant@mycoordinates.org

Web www.mycoordinates.org

Annual subscription (12 issues)
[India] Rs.1,800 [Overseas] US$100

Printed and published by Sanjay Malaviya on behalf of Coordinates Media Pvt Ltd
Published at A 002 Mansara Apartments, Vasundhara Enclave, Delhi 110096, India.
Printed at Thomson Press (India) Ltd, Mathura Road, Faridabad, India

Editor Bal Krishna
Owner Coordinates Media Pvt Ltd (CMPL)
Designed at Spring Design (ajay@springdesign.in)

This issue of Coordinates is of 52 pages, including cover.

HI-TARGET Surveying the world, Mapping the future

ZTS-360R

Total Station

Compact, lightweight design
High-performance MCU STM32
Powerful 600m reflector-less measurement capability
Dust and water protection IP66

ps bedi SECURECOM

FC CE IP66

www.hi-target.com.cn
info@hi-target.com.cn

Hi-Target Authorized Distributor in India

PS Bedi SecureCom Pvt.Ltd.
D-14/2, Okhla Industrial Area, Phase-I, New Delhi-110020
Tel: +91 11 46055200
Fax: +91 11 41552911
Email: surveying@psbedi.com

Touring Kyoto

With actual location of the bus

And real time tourist information

In your own smart phone

Using Quasi-Zenith Satellite System (QZSS) signals

Was an apt application

Specially developed for the benefit of delegates

Of the International Symposium on GNSS 2015.

QZSS, still in evolving stage

When put for such and many other uses

Does provide a cue

About the myriad potential it holds.

Bal Krishna, Editor
bal@mycoordinates.org

Navigating Kyoto

Quasi-Zenith Satellite System Service Co., Ltd. (QSS) has proposed a system to provide tourist information in a timely manner for international tourists, and has demonstrated its potential

Hiroshi Shinohara
Director
Quasi-Zenith Satellite System Services Inc.
Japan

On November 18, 2015, the Quasi-Zenith Satellite System Service Co., Ltd. (QSS) conducted an experiment in Kyoto, Japan using a quasi-zenith satellite system (QZSS) in collaboration with the GNSS International Symposium, IS-GNSS2015, in order to verify the effectiveness of the QZSS in providing highly accurate bus location information and tour information for participants on a sightseeing bus tour.

The QZSS is an exclusive GPS compatible navigation system that is being developed under the jurisdiction of the Government of Japan.

The QZSS satellite positioning service system for this experiment consisted of 3 Quasi-zenith satellite orbit (QZO) satellites and 1 Geostationary orbit (GEO) satellite. Table 2.1-1 shows transmission signals.

The positioning signals, L1C/A, L1C, L2C and L5 are compatible with GPS, the augmentation signals, L1S and L6, reduce positioning error, and a messaging service is expected to be used for disaster recovery. The coverage area is focused on the Asia-Oceania region as well as Japan.

The first Quasi-Zenith Satellite (QZS-1), MICHIBIKI was launched on September 2010, and an additional 3 satellites (2 with QZO and 1 with GEO) are planned to be launched so that a 4 satellite constellation will provide the service. The Japanese government plans a 7 satellite constellation by 2023.

Table 1: QZSS service overview

Category	Service name	Service overview
Navigation service	Satellite positioning service (L1-C/A,L1C,L2C,L5)	• The transmitted signals are L1C/A, L1C, L2C and L5 signals which will be compatible with the signals of GPS Block III.
	Sub-meter Level Augmentation Service (L1S)	• DGPS correction data which provides pseudo-range for each satellite at the location of the reference station. • Positioning accuracy (95%) • Horizontal 1-2m, Vertical 2-3m • At the launch of the service, the coverage area is limited to Japan. • It is expected that this service will be used for ITS.
	Centimeter Level Augmentation Service (L6)	• High-precision positioning information calculated from GEONET (GNSS Earth Observation Network system)* is transmitted via QZS as an L6 signal to achieve positioning accuracy within a matter of centimeters. * Geospatial Information Authority of Japan (GSI) operates GNSS-based control stations that cover the Japanese archipelago with over 1,300 stations. • Positioning accuracy (95%) • Horizontal 6-12cm, Vertical 12-24cm • It is expected that this service will be used for Surveying, Agriculture and Civil engineering construction.
	Positioning Technology Verification Service (L5S)	• The service is to provide an application demonstration for new positioning technology. • R&D tests of L5 SBAS.
	SBAS Transmission Service (L1Sb)	• This service will transmit the SBAS signal that is provided from the JCAB.
Message service	Satellite Report for Disaster and Crisis Management (L1S)	• By using the reserve space of the "L1S" signal, short messages (Disaster-related /Crisis management information) can be transmitted. • Improved firmware enables the SBAS receiver.

The QZSS provides 2 kinds of services; a navigation service and a messaging service. Table 1 shows service overview.

Purpose and background of the test

Many new business opportunities are expected to arise in Japan as it is anticipates a significant increase in international tourists leading up to 2020.

However, there is concern about missed business opportunities due to a lack of multi-lingual human resources in Japan.

A lack of tourist information services, such as bus tour guides, ranks high among these concerns.

As a result, QSS has proposed a system to provide tourist information in a timely manner for international tourists, and has demonstrated its potential. This system is a combination of a "quasi-zenith satellite system" which is expected to start in the 2018 fiscal year, using GIS technology and conventional IoT technology.

Participants in the experiment included those who attended the GNSS international symposium, IS-GNSS 2015, which was held in Kyoto in November 2015.

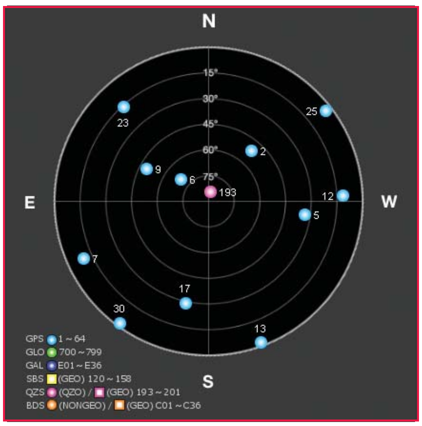


Figure 1: Sky Plot (Each Satellite's Position during the experimentation)

Figure 2: Overview of the Experimental System

Kyoto City is regarded as an important symbol of Japan, and it is very popular with international tourists.

Consequently, this testing represented an ideal opportunity for QSS to demonstrate the possibility of related services and Japan's Quasi-Zenith Satellite to GNSS experts from around the world.

Figure 1 Shows the Sky Plot during the experimentation.

Overview of the Experimental System

The system constructed for this study consists of the following three major segments.

1) On-Board(Bus) segment
   This is the receiver that was installed on the ceiling of the tourist bus. The receiver collects accurate position information for the bus, and sends the location to the data center.
2) Data Center; Web Server segment
   The Web Server maps the location information of the bus on Google Maps, then combines it with the tourist information around the bus.
3) User segment
   The User segment is the tourist's own smartphone. When users access the Web server from the smartphone, points of interest and the current position of the bus is displayed on the smartphone.

Attractions near the travel route

From the bus window

Checking tourist information by smartphone

In addition, photos and descriptions of attractions can be displayed by tapping an icon.

Figure 2 Shows an overview of the experimental system

The testing of this system was aimed at demonstrating commercial service possibilities. Therefore, the system was configured in consideration of cost and technical ease.

Results

Approximately half of the 94 participants in this experiment were international visitors. Five buses were used during a half-day tour of some of Kyoto's most historic locations, including the Kinkakuji Temple, Nijyo Castle, Fushimi-inari Shrine and Kiyomizu Temple.

The trial version of this tourist guide application received positive evaluations from participants for its functions and performance.

Although the experiment also exposed some issues that need to be overcome, the development teams view this as an opportunity to further improve the tourist information system with even more helpful content.

Going forward, QSS will continue to proceed with further verifications in order to ensure that international visitors can enjoy the best travel experience possible.

For the information on the QZSS, please visit, http://qzss.go.jp/en/

GNSS education: Issues and Challenges

Experts share views on issues and challenges of GNSS education

People are needed who are pioneering services and put them to practice

Univ Prof Dr Ing Habil Bernd Eissfeller
Institute of Space Technology and Space Applications, University of Federal Armed Forces Munich, Neubiberg, Germany

The requirements on human resources in GNSS are at least two-fold: On the one hand very specialized engineers are needed; on the other hand generalists are needed who are able to understand the system aspects. Decision makers in institutions and industry need special knowledge in technologies, economics and political strategies.

Key Technology Areas

Satellite navigation like we know it today became only possible over the last 50 years by the integration of several key technology areas: First, we need the ability to build robust satellite platforms with a life-time of 12-15 years. And we need access to space i.e. we need adequate launchers and space transportation systems to reach the MEO (20.000 km) orbit. Secondly, we need the ability to build precise atomic clocks (Rubidium, Cesium, H – Maser, optical clocks in future) and operate them in the satellite orbit for many years. GPS was the first system where spread-spectrum digital signal processing based on BPSK (Binary Phase Shift Keying) was implemented. Thus, thirdly we need the digital technology on hardware and software level to generate the baseband signals and to modulate these finally on one or more carrier frequencies. This includes the design of electronic and digital payload components. In the design and production of GNSS receivers in the user segment leading-edge semiconductor technology and fast digital signal processing on high – performance micro-processors is a key requirement. Not to forget the ability of high precision orbit determination and prediction (decimeter – accuracy over 24 h) and the modelling and prediction of the deterministic and stochastic drift of atomic clocks. Other important key areas are the propagation of electromagnetic waves on L – band frequencies in the atmosphere of the earth. Corrections for time and frequency based on general and special theory of relativity have to be applied. Last but not least theory and practice of precise geodetic and astronomical reference and time systems is an important element of GNSS.

Disciplines involved

On the technical side of GNSS it is not so difficult to identify the academic and technical disciplines which are involved. However, GNSS has not only a technical dimension but also several non-technical dimensions. Basically the disciplines involved are Aerospace engineering, Communication engineering, Electrical engineering, Informatics, Physics, Mathematics, Geodesy, Product and Service design. Additionally several partly non – technical, more general and soft – skill abilities are necessary. At first people are needed who are by themselves no specialists in the above listed domains but have an overview about the interconnections and the interdependences. These people are often called system engineers. Because the built – up of the space and ground infrastructures in a GNSS (the same holds for the sub-systems) are large projects for several 1000 M $ project managers are needed who are able to keep control of the complex work package structures and the time schedules. They are supported by project controllers who have a commercial background. Because various contracts have to be signed in the development of the space, control and user segments also specialized lawyers are involved. Finally people are needed who are pioneering services and put them to practice.

Status of the current GNSS academic education system

Although GPS development started in the 1970s in military programs academic research in GPS is visible since the early 1980s. A pioneering role was taken over by geodesists because they got aware of the high precision potential of the GPS carrier-phase observable. They discovered that centimeter level accuracy may be obtained by processing the recovered carrier-wavelength of 0.2 m. The US National Geodetic Survey (NGS) in Rockville, MD was among the first surveying institutions to assess the use of GPS for precise point positioning. Many European professors joined the NGS for a sabbatical year in the 80s. When coming back to their home universities they were among the first to establish GPS in research and teaching in the European university system. The same happened in continental US, Canada, Japan and Australia. Thus, geodesy and surveying somehow was the first academic discipline which integrated GPS elements in the study courses. Later when aviation, land and maritime aspect came into the scope of GPS other faculties from aerospace engineering and electrical engineering joined this very compact science community. The roots of the early days in GPS in academic GPS research are still visible: Among others the sustained players on university level in the PNT community are Stanford University, Ohio State University, Ohio University, University of Colorado, University of Calgary, University of Nottingham, Technical University Delft, Technical University Graz, University of New South Wales and my own university. These historical core players have been joined by a lot of new university institutes especially in Asia during the last decade. In general the situation at these universities is that teaching in GNSS is integrated in the more classical study courses like e.g. aerospace engineering. GNSS is usually one special teaching area among many others like aircraft design, space systems technology, structural mechanics, etc. As pointed out earlier GNSS has basically an interdisciplinary nature comprising many key technology areas. This leads to the fact that GNSS research and teaching is distributed among all the different faculties involved. Somehow this is a proliferated situation which is not fulfilling the demands on human resources in institutions and industry.

> On the one hand very specialized engineers are needed; on the other hand generalists are needed who are able to understand the system aspects. Decision makers in institutions and industry need special knowledge in technologies, economics and political strategies

Future looking options in academic training for GNSS

On the human resources side of GNSS a new professional academic is needed: This specialist could be called "GNSS engineer". Typically after a B.Sc. in one of the key technology areas he should have an interdisciplinary academic training. He should be able to work on the level of system engineering but if it is required also in a special technical field of satellite navigation. It is quite straight-forward for insider professors to define a study course and the respective curriculum. The level of such a study course would be a M.Sc. in "Satellite Navigation". Thus, it could be asked: Where is the problem? Many new master courses are and were established in the classical academic faculties.

Integration of GNSS engineering master course into classical faculties

This concept would be the most direct approach. It would be important to integrate such a satellite navigation master in one of the larger engineering faculties like information technology or electrical engineering. For instance a faculty of geodesy would be too small. The financial issue for such a master course is solved because it would be fully integrated into the university infrastructure. However, the problem could be the awareness of the faculty members on the importance of GNSS. Usually the larger faculties try to cope with highest priority with some megatrends in their discipline like e.g. green energy. A decision process is necessary to appoint specialist professors and the supporting staff for a satellite navigation master. The minimum number of students in such master should be about 30 first-semester students. Although currently there is a high demand on satellite navigation engineers in Europe in none of the big German (European) universities an implementation of such a M.Sc. happened up-to now because believe is that the area of satellite navigation is too special.

Integration of GNSS engineering in classical faculties as an executive master course

A first alternative approach would be to implement a so-called executive master. This master is only partly integrated into a faculty mainly with respect to the curriculum side. The students in this case have already an employment contract in agencies or industry. The executive master consists of presence stages at the university and idle phases where the students are doing their job in industry or agencies. The employer will pay a certain amount of fee to the university to support for the budgetary issue. These fees from employers could be augmented by various ways of sponsoring. The disadvantage for this approach is that the organizational and contractual effort for all parties involved is very high.

Implementation of GNSS international master courses

This concept starts from the assumption that no university on a national level would be able or willing to establish a specialized master course on GNSS by its own. The idea is then to group a certain number of leading professors from different international universities together. An organizing university is providing the infrastructure (curriculum issues, lecturing rooms, board and lodging). The various financial issues like travel expenses for the lecturers have to be solved. This approach requires a contract between the universities involved which is not easy to obtain in the administrations. Alternatively an external funding layer could be used. In Europe an international master was e.g. established at ENAC (L'Ecole Nationale de l'Aviation Civile) in Toulouse by funding of the European GNSS Agency (GSA).

External GNSS training courses

This possibility is more or less a standard. The concept is that employees are taking part in timely limited training courses (1 to 3 days) besides their jobs. On worldwide basis a lot of public and private providers offer such courses in the GNSS field. In this context the ESA Summer School on GNSS has to be mentioned.

Why Surveyors are GNSS Experts

Chris Rizos
Professor, Geodesy & Navigation, Surveying & Geospatial Engineering, School of Civil & Environmental Engineering, UNSW Australia (The University of New South Wales), Sydney Australia

Its been a claim whose veracity can now be confirmed. Over the past decade or so I have noticed that the GNSS experts, commentators, advocates and decision-makers with whom I deal with in a variety of academic, research, government and commercial circles, have something of a similar background. They have gained their GNSS knowledge and expertise by virtue of receiving a Surveying or Geomatics education. From the highest international scientific bodies, through international policy and professional organisations, to regional and national committees that deal with GNSS matters, I find colleagues that have remarkably similar career trajectories as myself. I am of course referring to office bearers and members of organisations as diverse as the International Association of Geodesy (and its services, in particular the International GNSS Service), the International Committee on GNSS, the Committee of Experts UN-GGIM (Global Geospatial Information Management), the International Federation of Surveyors (FIG), a number of national Institutes of Navigation, and many other boards, committees and organisations. We all were attracted to GPS in the 1980s, and have maintained our passion and commitment to GNSS ever since. How is this so?

Real world GNSS performance is boosted by innovations that address the limitations of standard GNSS solutions. Surveyors have been in the past, are currently, and should remain the "GNSS experts"

The first civilian applications of GPS were in the fields of Geodesy and Surveying. GPS in the early 1980s offered a revolutionary new technology for coordinating geodetic control marks to very high accuracy. GPS was never designed to satisfy the needs of these disciplines – for centimetre-level accuracy – hence the 1980s was a fertile period of innovation that led to the development of reliable carrier phase-based differential GPS positioning technologies and methodologies. This spirit of innovation to support high accuracy GNSS positioning continues to this day. We now can see the fruits of that innovation, in the global investment in CORS (Continuously Operating Reference Stations) infrastructure, multi-GNS/multi-frequency "high end" GNSS hardware, and services supporting "RTK" (Real-Time Kinematic) cnetimetre-level accuracy positioning in seconds (under favourable observing conditions). Without this Geodesy and Surveying market driving this innovation we would not have seen the explosion of use of GNSS for critical applications such as machine guidance and control in construction, agriculture, mining, port operations, and, in the near future, on our roads within autonomous vehicles.

Survey graduates have been educated in the principles, technology and practices of high accuracy GNSS positioning since the mid-1980s. The first textbooks were written, and the first conferences and workshops were run, to support this market segment and applications discipline. The university departments offering Surveying or Geomatics programmes also started research in the relevant topic areas, and soon were producing PhD and Masters graduates who went on to become leaders in academia, government and the private sector. What is interesting is that this lead has never really been pegged back by electronics or RF engineers, or signal processing or applied mathematics experts. GNSS expertise is concentrated in the hands of those with surveying backgrounds to an extent that belies their relatively small numbers. They may not understand the intricacies of digital codes, or tracking channels, or the arcane art of RF signal propagation, but they have their own cache of skills. These include mastery of carrier phase measurement modelling, optimal estimation algorithms, error analysis and mitigation, ambiguity resolution, datum definition, network processing, geodesy, and the operational matters that must be managed to ensure users have consistent quality, high accuracy GNSS positioning solutions, tailored to their particular application.

You see, working with high accuracy GPS from the 1980s, and the continued innovation in the technologies and methodologies underpinning this level of performance is like being associated with Formula One racing. It means that all "lesser" demanding GNSS applications and technologies are not beyond the knowledge and expertise of the Surveying or Geomatics graduate. That is what I tell surveying students during lectures at my university. That is what I truly believe, because that is what happened to me, and to my contemporaries. The exciting new technologies and applications that will develop as we move from a GPS-only to a multi-constellation GNSS era offer exciting opportunities to our discipline. The future of GNSS is more than just microelectronics and signal processing, and accepting GNSS at face value. What GNSS for Geodesy and Surveying has shown us in the last three decades is that real world GNSS performance is boosted by innovations that address the limitations of standard GNSS solutions. Surveyors have been in the past, are currently, and should remain the "GNSS experts".

GNSS education has to be the enabler of a virtuous value chain

Prof Fabio Dovis
Politecnico di Torino – Dept. of Electronics and Telecommunications, Italy

Education in Satellite Navigation is still a challenge. The development of new services and applications and the application of GNSS signals in new fields is showing how satellite navigation is at the crossroad of several disciplines. Communications, geomatics, aerospace, Electronics, Laws , are just some of the several aspects that might be the skills required to develop a satellite navigation projects. On one hand my personal experience when dealing with several students with an ICT background either in classes of satellite navigation or in the courses of the Specializing Master in Navigation and Related Applications (didattica.polito.it/master/navigation/2016/introduction) of Politecnico di Torino in Italy, is that they find always a specific aspect that enables their curiosity about the topic. Nevertheless, such a multidisciplinary complexity requires to the teachers to be able to provide a global view of the implications of every single element in the overall system, from the receiver to the satellite antenna.

The European experience of the latter years, is that there is a large interest by professionals in getting trained in this field, that is somehow new, and it's becoming more and more popular.

However, there is maybe an even more global challenge for the instructors. Even if basics of satellite navigation are consolidated, there is an ongoing evolution in the research field driven by the development of new systems, and by a kind "competition" both at system level and at user level (new receivers, new added value features, position reliability and confidence, new services, etc…).

GNSS education cannot then be limited to the basics or to train "users" of the different systems, but it has to be the enabler of a virtuous value chain and drive the innovation creation, with also the ultimate objective of pushing the evolution of the market.

In Europe, where the Galileo program is seen as a new opportunity by many companies, this aspect is a key factor to grant competitiveness, and it can stem by a strengthening of the higher levels of education (post-graduate and Ph.Ds). In fact, Galileo, EGNOS and the satellite navigation field at large, are affected by a lack of skills and competence; from an end-users perspective, the space segment, which is nowadays well under development, is only a part of a more complex knowledge system, needed to exploit the satellite navigation opportunities. Communications, applications development skills, creativity, and business competences are relevant and essential to leverage on the Galileo and EGNOS initiative to make Europe a credible player in this international context and satellite navigation a concrete asset for the European economy in terms of innovation, market development resulting in job creations. With respect to the growing competition and resource optimization the sustainable success of industry is crucially linked to effective identification and transfer of knowledge, innovative technologies and solutions available. Education is not a "per se", but it is strictly related to the development of leading edge research and technology in the industrial world. Only a strong interaction and coordination among education, research, and industry yields a capacity building in the field of satellite navigation and related applications.

With respect to the growing competition and resource optimization the sustainable success of industry is crucially linked to effective identification and transfer of knowledge, innovative technologies and solutions available. Education is not a "per se", but it is strictly related to the development of leading edge research and technology in the industrial world

For this reason, in the past years, several projects at European level (the latter of which is the e-KnoT project funded by the GSA) (www.eknotproject.eu) aimed at improving the number and the quality of PhDs in GNSS, coordinating the efforts of different universities by the creation of a Satellite navigation University Network (SUN) (www.gnss-sun.eu) and supporting specific educational initiatives for students addressing the technologies related to GNSS, but also the other multi-disciplianry topics.

These initiative assured excellent results in terms of quality of training and cooperation between universities where the GNSS research is consolidated by several years and newcomers, however they also highlighted some difficulties in obtaining a generalized involvement of the industrial world in supporting such educational initiatives. Compared to other sectors and to other area of the world, commitment of the industrial world toward specialized education in GNSS is weaker. There is still work to do in raising awareness about the relevance of a proper education to fully exploit the GNSS opportunities.

The ultimate goal of the university is creating innovation and new values

Nobuaki Kubo
Tokyo University of Marine Science and Technology, Tokyo, Japan

Japan suffers from a lack of GNSS education opportunities because very few teachers are able to teach GNSS at the university level. Many researchers in Japan consider GNSS to be just a navigation tool and not a research object. Furthermore, compared to their international counterparts, Japanese universities do not have dedicated Geomatics departments. There are signs, however, that the number of talented young teachers and engineers has been increasing in recent years. Instead of universities, some companies and research institutes have provided training and development of GNSS receivers and navigation software. I am going to share my views on GNSS education, based on my 14-year teaching experience at the university level. My university is concerned with marine navigation, and the importance of knowing one's location at sea is a matter of course. Although it is impossible to navigate a ship without knowing its current location, we tend to forget the existence of GNSS because it is like the air for us. GNSS has been one of the most important systems used for ship navigation for many years.

GNSS is not like other basic subjects at university because it encompasses a variety of subjects, such as wireless communication, physics, statistics, and geoscience. In addition to basic subject knowledge, the ability to develop software is essential to a successful career in GNSS because GNSS itself is a kind of software package. I am not belittling the role of the hardware of a GNSS receiver, but the role of software far outweighs it. Basically, students of electrical, aerospace, and survey engineering are expected to enter the GNSS field. The GNSS field can be divided into three divisions for students: GNSS receiver development, GNSS navigation software development, and GNSS application engineer. Since the market demand for GNSS in Japan is projected to exceed supply over the next 10 years, especially in the development of QZSS, employment prospects are not bad at present. Moreover, the use of GNSS applications is quite popular worldwide and it is easy for students to get involved with GNSS. Therefore, the motivation of students of GNSS courses is relatively high. Positioning is essential to our lives and GNSS is going to be the main system to provide positioning solutions in the future. It is perhaps difficult to stimulate

Lack of ability to adapt the current Geomatics Engineering education programs to the upcoming fields

Reha Metin Alkan
Professor, Department of Geomatics Engineering, Istanbul Technical University, Istanbul, Turkey

Regarding the improvements in technology, the Geomatics Engineering has become more automated and human in-dependent science and discipline. The automated instruments created a sense like there will be no more need for the human geomatics engineers on the related fields and people. However, it is still obvious that the geomatics engineers are required to answer the questions that includes the where the word. With the advent on computers and developed software which are designed by the geomatics engineers, the use of classical geodesy decreased, but not totally eliminated. It should be taken into consideration that most of the automated systems of instruments and software only work on general conditions that may not be applied on every problem. That is why the students and the engineers should be encouraged to develop themselves more in coding and designing the solutions for specific cases. The technologic developments should not be accepted as a replacement of the geomatics engineers or the engineering itself but should be accepted as the opportunities as ease of application, implementation on the work hours and conditions. So, it will also spare the time of Geomatics Engineers to study on coding of software and development of new technology on their study area.

The advances on technology has also opened new study areas for Geomatics engineers like GNSS applications, general navigation, indoor navigation, extragalactic object mapping, disaster management, GIS, engineering surveying etc. and seems to open more areas in the upcoming future.

The main problem on this issue is the ability to adapt the current Geomatics Engineering education programs to the recent and upcoming fields. Some of the higher education institutions still focusing just on the traditional geomatics/ surveying applications and giving less attention for the future development. The main objective of the Geomatics Engineering should be the renovation of the education programs to lead the students on the new trend of technology development on geomatics and help them to adapt their learning and studying styles basically on new application areas. By this way, the motivation of the students can be increased on the Geomatics.

students regarding innovations in GNSS, since most of the fundamental as well as innovative GNSS techniques have already been developed by many researchers and engineers. However, studying GNSS is still very important because there are new applications of GNSS to contribute to society. GNSS is a key technology for applications that require the knowledge of location and is sometimes a thankless task. For example, generation of precise maps is fundamental to all the countries. The integration of other types of sensors with GNSS technology is becoming quite important because GNSS is very vulnerable to interference and spoofing. If we educate and train students well in the field of GNSS, they will support the future of our country because GNSS cannot easily be replaced with new positioning technology in the future.

As mentioned earlier, the GNSS has a wide scope, and it is impossible to cover all aspects of GNSS during a 2-year master's course. Even in the case of a 5-year Ph.D. course, it will be impossible to learn everything. I suggest that students focus on their favorite applications such as ship, automobile, UAV, train, and geodesy. They can then identify a specific research objective according to their selection. The students will also be given the opportunity to collaborate with a company or a research institute on certain research topics. Since companies are closely involved with society, students will be able to learn GNSS as well as the needs of society through this collaborative work. These projects also offer attractive salaries to students, who do not have time to take up part-time jobs. The companies involved will benefit from this arrangement by getting the know-how at a reasonable cost.

The ultimate goal of the university is creating innovation and new values. GNSS itself will not be an innovative technology because USA invented GPS more than 35 years ago, but GNSS could be used in innovative applications in the future.

Only a handful of Universities/ Institutions in India have GNSS as a separate course

Dr Anindya BOSE
Department of Physics,
The University of Burdwan,
Golapbag, Burdwan, INDIA

GNSS with its technical advantages and economic opportunities has become very popular and new systems are being implemented by many countries to exploit the potentials. GNSS is a classic example for case study for the students as many theoretical concepts may be seen implemented in a fully functional, real-time extremely successful system. Importance for learning the theory and practices of GNSS is increasing with the applications and possibilities of it. GNSS, with a growing business, would provide career opportunities for a large number of students of Physics, Engineering, Geography, Earth Sciences and allied subjects. The students would have ample opportunity to contribute in the field as working professionals or as new entrepreneurs. Increased use of handheld devices, PDAs, PNDs and the developed applications is enhancing the opportunities. For the growing L-commerce, industry requires more trained manpower to efficiently exploit the market demand in time. Users, at the same time, need best efforts and skills from the professionals capable to cater theirs needs and expectations. Therefore, capacity building through education in GNSS is a major issue for all the stakeholders, especially for countries like India with growing business and availability of signals from multiple GNSS.

Unfortunately, to the best of information, only a handful of Universities/ Institutions in India have GNSS as a separate course/ part of the curriculum in baccalaureate or in post graduate studies. In most of the cases, GNSS is introduced to the students during their under/ post graduate internships/ mandatory project works or for their Ph D dissertations. A larger part of the academic endeavour in GNSS by the academia is concentrated more on the use of GNSS for atmospheric research in comparison to other counterparts- location based or time transfer applications, receiver and application developments. The later issues are mostly dealt by the Govt. research organizations and private industries, where the professionals start working only after finishing their education and therefore both the industry/ organization and the professionals need to engage new effort and time in training on GNSS. Simultaneously, aspiring and working young professionals do not have much opportunity to get themselves trained formally in GNSS. Therefore, a large gap exists between the demand and supply of trained manpower for the GNSS industry and research- suitable formal GNSS education from academic institutions and Universities would help in bridging this.

Other than the previously mentioned issue, other major problems associated with GNSS education in India are (i) not proper importance on introduction of GNSS and the potentials of it, (ii) less popularity of other GNSS systems in comparison to GPS, (iii) lack of enough funding for the Universities in setting up of a fully equipped GNSS laboratory and facility for education and training, (iv) lack of uniform GNSS curriculum both for the students and the working professionals, (iii) lack of regular industry-academia interaction to identify the current market needs and trends – this is an important issue also from the industry point of view. It is proven that, synergy among GNSS industry and academia has benefited both the sides to cater their needs and demands. (iv) lack of networking and established discussion platform for the teachers, researchers and professionals of GNSS from academia and industries to discuss the academic and research related issues and resource sharing. Till now, small sessions in few conferences on electronics and allied topics provide some opportunity of limited interaction and networking.

Currently, effort has been initiated by various agencies to address some of these issues. With efforts initiated by United Nations Office of the Outer Space Affairs

(UNOOSA), one international centre for training in the field of GNSS has been set up in India with active support from Indian Space Research Organization (ISRO) and Govt of India. A standard curriculum for GNSS education proposed by UNOOSA is readily available in the public domain. Few Indian Universities have introduced GNSS as a part of the curriculum and tailor-made courses for students and professionals are being offered by Universities and Govt R&D organizations. Industries are showing interest for collaboration with academia. One major contribution in GNSS popularization for education and R&D is seen from ISRO where few of the first IRNSS-GPS-GGAN enabled receivers are being distributed to 15 academic institutions and Universities for field trial and experiments.

To exploit the full potentials for improvement of human life quality, more efforts in GNSS education are needed. Academia should enhance scopes for education and need-oriented research. Students need to utilise existing and upcoming opportunities in and outside the country to develop themselves to meet the professional challenges. Indian industries need to take a pro-active role and responsibility here because only through the industries the advantages of GNSS would reach the society benefitting all associated stakeholders. Industry initiatives are required for collaborative efforts with academia for real life problem identification and for utilization of developed expertize. Industry may provide opportunity for students to take up internships with them to have real feel of the demand and should extend financial support and incentives to academia through sponsored research projects. Government need to play a catalytic role here through encouraging and promoting introduction of GNSS curriculum, through identification of socially relevant problems involving use of GNSS and priority in funding for these researches. Govt need to have roles in patronizing GNSS academic forums, in popularization of the topic among students and faculties as a potential career opportunity. Separate professional bodies and forums on GNSS are needed for providing platform for idea and resource sharing, information interchange, and networking.

Advantages of the proposed 400 B€ GNSS market in 2013 and 1.0 GNSS device per capita for the Indian region (GNSS Market Report, Issue 4, European GSA, March 2015) would only be achievable though extensive effort, comprehensive planning and responsibility sharing by all Indian stakeholders for developing and improving the Indian GNSS education scenario.

> capacity building through education in GNSS is a major issue for all the stakeholders, especially for countries like India with growing business and availability of signals from multiple GNSS

A Case study on PPP kinematic and RTK positioning methods in Urban Environment

A case study has been executed for obtaining the PPP Kinematic and RTK positioning results

Raghupati Shukla
PhD student, Curtin University, Australia

Introduction contains sections of status about the GNSS satellites, back ground of GNSS–based positioning methods, Threats in positioning and description of faults.

Global Navigation Satellite System (GNSS)

The Global Positioning System (GPS) is currently main GNSS system used for positioning and navigation. The GNSS emerge for civilian use. These include Galileo (European Union in cooperation with European Space Agency), BeiDou (China), Global Navigation Satellite System (GLONASS); and the Japanese regional augmentation systems such as Quazi-Zenith Satellite System (QZSS) (Japan) and the Indian Regional Navigation Satellite System (IRNSS). For GPS, the Block IIF GPS satellites, of which two are in operation, are delivering carrier signals on a new civil frequency, L5 centred at 1176.45MHz, in addition to the existing dual frequency carriers, L1 (1575.42 MHz) and L2 (1227.60MHz) (Cao et al., 2010). The Block IIR-M satellites, seven of which are in operation, are delivering a civilian code on the L2 carrier, namely the L2C. Future Block III satellites will transmit a new civil code on the L1 carrier, namely L1C. GLONASS is currently fully operational and is being modernized to transmit triple-frequency signals using Code Division Multiple Access (CDMA), from Glonass-K1 satellites. BeiDau currently has 15 operational satellites with a regional coverage over Asia–Pacific region with satellites transmitting signals on three frequencies: B1 at 1561.098MHz, B2 at 1,268.52 MHz and B3 at 1,207.14 MHz (Hauschild, Steigenberger, & Rodriguez-Solano, 2011). Galileo signals are delivered on four frequency bands, namely E1 at 1575.42 MHz, E5a at 1176.45 MHZ, E5b at 1207.140 MHZ and E6 at 1278.45 MHz (Hein et al, 2001). The first QZSS satellite was launched on 11 September 2010, and is transmitting signals on the three GPS frequencies as well as fourth carrier frequency (E6), LEX, on 1278.75 MHZ (Sawamura et al, 2001). The first IRNSS was launched in 2015 and has one operating frequency on the L1 band.

GNSS-based Positioning algorithms (PPP, RTK and NRTK)

The GNSS-based positioning methods typically used in land applications such as (i) precise point positioning (PPP) (ii) real-time kinematic (RTK) and (iii) Network RTK. Some of their characteristics are summarised in the following.

PPP is a method that utilize precisely available satellite orbit and clock correction data to perform absolute positioning using measurement from a single GNSS receiver (Rizos, Janssen, Roberts, & Grinter, 2012). PPP requires a long convergence time of approximately 30 minutes to achieve decimetre-level accuracy and several hours to achieve cm-level accuracy, which makes it impractical for most real-time applications (Bisnath & Gao, 2009). The main factors which cause the long convergence time include the high noise amplification of the code measurements, the number and geometry of satellites tracked, user environment, and dynamics and measurement quality. In case of ionosphere correction and ambiguity resolution, it is possible to reduce the convergence time of PPP to 10 cm horizontal accuracy (Banvile & Langley, 2012; Banville, Collins, Zhang, & Langley, 2014; Chen & Gao, 2008).

The observation equations for the carrier-phase and pseudorange measurements, from a GNSS satellite, *s*, to receiver, *r*, on frequency, *j*, are as follows (Odolinski et al, 2014).

$$\phi^s_{r,j} = \rho^s_r + dt_r + \delta_{r,j} - dt^s - \delta^s_{,j} + m^s_r\tau - \mu_j I^s_r + \lambda_j\left[N^s_{r,j} + \varphi_{r,j}(t_0) - \varphi^s_{,j}(t_0)\right] + e_{\phi,j} \quad (1)$$

$$P^s_{r,j} = \rho^s_r + dt_r + d_{r,j} - dt^s - d^s_{,j} + m^s_r\tau + \mu_j I^s_r + \varepsilon_{P,j} \quad (2)$$

Where,

- $\phi^s_{r,j}$ and $P^s_{r,j}$ are the carrier phase and code observables, in distance units, respectively.
- $\rho^s_r = \sqrt{(X^s - X_r)^2 + (Y^s - Y_r)^2 + (Z^s - Z_r)^2}$ is the receiver-satellite geometric range, with X^S, Y^S, Z^S the satellite coordinates and X_r, Y_r, Z_r the receiver coordinates.
- dt_r, dt^s are the receiver and satellite clock errors in distance units, respectively.
- $\delta_{r,j}, \delta^s_{,j}$ are the frequency-dependent receiver and satellite hardware phase delays in distance units, respectively.
- $d_{r,j}, d^s_{,j}$ are the frequency-dependent receiver and satellite hardware code delays in distance units, respectively.
- τ denotes the tropospheric Zenith Path Delay (ZPD) which is multiplied with the mapping function, m^s_r to map the ZPD to the satellite's elevation dependent slant delay. The ZPD can be separated into a hydrostatic and wet component, where the hydrostatic part can be a-priori corrected using a model, e.g. the Saastamoinen model (Saastamoinen 1972), and the wet ZPD delay is estimated in the PPP model.
- $\mu_j = f_1^2 / f_j^2$ is the conversion of the to a first-order approximation estimated ionospheric delay from L1 to a chosen frequency $j = 1, 2, \ldots, f$, where f is the number of frequencies.
- I^s_r is the ionospheric slant delay, of which the impact on the code and phase has opposite signs, the first-order absolute ionospheric delay being in the order of several meters, whereas the higher-order terms being a few mm/cm.
- $M^s_{r,j} = N^s_{r,j} + \varphi_{r,j}(t_0) - \varphi^s_{,j}(t_0)$ non-integer ambiguity due to initial phase delays for the receiver $\varphi_{r,j}(t_0)$ and satellite $\varphi^s_{,j}(t_0)$ that originate from the frequency oscillators (Ge et al., 2008)
- λ_j the wavelength corresponding to frequency *j*
- $e_{\phi,j}, \varepsilon_{P,j}$ the carrier phase and pseudorange observation noise, including systematic and non-random effects such as multipath, which is larger for the code observable, and is not modelled here but its expectation assumed equal to zero. For GPS, the typical pseudorange noise is at the 0.2 meter level, whereas carrier phase noise is 0.01 cycles or few mm.

The PPP observation equations require precise error modeling. PPP solution is sensitive to errors in the used or computed values of the following: (i) precise satellite clock corrections (ii) satellite antenna phase center offset (iii) satellite antenna phase center variations (iv) precise satellite orbits (v) code and phase biases (vi) relativity term (vii) satellite antenna phase wind-up (viii) receiver antenna phase center offset (ix) receiver antenna phase center variations (x) receiver antenna phase wind-up (xi) solid earth tide displacements (xii) ocean loading (xiii) polar tides (xiv) plate tectonic motion (xv) tropospheric delay and (xvi) ionosphere delay. Errors in these parameters will have a direct impact on integrity and positioning performance.

Real Time Kinematics (RTK) is a technique which provides high positioning performance in the vicinity of a base station. The technique is based on the use of carrier measurements and the transmission of corrections from the base station. RTK is a technique that applies differential positioning, where a rover receiver receives measurements corrections from a reference station to cancel atmospheric, orbital and satellite clock errors in the measurements. RTK can achieve centimeter positioning accuracy for short baseline from the reference station under different operational conditions (open sky, partially blocked sky) (Kashani, Grejner-Brzezinska, Wielgosz, & Wielgosz, 2005; Kozlov & Tkachenko, 1998; Henkel & Gunther, 2012; Kim & Langley, 2007; De Jonge, Tibernius, & Teunissen, 1996). Two types of RTK techniques are available: local RTK (using a single reference station) and network RTK (using multiple reference station).Local RTK has a limitation where the distance dependent errors will be significant when the baseline exceeds 15km.In network RTK, Continuously operating referenced station (CORS) network is used to reduce the number of reference station can reach tens of kilometers NRTK GPS observation data are supplied to users via the Internet and are able to support high-accuracy position requirements. However, few of the issues affecting the performance of NRTK are (i) ionosphere delay (ii) ambiguity resolution (iii) error in computing network corrections (v) communication method between the network and the user. These errors have an impact on integrity and positioning performance of the system.

Figure 1: Perth Central Area Trajectory

Figure 2: Car Trajectories from Curtin University to Perth Central (Yellow Line)

Table 1: Settings

Data start	Data End	Durations of Observations
2015-11-04 03:01:08.000	2015-11-04 04:27:01.000	1h 25m 53.00s
Apri / Aposteriori Phase Std		**Apri / Aposteriori Code Std**
0.015m / 0.008m		2.0m / 2.021m
Observations	**Frequency**	**Mode**
Phase and Code	L1 and L2	Kinematic
Elevation Cut-Off	**Rejected Epochs**	**Observation & Estimation Steps**
10.000 degrees	22.89 %	1.00 sec / 1.00 sec
Format	RINEX 3	

PPP Kinematic and RTK positioning results (Post Processing)

A case study has been executed for obtaining the PPP Kinematic and RTK positioning results. An R10 GNSS receiver was mounted on roof top of the car. The figure 1 and 2 shows trajectory of the car from Curtin University to Perth central area where high rise buildings are located. A total running time of the car was 01:25:55.

Three different softwares have been used to analyse the results of PPP kinematic and RTK algorithms such as (i) Canada Centre for Remote Sensing (CSRS-PPP) (ii) Magic GNSS (iii) Trimble software.

Simulation of CSRS-PPP software

The table 1 shows input parameters for processing CSRS-PPP software. The figure 3 shows pseudo range residuals sky distribution.

The figure 4 shows tracked satellite and reset ambiguities.

The figure 5, 6 and 7 shows ambiguities, carrier phase residuals and pseudo range residuals respectively. The ambiguities are fluctuating between -5 to 5 m with respect to time. Lesser is the number of satellites, more are the ambiguities found in the figure.

The figure 8 shows standard deviation of the geodetic coordinates with respect to the time.

Simulation of Magic GNSS software

Magic GNSS was used for two scenarios such as 1) GPS only 2) (GPS+GLONASS)

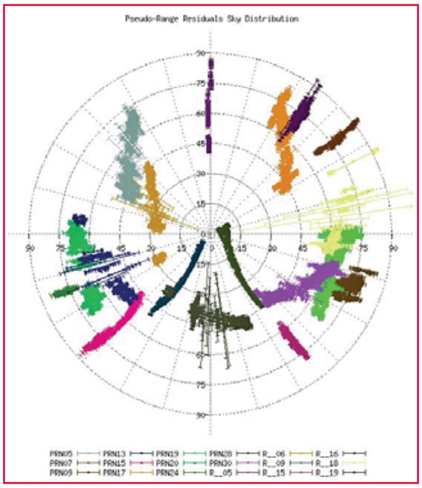


Figure 3: Pseudo-range Residuals Sky Distribution

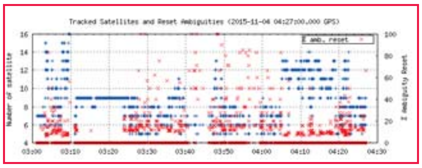


Figure 4: Tracked Satellites and Reset Ambiguities

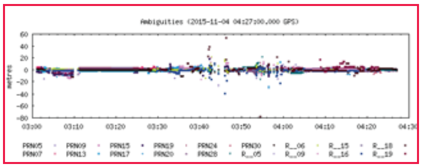


Figure 5: Ambiguities

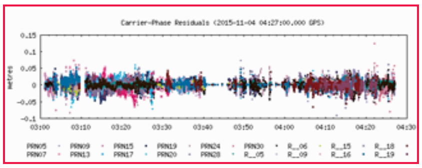


Figure 6: Carrier-Phase Residuals

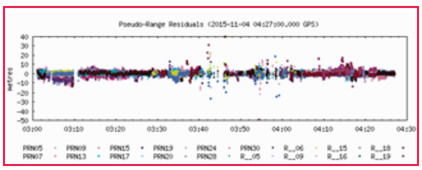


Figure 7: Pseudo-Range Residuals

Table 2 and 3 shows the settings of Magic GNSS software and Parameter estimation summary.

The figure 9 and 10 shows the numbers of used and rejected parameters for GPS case. It can be seen that Go5 has used more numbers of code measurements compare to phase measurements. And G09 has used more numbers of phase measurement compare to code measurements. The figures 11 and 12 show RMS of Code and Phase residuals.

The figure 13 and 14 shows the number of parameters used and those rejected for GNSS case. The figure also shows that more measurements are available for GNSS rather than GPS and similarly more ambiguities are presents in case of GNSS compared to only GPS.

The figure 15 and 16 shows RMS of Code and Phase residuals.

Figures 17 and 18 shows the standard

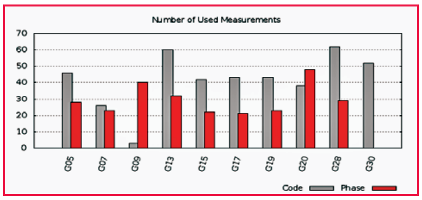


Figure 9: Numbers of Used Measurements

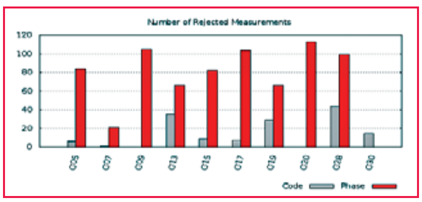


Figure 10: Numbers of Rejected Measurements

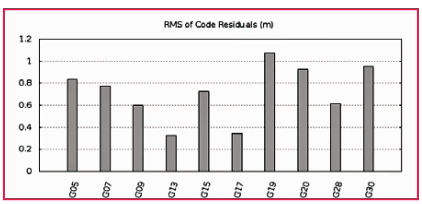


Figure 11: RMS of Code Residuals

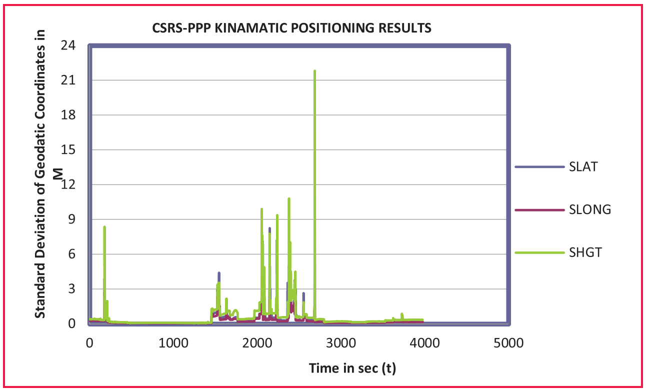


Figure 8: CSRS-PPP Kinematic Positioning Results

Table 2: Settings

Mode	Kinematic
Data sampling Rate	1 sec
Minimum Elevation Angle	10 deg
Numbers of iterations	6
Reference Products	GMV Rapid
Format	RINEX

Table 3: Parameter estimation summary

Total Measurements	Clock Parameters	Non Clock Parameters	Ambiguities
686	11524	38	13(GPS)
1231	11524	54	22(GPS+GLONASS)

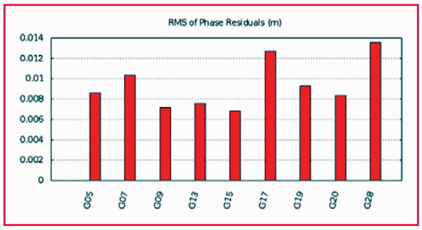


Figure 12: RMS of Phase Residuals

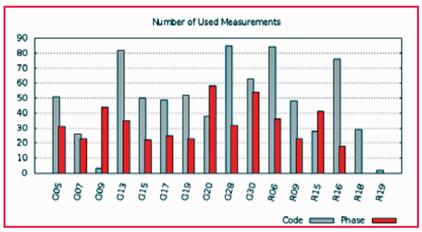


Figure 13: Number of Used Measurenement

Figure 14: Number of Rejected Measurenements

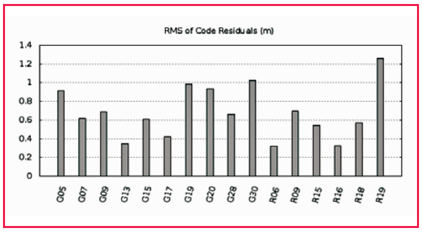


Figure 15: RMS of Code Residuals

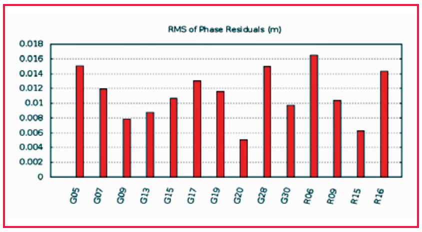


Figure 16: RMS of Phase Residuals

deviation of geodetic coordinates with respect to time for Magic GPS and Magic GNSS. These figures are the proof that Continuity can be improved by using multi constellation system rather than use of one constellation.

Simulation of Trimble software

Trimble software has been used for getting RTK (Real-time Kinematic) positioning results. Table 4 shows settings of the Trimble software. The figure 19 and 20 shows track summary of all the satellites

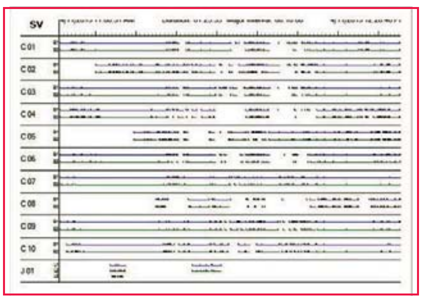


Figure 19: Track summary of Satellites

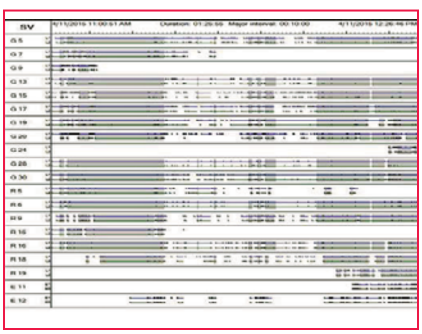


Figure 20: Track Summary of Satellites

such as (i) GPS (ii) Beidau (iii) GlONASS (IV) QZSS. Only two satellites are available throughout the time and rest of the satellites have signals blocked for some time duration. Figure 21 shows residuals of each satellite with their standard deviations and means. Table 5 shows standard deviation and mean of each satellite.

This research case study proved that Trimble software achieves cm level accuracy by using RTK method. The Magic GPS gives more accurate positioning results compared to the Magic GNSS in PPP kinematic method. However, continuity is better achieved in case of Magic GNSS compared to the magic GPS in PPP kinematic method. The Magic software achieves more accurate positioning result than CSRS-PPP and CSRS-PPP achieves more continuity compare to the Magic software.

Total epochs are 5155. Out of these total epochs, the Trimble software processed 2567, the CPRS-PPP software processed 3976 and Magic software processed 2739 epochs. The rejected epochs are the result of a signal blockage, poor satellite visibility and insufficient measurements to calculate positioning. (Sample rate 1 sec).

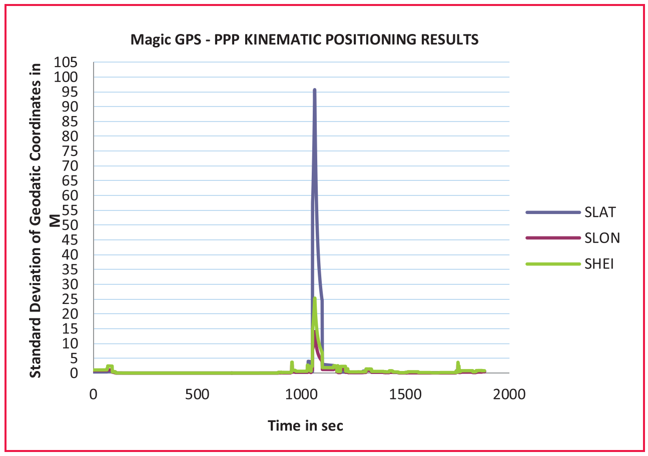


Figure 17: Magic GPS–PPP Kinematic Positioning Results

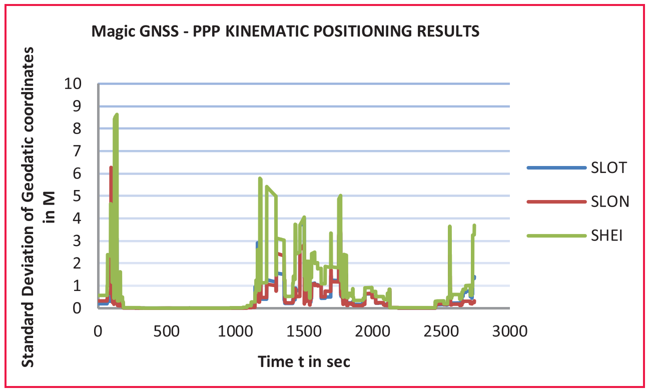


Figure 18: Magic GNSS – PPP Kinematic Positioning Results

Table 4: Settings

Elevation mask	10.0 deg
Frequency	Multiple frequencies
Auto start processing	Yes
Solution type	Fixed
Processing interval	1 sec
Solutions	4767 (2567 Passed)
Horizontal Precision	0.050m+1.000PPM
Format	RINEX

Conclusion

The case study presented shows that good software like Magic, CSRS-

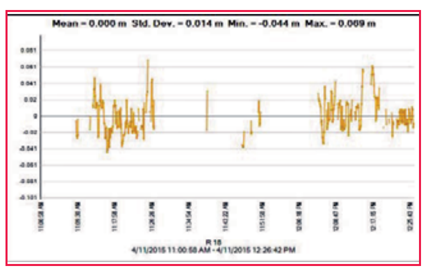


Figure 21: Standard Deviation and Mean of each Satellite (Residuals)

Table 5: Standard Deviation and Mean of each Satellite (Residuals)

Satellite	Mean	Std. Dev.	Min.	Max
R18	0.000m	0.014m	0.069	-0.044
G5	0.002	0.011	-0.087	0.061
G7	0.014	0.011	-0.031	0.047
G9	0.010	0.011	-0.023	0.037
G13	0.000	0.004	-0.024	0.032
G15	-0.002	0.013	-0.103	0.035
G17	-0.008	0.013	-0.050	0.050
G19	0.004	0.008	-0.027	0.043
G20	-0.005	0.008	-0.088	0.032
G24	-0.008	0.015	-0.050	0.039
G28	-0.003	0.005	-0.023	0.027
G30	0.002	0.007	-0.030	0.037
R5	-0.001	0.009	-0.034	0.059
R6	0.000	0.004	-0.021	0.015
R9	-0.005	0.012	-0.065	0.059
R15	0.013	0.020	-0.063	0.061
R16	0.000	0.007	-0.092	0.025
R18	0.000	0.014	-0.044	0.069
R19	0.003	0.017	-0.042	0.050

PPP and Trimble can achieve 70% availability to target applications such as (i) Ambulance tracking (ii) Fire Brigade (iii) Machine Automation with Metre to Cm level accuracy and using PPP-kinematic and RTK methods. However, signal blockage, poor satellites visibility and insufficient measurements can reduce availability to achieve target application. It is also shown that integration of other navigation technology like Locata and inertial navigation technology is an option to increase availability for required target application. The future work of this research is to implement a case study using GNSS-Locata receiver and by using PPP-Kinematic method to increase availability for required target application.

Acknowledgement

I would like to specially thank Mr. Carl Lares (Technical Officer) for helping me with executing the case study.

References

Banville, S., & Langley, R. B. (2010). Instantaneous Cycle-Slip Correction for Real-Time PPP Applications. Navigation, 57(4), 325-334. doi: 10.1002/j.2161-4296.2010.tb01786.x.

Banville, S., Collins, P., Zhang, W., & Langley, R. B. (2014). Global and Regional Ionospheric Corrections for Faster PPP Convergence. Navigation, 61(2), 115-124. doi: 10.1002/navi.57.

Bisnath, S. B., & Gao, Y. (2009). Innovation: Precise point positioning.

Cao, W., Hauschild, A., Steingenberger, P., Langley, R. B., Urquhart, L., Santos, M., & Montenbruck, O. (2001, October). Performance evaluation of integrated GPS/GIOVE precise point positioning. In *Proceedings of the 2010 International Technical Meeting of The Institute of Navigation* (pp. 540-552).

Chen, K., & Gao, Y. (2008). Ionospheric Effect Mitigation for Real-Time Single-Frequency Precise Point Positioning. Navigation, 55(3), 205-213. doi: 10.1002/j.2161-4296.2008.tb00430.x

Crews, M. (2007). GPS Wing Program Update. *Munich Satellite Navigation Summit.*

Datta-Barua, S., Walter, T., Blanch, J., & Enge, P. (2008). Bounding higher-order ionosphere errors for the dual-frequency GPS user. *Radio Science*, *43*(5).

De Jonge, P., Tibernius, C., & Teunissen, P. (1996). *Computational aspects of the LAMBDA method for GPS ambiguity resolution.* Paper presented at the PROCEEDINGS OF ION GPS

Hauschild, A., Steigenberger, P., & Rodriguez-Solano, C. (2012). Signal, orbit and attitude analysis of Japan's first QZSS satellite Michibiki. *GPS solutions*, *16*(1), 127-133.

Hein, G. W., Godet, J., Issler, J. L., Martin, J. C., Lucas-Rodriguez, R., & Pratt, T. (2001, September). The Galileo frequency structure and signal design. In *Proc. of ION GPS* (Vol. 2001).

Henkel, P., & Günther, C. (2012). Reliable Integer Ambiguity Resolution: Multi-Frequency Code Carrier Linear Combinations and Statistical A Priori Knowledge of Attitude. Navigation, 59(1), 61-75.

Jokinen, A., Feng, S., Milner, C., Schuster, W., Ochieng, W., Hide, C., ... & Hill, C. (2011). Precise Point Positioning and Integrity monitoring with GPS and GLONASS. In *European Navigation Conference* (Vol. 2011).

Kashani, I., GREJNER-BRZEZINSKA, D. O. R. O. T. A., & Wielgosz, P. (2005). Toward Instantaneous Network-Based Real-Time Kinematic GPS over 100 km Distance. *Navigation*, *52*(4), 239-245.

Kim, D., & Langley, R. B. (2007). Ionosphere-Nullification Technique for Long-Baseline Real-Time Kinematic Applications. Navigation, 54(3), 227-240.

Kozlov, D., & Tkachenko, M. (1998). Centimeter-Level, Real-Time Kinematic Positioning with GPS+GLONASS C/A Receivers. Navigation, 45(2), 137-147.

Murphy, T., Geren, P., & Pankaskie, T. (2001, July). GPS Antenna Group Delay Variation Induced Errors in a GNSS Based Precision Approach and Landing Systems. In *Proceedings of the 20th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS 2007)* (pp. 2974-2989).

Odolinski, R., Odijk, D., & Teunissen, P. J. (2014). Combined GPS and BeiDou instantaneous RTK positioning. *Navigation*, *61*(2), 135-148. doi: 10.1002/navi.61.

Rizos, C., Janssen, V., Roberts, C., & Grinter, T. (2012). PPP versus DGNSS. *Geomatics World*, *20*(6), 18-20.

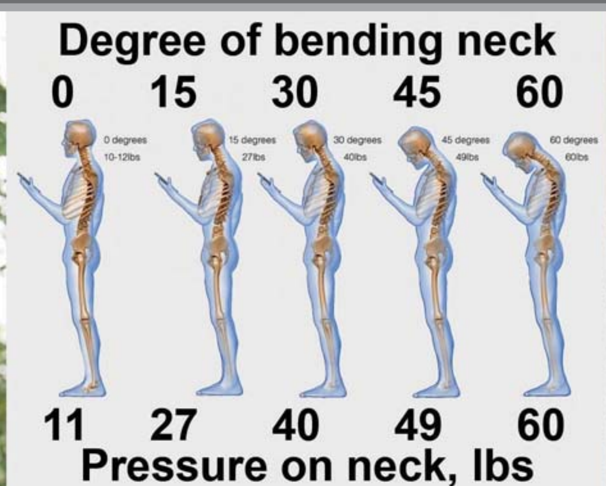
Sawamura, T., Takahashi, T., Moriguchi, T., Ohara, K., Noda, H., Kogure, S., & Kishimoto, M. (2001, December). Performance of QZSS (Quasi-Zenith Satellite System) & L-Band Navigation Payload.

Virtual Roadshow

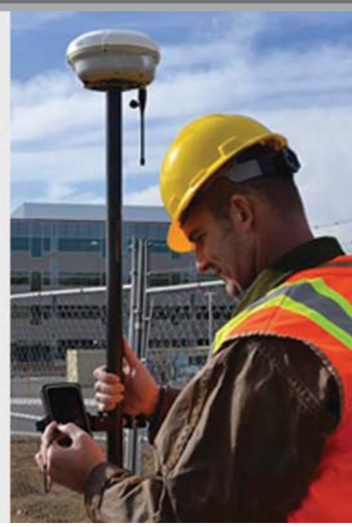
Test drive TRIUMPH-LS from the comfort of your home or office, 24/7 anywhere in the world.

Log on to any of our TRIUMPH-LS units and take control of the device. It is as real as sitting next to it and test-drive it.

This is another innovation that saves you time.



(Courtesy of Dr. Ken Hansraj M.D.)



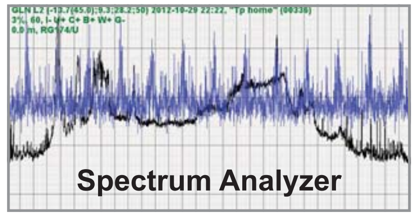
They all break your necks, TRIUMPH-LS does not!

(and your wallets too). See the report from The Washington Post at www.javad.com

Innovations and features that only we have

Verify, Monitor, record, and defend the accuracy of your shots with our six different RTK engines and verification systems. Export results in PDF and HTML formats.

5 Hz BEAST MODE RTK resolves ambiguities 5 times faster. This is not extrapolating the 1 Hz base data. Base transmits correction data 5 times per second.



Interference in the GNSS spectrum exists in many places. Monitor and avoid it with the TRIUMPH-LS.

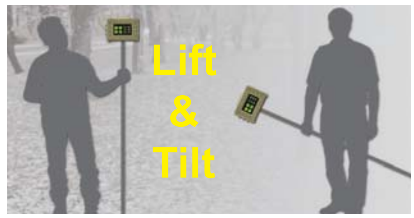
Multipath acts like a “ghost” signal and degrades the accuracy of your shots. We isolate multipath effects in both code and carrier phase measurements and remove them.

Mount your base on top of your car; park it near your job site and perform RTK survey. Then DPOS-It or Reverse-Shift-it.

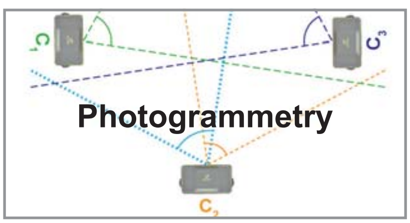
Don’t break out the Total Station! Complete the job with the TRIUMPH-LS only.

Highly rugged. Gorilla Tested, 180 pounds of surveyor driving it into the pavement. Also, check out our concrete drop test on www.javad.com

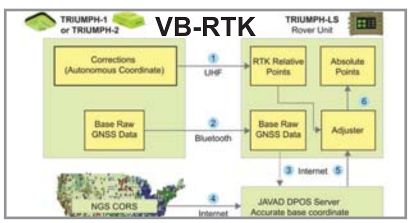
Bottom camera shows Double Bubble on the screen and documents it. Also, you can use these physical bubbles to calibrate the built-in electronic tilt sensors.



Survey starts with you lift the pole. You don’t need to level the rod, tilt sensors and compass automatically compensate for tilts.

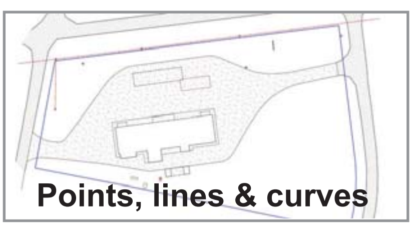


You can survey points that you or GNSS signals can’t reach. Camera Offset Survey (Photogrammetry in the box) with the internal forward facing camera.

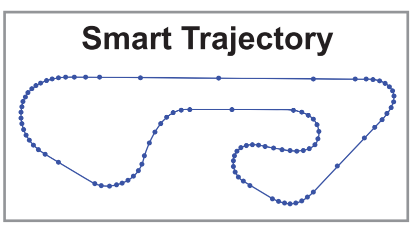


Process data collected at the base with OPUS or DPOS and automatically verify your shots. It basically ties your shots to the well-established NGS/IGS base stations.

The most comprehensive world-wide Coordinate Systems, transformation and localization, including “time dependent” coordinate systems.



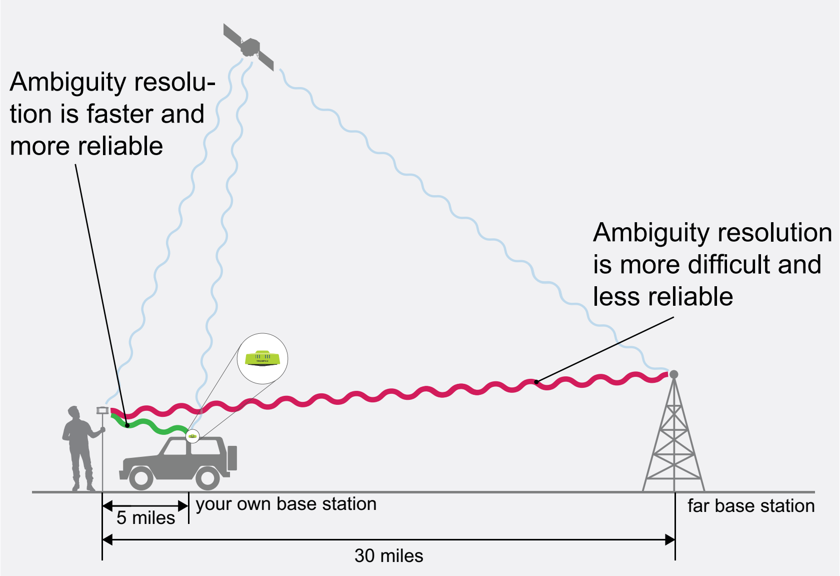
Survey Points, Lines and curves automatically. No need to codes like BOC, MOC, and EOC, or others.



The deeper the curve, the faster points will be recorded automatically for accurate representation of trajectories.

Append your shots with audio, photo and other technical and meta files automatically.

Advantages of your own base station and short baselines



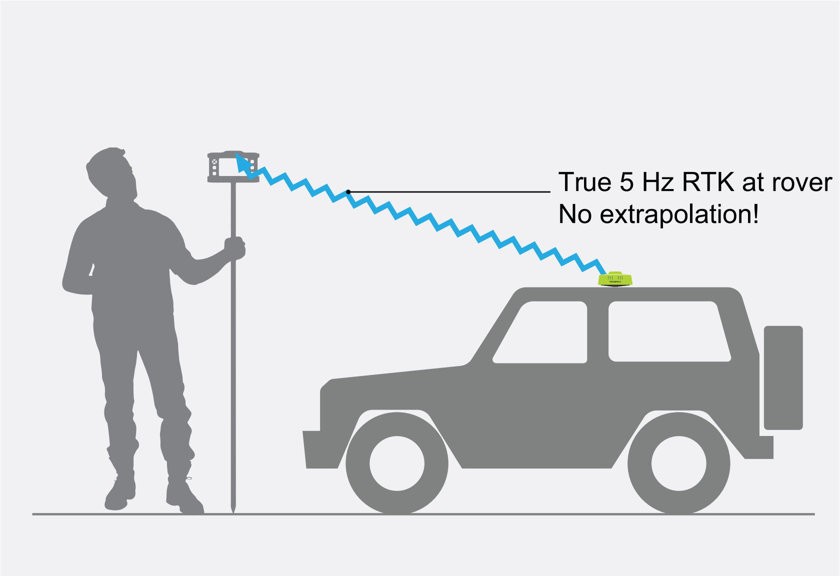
1. Shorter baselines provide significantly better **reliability** because the ambiguities are much easier to resolve and the correct ambiguity solution has an obvious contrast.

2. Shorter baseline has better **accuracy** because most of errors (like atmospheric and tropospheric effects) are common and cancel.

3. Shorter baseline ambiguities are resolved much **faster**. In longer baselines, incorrect ambiguities may pose as being correct in the statistical evaluations and it takes longer to isolate incorrect ambiguities.

4. Shorter baselines make it feasible to work in **difficult** areas (under tree canopy and in urban environments) because ambiguities have better contrast and are easier to resolve.

5. **Beast Mode RTK** is available only via our TRIUMPH-2 and TRIUMPH-1M base station. It makes ambiguity resolution up to 5 times faster because base station transmits base data 5 times per second. 5-Hz Beast Mode RTK is totally different from the up to 100-Hz RTK that is done by extrapolating the same 1-Hz data 100 times per second AFTER the ambiguities are fixed. This extrapolation technique does not improve the ambiguity resolution speed and is mainly used in applications like machine control after the ambiguities are fixed.



6. In addition to savings due to speed and reliability, it saves you RTN and communication charges. A complete system, Base + Rover + Radio + Controller & Controller Software, starts at **$19,990**. 0% financing available ($1,537.69 per month for 13 months) to active license US Professional Land Surveyors (PLS). Extended finance terms also available

contact **sales@javad.com** for details.

1 Equip your car

Mount the TRIUMPH-2 and radio on top of your car or truck. You can use either **UHF or FHSS** (Frequency Hopping Spread Spectrum) radios. You may want to bolt them down in your car for everyday use. FHSS does not need a license but its range is limited to a couple of miles. UHF has a longer range (up to 50 miles with a 35 Watt amplifier) but it needs a license. FHSS is particularly helpful in connection with our Beast Mode RTK which provides corrections from a TRIUMPH-2 near your job site. Use an appropriate long whip UHF/FHSS for longer range transmission.

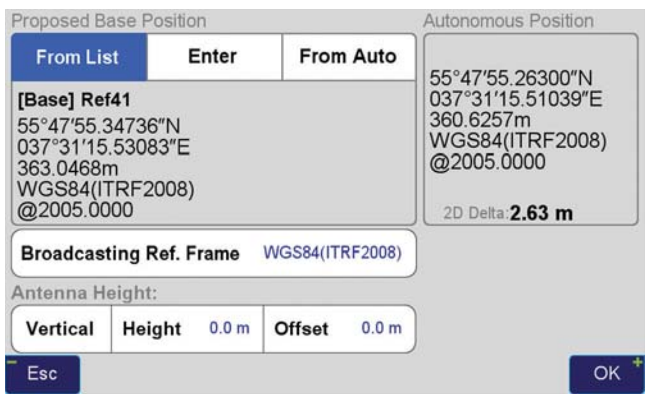
HPT401BT
1W UHF Radio

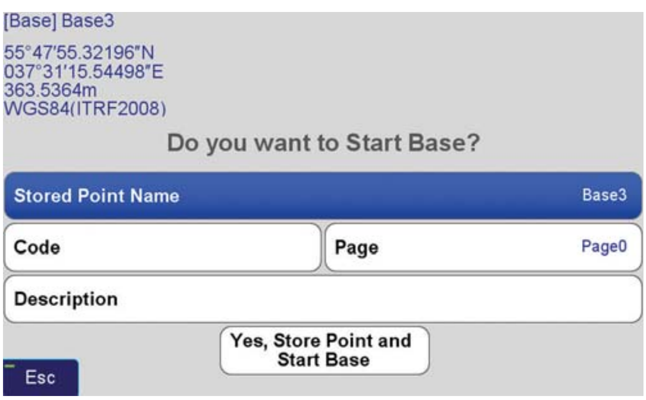
TRIUMPH-2
GPS+GLONASS
L1/L2

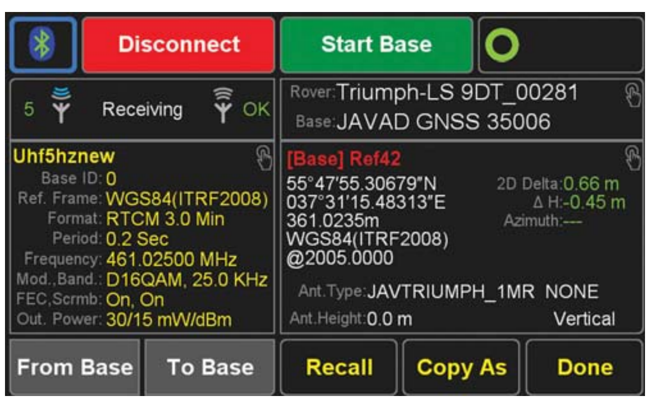
2 Park your car, Start Base

Park your car in an open area near your job site. It may be even in the middle of your site job. Engage all the brakes and ensure the car will not move. The Base/Rover Setup screen makes it easy to configure the base and rover with the same parameters.

Use "**Auto**" for the base coordinate. "Auto" will use an autonomous solution as the base coordinates which may be off by several meters (this will be corrected later). Then click **Start Base**.

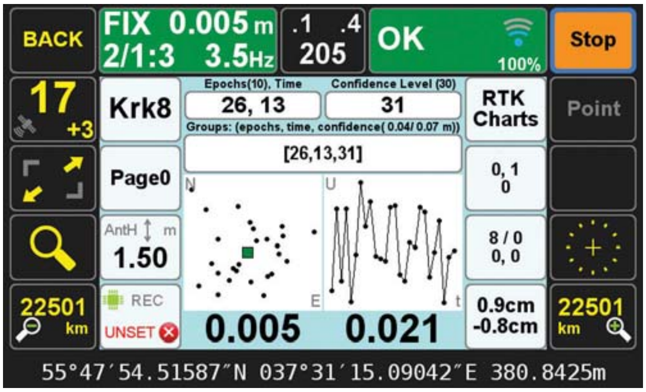




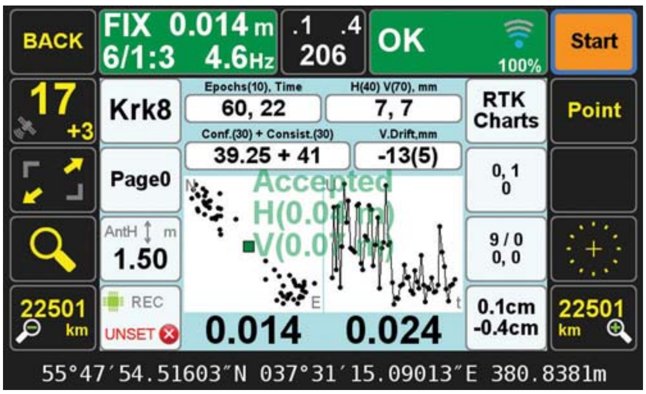


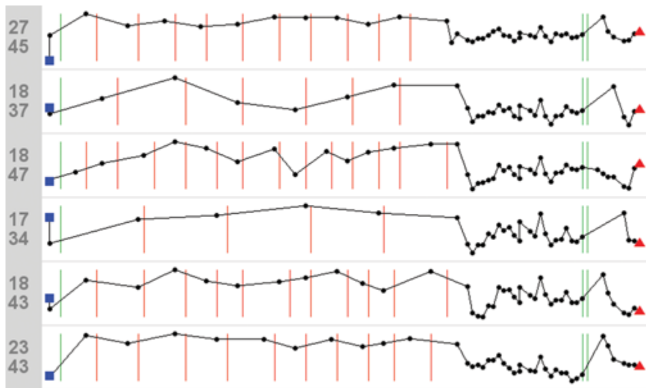
3 RTK Survey

Use your rover to perform your tasks. We have combined UHF and Spread Spectrum Frequency Hopping (FHSS) in the same module in TRIUMPH-LS as an option. The automatic “**Verify**” feature (Phase-1 and Phase-2) ensures that you will never get a wrong solution.



Since your RTK baselines are short, you benefit from all advantages that we discussed earlier BUT all your rover shots are shifted by the offset error of the autonomous base coordinates (up to several meters). “DPOS-It” or “Reverse-Shift-It” to correct for the error from the autonomous position.

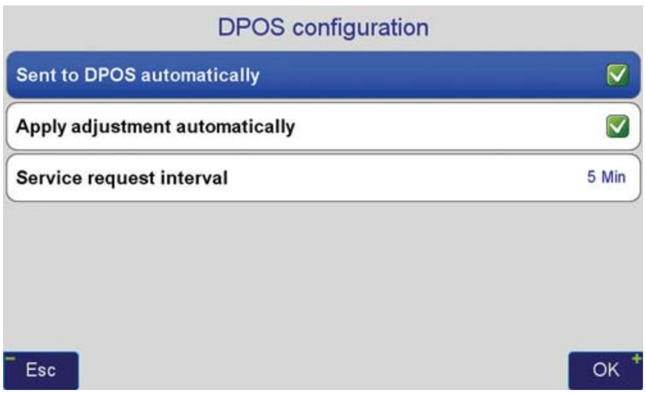


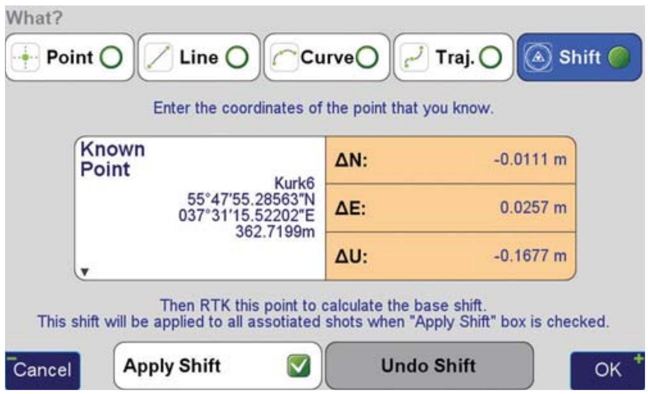


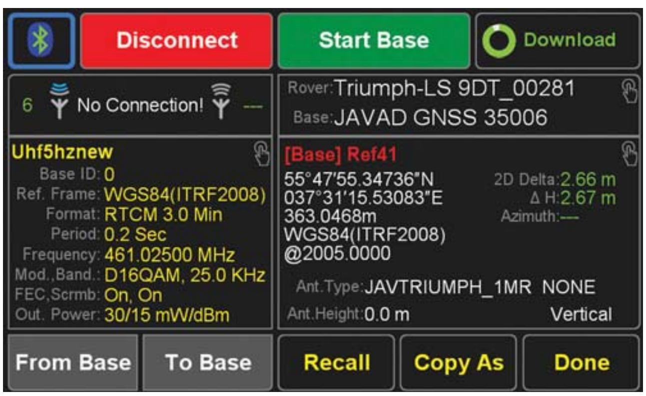
4 DPOS-it or Reverse-Shift-it

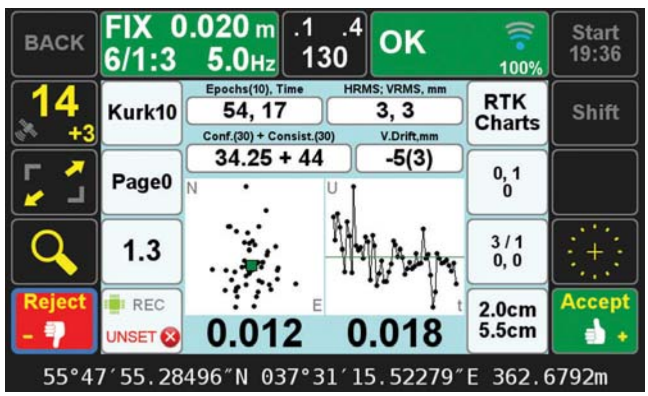
DPOS-it:
Press Stop Base and this will automatically **download** the raw GNSS base data to TRIUMPH-LS and send it to **DPOS** for processing with data from nearby CORS receivers. The TRIUMPH-LS then receives the **correct coordinates** of the base and **shifts** all the rover points accordingly. DPOS, CORS data and J-Field's RTK Verification guarantee your rover solutions.

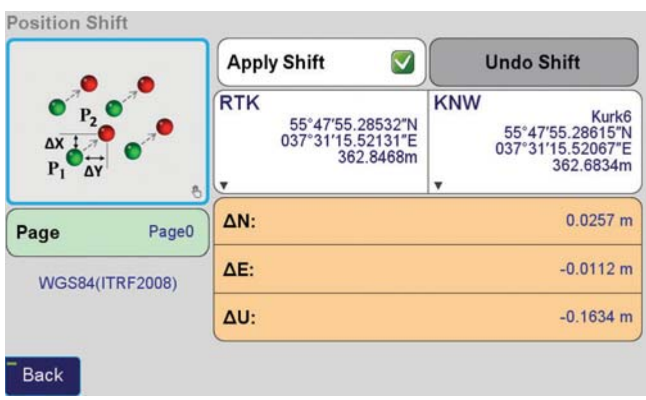
Reverse-Shift-it:
1) Take the TRIUMPH-LS to a **known point** and select the "**Shift**" function in the Setup Advanced screen. 2) Enter the **known coordinates** of that point. 3) Take a **shot** at that point and a base station shift will be **calculated and applied** to all previous and subsequent points surveyed in this session. You can then also use the newly surveyed points as known point for leap frogging during the project.











See detailed descriptions and more at www.javad.com

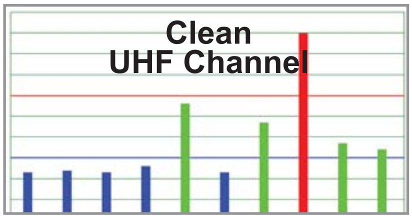
REVERSE SHIFT<<it

Setup base anywhere. Put the rover on a known point and click reverse "SHIFT". The base correction will be applied to all past and future points in that session.

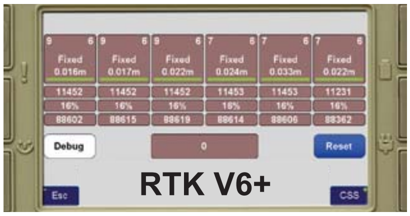
the most advanced GNSS chip with 864 GNSS channels, 24 digital filters and 24 anti-jam filters to protect against out-of-band and in-band jammers.

RAMS
Remote Assistance & Monitoring Services

Monitor and control the activities of your field crews from the comfort of your office via a PC, iOS/Android device. It is also a great tool for training and receiving support.

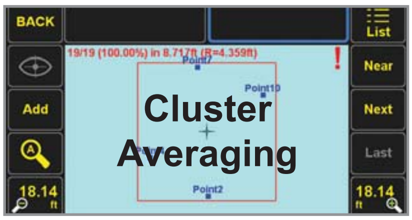


Similar to monitoring the GNSS bands, monitors and scans all UHF bands and shows interferences in all channels. It assists you to select the cleanest channel.



Six RTK engines plus one support engine provide robust RTK performance, even in challenging environments.

Fully integrated, all antennas, radios, controller, high resolution sunlight readable display, over 20-hours of internal batteries 2.5 Kg (5.5 lb) including monopod.

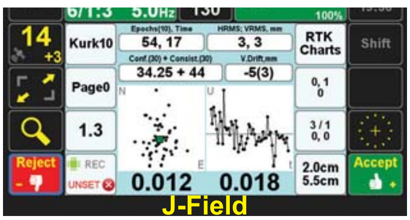


If you are required to repeat your shots we find clusters and average them automatically. You don't need to make any attempt to manually tie shots together.

DPOS
Data Processing Online Service

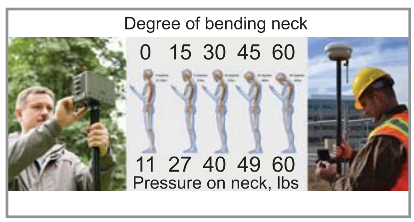
DPOS is similar to OPUS but processes GLONASS when available. It also applies corrections to the base coordinate and all RTK solution as mentioned in VB-RTK.

Visual Stakeout overlays stake points on top of the camera image to easily guide you to the stake point. A nice virtual reality.

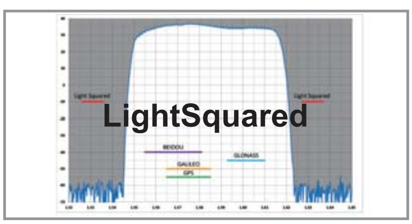


Horizontal and vertical graphs of every epoch along with statistical data can automatically be recorded with each point for documentation and protection.

TRIUMPH-LS has the most comprehensive COGO functions (grid, ground and geodetic surfaces) and Time Dependent Transformations (US, HTDP)



They all break your necks! TRIUMPH-LS does not. Looking down puts 60 lbs of pressure on your neck. Look straight! (See Washington Posts report on www.javad.com)



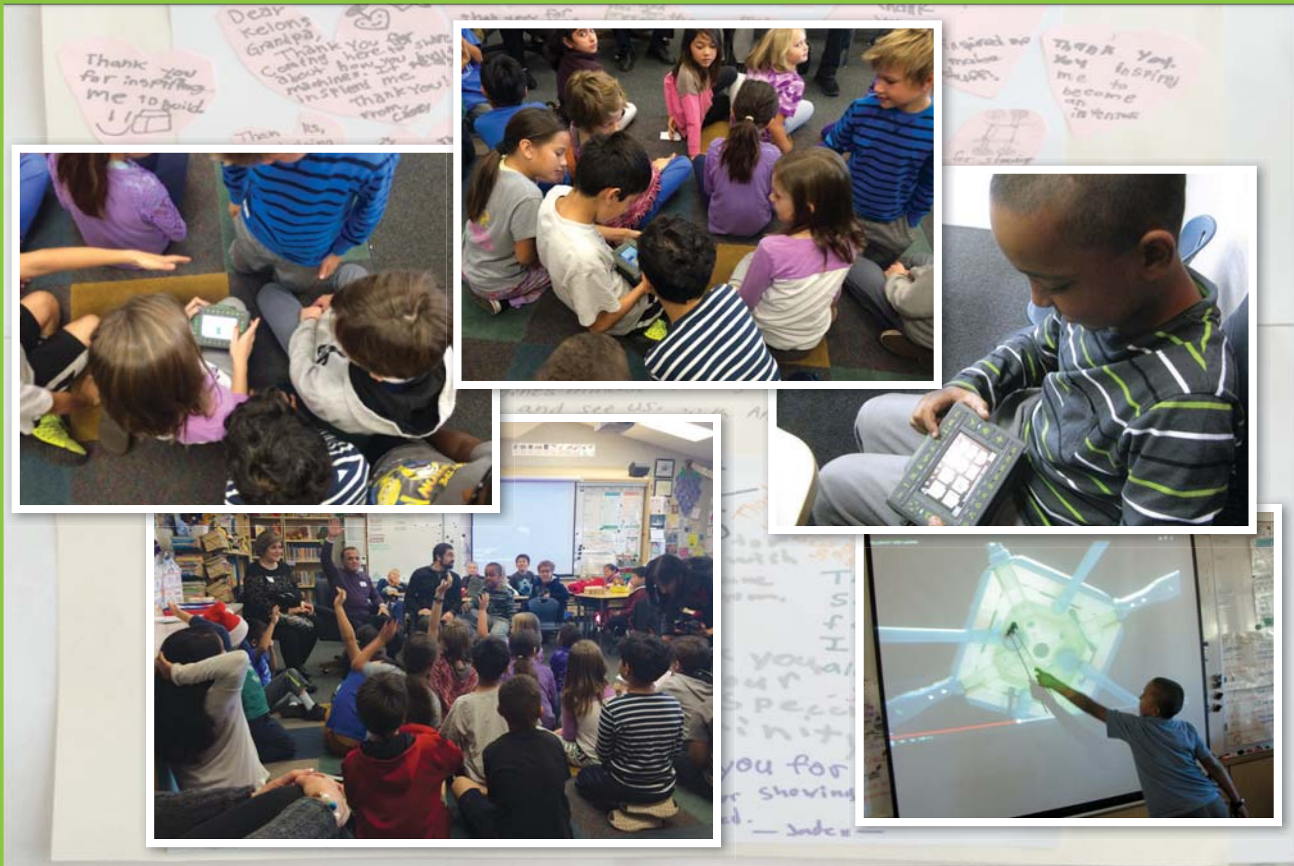
We told you so! LSQ issue was political and financial. Some edi-tors, professors and generals must now eat what they wrote and testified. We do have J-Shield filter.

Dropbox & Google drive

Send your survey results to Dropbox and Google Drive automatically.

You can quickly measure angles with the internal forward facing camera of the TRIUMPH-LS.

All these unique features at price of $12,990



Happy Future Surveyors

Students at Marshall Lane Elementary School and Rolling Hills Middle School in Saratoga, California, enjoying TRIUMPH-LS.

International lessons for land administration in Nepal?

This paper involves a review of disaster recovery and land administration following earthquakes in Haiti and New Zealand in order to identify lessons for Nepal

Assoc. Prof. Donald Grant
RMIT University, Melbourne, Australia

Assoc. Prof. David Mitchell
RMIT University, Melbourne, Australia

A major disaster puts any land administration system at risk of failure at the time it is most needed. This paper addresses the lessons that Nepal may learn from 2 quite different countries affected by earthquakes in 2010 – Haiti and New Zealand.

Following this analysis, some lessons for land administration in Nepal are provided as well as questions that Nepal agencies and land professionals should consider to devise the best approach to recovering from this disaster and rebuilding their country.

Why look at Haiti & New Zealand?

Apart from the fact that they both suffered a major earthquake in 2010, why is it useful to look at Haiti and New Zealand?

Haiti and New Zealand are close to the extremes for land administration systems that are recovering from recent major earthquakes, with Nepal somewhere in between. This is evident from Table 1 which provides some economic and governance indicators illustrating the differences in capacity of these 2 countries to manage the challenges resulting from major disasters. Identifying common themes from Haiti and New Zealand provides an opportunity for lessons that are likely to be relevant for Nepal.

It is evident that New Zealand is in a much stronger position to respond to the disaster than Haiti. And yet in New Zealand, the land administration systems were put under considerable and unusual pressure. It is therefore reasonable to say that all countries will struggle to cope for many years following a major earthquake.

Table 1: Indicators of capacity to respond to economic and land administration issues resulting from major earthquakes

Response capacity indicators	Haiti	New Zealand	Nepal
Main seismic event(s)	January 2010	September 2010 & February 2011	April 2015
Estimated economic damage	US$7.8B	US$30B	US$7B
GDP[1]	US$6.6 (2010)	US$145B (2010)	US$19.8 (2014)
Damage as proportion of GDP	118% of GDP	20.6% of GDP	35% of GDP
GDP per capita[1]	US$650	US$29,390	US$2,374
World Bank Doing Business – Registering Property 2015[2]	179th of 189 countries	1st of 189 countries	72nd of 189 countries
World Bank Doing Business – Construction Permits 2015[2]	167th of 189 countries	2nd of 189 countries	78th of 189 countries
World Bank Property rights & rule based governance index (1-low, 6=high) 2015[1]	2.0	Not available – estimated to be 6	3.0
Transparency International Corruption Perception Index 2014[3]	161st of 175 countries	2nd of 175 countries	126th of 175 countries

[1] World Bank Open Data (data.worldbank.org/)
[2] World Bank Doing Business (www.doingbusiness.org/)
[3] Transparency International (www.transparency.org/cpi2014/results)

Lessons from Haiti

The land administration system before the earthquake

Giampaoli & Freudenberger (2010) and Levine et al (2012) outline the land tenure issues that existed in Haiti at the time of the 2010 earthquake. They note the complexity of the land tenure arrangements and in particular the informal tenancy agreements known as affermage. These agreements initially developed in rural areas where rural landowners tolerated a tenant building a house which the tenant owns while not owning the land. This practice then became widespread including in urban areas.

There were grants of state land by Presidential decree of doubtful legality, illegal occupation, unpaid tenancy and squatting. Legal doubts apply to inheritance and the limitation periods for acquiring rights through adverse occupation. Informal agreements developed, in part due to low levels of trust in the government institutions responsible for land administration.

As a result, only 40% of landowners had any documentation of rights. It was almost impossible to know definitively who owned what and this extended to the government which also does not know exactly what it owns.

Neither land tenure nor land use planning had a single "home" within government. An attempt to create a central land register had only been trialled in one province and parts of Port au Prince.

Post-earthquake challenges for land administration

These existing problems were made much worse by the earthquake that hit Haiti on 12 January 2010 (Giampaoli & Freudenberger, 2010; Levine et al, 2012). The land agency was decimated with significant loss of land records, staff and damage to buildings and infrastructure.

The Haiti government was unable to provide a lead on land issues and the aid agencies did not adequately understand the complex informal tenure arrangements that were such an important part of the existing system for most Haitians. Aid agencies were unable to adapt to existing systems or coordinate responses where land tenure was a critical factor in the response such as locating "temporary" camps. They sought proof of land ownership before erecting new temporary structures or providing assistance for repair of damaged dwellings. Proof of land ownership was difficult even before the earthquake and worse after the earthquake.

As is usually the case following a disaster, vulnerable groups were most adversely affected initially and remained at risk the longest. Two and a half years after the earthquake, nearly 400,000 people remained in transitional settlement camps without access to basic infrastructure. These camps are becoming permanent. Initially half the camp population was on state land, with half on private land and there were efforts to reclaim private land by evicting camp occupants.

Restitution for private land occupied by camps or required for recovery efforts was severely hampered by the difficulty of proving rights to land – and thus compensation.

Some reconstruction projects have been halted by disputes over who owned the land. The institutional connection between humanitarian action and town planning was highly fragmented and ineffective. As a result, funding was poorly used or wasted and opportunities to "build back better" were missed.

There are indications (Levine et al, 2012) that assistance for rebuilding houses would have cost much less than the cost of prefabricated temporary structures that led to long term settlement in camps. Thus the aid funding was not directed towards helping as many people as possible.

Lessons from New Zealand

On 4 September 2010, an earthquake in the Canterbury plains near the city of Christchurch caused widespread damage to property in the region and particularly in the city. Surprisingly there was no loss of life – mainly because the earthquake occurred in the early hours of the morning when damaged offices and shops were empty.

On 22 February 2011, an aftershock of lower magnitude but greater severity (peak accelerations more than double that of gravity) was located under the city of Christchurch and caused enormous damage including the collapse of many buildings. The number of deaths was relatively low at 185 – in part because many buildings that collapsed were still unoccupied as a result of damage from the September 2010 event.

With both events, a key aspect of the response was rapid and strong leadership from Government. This was evidenced by legislation – the Canterbury Earthquake Response & Recovery Act 2010 came into force only 10 days after the first earthquake and provided broad and unprecedented emergency powers. This included setting aside many other Acts to the extent that they may hamper or delay response and recovery.

This was extended by the Canterbury Earthquake Recovery Act 2011 passed not long after the February 2011 aftershock. This included specific surveying & title provisions to avoid delays in rebuild including fast-track safeguards to protect property rights and protection of surveyors and public servants from liability while acting in good faith. It also included powers to demolish unsafe buildings, erect temporary buildings, undertake works, and to take land – with full compensation – to support recovery, rebuild and public safety.

Following the earthquakes, it was clear that the world class land administration system was struggling in Canterbury. This system is overseen by 3 statutory regulators, the Surveyor-General, Registrar-General of Lands and Valuer-General. They set standards and monitor compliance by land professionals and government agencies. These three statutory regulators worked with government to make necessary changes (standards, processes and advice on legislation) while retaining important protections.

Changes to boundaries from seismic land movement – fault rupture

The fault rupture for the September 2010 earthquake reached the land surface resulting in lateral movement of up to 4 metres. Straight-line boundaries across the fault trace were split, other boundaries nearby were bent or distorted.

In the absence of any statutory or common law applying to this situation, the Surveyor-General was empowered to decide that such boundaries would move with the bedrock. This is consistent with slow non-seismic tectonic plate movement. It preserves ownership of the land and the assets located upon the land.

Changes to boundaries from seismic land movement – soil liquefaction

A more complex situation prevailed in Christchurch City. While also subjected to some movement of the bedrock, greater movement resulted from liquefaction of soils, which caused fences, houses and survey marks to move inconsistently by decimetres up to metres.

The practical application of common law on boundary definition is difficult and unclear in this situation. Given the ambiguous movement of survey evidence, accepted survey practices lead to uncertain or inconsistent results (O'Brien, 2015). Therefore a bill is before Parliament at the time of writing – the Canterbury Property Boundaries and Related Matters Bill – to allow the Surveyor-General to provide legal clarity and confidence.

Protecting Survey Infrastructure

The earthquakes moved or damaged survey marks across the entire region. The importantce of the survey infrastructure to recovery and rebuild was recognised soon after the first earthquake. This included the need to reinstate vertical control for repair of roads, sewers and stormwater.

Additional funding was provided by government for rapid re-survey of the control network by GPS and precise levelling. These surveys also provided good scientific information and allowed extent of boundary issues to be determined. However successive re-surveys were subsequently required after major aftershocks that caused further movement of survey control marks.

Figure 1: Effects of fault rupture on previously straight fence and water race (Photo: Survus Consultants)

A secondary risk to the survey networks was the land clearance and rebuild plans, which threatened all survey & boundary marks in the central city. Contracts were let to locate all survey marks in the central city by GPS to preserve survey evidence without delaying the rebuild.

For a cadastre based on mapping such as in Nepal, before & after high resolution satellite imagery would achieve the same purpose.

Protecting Survey & Title Records

Lessons on the importance of protecting of survey & title records can be drawn from an earlier earthquake in New Zealand – the 1931 Hawke's Bay earthquake. The main shock was followed by fires in the city which burned for 72 hours. Almost all paper titles and survey plans in the region were destroyed. This caused severe disruption to the land administration system for many decades and missing records can still be a problem today.

Subsequently all survey plans throughout New Zealand were microfilmed with copies (disaster sets) held in different cities. Later these were converted to digital images along with images of all title records. The lessons from 1931 meant that there was no loss of information resulting from the 2010 and 2011 earthquakes. Survey & title transaction processing was able to continue after the earthquakes even though the land agency office was unable to be occupied for several weeks and though original paper records had been archived in a building that was unsafe to enter.

Residential Land Acquisition

Based on a geotechnical assessment of land damage – particularly the likelihood of soil liquefaction in future earthquakes –approximately 8000 private residential sections were deemed unsuitable for housing. These were acquired by the government with compensation for landowners set at the 2009 valuations. This was generally accepted as being fair because 2009 was a recent peak in the New Zealand property market. However suitable houses available for resettlement became scarce and therefore more expensive. Therefore the compensation values, while generally fair, were often not sufficient for replacement.

There was effectively no centralised re-settlement process. Compensated landowners resettled themselves in private sector new developments on stable land on the outskirts of the city. This unusual situation was made possible by the high proportion of properties insured under a government scheme created after 1931 Hawkes Bay earthquake. This resettlement model offered maximum private choice which suited New Zealanders, but might not work in many countries.

Planning to Build Back Better

"Build back better" is a commonly used expression after a major event. This goal should be part of the early planning but Improvement is not achieved until the end of the plan. The more urgent needs are Emergency, Restoration of Basic Needs and Reconstruction. This is shown in the Christchurch Recovery Plan (Canterbury Earthquake Recovery Authority, 2012).

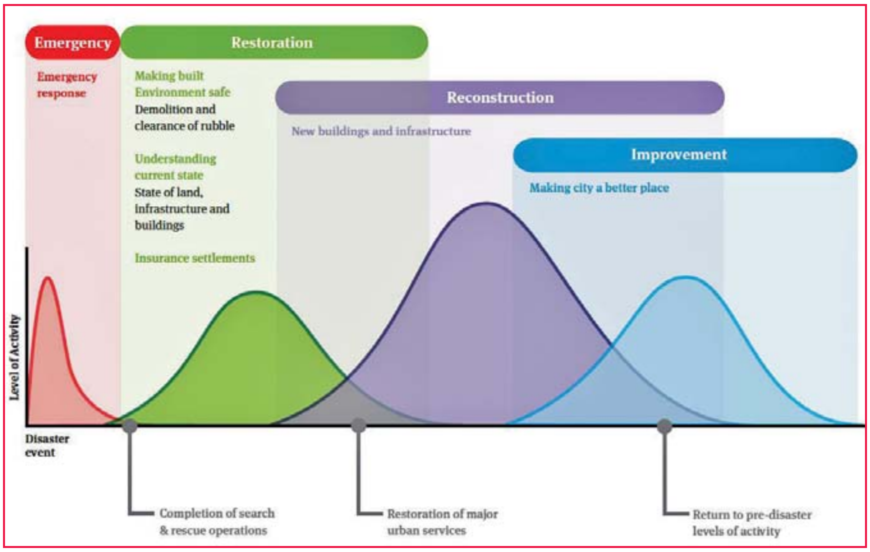


Figure 2: Christchurch recovery Plan Timeline (Canterbury Earthquake Recovery Authority, 2012)

Common Challenges for Land Administration in a Post-Earthquake Context

Based on analysis of Haiti and Canterbury, New Zealand, the following challenges can be identified for other countries, like Nepal, responding to major destructive earthquakes.

Physical Damage

- Damaged survey marks (geodetic, survey, boundary).
- Damage or loss of land records.
- Residential land or farmland is no longer habitable or arable.
- Boundary disputes result from loss of buildings and survey marks as boundary evidence.
- Movement and distortion of property boundaries due to liquefaction or fault rupture.

Adjudication

- Difficulty resolving legitimate rights to land.
- Eviction and land grabbing.
- Lack of data on pre-disaster boundaries or building footprints.
- Lack of recognition of legitimate pre-disaster informal rights to land.
- Informal right holders such as tenants lose access to land or housing and are denied finance and compensation.
- Government acquisition of land may not recognise or compensate all legitimate land rights.
- Government compensation may be based on inadequate valuations.

Capacity of land agencies

- Loss of personnel (death, injury or staff moving away from seismic risk) may severely reduce expertise available to land agencies.
- Damage to government buildings and infrastructure may prevent ongoing processing of land transactions.

Pressure on land agencies

- Increased demand for land agency services is likely post-disaster – at a time when capacity has been reduced.
- There will be additional pressure from government to respond quickly.
- Responsibility for land administration may be spread across more than one Ministry.
- Loss of agency capacity also reduces the ability to coordinate responses.

Less clarity of the role of land agency officials

- In normal times, officials are expected to apply land transactions rules and standards carefully and cautiously to protect rights in land. However in the aftermath of a disaster, bureaucratic caution may be discouraged by public or political leaders.
- Staff may be unclear whether the old rules and standards are still sensible or applicable.
- Short-term expediency to assist recovery and rebuild efforts may have long term negative implications for land tenure and administration.

Conclusions

Some lessons for land administration in Nepal from the experiences in Haiti and New Zealand include:

- Leadership comes from the government – solutions often come from the people (they know what they need) and from land professionals (they know what will work).
- It is important to engage with ALL stakeholders and interests in land.
- Target the vulnerable through awareness-raising of people's rights to land and education on the processes of land administration.
- The land agency is central and capacity building will be needed.

- A multi-stakeholder, multi-sector response is needed.
- Sound adjudication principles are still required – decisions must be transparent equitable and enduring.
- Build Back Better is a long term plan – immediate needs may need temporary solutions that can evolve to longer term improvement.

From these lessons, some questions for people involved in post-disaster land administration in Nepal to consider might include:

- What are biggest risks to the land administration system?
  - How are those risks best managed with limited resources?
- What is needed now? What will be needed later?
- What is "Fit-For-Purpose" in Nepal? Specifically, clarity is required on what immediate and longer term purposes or outcomes are to be achieved.
  - The model for Fit For Purpose Land Administration proposes adaptive process of staged improvements that are most "fit" (sufficiently effective) for meeting the defined purposes.
- Are the survey infrastructure and the documentation of boundaries and rights at immediate risk of further loss or severe damage?
  - How can they be protected?
- Are valuations sufficient for land acquisition compensation?
- How will the transition back to a better "normality" be managed?
- What use can be made of a range of international land administration tools?
  - Fit for Purpose Land Administration
  - Gender Evaluation.
  - Pro-Poor Land Recordation.
  - Social Tenure Domain Model and Land Administration Domain Model.
  - International Guidelines on Urban and Territorial Planning

References

Canterbury Earthquake Recovery Authority, (2012) Christchurch Central Recovery Plan. Retrieved from https://ccdu.govt.nz/the-plan

O'Brien, C., (2015) Regulatory impact statement: Canterbury property boundaries policy decisions. Retrieved from: http://www.linz.govt.nz/land/surveying/canterbury-earthquakes/faqs-for-canterbury-property-owners

Giampaoli, P., Freudenberger, M. (2010) Land Tenure and property rights in Haiti. USAid, Retrieved from: http://www.usaidlandtenure.net/sites/default/files/USAID_Land_Tenure_Haiti_Issue_Brief_0.pdf

Levine, S., Bailey, S., Boyer, B., & Mehu, C. (2012) Avoiding reality: land, institutions and humanitarian action in post-earthquake Haiti. Humanitarian Policy Group. Retrieved from: http://www.odi.org/publications/6979-haiti-land-earthquake-humanitarian-cluster-camp-shelter

Adaptively Steered Antenna Array and Receiver Testing

The paper discusses the GALANT adaptively steered antenna array and receiver and demonstrates the test scenarios generated with the GNSS simulator

Thorsten Lück
Product Manager, IFEN GmbH, Germany

Günter Heinrichs
Head, "Customer Applications" department and business development, IFEN GmbH, Germany

The vulnerability of GNSS to radio frequency interference and spoofing becomes more and more of concern for navigation applications which require a high level of accuracy and reliability, e.g. for safety of life applications in aviation, railway and maritime environments.

Besides pure power jamming with CW, noise or chirp signals, also cases of intentional or unintentional spoofing with wrong GNSS signals have been reported.

Hardware simulations with GNSS constellation signal generators allow investigating the impact of radio interference and spoofing on GNSS receivers in a systematic, parameterized and repeatable way. The behaviour of different receivers and receiver algorithms for detection and mitigation can be analysed in dependence on interference power, distance of spoofers and other parameters. Goal of this paper is to show examples how realistic and advanced simulation scenarios can be set up for simulation of several user antennas simultaneously.

Multi-RF NavX®-NCS

The NavX®-NCS Professional is a high-end, powerful but easy to use satellite navigation testing and R&D device. It is fully capable of multi-constellation / multi-frequency simulations of Global Navigation Satellite System (GNSS) for safety-of-life, spacial and professional applications. The NavX®-NCS Professional is one of the leading solutions on the market providing all L-band frequencies for GPS, GLONASS, Galileo, BeiDou, QZSS, SBAS and beyond in one box simultaneously.

Figure 1: Multi-RF GNSS Constellatio Simulator NavX®-NCS

Due to its superior technology, the outstanding performance features of the NavX®-NCS Professional are beyond the capabilities of many other signal generator on the market today. Furthermore, the extra complexity and cost of using additional signal generators or intricate architectures involving several hardware boxes is avoided, while improving reliability and not compromising on functionality. It was the first GNSS simulator on the market offering both flexibility and scalability together with full multi-constellation capability, all in a single chassis.

Unlike many other GNSS simulators, the NavX®-NCS Professional gives you full control on scenario generation.

IFEN offers a Multi-RF capable version of its NavX®-NCS which provides up to four independent RF outputs (Figure 1). In addition to each individual RF output, the NavX®-NCS provides a master RF output which combines the RF signal of each of the up to four individual RF outputs.

Each individual RF output is connected to one or more Merlin modules allowing simulating of up to twelve satellites per module. Due to the flexible design

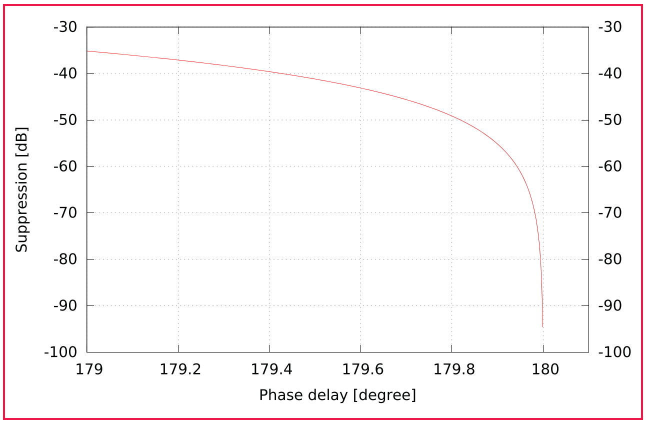


Figure 2: Carrier suppresion as a function of phase delay.

of the Merlin module, each one can be configured to any of the supported L-band frequencies (see above).

As one NavX®-NCS chassis supports to carry up to nine individual Merlin modules, a couple of different Multi-RF combinations are feasible, e.g.

- 2 RF outputs with up to four modules each
- 3 RF outputs with up to three modules each
- 4 RF outputs with up to two modules each

With this configurations IFEN gives the user of the NavX®-NCS the capability to simulate different static or dynamic receivers or even one receiver with multiple antennas, covering such challenging scenarios like ground networks, formation flying or usage of beam-forming antennas.

As the user is free to assign each individual module to a dedicated simulated antenna, the user could also use all of the up to nine modules to simulate nine different carrier signals for one single antenna using the master RF output and thus simulating the complete frequency spectrum for all current available GNSS systems in one single simulation.

All modules are calibrated to garantue a carrier phase coherency of better then. Figure 13 shows the output at the RF master of two modules assigned to the same carrier but with a phase offset of . Theoretically the resulting signal should be zero because of the destructive interference. In practice a small residual signal remains because of component tolerance, small amplitude differences and other influences. Nevertheless the best cancellation can be seen at this point. The phase accuracy can now simply be estimated from the measured power level of the residual signal:

$$s(t) = \sin(2\omega t) + sin(2\omega t + \phi) \quad (1)$$

$$= 2\sin(\frac{2\omega t + \phi}{2})\cos(-\frac{\phi}{2}) \quad (2)$$

$$= 2\sin(2\omega t + \frac{\phi}{2})\cos(\frac{\phi}{2})$$

$$= A\sin(2\omega t + \frac{\phi}{2})$$

with

$$A = 2\cos(\frac{\phi}{2})$$

This means that the sum of two sine waves with the same frequency gives another sine wave. It has again the same frequency but a phase offset and its amplitude is changed by the factor A. The factor does affect the power level. If ø is 180º then A is 0 which means complete cancellation.

So shows the power of the resulting signal relative to the single sine wave. It can also be transformed to dB:

$$A_{dBc} = 20\log_{10}(A) \quad (3)$$

$$= 20\log_{10}(2\cos(\frac{\phi}{2}))$$

Figure 2 shows the carrier suppression as a function of carrier phase offset with a pole at 180º.

The factory calibration aligns the modules to a maximum of 0.5º misalignment. The measured suppression therefore shall be better than 41.18dBc. In practice, the residual signal is also caused by other influences, so that the actual phase alignment can be expected to be much better.

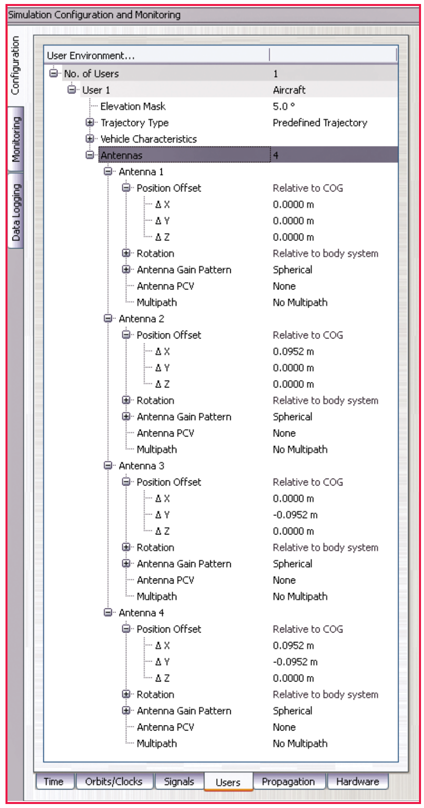


Figure 3: Configuration of individual antennas per receiver

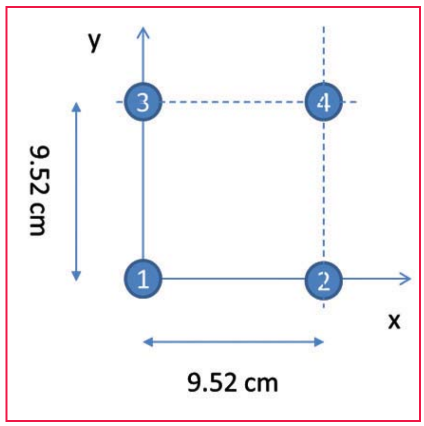


Figure 4: Geometry of the GALANT four-element phased-array antenna (view from top).

The very accurate carrier phase alignment of the different RF outputs makes the NavX®-NCS an ideal simulator to generate the GNSS signals for multi-antenna systems. With four RF outputs, the received signal of a four element antenna can be configured very easily. Figure 3 show the dialog to configure a four element antenna with the geometry shown in figure 4. Please note that the antenna elements are configured in the body-fixed system with the x-axis to front and the y-axis to the right (inline with a north-east-down (NED) system when facing to north) whiles the geometry shown in figure 4 follows an east-north-up (ENU) convention).

The subsequent sections will give an overview of multi-antenna systems and will discuss some results from a measurement campaign of the German Aerospace Center (DLR) utilizing the NavX®-NCS and their GALANT four-element multi antenna receiver.

Multi-Antenna Receivers

Multi-antenna receivers utilize an antenna array with a number of antenna elements. The signals of each antenna element are mixed down and converted from analogue to digital for baseband processing. In the baseband the signals received by the different antenna elements are multiplied with complex weighting factors and summed. The weighting factors are chosen in such a way, that the received signals from each antenna element cancel out into the direction of the interferers (nulling, CRPA) and, additionally for advanced digital beamforming, that the gain is increased into the direction of the satellites by forming of individual beams to each satellite. Because all these methods work with carrier phases, it is important that in the simulation setup the signals contain the correct carrier

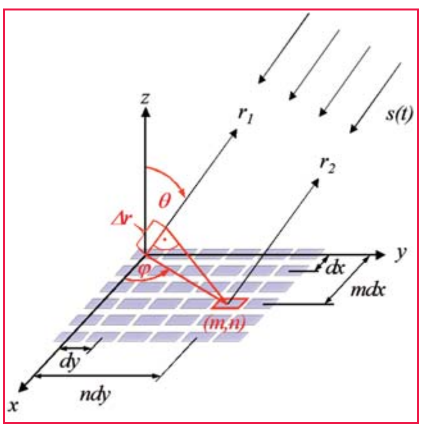


Figure 5: Parallel wave front impinging on a rectangular array with MxN elements [2].

phases at the RF-outputs of the simulator corresponding to the user-satellite and user-interferer geometry and the position and attitude of the simulated array antenna.

Figure 5 presents the geometry of a rectangular antenna array with MxN elements and a signal $s(t)$ impinging from direction (φ,θ).

The spacing of the *dx, dy* elements, are typically half a wavelength, but can be also less. The range difference for antenna element i relative to the reference element in the centre of the coordinate system depend on the incident direction (φ,θ) and the position (m,n) of the element within the array [4]:

$$\Delta r_i = m d_x \sin\theta \cos\phi + n d_y \sin\theta \sin\phi \qquad (4)$$

The corresponding carrier phase shift is:

$$\Delta\Phi_i(\theta,\phi) = -\frac{2\pi}{\lambda}\Delta r_i \qquad (5)$$

For controlled reception pattern antennas (CRPA) and adaptive beam forming applications, the differential code delays may be neglected if they are small compared to the code chip length. However, it is essential that the carrier phase differences are precisely simulated, because they contain the information about the incident direction of the signal and are the basis for the array processing in the receiver. For instance, the receiver can estimate the directions of arrival of the incident signals from these carrier phase differences.

In the following a 2x2 array antenna is considered. It can be simulated with the Multi-RF NavX®-NCS with four RF outputs, where each output corresponds to one antenna element. In the NavX®-NCS ControlCenter a user with four antennas is set up, where the position of each antenna (antenna element) is defined as an antenna position offset relative to the user position. In this approach both differential code and carrier delays due to the simulated array geometry are taken into account, because the code and carrier pseudoranges are computed by the simulator for the position of each antenna element. However, the RF hardware channels of the receiver frontend

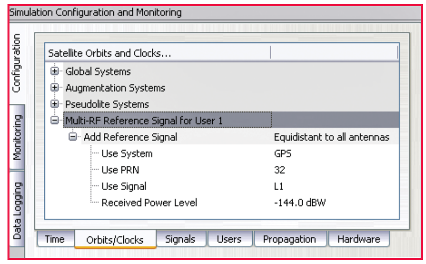


Figure 6: Configuration of a modulated reference signal.

may have differential delays against each other, which may even vary with time. If the direction of the satellites and interferers shall be estimated correctly by the receiver algorithms, a calibration signal is required to measure and compensate these differential hardware delays.

For the real antenna system, a BPSK signal with zero delay for each antenna channel is generated by the array receiver and fed into the antenna calibration port [6]. For the simulation, this calibration signal must also be generated by the constellation simulator.

In a simply way a satellite in the zenith of the user antenna can be simulated, which has the same distance and delay to all antenna elements. Unfortunately, this simple solution includes some limitations to the simulated position and attitude of the user, because the user position must be at the equator (if a "real" satellite is simulated in form of a geostationary satellite) and the antenna must not be tilted.

With a small customization of the NavX®-NCS ControlCenter software these limitations could be overcome. Figure 6 show how to set up the generation of a reference signal. This reference signal can either be simulated as a transmitter directly above the user position, which follows the user position and thus allows also simulations offside the equator or - which is the preferred method - simulating a zero-range signal on all RF outputs neglecting any geometry. The latter one is more or less identical to the reference/calibration signal generated by the receiver itself.

The power-level of this signal is held constant and is not affected by

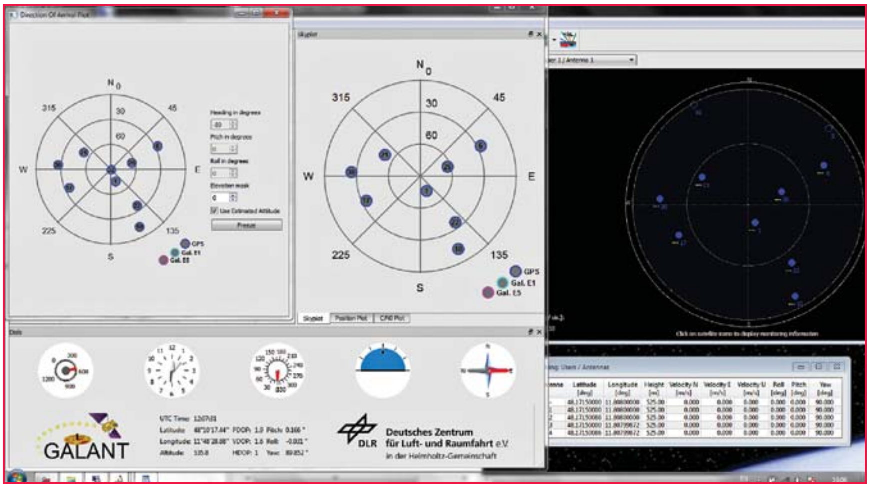


Figure 7: Simulating and estimating attitude with a multi-element antenna.

any propagation delay or attenuation simulated by the ControlCenter.

Attitude determination

According to Figure 5 phase difference measured between antenna elements is a function of the direction of arrival (DoA). Maximizing the received power of one dedicated signal thus provides an estimate of the DoA. Compared with the (known) positions of the GNSS satellites, this allows the estimation of the antenna array attitude. Figure 7 show the sky-plot of simulated satellites as seen at receiver location (simulated on the right; reconstructed by the receiver from the decoded almanac in the middle) and the DoA on the left. By comparison of the estimated DoAs of all satellites and the sky plot from the Almanac the attitude of the antenna is estimated (left). In addition the attitude angles simulated by the NavX®-NCS are given (right).

Simulation of interference

Using the NavX®-NCS it is possible to simulate some simple types of (unintentional) interference. Possible interference scenarios are

Wideband Noise

By increasing the power of a single satellite of the same or another GNSS constellation, a wideband pseudo-noise signal can be generated. Using a geostationary satellite allows also simulating an interference source at low elevations and constant position. Use of power-level files does also allow generating scenarios with intermittent interference (switching on and off the interference) with switching rates up to 5 Hz.

CW or Multi-Carrier IF

By disabling the spreading code and navigation message, a continuous-wave (CW) signal can be generated. The NavX®-NCS also allows configuring a subcarrier modulation. Without spreading code (or - to be precise - with a spreading code of constant zero) the generated signal will consist of two carriers symmetrically around the original signal carrier (e.g. configuring a BOC(1,1) signal will create two CW signals at 1.57542 *GHz* ± 1.023 *MHz*, thus producing "ideal" interferer for the Galileo E1 OS signal.

Depending on the number of Merlin modules per RF output, interference to signal ratios up to 80dB could be realized, limited by a dynamic range of 40dB within one module and additional 40dB range between two modules. However, the maximum power level of one individual signal is currently limited to -90dBm. If only one channel per module is used, the maximum power level of this single signal can be increased by another 18dB (e.g. by using one module solely for interference generation and another module for GNSS simulation).

Figure 8 show the simulated geometry for a interference scenario based on wideband noise generated by a geostrationary satellite, producing -90 dBm signal power at the receiver frontend. The interference source is very near to the direction of PRN 22 with a jammer power of -90 dBm, resulting in a jammer to signal ratio of *J/S = 25 dB*. Figure 9 show the two-dimensional antenna pattern as a result of the beam-forming before and after switching on the interferer. The mitigation algorithm tries to minimize gain into the direction of the interferer. As this also decreases gain into the direction of the intended satellite, the C/N0 drops by approx. 10dB for PRN 22, because its main beam is shifted away from the interference direction. For satellites in other directions the C/N0 decrease is less (Compare Figures. 9 and 10).

However, the receiver still keeps tracking the satellite. After switching of beamforming, the signal is lost (Figure 10).

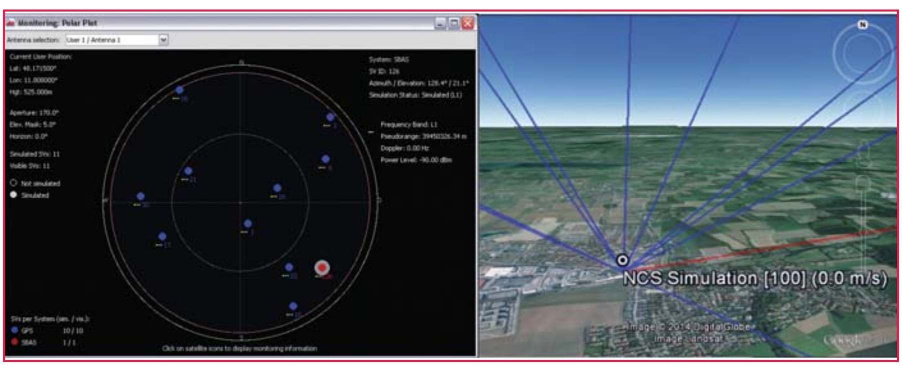


Figure 8: Geometry for the Wideband Noise interference scenario.

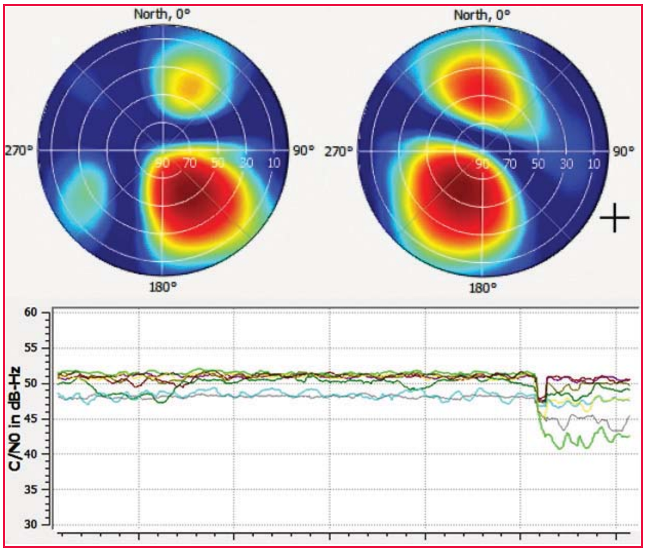


Figure 9: Beamforming for PRN 22 (light green line in lower plot) to mitigate for interference.

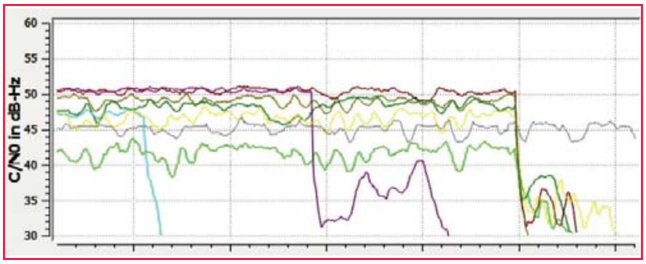


Figure 10: Tracking is lost after switching off beamforming for individual channels (light blue, purple) and all channels (at the end of the plot).

Simulation of spoofing

The simulation of an intentional interfering signal requires twice the resources as the real-world scenario, as every ``real'' LoS-signal must also be generated for the spoofing source. A simulation of an intentional spoofer who aims to spoof a dedicated position in this context is however very similiar to the simulation of a repeater ((un-)intentional interferer) device:

The repeater (re-) transmits the RF signal received at its receiver position. A receiver tracking this signal will generate the position of the repeater-location but will observe an additional local clock error defined by the processing time within the repeater and the travel time between repeater and receiver position. A correct simulation for a multi-antenna receiver therefore has to superpose the code- and carrier-range as observed at the repeater location (considering geometric range between the transmit antenna of the repeater and the individual antenna elements) with the code- and carrier ranges at the receiver location.

Instead of the location of the repeater however, any intended location could be used to simulate an intelligent spoofer attack (figure 11).

The NavX®-NCS allows to generate such scenarios by configuring the position of the (re-)transmitting antenna and the intended position (e.g. the position of the repeater). By calculating the difference between the

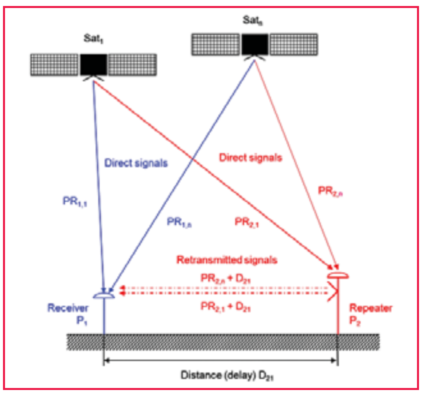


Figure 11: Geometry of repeater/ spoofer and GNSS receiver [3].

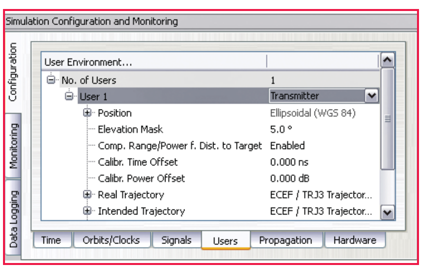


Figure 12: NavX®–NCS capability to simulate a repeater.

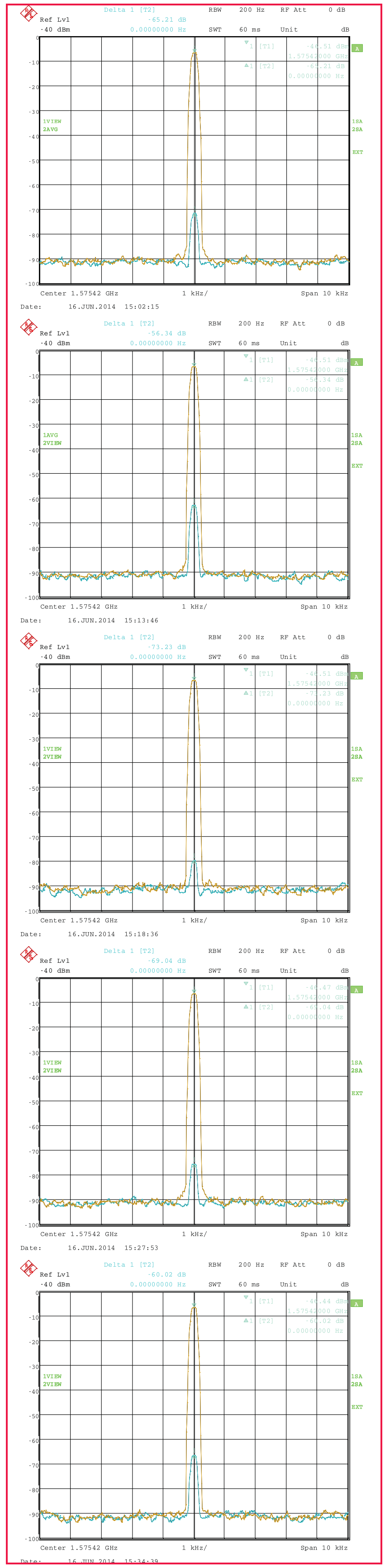


Figure 13: Carrierphase Alignment of a NavX® –NCS with six modules.

real receiver position and the position of the transmitting antenna, the additional delay and free-space loss can be taken into account. The user may also configure the gain of the transmit antenna and the processing time within the repeater. Currently this setup does only support one "user" antenna to be simulated. However, this feature combined with multi-antenna support will enable the NavX®-NCS to simulate repeater or intelligent spoofer attacks in the future. To distinguish the "real" signal from the "repeated" signal, the "repeated" signal could be tagged as a multipath signal. This approach would allow to simulate the complete environment of ``real'' and ``repeated'' GNSS signals in one single NavX®-NCS.

Conclusion

The Multi-RF NavX®-NCS is valuable laboratory equipment for testing not only standard or high end single-antenna GNSS receivers but offers also additional benefit for multi-antenna GNSS receivers like the DLR GALANT controlled reception pattern antenna system.

The GNSS constellation simulator offers up to four phase-coherent RF outputs allowing the simulation of four antenna elements with two carrier frequencies each utilizing one single chassis being 19 inch wide and 2 HU high.

Simulation of intentional and unintentional interference is a possible simulation feature of the NavX®-NCS and allows receiver designers and algorithm developers to test and enhance their applications in presence of interference to identify, locate and mitigate for interference sources.

References

[1] Manuel Cuntz, Lukasz Greda, Marcos Heckler, Andriy Konovaltsev, Michael Meurer, and Lothar Kurz. "galant - architecture of a real-time safety of life receiver". In *ION GNSS 2009*, Savannah, Georgia, September 2009. The Institute of Navigation.

[2] Manuel Cuntz, Andriy Konovaltsev, Marcos Heckler, Achim Hornbostel, Lothar Kurz, Götz Kappen, and Tobias Noll. Lessons learnt: The development of a robust multi-antenna gnss receiver. In *ION GNSS 2010* [5].

[3] A. Hornbostel. Simulation of spoofing and interference for single antenna and multi-user/ antenna configurations. In *CERGAL 2014*, Juli 2014.

[4] A. Hornbostel, A. Schroth, H. Denks, and M. Holbrow. A new signal simulation tool for testing of receivers with controlled reception pattern antennas. In *ION GPS '04*, Long Beach, California, September 2004. The Institute of Navigation.

[5] The Institute of Navigation. *ION GNSS - 2010*, Portland, Oregon, September 2010.

[6] Andriy Konovaltsev, Manuel Cuntz, and Michael Meurer. Novel calibration of adaptive antennas. In *ION GNSS 2010* [5].

"Lidar is the mapping and navigation technology of this age"

says Ananda Fowler, Manager, Terrestrial Laser Scanning Software Development, RIEGL Laser Measurement Systems in an interview with Coordinates

RIEGL VZ-400i 3D Laser Scanner – redefining productivity!' Please elaborate.

The standard for productivity in 3D Laser Scanning extrapolates to a few key factors: area coverage, point density and spatial accuracy. The total workflow to produce a point cloud combining these factors must include planning, acquisition, registration, adjustment, filtering, and export. The VZ-400i will be the first commercially available 3D Laser Scanner with the processing power to execute all of these processes, in near-real-time. What this means is that the scanner will be able to produce georeferenced point clouds without the need for additional post-processing, eliminating post-processing results in serious time-savings when considering overall productivity.

Please explain briefly major updates of RIEGL's Terrestrial Laser Scanning Software Suite.

Foremost is the complete reconstruction of our point cloud storage technology. With this update, we've introduced a new point format along with an SDK for it that will take us into the future. The same format will be used for Terrestrial, Mobile, Airborne and future systems' data and will allow us to provide drag and drop support between all of these data types.

A good example of the new technology is the introduction of the instant toggle between scan attributes. Once loaded, a user can now instantly switch between true color, reflectance, deviation and any of the 20+ other attributes produced by our laser scanners.

Combined with our new Filtering Tools and Registration capabilities, the workflow for Terrestrial data processing has become much easier.

In the near future, we'll release a few add-ons that will provide faster data export to more formats and work to make the transition from the instrument to the cloud far simpler. This new set of tools makes that possible.

How do you see the growth potential of Laser Scanning business in next few years.

Lidar is the mapping and navigation technology of this age. This means we will continue to see growth in the technology and adoption in many more applications. As the technology becomes more widely adopted by a larger audience, awareness and competition will continue to force prices down. The demand for real-time will grow exponentially as systems reach video framerates and reach distances far enough to enable truly autonomous navigation in the very near future. Some form of laser scanners will be in phones, on vehicles, robots, machines, and will enable such an incredible level of accuracy and detail in 3D maps, that augmented reality will become a reality soon. The professional and scientific instruments we develop and manufacture will serve as the foundation for the navigation and mapping services of the future.

Major Update of RIEGL's Terrestrial Laser Scanning Software Suite

The latest terrestrial laser scanning software suite update includes a number of key upgrades featuring the new *RIEGL* Point Cloud Database (RDB 2.0), which provides new and advanced point cloud capabilities. With this upgrade, it is now possible to visualize and manage massive files, hundreds of scans and billions of points simultaneously with a new level of detail approach. These new features enable massive point clouds to be visualized with the added advantage of providing the user with the ability to instantly toggle between a number of different 3D point attribute view-types. These key features of the software provide an impressive level of data visualization capabilities.

"We're thrilled to introduce this level of computing performance, visualization capability and data storage in a single platform. With improvements to many aspects of our software; data compression, extended point attributes, level of detail, and a few key innovations which will be revealed in future updates, our point cloud technology has taken a tremendous leap forward.", Ananda Fowler, Manager of TLS Software Development, announces.

Filtering has also received a major upgrade with the support for all point attributes along the point cloud processing chain. This means that point clouds generated from scans will retain all attributes, such as reflectance, echo number, and deviation values. These new features will enable additional export capabilities to be released soon!

In tandem with the new TLS Software, RDB 2.0 SDK is also being released for support in 3rd Party Software packages.

This new point cloud format sets a foundation for growth with additional capabilities to improve a number of workflows in the future with additional metadata including pose and geo-referencing information.

City to spend $222,000 for GIS mapping of utilities

The city of Hudson will spend an estimated $222,000 to create digital mapping for its storm sewer, sanitary sewer and water utilities. The city expects to receive grant money from the Wisconsin Department of Natural Resources to offset a share of the expense. The City Council on Dec. 21 approved a letter of engagement with the Short Elliot Hendrickson engineering firm to do the field inventory of utility mains and other structures, and then create the GIS database mapping of the systems. *www.hudsonstarobserver.com*

SOI to train officers to strengthen Geoinformatics

The second part of the 'Indo-Thai Geo Spatial Cooperation Programme' has been launched recently. An agreement was signed under the programme by the two countries, which included mapping on 1:4000 scale of a town in Thailand with expertise from Survey of India (SOI), in the first part. The second part of the contract focuses on strengthening of Geoinformatics and Space Technology Development Agency (GISTDA), Thailand, under which SoI will provide training to GISTDA officers.

Currently, mapping is underway of U Thong town in Supanburi province of Thailand. The objective of this programme is to provide knowhow to GISTDA about processes for large scale mapping. According to UN Gurjar, additional surveyor general, seven officers from GISTDA will undergo training for one month here from February 1.

Satellite technology to help NHAI monitor highway projects

Indian Space Research Organisation (ISRO) and North East Centre for Technology Application and Research (NECTAR) will provide help in monitoring and managing the National Highways. A Memorandum of Understanding (MoU) was signed by the National Highways Authority of India (NHAI) with the National Remote Sensing Centre (NRSC) under ISRO and NECTAR recently. *www.thehindu.com/*

SK Telecom to merge with SK Planet's LBS unit

South Korean operator SK Telecom has announced that its subsidiary SK Planet will spin off its location-based services (LBS) unit and merge with SK Telecom. Both entities separately held board meetings on 21 January and decided to split and merge SK Planet's LBS unit. The date of the division-merger has been set for 5 April.

Via the spin-off and merger of the LBS business unit, including T Map, SK Telecom expects to create a synergy of various businesses, such as online-to-offline (O2O), LBS, and Big Data, in the living value platform sector. *www.telecompaper.com*

Subaru partners with Magellan

Subaru has named Magellan SmartGPS as its mapping partner in future Subaru vehicles. The appointment means that Magellan's smartphone-based cloud navigation, which works on both Apple iOS and Android, will port fully voice-guided navigation using constantly updated maps to the head unit in the car.

HERE and 1Spatial announce a strategic partnership

HERE and 1Spatial which manages the world's largest spatial data, announced that they are teaming up to deliver high grade map content to the enterprise market.

As part of a strategic partnership formed to fulfil key enterprise account requirements and market opportunities, HERE is working with 1Spatial to provide data quality and processing solutions incorporating selected high quality map data from HERE. *http://1spatial.com*

Pitney Bowes acquires Enroute Systems

Pitney Bowes Inc. will acquire Enroute Systems Corp., a Seattle-based provider of cloud-based retail and fulfillment software. The company said the acquisition would complement its e-commerce offerings for companies throughout the retail supply chain and allow businesses to more efficiently manage their omnichannel operations.

Enroute Systems runs a transportation management system (TMS) that it said allows high-volume retailers and e-tailers to cut shipping execution times, lower shipping costs, enhance business intelligence, and generate real-time supply chain visibility and tracking. *www.dcvelocity.com*

GPS module gets access to Galileo

Swiss GPS module maker uBlox has added Galileo satellite navigation reception to its M8 series. Galileo reception comes as part of the FW 3.01 software update and allows any M8 product to track: Galileo, GPS, GLONASS, BeiDou, QZSS and SBAS.

BeiDou acquisition sensitivity has been boosted, and the Indian GAGAN augmentation system added. Power consumption is said to be improved by 10%.

Up to three constellations can be tracked concurrently and use is made of all SBAS and QZSS augmentation systems at the same time. Security mechanisms are embedded in FW 3.01. *www.electronicsweekly.com*

Improved positioning with new Broadcom chip

Broadcom has released new BCM89774 tri-band navigation chip that reads five different global positioning satellite networks, allowing for more accurate positioning.

The more satellites a navigation chip can "see", the more quickly and accurately it can determine its position. The new chip, which has been built to automotive quality standards, can read satellites from every major positioning network.

Galileo update

10 Productive Years in Orbit for GIOVE-A, Galileo's Pathfinder

Surrey Satellite Technology Ltd (SSTL), UK is marking the 10th year of in-orbit operations from its GIOVE-A satellite, the pathfinder mission for Europe's Galileo satellite navigation programme. Since retirement from its original mission for the European Space Agency, SSTL has operated the spacecraft at 23,300km where it provides valuable data about the radiation environment in Medium Earth Orbit (MEO), and an on-board experimental GPS receiver is used to map out the antenna patterns of GPS satellites for use in planning navigation systems for future high altitude missions in Geostationary orbit (GEO), and beyond into deep space.

John Paffett, Director of Telecommunications and Navigation at SSTL, summed up GIOVE-A's achievements by commenting "GIOVE-A is a milestone mission for SSTL which has demonstrated that our pragmatic approach and innovative, low cost, small satellites can deliver critical mission requirements for landmark space programmes, such as Galileo."

GIOVE-A was designed, built and tested by SSTL in only 30 months for the European Space Agency (ESA) and was launched on 28 December 2005 with a mission to secure vital frequency filings, generate the first Galileo navigation signals in space, characterise a prototype rubidium atomic clock, and model the radiation environment of Medium Earth Orbit (MEO) for future Galileo spacecraft.

GIOVE-A was the first European satellite launched into the demanding MEO radiation environment, where it has greatly out-performed its 27 month design lifetime, and is still in operational use.

In 2008 GIOVE-A was declared a full mission success by the European Space Agency and the following year the pathfinder satellite was retired from its original successful extended mission and manoeuvred into a higher "graveyard" orbit. SSTL then took over spacecraft operations from ESA and, at its new altitude of 23,300km, GIOVE-A has continued to provide valuable in-orbit data, both on the MEO environment and also from SSTL's SGR-GEO, an experimental GPS receiver. *www.sstl.co.uk/*

European Space Agency dumps Russian Soyuz launchers

The European Space Agency (ESA) renounces in 2016 the use of Russian a Russian Soyuz-ST carrier rocket in bearing the European Galileo satellite navigation system to the orbit, according to ESA chief Johann-Dietrich Werner, TASS reports.

The preference will be given to Europe's own heavy-lift Ariane-5 launcher, Werner said recently. The launch from the French Guiana Space Center is scheduled for October. The heavy class Ariane-5 can bring four satellites in one trip, while Soyuz was only able to deliver two satellites in a single launch. *http://uatoday.tv*

Russia to launch New Resurs-P Satellite on March 12

The launch of Russia's Resurs-P No. 3 remote sensing satellite has been scheduled for March 12, the Russian Space Systems (RSS) company said.

The Resurs-P satellites possess hyperspectral and stereo spectral image recording capabilities with an accuracy of up to 10-15 meters (30-50 feet). The new Resurs-P No. 3 has been under construction since 2012. *http://sputniknews.com*

Saudi Arabia to launch remote sensing satellite from China

King Abdulaziz City for Science and Technology (KACST) is working to complete preparation of the components of the Saudi satellite (Saudi SAT 5B) which is locally made, in preparation for its launch, via the Chinese space rocket (Long March 2D) to support remote sensing services in the Kingdom of Saudi Arabia.

This came in the framework of the cooperation between the Kingdom and the Republic of the People's Republic of China in various fields, including scientific field, which also includes the establishment of a project on genetics studies. *http://susris.com*

IBM and NRSC signed MoU

Indian Bureau of Mines (IBM) and National Remote Sensing Centre (NRSC) recently signed Memorandum of Understanding (MoU) for monitoring mining activity through satellite technology. The MoU helps in the sustainable development and responsible use of precious mineral resources and also checking any anomalies in mining activities by licensee. As part of the MoU, the IBM would set up an exclusive remote sensing cell under the technical guidance of the NRSC at its offices in Nagpur and Hyderabad. These cells utilise Bhuvan-based services for monitoring mining activities across the country. A mobile application will be developed for field data collection to verify ground realities with respect of approved proposals. The NRSC would carry out a pilot project to demonstrate the feasibility of using high resolution satellite imagery in monitoring the changes over a period of time in select group of mines. *www.jagranjosh.com*

Aerial Photomap Production with Microsoft UltraMap by Bluesky

Aerial mapping company Bluesky has revolutionised the production of aerial photography, reducing the time taken to process the terabytes of data captured by more than 75 percent. Following a major research project, the team at Bluesky's Leicestershire production facility has implemented a Vexcel UltraMap system, which has allowed for the introduction of a continuous, uninterrupted processing workflow. By investing in an entirely new workflow, Bluesky has also improved the quality of the aerial images, reducing "building lean" and image distortion, and the accuracy of its digital height models. Bluesky's investment in software follows the recent purchase of two UltraCam Eagle cameras, also from Microsoft, and the introduction of new flying practices. www.bluesky-world.com

Private-sector space rocket industry heads toward launch in Japan

The government is to create a framework to promote private-sector investment in the space rocket industry while protecting the public interest, setting rules on technical specifications and on operators' liability in the event of an accident, according to Kyodo News. Under the Basic Plan on Space Policy set in early 2015, the government aims to expand the size of the space industry to around ¥5 trillion over the next decade. The government would also oblige companies to pay compensation in the event of accidents. Victims would receive government compensation if private operators are unable to cover all the damages, according to the drafts.

Currently, the only entity that has a space program is the state-sponsored Japan Aerospace Exploration Agency. Meanwhile, under the Satellite Remote Sensing Act, the government can limit usage of high-precision images captured by satellites to address security concerns. *www.japantimes.co.jp*

China launches most advanced remote sensing satellite into high orbit

In its last space mission of 2015 China has launched its most sophisticated Earth observation satellite to date, Gaofen-4. It is to become the country's first high-definition satellite in geosynchronous orbit. It is the fifth mission in China's Gaofen ("High Definition") series launched under the China High-definition Earth Observation System (CHEOS) program. The program was launched in 2010 and has between seven and 14 satellites considered for launch between 2013 to 2020. Unlike most Earth-observation satellites, Gaofen 4 will operate from a high geosynchronous orbit, allowing it to continuously monitor the same area. It can direct its visible light and infrared cameras on an area about 7,000 km by 7,000 km, which includes China and its surrounding region. *https://www.rt.com*

India to set up ground satellite station in Vietnam

New Delhi would soon activate a ground satellite station in Vietnam, the Vietnamese Ministry of Natural Resources and Environment has said that this is a project for "establishing stations for probe, satellite data collection and remote sensing data processing facility for ASEAN," based in Vietnam, in the framework of cooperation between ASEAN and India.

MoU between India, Kuwait in area of outer space

A Memorandum of Understanding (MoU) was signed between Indian Space Research Organisation (ISRO) and Kuwait Institute of Scientific Research (KISR) on cooperation in the exploration and use of outer space for peaceful purposes.

The MoU will enable pursuing potential interest areas in both cooperative and commercial mode such as use of data from Indian Remote Sensing (IRS) satellites by KISR for initiating a few research and application projects; training; and building and launching of remote sensing and communication satellites on commercial terms.

The MoU will lead to setting up of a Joint Working Group, drawing members from ISRO and KISR, which will further work out the plan of action, including the time-frame and the means of implementing this MoU. *www.business-standard.com*

Diwata-1 satellite will be deployed from ISS on april 2016

Diwata-1 is result of the cooperation between DOST, University of the Philippines, Hokkaido University and Tohoku University. Satellite was designed under program by Hokkaido University and Tohoku University which assumes launching fifty remote sensing nanosatellites until 2050. Main objective of program is using satellites for monitoring natural disasters in South East Asia. Program is based on partnership different research institutes, universities and government agencies from Bangladesh, Indonesia, Malaysia, Myanmar, Mongolia, Philippines, Thailand , and Vietnam. Diwata-1 is first from two satellites which will be commissioned by government of Philippines and its Department of Science and Technology. It is also part of Philippine Scientific Earth Observation Micro-Satellite (PHL-Microsat program started in December 2014) Program and third Philippine satellite in history- first two, Agila-1 and Agila-2 were operated by private companies. *https://en.wikipedia.org*

Commitments for WorldView-4 Satellite Capacity

DigitalGlobe, Inc. announced its third customer commitment for direct access capacity on the WorldView-4 satellite, which is expected to begin commercial operations in early 2017 following its launch in September. Since the end of the third quarter of 2015, DigitalGlobe has received contracts and letters of intent from international defense and intelligence customers totaling $335 million for capacity on WorldView-3 and WorldView-4, representing $38 million of incremental annual revenue starting in 2017.

India launches 5th navigation satellite

Indian Space Research Organization (Isro) has launched the fifth (IRNSS-1E) navigation satellite in the Indian Regional Navigation Satellite System (IRNSS).

An XL version of a Polar Satellite Launch Vehicle (PSLV-C31) placed in orbit the satellite 19.36 minutes after lift-off from the Satish Dhawan Space Centre in Sriharikota. Isro scientists said the indigenous navigation system will be fully operational in six months though all the seven satellites would be in orbit much earlier. "We have two more satellites in the series which we intend to launch in a couple of months," said Isro chairman AS Kiran Kumar.

IRNSS will provide navigation and positioning services in areas that require high precision for aviation, marine navigation, rail transport and military applications. In six-months, Isro expects the system to be integrated with smartphones.

The four satellites, meanwhile, have been functioning from their designated orbital slots with an achieved position accuracy of 20m over 18 hours every day. They will be operational over 24 hours once the IRNSS configuration is complete. *http://timesofindia.indiatimes.com*

Directorate releases GPS III Phase 1 Vendor Feasibility RFP

The GPS Directorate at the Space and Missile Systems Center (SMC) released a request for proposals on January 8, 2016 seeking proposals for the GPS III Space Vehicles 11+ Phase 1 Production Readiness Feasibility Assessment contract.

This solicitation is for a competitive firm-fixed-price acquisition with up to three contracts not-to-exceed $6 million, with a base contract of $5 million and a 26-month period of performance, plus two $0.5 million options with a six-month period of performance for each option awarded, for a total possible period of performance of 38 months. The RFP reflects the GPS program's interesting in having options for the prime contractor to build the second tranche of GPS III spacecraft after Air Force officials became dissatisfied with delays in delivering the initial set of satellites. SMC's GPS Directorate intends to award the GPS III Phase 1 contract in the third quarter of fiscal year 2016.

Oldest GPS navigation satellite to be retired with next launch

A new Global Positioning System craft will ride a United Launch Alliance Atlas 5 rocket into orbit next month to replace a satellite that has operated in space for 25 years.

The GPS 2A-10 spacecraft, launched aboard Delta 201 in 1990, will fade into retirement with the launch of GPS 2F-12, the latest satellite to join the navigation network.

Lockheed passes in GPS III thermal vacuum test

The long-awaited first satellite in the US Air Force's GPS III program, has "successfully completed" its thermal vacuum test, wrote Rick Ambrose, executive vice president of Lockheed Martin's space systems on his Twitter account. Lockheed is contracted to develop eight GPS III satellites with options to build four additional satellites. The first GPS III satellite is scheduled for launch by 2017. The test is used to validate that the satellite can operate in extreme temperatures comparable to the space environment. *EinNews*

Govt seeks help from small companies to counter GPS jamming

The US federal government is seeking help from small firms to resolve some of its toughest GPS-related technology problems with many of the projects focusing on countering jamming while others endeavour to simplify signal acquisition and improve links within the constellation. And therefore, proposals for Small Business Innovation Research (SBIR) contracts have been released by various agencies.

The Defense Department is looking for a ground-based system that can track multipath signals back to their source — enabling a new way to locate jammers in urban areas. Although multipath signals, that is, signals that have bounced off reflective surfaces, can confuse GPS receivers, recent research suggests that multipath can be used to help locate jammers.

The Department of Defense (DoD) is looking for a single-receiver solution able to detect and estimate the location of a jammer within 100 meters using this technique. If networked with other sensors the system should be able to estimate location within 10 meters.

Russia postpones launch of Glonass-M satellite

The launch of Russia's navigation satellite Glonass-M No. 51 had to be postponed. Glonass-M No. 51 is to replace a satellite which is three years past the expiry date, the manufacturer said. The previous launch of a satellite of the Glonass-M family - the backbone of the national orbital cluster, took place in the summer of 2014. The Reshetnev Information Satellite Systems has eight such satellites in stock. *http://tass.ru/en/*

Russia to continue launching early warning defense satellites

The Russian military is believed to have launched the first early warning satellite for its new United Space System sometime in late 2015. Information about launches from the Plesetsk Comodrome is classified, although the military confirmed that the launch would be its second for the early warning system.

"In 2015, specialists from the Aerospace Force's Space Forces launched 21 spacecraft, used for a variety of purposes, from the Plesetsk and Baikonur cosmodromes," the ministry stated. The ground-based early warning system increased its satellite registry by 5,000 satellites in 2015, with 15,000 Russian and foreign satellites now tracked by the system.

"The missile attack early warning system detected 14 Russian and foreign missile launches in 2015," the head of the Aerospace Forces' 15th army, Gen. Maj. Anatoly Nestechuk said in October. *http://sputniknews.com*

Govt of India to put in place system for regulating UAVs

To check use of UAVs by rogue elements to carry out terror attacks, the government is mulling to put in place a system to detect and defeat such threats and regulate low flying objects. Recently, Union Home Secretary, Mr. Rajiv Mehrishi said there was a need for regulating Unmanned Aerial Vehicles to prevent its misuse, particularly in populated areas and sensitive locations like airports. The Home Secretary said the process of detection and destruction of UAVs is an evolving process and experts are still working on it. He said putting in place certain regulations in operating UAVs have two aspects -- preventive and enabling -- and the government was working on both. He said the government was also exploring the option of using UAVs for works like surveillance in large establishments such as refineries, secure oil pipelines from being broken or stolen, crime detection etc. *http://economictimes.indiatimes.com/*

UK to use drone jammers to track UAV

The UK is set to use sophisticated drone-jamming technology at major public and sporting events for detecting, tracking and disrupting the controls of any rogue as airborne weapons. According to 'The Sunday Times', a radar device was installed on the roof of New Scotland Yard headquarters of the Metropolitan police in London, close to Whitehall where World War commemoration event took place in early December. The equipment, made by a consortium of British firms and a more advanced version of the kit used by some celebrities to protect their privacy, is capable of detecting, tracking and disrupting the controls of any rogue drones flown remotely by terrorists as airborne weapons. It uses an electro-optical camera to track the drone before jamming the radio signals that control it, forcing it to land. *http://economictimes.indiatimes.com/*

New technique to help drones manoeuvre safely in mountains

Scientists have developed a new technology that can allow unmanned aerial vehicles (UAV) to manoeuvre safely in plateau mountain regions. The UAVs designed for plateau missions are usually installed with high span chord ratio wings, which provides more lifting force at a relatively low airspeed. The UAVs employ high span chord ratio wings, however, tend to lose their manoeuvrability. Hence, they usually need larger turning radius and are unable to maintain the altitude during sharp slope turning as the lifting force produced by the wings decrease dramatically when the bank angle is large. The discarding of the flight performances may risk the safety of the flight in plateau mountain regions. Variable thrust direction (VTD) technology is a type of thrust vectoring control (TVC) approach that allows to manipulate the directions of thrust to the fuselage of the aircraft.

The proposed variable thrust direction mechanism consists of a conventional propeller engine which is mounted on a two dimensional rotate disk driven by two servo actuators. By combining the linear motions of the actuator, both the azimuth and the altitude angle of the disk with respect to the fuselage can be controlled, and thus changing the thrust direction of the propeller. By the introduction of the VTD capability to the conventional propeller UAV, the manoeuvrability of the UAV has been greatly enhanced, since the VTD engine enables direct force control of the aircraft. *http://economictimes.indiatimes.com/*

Drone Liability Bill continues flying in senate

A proposal that would make owners of drones liable for the negligence of the aerial devices' operators was revamped, but critics still say the measure could ground the industry's growth in Florida, USA. The Senate Commerce and Tourism Committee voted 6-1 to support an amended proposal (SB 642) by Sen. Miguel Diaz de la Portilla, R-Miami, that would expand who could be sued when a drone causes damages.

He said the revamped measure is intended to focus more on small, toy-sized drones that may be loaned to other people for recreation, while letting courts determine how responsible the owners are when drones cause damage or harm to others.

In its place the proposal would now classify all drones weighing between 0.55 pounds and 55 pounds as a "dangerous instrumentality," similar to a car or boat. *http://miami.cbslocal.com*

New SOPs for UAVs and RPASs

The Home Ministry in India is in the process of finalising new Standard Operating Procedures (SOPs) for UAVs and Remotely Piloted AircraftRPA) to secure India's borders especially in the wake of recent terror attack in Pathankot. UAVs and RPA are used by Indian security and intelligence agencies for surveillance related works within the Indian air space. The Home Ministry will form new guidelines to help security forces guard the country's frontiers. A meeting was held in the Ministry to discuss the provision of licensing for UAVs and RPA, adding that the role of a centralised agency for their licensing was also discussed. *http://economictimes.indiatimes.com/*

NHAI to use space technology, UAVs for highway projects

The government of India will use space technology and unmanned aerial vehicles to monitor and manage national highways and road assets. The National Highways Authority of India (NHAI) has signed MoU with the Indian Space Research Organization's National Remote Sensing Centre and the North East Centre for Technology Application and Research for use of spatial technology. Satellite data and geospatial technology will be useful in providing inputs in highway and infrastructure projects for preparation of detailed project reports (DPR), prefeasibility status in new alignment, upgrade and road widening, monitoring of road segments under construction and the Road Asset Management System. *http://economictimes.indiatimes.com/*

Eos Positioning Systems Announces RTK NTRIP App for Android

Eos Positioning Systems introduced a comprehensive RTK NTRIP app for Android that works with its Arrow line of RTK GNSS receivers. An Arrow GNSS receiver combined with the NTRIP app turns your Android smartphone or tablet into a powerful data collector capable of recording 1cm accurate GIS data in real-time. The app, named Eos Tools Pro, has user-configurable audible and visual alarms to alert the user of high PDOP, lost RTK correction, unacceptable correction age and several other important metrics. It supports all current and future constellations (GPS, Glonass, Galileo and Beidou).

Google Maps is tightly integrated with the app to display the user's location anywhere in the world. Eos Tools Pro and Arrow receivers are targeted at high-accuracy applications like GIS, environmental, agriculture, electric/gas/water utilities, surveying, machine control, and federal/state/local government.

KVH Introduces FOG-based INS

KVH Industries, Inc., has introduced the GEO-FOG 3D inertial navigation system (INS), targeting unmanned, autonomous, and manned aerial, ground, marine, and subsurface platforms, such as subsea remotely operated vehicles (ROV) or mining systems. It is based on the company's high-performance fiber optic gyro (FOG) technology combined with centimeter-level precision RTK GNSS receivers and advanced sensor fusion algorithms, offers roll, pitch, and heading accuracies of .05 degree. The rugged systems are designed to deliver continuous, highly accurate position, navigation, and control information, even when GNSS is unavailable

Hexagon Acquires SCCS

Hexagon AB has announced the acquisition of Paul MacArthur Limited ("SCCS") – one of the UK's leading suppliers of surveying equipment to the engineering and infrastructure market and a Leica Geosystems distributor for over 20 years.

Headquartered in Cambridge, UK, SCCS provides surveying solutions across the country, offering customers rent, purchase and service options. As the UK continues to fund major infrastructure projects with more stringent processes related to Building Information Modelling (BIM), collaboration between the construction and software sectors becomes increasingly vital. *www.hexagon.com*

Contract for Northrop Grumman from US Air Force

Northrop Grumman Corporation has been awarded an order to support embedded GPS/Inertial Navigation System (INS) Pre-Phase 1 modernization efforts.

The Military GPS User Equipment (MGUE) program is developing M-Code-capable GPS receivers, which are mandated by Congress after fiscal year 2017 and will help to ensure the secure transmission of accurate military signals.

Under the cost-plus-fixed-fee order valued at $4.8 million from the Joint Service Systems Management Office, Northrop Grumman will evaluate new GPS receivers' modes of performance, including M-Code and Selective Availability Anti-spoofing Module. Additionally, the company will perform trade studies, assess the state of development of MGUE for upcoming applications and contribute to architecture development for next-generation GPS/inertial navigation systems.

The updated GPS/inertial navigation system will also comply with the Federal Aviation Administration's NextGen air traffic control requirements that aircraft flying at higher altitudes be equipped with Automatic Dependence Surveillance-Broadcast (ADS-B) Out by January 2020.

Trimble bags $5.8 mn US Marine Corps contract

Trimble has bagged a $5.8 million, five-year IDIQ (Indefinite Delivery Indefinite Quantity) contract from the US Navy to provide survey systems for the US Marines Corps to support topographic missions. Under the contract, Trimble will supply its Trimble M7 Anti-Spoofing GPS-S systems, Trimble S9 robotic total stations, TSC3 data controllers with Trimble Access™ field software, Trimble Business Center office software, and the Trimble MX2 mobile scanning system.

The Trimble M7 GPS-S is a Selective Availability Anti-Spoofing Module (SAASM) compliant GPS system with GNSS capability. Developed and designed based on U.S. Army Geospatial Center (AGC) specifications, the Trimble M7 receiver was selected as part of a separate U.S. Marine Corps contract awarded to Trimble in June of 2012. It is the first and only SAASM-based GPS-S survey solution delivered to and currently in use by the U.S. Military. In addition, the Trimble M7 GPS-S system has been granted Security Approval by the GPS Directorate.

Phase One iXU 1000 and iXU-R 1000

Phase One Industrial announced two 100 MP CMOS-based medium format metric cameras for aerial mapping and other demanding applications. The development of the Phase One iXU 1000 and the iXU-R 1000 camera systems marks a shift toward higher value for the aerial data acquisition market.

These systems, which are available in either RGB or near infrared (NIR) variants, are distinguished from all other existing medium format aerial camera systems by their combination of higher image resolution, wider ISO range and faster capture speeds (as fast as 0.85 second per frame), offering large format advantages at medium format prices.

Kazakh Mines sign deals with Hexagon Mining

Hexagon Mining increases its presence in Kazakhstan after signing deals with two prominent mine sites, Bozshakol and Aktogay. Both greenfield sites are owned and operated by KAZ Minerals, a high-growth copper company focused on large-scale, low-cost open pit mining. KAZ Minerals is dedicated to modernizing both mine sites, and chose Hexagon Mining based not only on its technologies and services, but also the innovation offered by the greater Hexagon group. *hexagonmining.com*

DAT/EM Systems International Releases 7.2

DAT/EM Systems International® released the 7.2 edition of DAT/EM software products including Summit Evolution™, LandScape™, Capture™, MapEditor™, Ortho+Mosaic™, Airfield3D™ and Contour Creator™. The advancements in the 7.2 DAT/EM Photogrammetric Suite represent the latest evolution in technology and are based on customer input and growth within the geospatial industry.

GNSS RTK – V100 GNSS RTK by Hi-Target

Hi-Target released V100 - its compact, easy-to-use network GNSS RTK receiver, with network RTK operation by using a controller which has internet access to provide high quality RTK corrections. It is much smaller and lightweight than any RTK receivers Hi-Target has ever offered. 580g and 127.5mm×57mm, its compact design and only one-button operation brings much convenience in the fieldwork. Moreover, the built-in whole constellation BD970 OEM board, 4.0 standard dual-mode long-range Bluetooth, NFC module and Hi-Target Cloud service make V100 the most convenient and effective receiver for the network age.

SwiftNav Releases Specs on UAV-Focus GNSS Receiver Platform

Swift Navigation is going after a low-cost, high-precision market such as unmanned aerial vehicles (UAVs) with its Piksi GPS receiver platform. Measuring 53x53 millimeters and outputting 50 position/velocity/time updates per second, it supports real-time kinematic (RTK) positioning with centimeter-level relative positioning accuracy. The RF front-end, a Maxim MAX2769 integrated down-converter and 3-bit analog-to-digital converter, can cover the L1 GPS, GLONASS, Galileo, and satellite-based augmentation system bands.

Tap Into-High Accuracy GPS Data Collection

CHC and TerraGo are revolutionizing the GPS data collection market by integrating CHC's line of X20i GNSS receivers with TerraGo's mobile field data collaboration solution, TerraGo Edge. Now a user can implement a cost-effective, survey-grade GPS data collection solution using the phone in pocket to capture high-accuracy, location-tagged notes, custom forms, photos and videos.

New Windows 10 Rugged Tablet: Mesa 2™

Juniper Systems released its newest rugged handheld computer, the Mesa 2™ Rugged Tablet, running on Microsoft's® Windows® 10 operating system. Mesa 2 is also Juniper's first handheld to run on the Microsoft® Windows® 10 operating system, improving decision-making in the field, and smoothing the transition of field data collection to office work.

SUBSCRIPTION FORM

YES! I want my Coordinates

I would like to subscribe for (tick one)

☐ 1 year	☐ 2 years	☐ 3 years
12 issues	24 issues	36 issues
Rs.1800/US$100	Rs.3000/US$170	Rs.4300/US$240
		SUPER saver

First name ....

Last name ....

Designation ....

Organization ....

Address ....

....

City .... Pincode ....

State .... Country ....

Phone ....

Fax ....

Email ....

I enclose cheque no. ....

drawn on ....

date .... towards subscription

charges for Coordinates magazine

in favour of **'Coordinates Media Pvt. Ltd.'**

Sign .... Date ....

Mail this form with payment to:

Coordinates
A 002, Mansara Apartments
C 9, Vasundhara Enclave
Delhi 110 096, India.

If you'd like an invoice before sending your payment, you may either send us this completed subscription form or send us a request for an invoice at iwant@mycoordinates.org

MARK YOUR CALENDAR

March 2016

Munich Satellite Navigation Summit 2016
1 - 3 March
Munich, Germany
www.munich-satellite-navigation-summit.org

April 2016

IGRSM 2016
13 - 14 April 2016
Kuala Lumpur, Malaysia
http://www.igrsm.com/igrsm2016

Interexpo GEO-Siberia-2016
20 - 22 April
Novosibirsk, Russia
www.expo-geo.com

Geo-Tunis 2016
26 - 30 April
Tunis
www.geotunis.org

May 2016

XPONENTIAL 2016
2 – 5 May
New Orleans, USA
www.xponential.org/auvsi2016/public/enter.aspx

FIG Working Week 2016
2 - 6 May
Christchurch, New Zealand
www.Figure net/fig2016/call.htm

10th Annual RIN Baska GNSS Conference
8 - 10 May
Baska, Krk Island, Croatia
www.rin.org.uk

MundoGEO#Connect2016
10 - 12 May
Sao Paulo, Brazil
http://mundogeoconnect.com/2016/

NAVITECH 2016
10 - 13 May
Moscow, Russia
www.navitech-expo.ru/en/

GEO Business 2016
24 - 25 May
London, UK
http://geobusinessshow.com

European Navigation Conference
30 May - 02 June
Helsinki, Finland
www.enc2015.eu

June 2016

HxGN LIVE
13 - 16 June
Anaheim,USA
http://hxgnlive.com/anaheim

6th International Conference on Cartography & GIS
13-17 June
Albena, Bulgaria
www.iccgis2016.cartography-gis.com

2016 Esri International User Conference
27 June to 1 July
San Diego, USA
www.esri.com

July 2016

ISPRS - PRAGUE 2016
12 - 19 July
Prague, Czech Republic
http://www.isprs2016-prague.com/

September 2016

Interdrone 2016
7-9 September
Las Vegas, USA
www.interdrone.com

ION GNSS+ 2016
12 - 16 September
Portland, Oregon USA
www.ion.org

EUROGEO 2016
29 - 30 September
University of Malaga,Spain
www.eurogeography.eu/conference-2016-malaga/

October 2016

INTERGEO 2016
11 - 13 October
Hamberg, Germany
www.intergeo.de

37th Asian Conference on Remote Sensing (ACRS)
17 - 21 October
Colombo, Sri Lanka
www.acrs2016.org

Commercial UAV Expo 2016
31 October - 2 November
Las Vegas, USA
www.expouav.com

November 2016

Trimble Dimension 2016
7-9 November
Las Vegas, USA
http://www.trimbledimensions.com/

INC 2016: RIN International Navigation Conference
8 - 10 November
Glasgow, Scotland
http://www.rin.org.uk/Events/4131/INC16

GSDI 2015 World Conference
28 November - 2 December
Taipei, Taiwan
http://gsdiassociation.org/index.php/homepage/gsdi-15-world-conference.html


AN INCREDIBLE LEAP
FORWARD FOR SURVEYORS
MicroSurvey®
CAD 2016
MicroSurvey CAD 2016 marks an unprecedented leap forward in terms of usability and productivity, including a streamlined interface and a point cloud engine running on Cyclone.
Get the 2 minute run-down and see why we're light years ahead of the competition:
www.microsurvey.com/2016
PART OF HEXAGON
® MicroSurvey is registered in the U.S. Patent and Trademark Office by MicroSurvey Software Inc.
MicroSurvey is part of Hexagon.
MicroSurvey®