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THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

GNSS JAMMER SENSORS PRIVACY LOCATION RF TIME

CYBERSECURITY IN LOCALIZATION

INTERFERENCE DISTRUPTION SPECTRUM SECURITY SPOOFING ANTENNA SIGNAL POSITION

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

Cybersecurity in localization

As GNSS applications increases

In monitoring, regulation, penalizing, …

Road tolling systems, asset tracking, fleet management …

So has the tendency to avoid and evade

And disable the devices that compromise

The personal interests of some.

Hence, rise of malicious mechanisms

Hacking, data faking, jamming, spoofing, …

These can result in serious consequences

Given many safety critical applications.

Also, it raises concerns about trustworthiness and robustness

Of GNSS receivers and systems (page 8).

Bal Krishna, Editor
bal@mycoordinates.org

Cybersecurity in localization

A panel discussion was organized on "Cybersecurity in Localization" at European Navigation Conference held at Helsinki, Finland during 30 May – 2 June 2016. Based on the discussion, we present here some of the opinions

A cat-and-mouse game of invention and ingenuity

James T Curran
Scientific Project Officer, Joint Research Center, Ispra, Italy

GNSS-based localization is no more or less secure today than it was a decade ago. From a technical standpoint, GNSS has always been vulnerable, and the equipment required to compromise it has long been accessible to everyone. Two features of GNSS lead it to be vulnerable: firstly, it is a passive system, based on one-way communication; and, secondly, it is not unusual for it to be sporadically unavailable due either to users being in urban or indoor environments, or temporarily shadowed by buildings or foliage. This said, although it is vulnerable, it has never really been at great risk. As yet, no evidence suggestive of a genuine spoofing attack has been found. Very few average GNSS users are concerned about GNSS security although many are concerned about jamming. However, all this may be changing, as we have recently begun to incentivize malicious behavior.

Over the past decades, being a free global service, GNSS was eagerly adopted by civilians. Those in possession of GNSS-enabled devices desired ubiquitous and accurate positioning had a vested interest in their GNSS-enabled device working correctly. Moreover, being interested in the positioning service, they would willingly adapt or intervene in the case of malfunction of the receiver. The naïve principle of operation of the average receiver was shielded by the earnestly motivated user. In the short term, this may be expected to continue.

> Very few average GNSS users are concerned about security although many are concerned about jamming. However, all this may be changing, as we have recently begun to incentivize malicious behavior

Now we are seeing the beginnings of a very different kind of GNSS application, where the receivers are being employed as tools to assist in monitoring, regulation or penalizing. This has taken the form of road-tolling systems, pay-per-use automotive insurance, geofencing, asset-tracking and fleet-management. In this situation, the personal interests of the holder or user of the receiver, and the primary function of the receiver itself, are starkly opposed. The possessor of the device is no longer an earnest user of a navigation tool, he is monitored and regulated by this device, and is the very person most interested in compromising it.

Naturally, the more creative and mischievous among us sought ways to disable these monitoring receivers, leading to prevalence of the now infamous cigarette-lighter jammer. Although initially very effective, the persistent use of jammers led to two further developments: authorities learned to localize the perpetrators, and more intelligence was built into the GNSS receiver. A number of government-initiated activities across Europe have made progress in the area of spectrum monitoring, interference detection and localization, such that the use of jammers may no longer be an effective strategy for denying localization. Further to this, interference monitoring and mitigation capabilities has begun to appear as a standard feature in mass-market GNSS receivers, which are now equipped to identify, log and report jamming events. The result is that simple brute-force denial of service may no longer be effective. This has raised the bar for the adversary.

Of course, we might expect a proportional response from the cheating user, who will only enhance the jamming device to a sufficient extent, and no more. As such, it is likely that the current jamming threat, as we know it today, will evolve somewhat, striving to successfully deny GNSS-based positioning to a receiver while remaining relatively undetectable or un-localizable. For example, this may take the form of clever pulsed signals, or the use of some form of GNSS-like signals. At some point, however, it is not unreasonable to expect that he will be forced to actively deceive the GNSS receiver: to feed it with synthetic signals corresponding to some other place or time.

The difficulty of successfully deceiving a receiver is heavily dependent upon two factors: one is the *a priori* level uncertainty of the receiver itself, and the second is the availability of auxiliary sensors and communication channels. The process of deceiving a GNSS receiver may take many forms, and might target one of many interfaces to the receiver including that of the RF chain, the internal memory, receiver-control, auxiliary sensors, timing or frequency references, AGNSS or correction streams. For typical road-tolling, asset-tracking, fleet-management applications, we might expect a simple, low-cost receiver, with limited or sporadic connectivity, and likely in a closed/sealed unit. In this case, the most practical approach to compromising the receiver may be either a synthesis of counterfeit signals, or a relaying/replaying of genuine signals gathered at some other location/time.

Over the past years, quite a lot of work has been done on GNSS spoofing, and a range of possible spoofing attacks have been postulated and even more possible spoofing detection and mitigation strategies have been conceived. Some of these have considered highly augmented receivers, which can avail of multiple antennas, inertial measurement units, odometer, where the receiver will examine features relating to angle-of-arrival and consistency between GNSS and other sensors. Other approaches have considered the case of a well calibrated receiver operating in a benign environment prior to the onset of a spoofing attempts. It is generally assumed that the adversary must dislodge the receiver from the genuine signals and coerce it into tracking the counterfeit ones. In this case the fidelity of the counterfeit signal and the transient behavior of the receiver during the time that the genuine and counterfeit signals interact is the focus of the spoofing detection scheme. In terms of dealing with likely spoofing scenarios in the future, unfortunately neither of these cases are representative.

Examining the likely applications of GNSS which may encourage spoofing, for example road-tolling/automotive insurance or asset-tracking/fleet-management systems, we can imagine a malicious user who has some degree of physical access to the target receiver, perhaps able to shroud the antenna, blocking the genuine GNSS signals, and allowing the introduction of counterfeit signals. In the case that a user were motivated to spoof the receiver, the most effective strategy might be to begin the spoofing operation when the receiver is in a highly uncertain state, for example having had experienced a GNSS outage for a protracted period, and thereby operating a cold- or warm-start acquisition.

Due to their limited resources, single-antenna mass-market receivers, during their cold- or warm-start phase, are quite vulnerable, and are not in a position to exploit many of the established anti-spoofing techniques:

- Without multiple antennas, angle-of-arrival based spoofing-detection schemes cannot be used, such that a simple signal generator can be used as a spoofing device. Other approaches, wherein a single GNSS antenna is moved in a prescribed fashion, so as to induce different carrier phase variations on signals arriving from different directions, may also fail. If a spoofer has direct access to the receiver, he may know the antenna movement profile and pre-adjust the spoofed signals appropriately.
- Without inertial sensors, coherency tests between the variation in the GNSS position estimate, and that observed by the inertial measurement unit, may not be possible. Even if low-quality inertial units are available, their initialization or calibration, in terms of bias and scale, is dependent on the prior availability of trustworthy GNSS. As such, although they may be useful for detecting the onset of a spoofing attach when the receiver starts in a safe condition with line-of-signt to the satellites, it may not be useful when the onset of spoofing occurs during cold-start.
- Because it is possible to shroud the antenna, anti-spoofing techniques which search for multiple instances of the same signal, genuine and counterfeit, will not be useful nor will the transient 'carry-off' behavior will not occur. The receiver will be presented with and allowed to acquire only one setoff signals, these being the counterfeit ones.
- During the acquisition stage, following a protracted absence of GNSS, it is also likely that the receiver uncertainty of the true time will be very high. This receiver may not perceive that a counterfeit signal is delayed by some tens or hundreds of milliseconds, relative to true time. This uncertainty might allow a spoofer to recover the navigation data carried by the genuine GNSS signals, and subsequently use it in the generation of the counterfeit signals, resulting in counterfeit signals which are bit-for-bit identical to the genuine ones. As a consequence, for these applications, anti-spoofing techniques which operate at the navigation data level, such as cryptographic navigation message authentication schemes (NMA), will not offer any protection.

Securing a cold- or warm-start receiver is challenging, and seems to remain an unsolved problem. Interestingly, very many of the GNSS applications which would benefit from, or even require secured localization, will operate under conditions where the receiver must endure brief or protracted unavailability of GNSS, and subsequently re-acquire all satellites in view. In many cases, the availability of GNSS will be under direct control of the user of the device, for example by shrouding the antenna, leaving the receiver at a distinct disadvantage.

Some means of securing a receiver at during this initial acquisition/re-acquisition stage must be found. It is not clear whether this might ever be possible for a stand-alone receiver, if some mechanism or degree of sensitivity to counterfeit signals can be found, or whether some form of duplex connectivity, such as UMTS/LTE or WiFi, will be required, enabling secure time-transfer and remote signal processing. However, even if a receiver is not absolutely secure, the market will reach an equilibrium, where the cost of compromising GNSS will outweigh the benefit. But, until this happens we are likely to see a cat-and-mouse game of invention and ingenuity.

Attacks and defences will somehow progress in a parallel way

Daniele Borio
Technology Innovation in Security Unit, European Commission - JRC, Directorate E - Space, Security and Migration, Ispra,Italy

Global Navigation Satellite Systems (GNSSs) have become, over the last decade, a pervasive technology which has found applications in different fields, from road transportation to leisure and sport, from spatial analysis of scientific data to safety and regulated applications. The pervasiveness and, sometimes, the invasiveness of this technology along with the economic interests related to the applications it enables have created incentives to disrupt GNSS operation. A clear example is from the road transportation sector where GNSS has promoted the fast deployment of electronic toll collection systems. In this respect, GNSS is the most cost-effective approach for building and expanding a road tolling network with the lowest requirements in terms of infrastructures. A malicious user could be definitely interested in interfering with GNSS operations to reduce or avoid tolling.

Privacy protection has also been often used as a reason for justifying improper behaviors possibly disrupting GNSS signal reception.

Irrespective of the cause, GNSS receivers, as key elements for the fruition of GNSS location-based services, are vulnerable to several forms of cyber-attack. The most known are jamming and spoofing. Jamming is a common reality and jamming attacks have been recorded in several occasions: from the truck driver using a jammer to avoid to be tracked by his employer to the "state-based" jamming perpetrated by North Korea to the detriment of their Southern neighbours. Spoofing is moving from the "research" to the "deployment" phase. Just a few years ago, spoofing was demonstrated only in labs and it is now object of interest of hackers.

When determining the threats we also have to keep in mind that "bad ideas move fast" and that forms of attacks can spread from one domain to another quite rapidly and sometimes in unexpected ways

Although spoofing may, for the moment, be found too complex or too expensive to have a sufficient incentive to perpetrate it, other options are at the disposal of the malicious user. A cyber-threat which has been probably underestimated till recently is the so called "GNSS data faking" problem or simply "faking". In this case, the signals at the antenna of the GNSS receiver are genuine, what have been falsified are the output data provided by the receiver itself. The final result is very similar to that achieved by a spoofing attack: false Position Velocity and Time (PVT) are provided to the application using GNSS data.

The risks connected to data faking have been strongly reminded to the public by the Pokemon Go game which exploits the location data provided by the GNSS receiver integrated within a smartphone. Pokemon Go players may find an advantage in faking (and sometimes spoofing) the GNSS receiver inside their phone. The Pokemon game resulted, somehow, the right incentive to perpetrate "innocent" cyber-attacks to GNSS receivers.

The lack of awareness of the possible consequences of jamming, spoofing and faking also plays a significant role in the proliferation and development of new forms of GNSS cyber-attacks. Data faking perpetrated for the Pokemon Go case may seem without consequences (maybe a small economical damage to the game developer). However, the same data faking strategies may be adopted in other domains.

Regulated applications such as the Digital Tachograph in road transportation and the Automatic Identification System (AIS) for vessel identification may suffer from faking attacks developed for the Pokemon Go and made popular through social media such as YouTube. Awareness and the possible deployment of rules for discouraging these types of cyber-attacks are important.

It is also important to change the conception of a GNSS receiver which has to be seen as a piece of a more complex puzzle. GNSS receivers are inserted in chains which do not end with the display of the user position. GNSS receivers are data providers and their information can, for example, be used by the on-board vehicle unit of the digital tachograph or by the AIS transmitter which will provide the vessel position to maritime authorities.

It is necessary to protect the full chain and not only the receiver input as traditionally done for jamming and spoofing attacks. Also the GNSS receiver output is vulnerable and has to be protected for example through authentication means.

The first steps towards the protection of a GNSS receiver (in its totality) are the "knowledge of the enemy" and the "fear for the unknown". Jamming can be effectively mitigated only if jamming signals are properly characterized and modelled. Spoofing can be detected only if its impact on the receiver is properly known. GNSS data faking will be effective only if unexpected and underestimated.

When determining the threats we also have to keep in mind that "bad ideas move fast" and that forms of attacks can spread from one domain to another quite rapidly and sometimes in unexpected ways. For examples, several GNSS threats originated from other domains, mainly from the wireless communication sector. Thus, forms of attacks well known, for example, in the telecommunication sector should also be monitored. It is important to verify that other domains don't become sources of inspiration.

This is the case of smart jamming which has been recently considered for disrupting the operations of a GNSS receiver. With respect to standard brute-force jamming, a smart jammer tries to operate without being detected and it does that by "hitting" where it hurts most. For example, jamming signals can be pulsed and interference may be generated only in correspondence of critical elements of the navigation message of the received GNSS signals. In this way, the receiver may be unable to recover the preamble of the navigation message or to decode important information.

A waste literature exists on smart jamming for wireless communications and sensor networks and concepts developed in these fields are (unfortunately) progressively percolating into the GNSS world. Since this "enemy" is still new to GNSS, a receiver may be unprepared with consequences on the applications depending on GNSS data.

The future of anti-jamming and GNSS cyber-security is probably to keep determining and characterizing the threats that may arise. Smart jamming has shown that there are components of the GNSS signal particularly vulnerable to time-localized interference events. GNSS cyber-security will focus on protecting these components, enhancing the GNSS signal design, providing alternative sources of information, designing specific detection approaches which specifically monitor the weakest signal components. Attacks and defences will somehow progress in a parallel way, in a continuous quest for solutions to new problems.

One of the keys to defeating spoofing is to detect it in devices

Guy Buesnel
PNT Security Technologist- Robust Position, Navigation and Timing, Spirent Communications plc, UK

GPS jamming is a widespread phenomenon today. Spirent has deployed interference detectors in several countries globally and found interference in the GPS L1 band in every country a DETECTOR has been deployed in.

Often spoofing is seen as the exotic and purely theoretical cousin to jamming. But actually GPS spoofing beginning to emerge as being a very real and malicious threat.

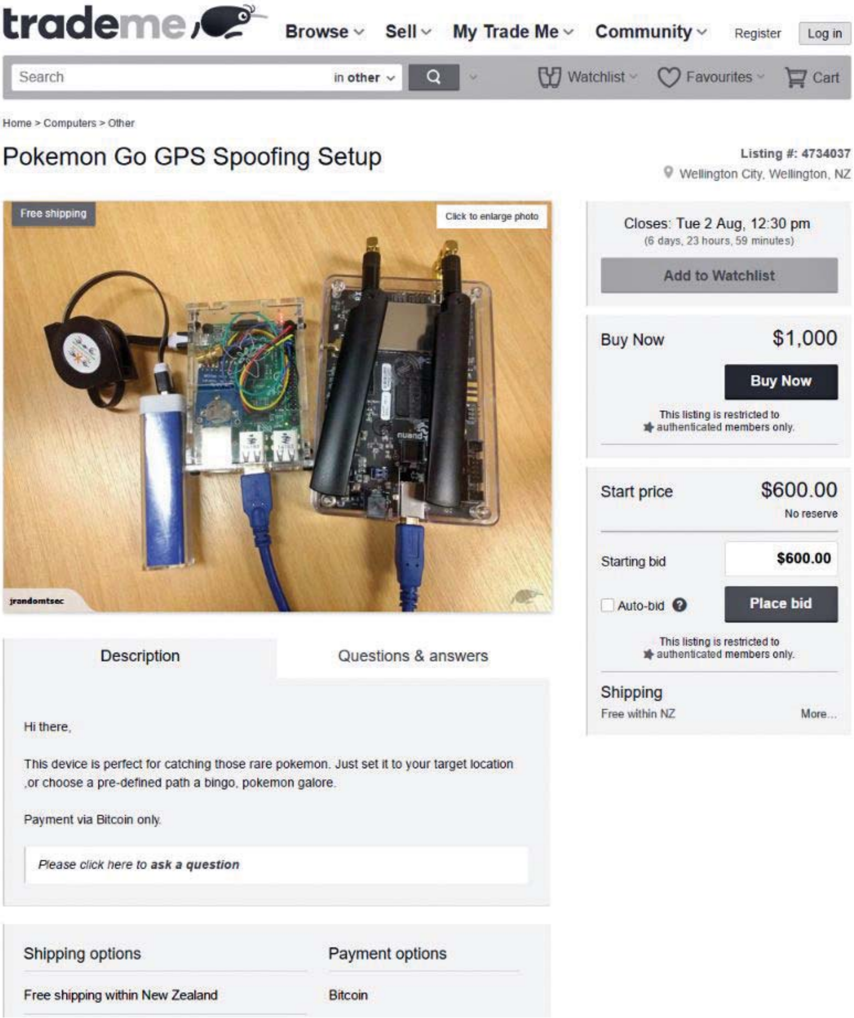
GPS spoofing involves a person or group broadcasting "fake" satellite signals to a GPS receiver to fool it into generating a false position and potentially following a false route.

While GPS spoofing is in its infancy compared with jamming, the wider use of time and location spoofing for malicious or misguided purposes has already started and there are several real, evidenced examples to back up the fact that GPS spoofing is becoming a threat as every bit real as RF interference.

Whilst spoofing has been referred to as a potential threat to GNSS and has been demonstrated several times in controlled environments (e.g. Todd Humphreys' spoofing of a super-yacht in the Ionian Sea in 2013) it has often been regarded as being very difficult to conduct and requiring a high degree of expertise and GNSS knowledge.

- In August 2015, Huang and Yang from the Unicorn Team, Radio and Hardware Security Research presented a low cost GPS spoofing emulator at DefCon 23 in Las Vegas. Remarkably, they had no expertise in GNSS but found it easy to construct a low-cost signal emulator using Commercial off the Shelf Software Defined Radio and RF transmission equipment. The code needed for a GPS transmitter was freely available on the internet. They were able to spoof a car's built in GPS Receiver in an underground car park, to spoof the date, time and location on two well-known brands of smart phone and to spoof a drone so that it would fly in a restricted area. Whilst the spoofing attack was relatively crude, none of the target devices were able to detect the attack or generate any warnings to the user.
- In December 2015 the Department of Homeland Security revealed that Drug Traffickers were attempting to spoof border drones as well as using GPS jamming equipment. http://www.defenseone.com/technology/2015/12/DHS-Drug-Traffickers-Spoofing-Border-Drones/124613/
- During 2016, with the release of the Pokemon Go Augmented Reality game, some hackers realised that they could sell gaming accounts to users who wanted to save time and effort capturing monsters. The hackers who sold these accounts faked their location in order to build up a large collection of captured monsters as quickly as possible without needing to visit real locations. The hackers

While GPS spoofing is in its infancy compared with jamming, the wider use of time and location spoofing for malicious or misguided purposes has already started



spoofed their position at application level to start with – this required the operating system of their tablet or smartphone to be jail-broken, and software installed that provides fake location data to any application that uses GPS data. Whilst this worked well to start with, the main drawback of this system is that it is relatively easy to detect whether an operating system has been jailbroken and to then prevent devices with jailbroken operating systems from accessing the game. However, very quickly, hackers realised that they could easily build an RF signal generator to transmit replicated GPS signals. They did this using Software Defined Radio (SDR) programmed to act as a GPS transmitter. Some enterprising hackers even tried to sell their home made devices online to others who lacked the skills needed to build their own.

What is very striking about events since 2013 is that the number of people with the specialist knowledge of GPS spoofing has risen from probably less than a hundred to (with Pokemon GO), tens of thousands, including many experienced hackers. This means that GPS spoofing is no longer a theoretical or improbable threat vector. Hackers have demonstrated that spoofing is not particularly difficult to accomplish and have used a wide variety of location spoofing techniques in order to cheat in augmented reality games.

Whilst it is true that spoofing is not happening on a widespread scale, it seems that it should be considered as a risk to the users of PNT-based navigation or timing systems in safety or liability critical applications. Systems that have been exposed to fake GNSS signals in addition to authentic ones, can often exhibit unexpected behaviour – this is perhaps not unsurprising as the presence of both replica and authentic satellite signals at similar power levels is not a usual test scenario. A spoofing attack does not always have to be successful in order to cause significant disruption in the targeted device or system and that is why testing against a realistic spoofing scenario is important. Mitigation to protect against spoofing attacks can range from relatively simple, inexpensive improvements to the use of sophisticated antenna technology that monitors the direction of arrival of the received signals but provides extremely high levels of protection against spoofing, or even the use of encrypted signals.

The military use encrypted GPS signals as protection against spoofing – only a user with the correct key can read the navigation data in the signals and a would be spoofer is not able to replicate the code. In Europe the Galileo constellation will offer the Public Regulated Service (PRS) which also uses encrypted signals to provide a high level of protection against GNSS signal spoofing – the PRS is intended to be made available to authorised governmental or military users.

One of the keys to defeating spoofing is to detect it in devices. There are ways to do this although there aren't many receivers today that will warn a user if someone is attempting to spoof their GPS signals. For example a relatively simple detection mechanism would be to monitor the power levels of received signals – the power level of the spoofed signals is likely to be greater than that of the received signals. Monitoring relative signal strengths in the receiver would also work well – signals will have slowly changing power offsets… a sudden change might indicate a problem.

The important thing is to test PNT dependent systems and devices with a realistic spoofing scenario to see how they behave and to find out what can be done to improve their performance or to alert a user that there is a problem.

"Expect to have autonomous protection as a default feature in all GNSS receivers"

Oscar Pozzobon
CTO, Qascom, Italy

> Cybersecurity defense and protection will be standard feature in almost all civilian receivers by 2020, and by 2035 in almost all GNSS civilian signals

The penetration of GNSS in different markets both professional and safety critical has risen concerns the last decade on its effective trustworthiness and robustness. Cybersecurity to date is known as everything that regards security including attacks and protection to computer, software and network systems. Attacks to radio signals have been known as signal intelligence, particularly in the defense sector. For GNSS, if the attention in the last decade has been mainly focused to radio frequency interference and vulnerabilities, the future will foresee a rising interest in cybersecurity, which includes the aspects of software, hardware and communication. In Qascom we call the combination of both as "Cybersecurity and intelligence". This for example include futuristic GNSS attacks that target all elements of the Open Systems Interconnection (OSI) layers, from physical to data level, in order to achieve both deception or denial of service. This as a result has impact in the following subsystems:

- Attacks and vulnerabilities of the signals,
- Attacks and vulnerabilities of the software and hardware,
- Attacks and vulnerabilities of the data links;

While for software and hardware we can leverage from lessons and existing standards in computer and networks, attacks to signals are a new frontier: industries, researchers and government attempted to categorize attacks and define protections since many years. However, no clear plans and standards are available for cyber protection on signal attacks. No lifecycles have been defined at application and user level, such as operational centres that can analyze and detect new attacks and patch receivers and applications. Qascom is currently contributing to governments and standard organization to categorize attacks and define security metrics that can be used to build protection profiles and security targets for every application. It is likely that in few years and by 2020 all safety and financial critical user communities will have specific requirements for cyber intelligence protection and defense.

The other big challenge will be for the GNSS system providers: if protection at receiver level can be accomplished to date only with what we call "Heuristic techniques", system providers are working to increase GNSS authentication and robustness at system level.

To better explain this concept, enabling protection at receiver level (such as anti-jam or anti-spoof) can be compared to an anti virus installed in a PC: it continuously monitor any upcoming attacks, and will alert and attempt protection if they arise. Protection at system level can be seen as the HTTPS connection with your bank. Regardless you have an antivirus or not, it will be hard for an attacker to eavesdrop the information that you transfer or to pretend to be the receiving party.

In this domain the new Galileo system is playing a leading role: Galileo has the capability to offer both an Open Service (OS) authentication and a Commercial Service (CS) authentication. These services are currently under design and testing, and Qascom has been a pioneer and one of the major players together with different partners. The Galileo OS authentication will provide initially protection of the navigation data, in order to verify that the data has been generated by the system. This is a fundamental step and very important from the legal perspective considering that to date any signal generator can produce any NAV data with any time in the past or in the future. The Galileo CS authentication will provide protection at code level, blocking the possibility for an attacker to generate a bogus PRN code. Qascom is also currently assessing for the European Commission the feasibility to provide authentication to EGNOS. Together with the Galileo authentication services, the use of the new Galileo modulations, larger bandwidth signals and use of multi frequency services will be a step forward for increasing robustness also.

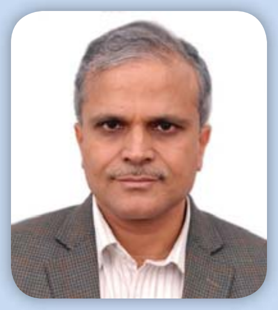
As a conclusion, considering that both at receiver level and at system level with Galileo there has been a relevant progress in the last decade, we can expect to have autonomous protection coming as a default feature in all GNSS receivers in the next few years and full service protection at system level in the next decade.

As a vision for the future, and following the current scenario of the ICT security, the user will simply pay some fees or features for the cyber security and intelligence protection. He will sit down, relax, and enjoy positioning and navigation while in the background massive warfare scenario might happens including hostile jammers, spoofers or hackers.

Will we reach the 100% solution to GNSS trust and robustness? Absolutely not: security is the only business where the more we protect the more the attack increase, getting worse and worse during the years.

"Application development under NGIS will be greatly facilitated by NDR"

says Dr P S Acharya, Scientist 'G' & CEO (NSDI), Department of Science & Technology, Government of India



> Mega projects like Digital India and Smart Cities could be viewed in the context of NSDI as having a large number of complex GIS applications or Decision Support Systems of different kinds requiring provision of and access to right resolution geospatial data

Not hearing much about NSDI? Is it a forgotten story?

No, not at all. It has been very much a live entity devoted to facilitating provision of discovery and access to spatial data sets captured by different partnering agencies of National Spatial Data Infrastructure (NSDI). Re-engineering the existing data, making those discoverable through a common gateway like NSDI Portal (https://nsdiindia.gov.in) or the National Data Portal (https://data.gov.in); and providing access to data sets as web-based services for visualisation and application development have been the priorities so far. Over the recent past, NSDI has further consolidated itself towards provision of map and feature data services, setting up of a National Data Registry (NDR), maintaining National Foundation Spatial Data sets (NFSD), and coordinating implementation of the National Geographical Information System (NGIS).

Where we stand on NSDI as of today?

NSDI has been instrumental in getting published OGC-compliant Web Map Services (WMS) for access with countrywide data/ image coverage available from Survey of India (SOI), National Remote Sensing Centre (NRSC), Forest Survey of India (FSI), Central Water Commission (CWC (WRIS)), Central Ground Water Board (CGWB (WRIS)) from their respective Data Nodes. OGC-compliant Web Feature Services (WFS) to facilitate download of 1:50K (or higher) processable topographic data after cleaning and re-engineering for Delhi and Haryana States have been completed. A total of 90% topographic data have been cleaned for publication of WFS for a major component of the National Foundation Spatial Data (NFSD). Data Node Specifications and Application Schemas for WFS/ GML in respect of Ministry of Statistics and Programme Implementation (MoSPI), Central Pollution Control Board (CPCB), National Atlas and Thematic Mapping Organization (NATMO), and Geological Survey of India (GSI) have been finalised to support the development of the National Data Registry in the near future. National Standard for Geospatial Metadata has been published through the Bureau of National Standards (BIS). ISO standards on WMS, WFS, Conceptual Schema Language (CSL), Rules for Application Schema, and GML have been co-branded as National Standards for publication.

What about state SDIs? Karnataka, Delhi, Uttarakhand...?

State SDIs have made substantial progress. Karnataka Geoportal has been maintained as an on-going infrastructure and its utility demonstrated in applications like Watershed Management and Health. District NRDMS Staff posted with the

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Zilla Parishat in each of the State's 30 districts have been trained on use of the Geoportal in updation and sharing of both geometric and attribute components. Test version of the Uttarakhand Geoportal has been made operational and is currently under User Acceptance Testing. System Integrators have been identified in West Bengal, Odisha, and Jharkhand where the geoportal development work is progressing in full swing. States like Madhya Pradesh, Punjab, Nagaland, and Mizoram have shown keen interest in setting up State SDIs.

Any successful example of any application of NSDI?

Enrolment of organisations at the national and state levels for operationalisation of SDIs, availability of the NSDI platform for ensuring commitment to a shared vision of standards-based data sharing; and creation of the enabling framework of policies have been the major factors contributing to the success of NSDI. Data sharing has just begun as web-based interoperable services (WMS/ WFS/ GML) from SOI, NRSC, FSI, GSI, CWC, CGWB, and State Governments like Karnataka, Uttarakhand, Kerala. Primary ingredients of SDIs like policies (NDSAP, State Policies), technologies (Service-oriented architecture), standards (CSL, WMS, WFS, GML, Metadata), human resources (training modules/ kits/ skills in spatial data modelling) etc. have come together to provide the required enabling framework. Development of real-life applications of NSDI for decision support has been now much closer to reality than ever before because of NSDI and State SDIs. But much more are required to be done on various fronts for achievement of automated development of GIS applications. NGIS Mission is expected to be mounted on the top of NSDI for the successful delivery of the applications.

The key challenges before NSDI?

The key challenges have been the lack of trained manpower for building and using web-based data services for application development, lack of data updation mechanism/ out-of-date data; non-availability of legacy data in proper processable format/ structure; delay in adequate adoption of technologies; inadequate policy support to enforce/ regulate data management/ sharing, and longer on-boarding time in deploying portals and data re-engineering etc.

Any update on National GIS (NGIS)?

NGIS proposal has been further revised in the wake of the progress made in Geospatial Technologies in the recent past and various other initiatives launched by the Government and re-submitted for approval.

Focus of NGIS has been on application development for decision support. Development of the GIS applications will rely on and use of standards-based and interoperable data/ processing services made accessible through NSDI and State SDIs

Will NGIS make NSDI irrelevant?

Focus of NGIS has been on application development for decision support. Development of the GIS applications will rely on and use of standards-based and interoperable data/ processing services made accessible through NSDI and State SDIs. National Data Registry (NDR) will be critical to faster development of GIS applications.

Please explain the importance and significance of National Data Registry (NDR)?

Over the past years, NSDI has compiled, updated and served metadata of different partnering agencies through India Geo-portal. Experiences suggest that there has been sub-optimal utilisation of the NSDI metadata in search, discovery and application development. Approach to metadata management needs to be upgraded and re-oriented with the deployment of a standards-based NDR. With NSDI and State SDI agencies increasingly publishing feature data sets as interoperable web-based services (WMS/ WFS) potentially useful in GIS, effective management and use of data services require access to additional metadata information. Such information may include definitions or semantics of underlying data, registration of each data/ service (with unique-id) for referencing purposes over the web; tracking changes in data storage/ format/ standard specifications etc. so that those could be put to appropriate interpretation and analysis in a GIS. A prototype of the NDR has thus been developed and demonstrated by NSDI with the involvement of IIT Bombay, IIT Kharagpur; IIIT Hyderabad; KSCST and Bengaluru for a select set of use cases. Based on the insights gained, it has been decided to develop an operational scale NDR for storing and sharing up-to-date metadata from the partnering agencies. The NDR will be capable of providing a set of registers containing metadata for the data sets and their services those could be used by humans and machines for developing GIS applications on-line.

What are the key elements of NDR?

Key elements of the NDR are proposed to be (i) a set of registers containing metadata like data definition, data catalogue, application schema, and classification code etc., (ii) registry service for publication of data/ service registration by the data/ service providers with unique-ids; (iii) catalogue service on web (CS-W) for sharing of metadata, and (iv) an automated facility for harvesting metadata from the Data Nodes of the NSDI partnering agencies/ State SDIs by the NDR for updating the metadata on the NDR.

How NDR is going to help NSDI/ NGIS?

NDR will help the end user/ utilities in searching and discovering right kind of spatial data sets for application development. It will also support keeping track of changes made to a data set through its definition, application schema, classification code and the version number of the underlying standard, if any, to facilitate correct interpretation and processing of the results, and avoid duplication in data capture. Application development under NGIS will be greatly facilitated by NDR.

How do you see the role of Survey of India?

SoI as the premier National Mapping Agency for topographic data will continue to remain a major partner of NSDI and contribute to the acquisition, maintenance, and sustained provision of authoritative, seamless, reliable, and consistent National Foundation Spatial Data (e.g. positioning network, DEM, administrative boundaries, transportation network etc.). Improvement of resolution and accuracy in the NFSD aligned to the end user needs of the stakeholders is expected to be a major item in the role of SoI in the coming years.

How you position NSDI vis-a-vis mega projects of Government of India like Digital India and Smart Cities?

Mega projects like Digital India and Smart Cities could be viewed in the context of NSDI as having a large number of complex GIS applications or Decision Support Systems of different kinds requiring provision of and access to right resolution geospatial data. In order to remain effective in meeting this requirement, NSDI will require formulation of the right kind of policies, organisational structure for sustenance of the underlying infrastructure, compliance framework, standards and interoperability specifications, training and capacity building.

How to encourage the incorporation of spatial components in such initiatives of the Government of India?

Automation in application development, improved accessibility to spatial data of right resolution; and user-friendliness of tools and applications are key to such encouragement. These are getting to be addressed by NSDI-NRDMS and NGIS Initiatives in the coming phase.

AURORA - The Arctic Intelligent Transport Test Ecosystem

The unique Arctic Intelligent Transport Test Ecosystem Aurora being built in Fell Lapland region of Finland promises to offer most certainly cold conditions for testing automated driving and ITS solutions

Alina Koskela
Project Manager, Aurora Snowbox, Mobility management and ITS, Finnish Transport Agency, Helsinki, Finland

Situated above the Arctic circle, the Northern Part of Finland called Lapland, is known for its unique know-how in technologies dealing with snow, ice and cold. This is not suprising taken into account that winter lasts here for more than 6 months and snow tchikness rises up to 1 metre. With temperatures going down to as low as -40 celcius and polar night lasting for 25 days, the region is more than suitable for winter and extreme weather testing of new technologies. The potential of the natural conditions in the Arctic is now being exploited to solve the challenges that self-driving vehicles and intelligent transport systems will have to face in harsh weather conditions. The unique Arctic Intelligent Transport Test Ecosystem ***Aurora*** being built in Fell Lapland region of Finland promises to offer most certainly cold conditions for testing automated driving and ITS solutions.

The idea behind Aurora is that ***intelligent transport is not just for the good days***. In order for intelligent transport automation and particularly self-driving vehicles to develop and become more common, the technologies will have to learn to deal also with unseasonal weather changes as well as with harsh weather climates. That is why the Aurora test ecosystem was designed for verifying and validating new ITS solutions and innovations in real extreme weather conditions. Initiated as a Finnish public-private partnership Aurora is an open platform for interested parties to join. With more than 40 network members Aurora is successfully bringing together private and public sector to cooperate, demonstrate and pilot new technologies in a multilevel Arctic test bed.

Picture 1: Aurora – the Arctic Intelligent Transport Test Ecosystem is located in Fell Lapland region of Finland alongside the main road E8 ending in Norway.

The arctic test ecosystem

Safety and reliability of self-driving technologies are the key factors for user acceptance and usage of self-driving vehicles to become wide-spread in the near future. Most of the testing is currently carried out in easy environments without major weather and climate hazards, but self-driving vehicles need to be able to operate also in conditions of ice and snow-covered roads, without visible lane markings and road routes narrowed down by piles of snow. Without these characteristics self-driving vehicles will not only be able to reliably operate in Finland, but also everywhere else where snowing occurs even occasionally.

In order to move from the automated to ***snow***tomated driving, the Aurora test ecosystem enables multilevel testing in real Arctic conditions to push these technologies to the limit. Firstly, the tests can be carried out on safe and secured private test tracks closed from traffic and suitable even for early phase prototype testing. Secondly, tests can be continued, paired or duplicated on public

Summary of Levels of Driving Automation for On-Road Vehicles

This table summarizes SAE International's levels of *driving* automation for on-road vehicles. Information Report J3016 provides full definitions for these levels and for the italicized terms used therein. The levels are descriptive rather than normative and technical rather than legal. Elements indicate minimum rather than maximum capabilities for each level. "System" refers to the driver assistance system, combination of driver assistance systems, or *automated driving system*, as appropriate.

, cne table also shows how SAE's levels definitively correspond to those developed by the Germany Federal Highway Research Institute (BASt) and approximately correspond to thons described by the US National Highway Traffic Safety Administration (NHTSA) in its "Preliminary Statement of Policy Concerning Automated Vehicles" of May 30, 2013.

Level	Name	Narrative definition	Execution of steering and acceleration/ deceleration	Monitoring of driving environment	Fallback performance of *dynamic driving task*	System capability (*driving modes*)	BASt level	NHTSA level
	***Human driver* monitors the driving environment**							
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a	Driver only	0
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes	Assisted	1
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes	Partially automated	2
	***Automated driving system* ("system") monitors the driving environment**							
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes	Highly automated	3
4	High Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes	Fully automated	3/4
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	All driving modes	-	

Picture 2: Summary of Levels of Automation for On-Road Vehicles. Source SAE International.

roads as the Finnish legislation already facilitates testing of automated vehicles in regular traffic. Testing of automated vehicles (SAE levels 0 - 5) is possible in road traffic in Finland using a test plate certificate. In testing automated vehicles, the vehicle must have a driver either inside or outside the vehicle. In liability issues, the driver is the person who makes decisions on the movement of the vehicle.

The public test area on main road E8

On top of the above mentioned testing possibilities, those coming to test in the Aurora test ecosystem will be able to make use of a public test area that is currently being built on main road E8. The test stretch of 9 km is being equipped and instrumented in order to support the needs of the testers within Aurora. Equipment and instrumentation of the stretch is carried out in close cooperation with the private sector and bases on actual needs of the testers. The public test area is planned to be ready and open for public use in early fall 2017 and it will include services of precise positioning, fibre connection, extensive high speed 3G/4G/LTE 800 mobile

Picture 3: Main road E8 forms the backbone of the Aurora Intelligent Transport Test Ecosystem.

Picture 4: Reindeers are not afraid of cars. Photographed from behind the steering wheel in Fell Lapland.

networks as well as on-demand 5G test network. In addition to the physical instrumentation, testers will be able to utilize high definition 3D maps of the test area to trial out performance of automated vehicles based on pre-collected data.

The public test area is an open platform for demonstrating and piloting performance of automated vehicles but also solutions for connected cars and new mobility services. In addition the test section will be used by public road authorities to monitor and survey the impact of automated driving on the road as well as potential of automated technologies in intelligent infrastructure asset management.

ITS reindeer warning system to half reindeer accidents

The Aurora test ecosystem enables testing of digital transport infrastructure (DTI) and connected cars initiatives. DTI and connected cars allow transport-related message delivery between the road users, the service providers and the authorities in a standard telecom network. One of the first DTI pilots in Aurora is the ***reindeer warning system*** pilot project which is carried out in years 2016 - 2017.

Reindeer husbandry area covers 36 % of Finland's area. Within this area there has occurred approximately 3 500 – 4 500 accidents every year involving reindeer and road vehicles. In the year 2011 the number of reindeer accidents came up to 4 624. Although traffic safety overall in the transport sector of Finland has increased, the number of reindeer accidents has remained high. Reindeer accidents result annually in 2.6 million € of compensations for reindeer owners, and approximately 15-20 million € spent in vehicle repairs. Figures do not include lost profit of deceased reindeer or time of professional vehicles spent in the garage instead of productive operation.

Typical way to warn drivers is with a road sign for reindeer. The impact of a static sign wears off in time because reindeer migrate between the winter and summer grazing grounds, but are not always on the road. Instead of giving static information of reindeers being spotted, the pilot project of reindeer warning system crowdsources the information of reindeer observations. With the help of smartphone applications professional drivers and road users will be able to send reindeer warnings to other road users in case they observe a reindeer on the road. As reindeer tend to roam around the same location for some time, other road users within the same geozone will receive a notification of reindeers being spotted on the road. Since August 2016 already 82 000 warnings have gone through the system increasing road traffic safety level of road users in the reindeer husbandry area. The project is implemented in cooperation with the Centre for Economic Development, Transport and the Environment of Lapland, the Finnish Transport Agency, the Reindeer Herders' Association, Paikkatieto Online Oy, HERE and V-traffic Mediamobile.

Mobility as a service pilot in Ylläs holiday resort

The principle of Mobility as a Service (MaaS) is to move towards more flexible and integrated services, building a network that is service-oriented and demand-driven, while providing a wider range of more flexible services to customers, but in a more environmentally friendly way. Ylläs ski resort is the oldest in the Finnish Fell Lapland, situated around 200km above the Arctic Circle. The resort is based around two traditional villages, Äkäslompolo and Ylläsjärvi, located on the opposite sides of the Ylläs fell. The fixed population of the area is approximately 1100, but in the tourist season, the population expands dramatically, filling most of the 23 000 beds available across several hotels and hundreds of log cabins spread around the countryside.

The Ylläs Mobility as s Service pilot project (YlläsMaaS) aims at flexible and affordable mobility services for tourist and locals without car dependency in the Ylläs area. The starting objective of the two-staged project is to deliver an integrated transport information system, along with automated finance management and fund distribution. During spring 2016 mobility services where offered via Ylläs Around application powered by telecom operator TeliaSonera.

The focus of the first stage was on the final legs of transportation to the Ylläs villages from both the airport and the railway station, and on the transportation within the area. Transport services were offered by local taxis, ski busses and feeder transport between the airport and Ylläs as well as between the railway station and Ylläs. Also shared taxi rides at a reduced price were available to the users. The variety of mobility services available for purchase is increasing for the second pilot stage starting at the end of 2016. The pilot project is implemented in cooperation with the Finnish Transport Agency, the Municipality of Kolari, the Ylläs Travel Association and Sonera.

Picture 5: Reindeers wandering in Fell Lapland.

Picture 6: Fat bikes are one of the means of transport in Ylläs ski resort area.

United Nations/Nepal Workshop on the Applications of GNSS

Kathmandu, 12 – 16 December 2016

The United Nations/Nepal Workshop on the applications of global navigation satellite systems (GNSS) was organized jointly by the United Nations Office for Outer Space Affairs and the Survey Department of the Ministry of Land Reform and Management on behalf of the Government of Nepal. The Workshop was co- organized and co-sponsored by the International Committee on Global Navigation Satellite Systems and GfRmbH Galileo Control Centre, German Space Agency (DLR). A total of 113 participants from the following 32 countries attended the workshop: Australia, Bahrain, Bangladesh, Brazil, China, Croatia, Egypt, Estonia, Fiji, France, Germany, India, Indonesia, Japan, Lao PDR, Latvia, Malaysia, Mongolia, Morocco, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Russian Federation, Saudi Arabia, Thailand, Turkey, Ukraine, United States of America and Uzbekistan. Representative of the European Commission was also present. Representative of the Office for Outer Space Affairs also participated. The Workshop was hosted by the Survey Department of the Ministry of Land Reform and Management and held in Kathmandu, Nepal, from 12 to 16 December 2016.

The Workshop addressed the use of GNSS for various applications that can provide sustainable social and economic benefits, in particular for developing countries. Current and planned projects that use GNSS technology for both practical applications and scientific explorations were presented. Cooperative efforts and international partnerships for capacity-building, training and research were discussed.

Building upon cross-cutting areas, in particular resiliency, including matters related to the ability to depend on space systems and to respond to the impact of events such as adverse space weather, a seminar on space weather and its effects on GNSS was held during the Workshop. The purpose of the seminar was to provide a background on the phenomena of space weather and illustrate its effects on GNSS. This seminar described the challenging aspects of space weather phenomena, their impact on GNSS users, the variability of these impacts and the actions that may mitigate their effects.

Seminar on GNSS spectrum protection and interference detection and mitigation was also organized during the Workshop. The purpose of the seminar was to highlight the importance of GNSS spectrum protection at the national level and explain how to reap the benefits of GNSS. It was highlighted that the seminar was successful in fulfilling its intended purpose of educating participants on the importance of GNSS spectrum protection, and challenging them to engage with their respective national spectrum management agencies to ensure continued access to the benefits GNSS provides.

GNSS reference frames, reference station networks and determination of vertical datums were the topics of major discussion, where the knowledge sharing was very essential. It was noted that continuously operating GNSS stations (CORS) play an important role in critical national priorities such as identifying seismic hazards, disaster recovery and mitigation and infrastructure development in developing countries. In order to take full advantage of emerging GNSS technology the development of modernized national horizontal reference systems including deformation models and vertical datums based on accurate local geoid models are essential. Therefore international cooperation in terms of knowledge, resource and sharing of the information in development of CORS networks and geodetic reference systems was emphasized.

RTKLIB (free open source software) demonstrations related with low-cost GNSS receiver system for real time kinematic (RTK) using RTKLIB were made. The system was based on a very low cost GNSS receiver, Raspberry-Pi computer using RTKLIB. The participants found such system very useful for education, training and even for survey and mapping where required accuracy is within a sub-meter level. The participants also requested to improve the system to make it compatible for different types of base-station receiver makers. The system will be developed in android platform in future.

Participants learned about the improvement in the existing infrastructure either by launching new satellites (in case of Galileo, Beidou Navigation

Satellite System (BDS), Quasi-Zenith Satellite System (QZSS), Indian Regional Navigation Satellite Systems (IRNSS)) or by modernization of the existing signals (as with Global Positioning Systems (GPS) of the United States and Global Navigation Satellite System (GLONASS) of the Russian Federation). Participants took note of the release of new interference control documents (ICD) for all GNSS along with activities for international collaboration on compatibility and interoperability among the GNSS operators.

Participants were also informed about the role of the international committee on global navigation satellite systems (ICG) as a forum for the providers and users to build the basis for compatible and interoperable operations for the benefits of end users.

Recognizing that GNSS technology has enormous potential to contribute to the management and protection of the environment, disaster risk reduction, agriculture and food security, emergency response, improving the efficiency in surveying and mapping, and to enhance the safety and effectiveness of transportation by land, sea and air, low cost GNSS receivers, the participants put forward a number of recognitions and recommendations, which are presented below:

GNSS Applications and Technology Development

Participants recognized that GNSS has very important applications in surveying and mapping and in the precise positioning. It plays a prominent role in every infrastructure development of the country. Participants also recognized the importance of the use of GNSS technology to improve emergency response to natural disasters and reduce the associated risk/impact to human life. This was an extremely important application for GNSS requiring robust information technology and multi-agency cooperation and interoperability that include both governmental and non-governmental organizations (NGO). Overall the presentations featured works that leverage existing mobile phone and internet technologies coupled with GNSS to provide improved services for disaster management primarily through reducing location uncertainties and information timelines.

> RTKLIB (free open source software) demonstrations related with low-cost GNSS receiver system for real time kinematic (RTK) using RTKLIB were made

Key recommendations included the following: (i) continue the development and integration of information technology, global information system (GIS), mobile phone, GNSS and remote sensing technologies to achieve improved disaster management tools accessible to the public; (ii) engage public and private agencies and organizations to favourably affect public policy to ensure maximum benefit to the population being served. These activities may include, but are not limited to the following: (a) obtain endorsement for these efforts; (b) enable access to data bases and data sources in support of these efforts; and (c) develop a framework to formally manage requisite cross-agency cooperative and collaborative efforts needed to adopt and exploit the new capabilities.

Space Weather

Participants recognized that the space weather seminar was very useful and more programs on the topic should be planned. The importance of space weather to civil aviation and future of space flight was highlighted. In that context, participants in the workshop recommended that: (a) space weather discussion forums should be developed to educate the public as well as policy makers about space weather phenomena; (b) other workshops should provide opportunities for students and professionals to be involved in space weather data analysis and prediction.

Continuously Operating Reference Station (CORS) Network and Reference Frames

Participants recognized that CORS operators should be encouraged to facilitate earth deformation studies. Participants emphasized the importance of modernizing national geodetic reference system. It was noted that the new geodetic datum of Nepal has made some progress but its completion will require international co-operations.

Capacity Building

The participants recognized the need for the continuous building of national and regional expertise, through the provision of scholarships, long-term and short-term training and education at the United Nations-affiliated Regional Centres and other academic centres of excellence. In addition, participants stressed the need to make the existing educational opportunities available to a wider university community.

Participants recognized the need for additional workshops building upon the results of this workshop, including workshops focusing on training decision-makers (covering the integrated application of combined remote sensing, GIS and decision support systems).

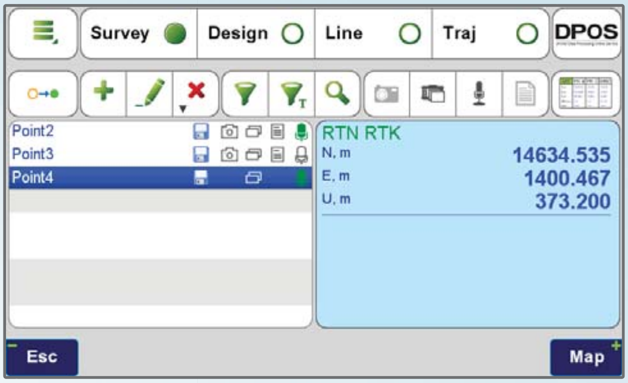
In order to enable knowledge sharing, participants recommended that institutions implement exchange programmes, providing opportunities for experts to visit and work with partner institutions. In particular, participants recommended that national, regional and international institutions make every effort to provide support to Nepalese institutions through exchange programmes and technical support.

Participants expressed their appreciation to the Survey Department of the Ministry of Land Reform and Management of Nepal for the hospitality, substance and organization of the Workshop. Participants also expressed their appreciation for the significant support provided by the Government of Nepal, the United Nations, ICG and GfRmbH Galileo Control Centre, DLR.

Don't take your gloves off!

Relax in field...
Relax in office.

1. Start by proximity sensor – stops automatically when all OK
2. Talk all info in microphone.
3. Takes photos and screen shots automatically or manually
4. TRIUMPH-LS converts to text automatically and created HTML and PDF reports.

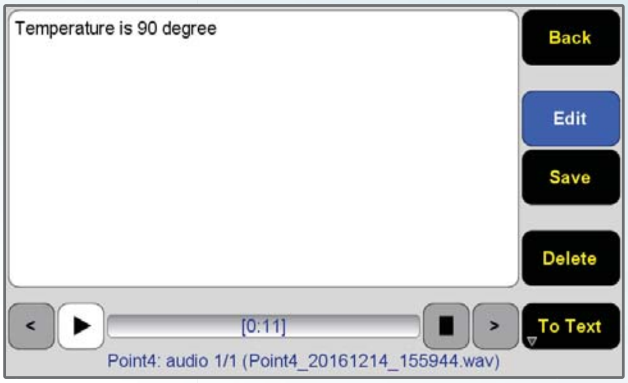


Icons description:

Raw GNSS data
Photo
Screenshots
Notes
Audio file
Audio file converted to text

to Text – converts voice to text. Long push converts all voice files attached to this point

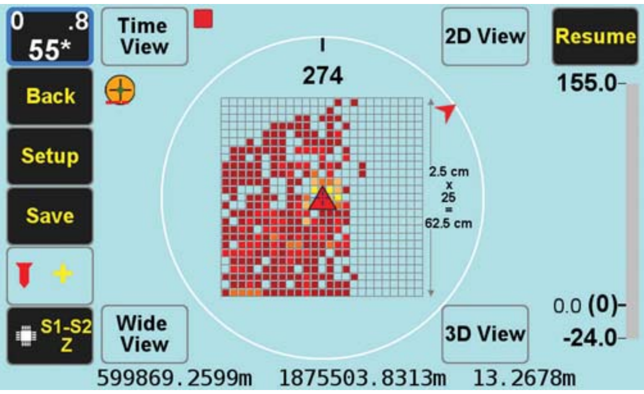
Edit – edit text after conversion and Save. Long push on these icons goes directly to screens to attach more.



Front

J-Tip

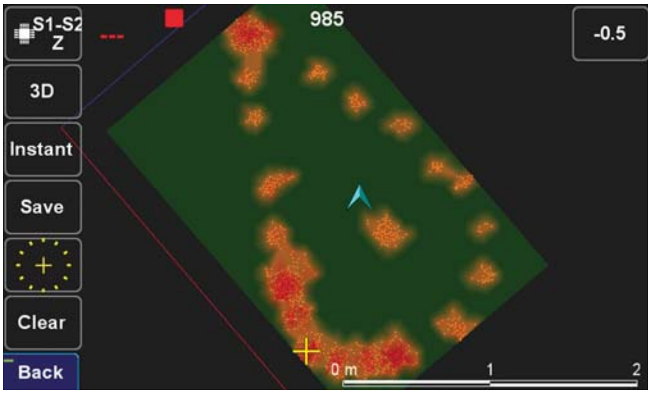
TRIUMPH-LS tags coordinates with magnetic values, It also guides you to top of the item to survey it.

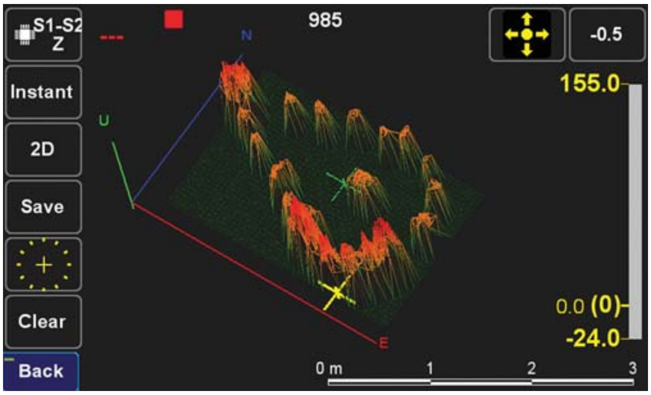


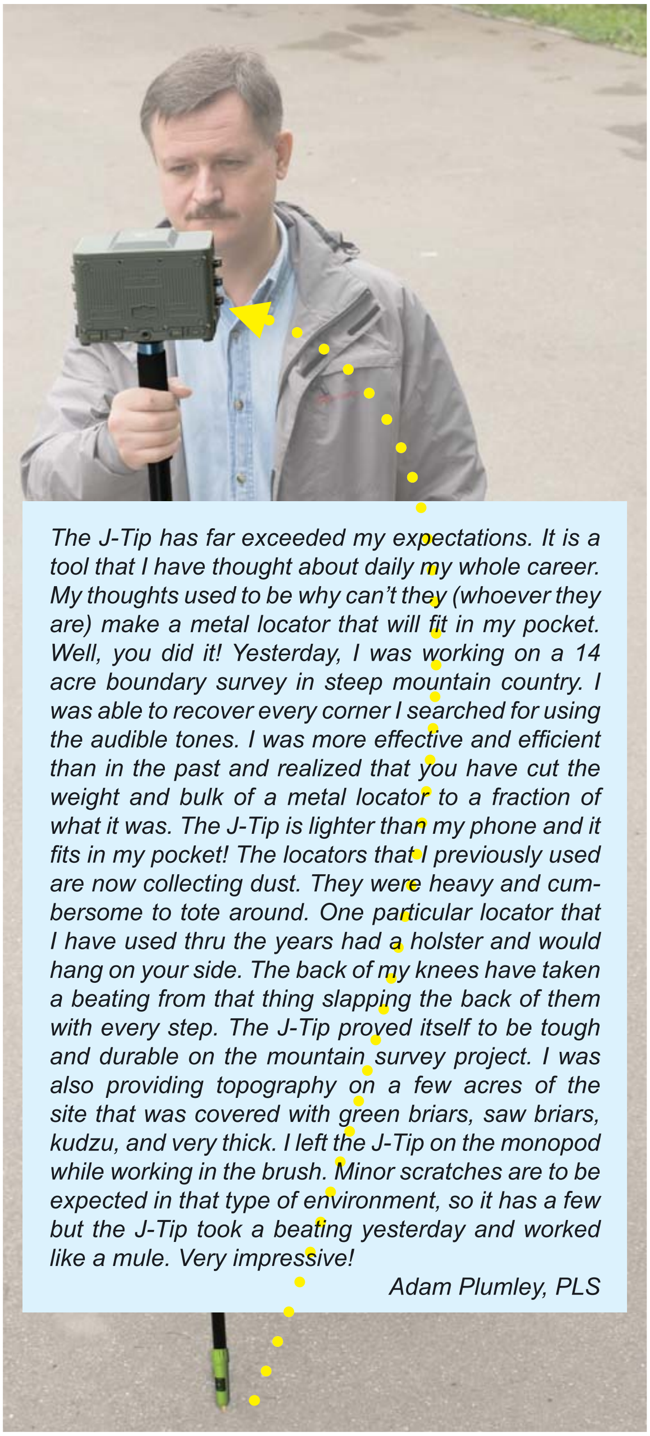
The Mag View focuses only on the mag object with the highest mag value.

The audio and graphical bar on the right side show the magnitude of the magnetic object.

In "Setup" you can select the cell size and the size of the field you want to scan.







The J-Tip has far exceeded my expectations. It is a tool that I have thought about daily my whole career. My thoughts used to be why can't they (whoever they are) make a metal locator that will fit in my pocket. Well, you did it! Yesterday, I was working on a 14 acre boundary survey in steep mountain country. I was able to recover every corner I searched for using the audible tones. I was more effective and efficient than in the past and realized that you have cut the weight and bulk of a metal locator to a fraction of what it was. The J-Tip is lighter than my phone and it fits in my pocket! The locators that I previously used are now collecting dust. They were heavy and cumbersome to tote around. One particular locator that I have used thru the years had a holster and would hang on your side. The back of my knees have taken a beating from that thing slapping the back of them with every step. The J-Tip proved itself to be tough and durable on the mountain survey project. I was also providing topography on a few acres of the site that was covered with green briars, saw briars, kudzu, and very thick. I left the J-Tip on the monopod while working in the brush. Minor scratches are to be expected in that type of environment, so it has a few but the J-Tip took a beating yesterday and worked like a mule. Very impressive!

Adam Plumley, PLS

2D and 3D views of the field show the magnetic objects that have been scanned.

Zooming the 2D and 3D screens can show the shape of the magnetic objects under the ground.

For many sophisticated features of the J-Tip see its Users Manual in www.javad.com

Concepts Behind RTK Verification

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

Multipath, the reflections of GNSS signals from ground and nearby objects and structures create their own indirect measurements from the satellites to the GNSS receiver. It's as if your measuring tape is bent around an obstacle such as a tree instead of a free and clear line of sight between two points. No calculator is going to improve this result.

TRIUMPH-LS has sophisticated hardware to distinguish between the direct and indirect signals and remove most of the indirect signals. It also reports the amount of indirect signal that has been removed. The worst case is when the receiver doesn't see the direct signal at all; e.g., the satellite is behind a building, but it's still receiving the signal reflected off of the nearby structure. It is the task of the RTK engines to isolate such indirect signals and then exclude them from the calculations.

If too many of the signals are affected by severe multipath or indirect signals, no solution may be found. Remember, indirect signals are analogous to the bent measuring tape! When you're preforming RTK surveying, observe your environment and come to recognize that the structures around you are like mirrors for GNSS signals.

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

While the **TRIUMPH-LS** can't move the obstacles that are creating multipath out of the way, its sophisticated hardware has advanced multipath reduction sub-system, its tracking software is designed to handle even the weakest signals, and its **J-Field** software provides reliable RTK solutions like no other system with its **Automatic RTK Verification System** (patent pending). J-Filed also has ample tools to demonstrate the reliability of the solution or warn against questionable results. You can readily see that without such tools other systems can provide you wrong and misleading solutions.

J-Field uses six RTK engines (Figure 1) running in parallel plus a support engine to monitor and aid the six engines. Each engine uses a different criteria and mathematical method tailored to resolve ambiguities in different conditions. These six parallel engines not only verify robust solutions but also maximize the possibility of providing solutions in all conditions.

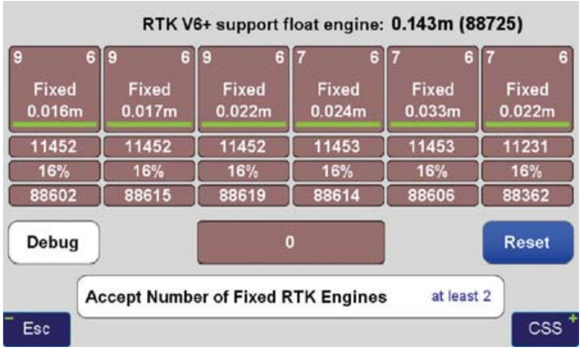


Figure 1 *V6+ six RTK Engines*

User Defined Verification Tools

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

J-Field employs two metrics to evaluate the performance of its RTK system of six engines: **1) Confidence Counter, and 2) Consistency Counter.** (Figure 2)

Confidence Counter

Figure 2 *Verify Settings*

This metric is incremented each time an engine is reset, ambiguities are recalculated, and the solution is in agreement with the previous ones (as defined by the **Confidence Guard (CG)**, default value 5 cm) is achieved. The Confidence Counter increments by 1, 1.25, 1.5, 1.75, 2.0, and 2.5 depending on the number of reset engines that fix in that epoch.

Consistency Counter

The Consistency Counter is incremented each time a solution is in agreement with the previous ones (as defined by the Confidence Guard) irrespective of engines being reset or not. The Consistency Counter is incremented by 0.0, 0.1, 0.25, 0.5, 1.0 and 1.5 depending on the number of fixed engines used in that epoch. Note that one fixed engine gets no credit and 6 fixed engines gets a **Consistency Credit** of 1.5.

Using these Confidence and Consistency verification tools, J-Field has two options to achieve reliable RTK solutions: **1) Verify With Automatic RTK Engines Resets** and **2) Verify Without Automatic RTK Engines Resets.**

Verify with Automatic RTK Engines Resets

This method has two steps: **1) Confidence Building** and **2) Smoothing and verifying**.

• **Step One.** In Step One, fixed engines are reset and solutions are collected into groups. Each group contains all the epochs located within a specified radius (the CG value) from its center and new groups are created as necessary so that all epochs fall into at least one group. Each group has its own Epoch Counter, Confidence Level and Elapsed Time. A point may fall into more than one group. The groups are sorted from best to last by the sum of their Time and Confidence with the current best group being shown within [ ] and others within ( ). Step One continues until a group reaches the Confidence Level. (Figure 3)

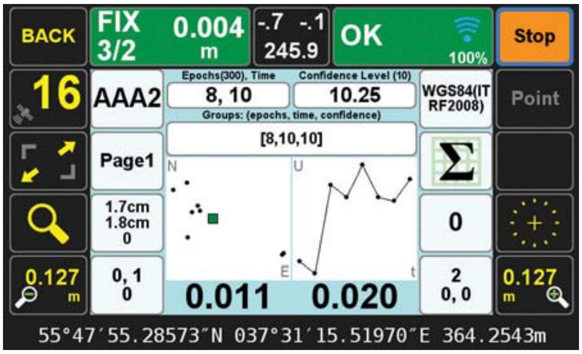


Figure 3 *End of Step one*

• **Step Two.** During Step Two the engines are not reset and solutions which are located inside the CG of the selected Group are added to that Group for the remaining number of epochs that user has requested (Epoch Number, EN) in the How to Stop screen. Epochs which are outside the CG of the selected Group will be stored in a new (or previously created) group; the RTK engines are reset if the epoch falls outside a sphere with a radius twice that of the CG and the process will then revert back to Step One and the Confidence Level of the current group will be reset to 0.

If the number of epochs falling outside of the current group (but less than 2X outside it) reaches 33% of epochs collected so far, the process will revert back to Step One. Previously created groups will remain intact and once an existing or previously created group meets the Step One criteria, it will pass to Step Two. (Figure 4)

In both steps the Consistency Counter is also incremented as mentioned earlier.

You can manually reset all RTK engines via the V6-RTK engines screen (Figure 1), or assign this

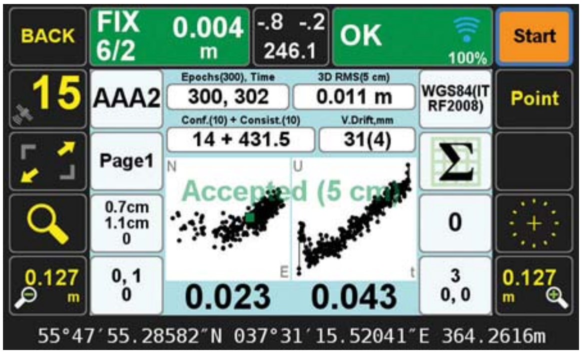


Figure 4 *End of Step 2*

reset function to any one of the U1 to U4 hardware buttons in front of the TRIUMPH-LS for easy access.

Verify without Automatic RTK Engines Resets:

In this method we don't force the RTK engines to reset but rely mostly on the Consistency Counter. There will be only one group as selected by the first epoch. Solutions that are not within the Guard band of the current average will be thrown out. If more than 30% of solutions are thrown out, the process will restart.

The horizontal and vertical graphs presented in both approaches also help the surveyor to evaluate the final solution. The linear drift of the vertical solution and its drift RMS are also shown above the vertical graph. A high linear drift (more than few centimeters) reveals severe multipath or, in rare cases, a wrong ambiguity fix. Pay close attention to the vertical drift and the horizontal and vertical scatter plots of epochs. Consider the scatter plots as doctors examine X-rays to determine anomalies.

The desired **Confidence Level** and **Consistency Level** are user selectable. Default values are 10. These parameters along with the desired number of epochs must be reached before a solution is provided.

In either case there is also a **Validate** option which, when selected, will reset all engines at the end of the collection and continues with 10 more epochs to validate if the solution is within the desired boundary of the Confidence Guard. (Figure 2) Minimum number of engines for the Validation Phase is user selectable.

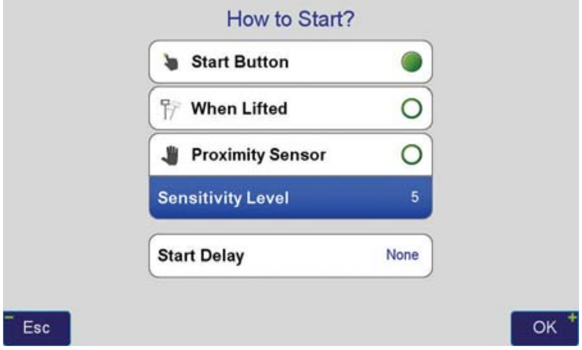


Figure 5 *How to Start*

Figure 6 *How to Stop*

In either case, if Auto-Accept is activated, the position will be automatically accepted if the RMS of the final solution is less than what user has selected in the Auto-Accept screen. (Figure 6)

You can also use **Auto-Restart** if you want to monitor structures or test the RTK system unattended. (Figure 6)

Screen Shots of Action Screen

Action Screen shows detailed information about each point collected. Screen shots can automatically be attached to each point and saved at the end of each collection (Figure 7). In **Verify with Automatic RTK Engines Resets** screen shots at the end of both Step One and Step Two are saved (Figures 3

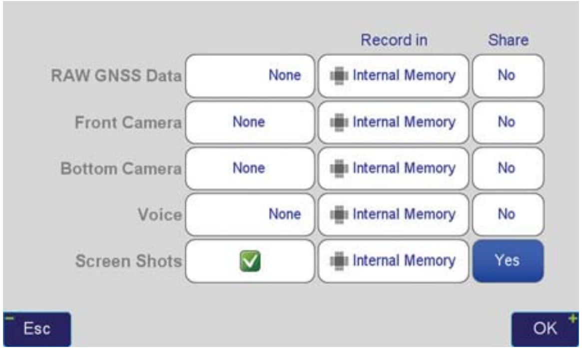


Figure 7 *What to record screen*

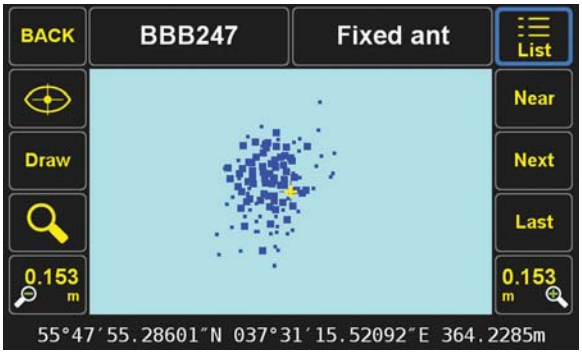


Figure 8 *Review screen shows cluster of 386 points*

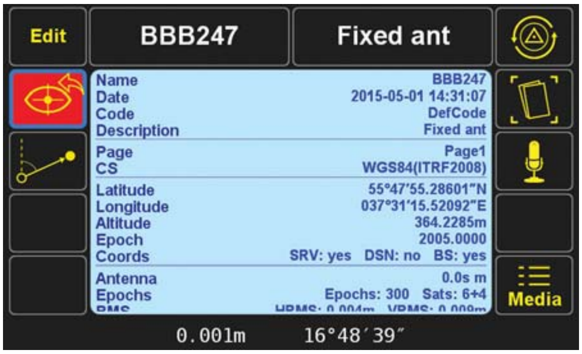


Figure 9 *Detailed information on selected point (scroll to see all information)*

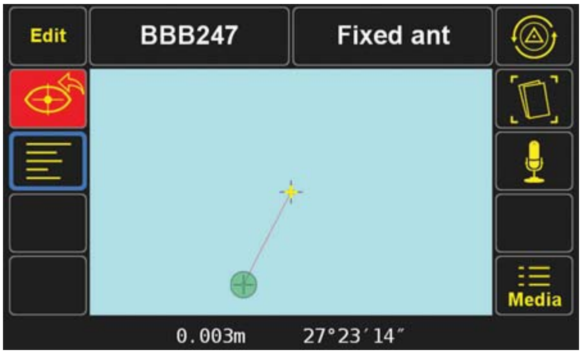


Figure 10 *Distance and direction from the current point to the selected point*

and 4). In Action screen there are 8 white boxes that selected items can be viewed on them.

Review Screen

View cluster of all points. Select the desired point to see its point cluster (Figure 8). Click the icons to see additional details about that point (Figure 9) including the distance and direction to the current point (Figure 10).

The effects of multipath, ionosphere, orbit, and other sources of problems somewhat exponentially increase as the baseline length increases. In a VRS/RTN scheme your **actual** baseline length is the actual distance to the nearest base station. The **virtual** base station that is mathematically created is not the actual length. We strongly recommend using your own base station near your job site in a Verified-Base RTK (VB-RTK) scheme.

In addition to providing you with the most reliable RTK solutions (especially true in remote areas where cell coverage is hit or miss), using your own base receiver allows you to easily tie your solutions to well-established IGS/NGS spatial reference systems through Javad's exclusive Data Processing Online Service (DPOS) and J-Field's user-friendly Base/Rover Setup. Note that post-processed results returned to the TRIUMPH-LS using DPOS are dependent on the availability of orbital data from NGS and may require several hours. For further reading about DPOS, its integration into J-Field and the streamlined approach developed by Javad for setting up the base and rover, please check out Shawn Billings' excellent article on VB-RTK on our website. Point your browser to: *http://www.javad.com/jgnss/javad/news/pr20150219.html*

Alternatively, if you don't have access to IGS-type stations to use DPOS, you can select an open area near your job site and use TRIUMPH-LS to obtain its position via RTN networks for about 5 minutes. You may repeat a couple of times for assurance. Then transfer this position to the TRIUMPH-1 or TRIUMPH-2 to use as the base station near your job site. The Base-Rover setup screen in the TRIUMPH-LS makes this job very easy.

Instantaneous Multipath charts

TRIUMPH-LS removes most of the multipath instantly on every epoch. Click on the Satellite icon to see the Signal Strength of satellites and then click the "+" key to see the multipath charts.

Figure 11 shows the amount of code phase multipath that TRIUMPH-LS has removed; relative to a fixed level. That is why negative numbers are in this figure. Units are in centimeter. Noting the signs in this figure, the amount of multipath in some satellites is in excess of 5.6 meters.

Figure 12 shows the amount of carrier phase multipath that TRIUMPH-LS has removed relative to a fixed level. Units are in millimeter. Noting the signs in this figure, the amount of multipath in some satellites is in excess of 4 centimeters.

SAT	EL	L1	P1	P2	L2C	L5
GPS2	29↑	273	281	-76	--	--
GPS6	44↑	55	201	-60	-5	189
GPS12	70↑	183	190	-90	-94	--
GPS14	25˜	281	317	-97	--	--
GPS17	23↓	332	364	-74	6	--
GPS24	53↓	117	566	67	-64	124
GPS25	30↑	243	218	-42	-50	-34
GLN1	10↑	305	229	-126	-404	--
GLN8	16↓	26	87	-484	-617	--
GLN9	32↑	359	301	-246	55	--
GLN15	31↓	276	203	-93	-2	--
GLN16	84↑	235	309	-133	-109	--
GLN17	39↓	52	-84	-156	-52	--
GLN18	69↑	190	168	-177	-184	--
GAL12	68˜	680	-121	246	--	32
SB127	25˜	469	--	--	--	319
SB128	15˜	206	--	--	--	322
QZ193	13↑	550	513	--	56	55
BDU2	16˜	299	--	--	--	275
BDU5	25˜	269	--	--	--	230
BDU8	25↓	145	--	--	--	143

SAT	EL	L1	P1	P2	L2C	L5
BDU11	75↑	362	--	--	--	305
BDU12	36↓	288	--	--	--	200
GPS3	10	--	--	--	--	--
GPS29	3	--	--	--	--	--
GPS32	3	--	--	--	--	--
GLN7	3	--	--	--	--	--
GLN19	12	--	--	--	--	--

Figure 11 *Code Phase multipath removed (cm)*

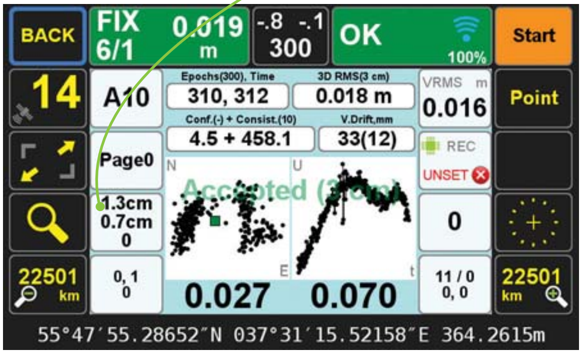
SAT	EL	AZ	L1	P1	P2	L2C	L5
GPS2	29↑	154	7	7	2	--	--
GPS6	44↑	98	11	9	2	2	-13
GPS12	70↑	282	7	8	-2	-2	--
GPS14	25˜	302	5	8	-4	--	--
GPS17	23↓	58	6	9	-6	-2	--
GPS24	53↓	196	1	4	13	1	-12
GPS25	30↑	282	4	8	7	1	-32
GLN1	10↑	34	1	4	-15	-23	--
GLN8	16↓	344	12	15	17	25	--
GLN9	32↑	316	0	2	-3	-6	--
GLN15	31↓	142	5	5	0	1	--
GLN16	84↑	266	2	2	-11	-18	--
GLN17	39↓	44	-1	-4	-12	-10	--
GLN18	69↑	188	-1	3	-1	-6	--
GAL12	68˜	108	0	-26	0	--	-14
SB127	25˜	160	7	--	--	--	-4
SB128	15˜	130	9	--	--	--	-11
QZ193	13↑	68	-3	-1	--	1	-19
BDU2	16˜	132	-7	--	--	--	-17
BDU5	25˜	154	-4	--	--	--	-7
BDU8	25↓	54	-10	--	--	--	-20

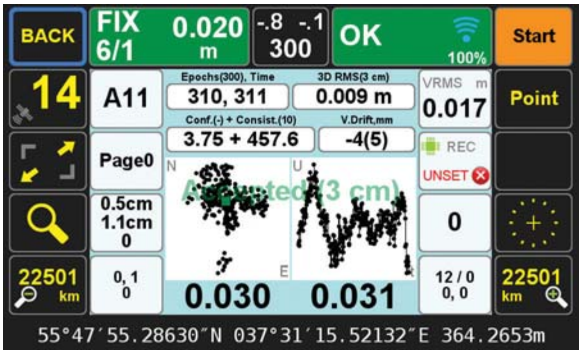
SAT	EL	AZ	L1	P1	P2	L2C	L5
BDU11	75↑	158	-6	--	--	--	-5
BDU12	36↓	60	-6	--	--	--	-14
GPS3	10	26	--	--	--	--	--
GPS29	3	229	--	--	--	--	--
GPS32	3	346	--	--	--	--	--
GLN7	3	297	--	--	--	--	--
GLN19	12	210	--	--	--	--	--

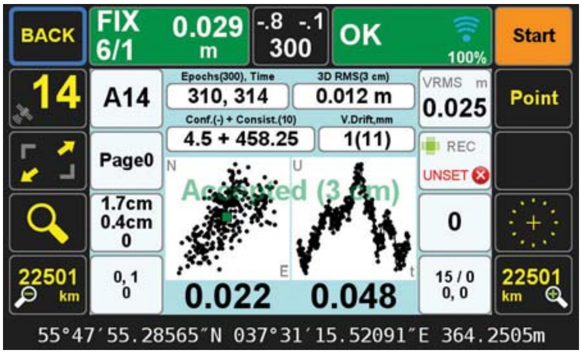
Figure 12 *Carrier Phase multipath remove (mm)*

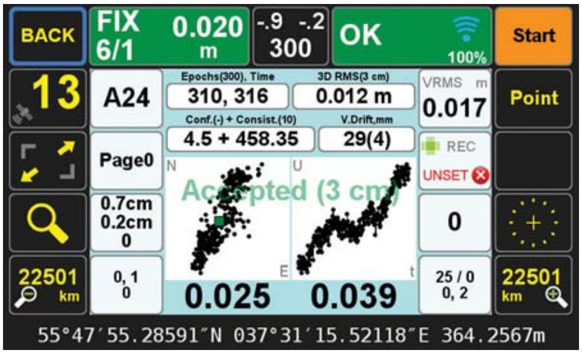
Multipath Showcase

Graphs in the following examples show multipath effects in a 13.8 km baseline where about 1/3 of the rover sky was blocked by a tall building. This box shows horizontal (top) and vertical (bottom) offsets from the actual coordinates of the point (earlier surveyed for test).









Javad Ashjaee, Ph.D.

TRIUMPH-LS
Rugged, Tough, Versatile

Built on a tough magnesium alloy chassis, all connectors, SIM cards, Micro-SD cards are protected against the harshest environment.

You can collapse the pole and take the unit next to you in your car seat.

9 buttons provide **direct access to all functions**. Six keys are user programmable.

The **built in GNSS full tracking antenna** has a large ground plane and the best centering and rotational performance on the market.

High resolution 800x480 pixels sunlight readable color display

Built in UHF, FH Spread Spectrum, WiFi, Bluetooth, Ethernet, GSM/GPRS.

Built in Microphone and two cameras for audio visual documentation.

20 hour battery life in RTK rover mode with full screen brightness and UHF/ GSM. Hot Swappable" and "removable batteries" are concepts of the past.

The internal batteries are field serviceable and can be easily replaced by the user when needed.

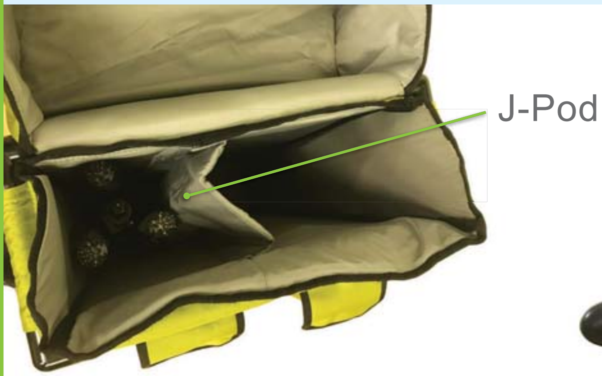
The TRIUMPH-LS, including batteries and pole is the lightest complete GNSS RTK receiver in its class. The total weight of the TRIUMPH-LS RTK system, including radio, controller, pole and 20 hours of internal battery is **2.5 Kg**.

For comparison, the Trimble R10, TSC3 data collector and pole, with about 5 hours of battery life is 3.57 Kg (7.86 lb).

Built in Spectrum analyzer for GNSS and UHF bands and protection against interference.

The J-Pack

It was not our job... You asked for it - we did it!



Javad......Bravo!!!!

The J-Pack is nicest bag I have ever seen for surveying. I especially like the pocket in the back and all of the places to tie down equipment and stuff.

Adam Plumley, PLS

Ship date - January 2017
See full video “J-Pack & J-Tip in Use” at our website.

Advancing Infrastructure

Technology, trends, prospects, practices, solutions,....
Bentley representatives share their views

"We strive to provide smarter solutions"

Aidan Mercer
Industry Marketing Director, Utilities and Government, Bentley Systems

Bentley's tagline is "Advancing Infrastructure". Would you like to elaborate this?

Bentley advances infrastructure by delivering solutions for the entire lifecycle of the infrastructure asset, tailored to the needs of the various professions – engineers, architects, planners, contractors, fabricators, IT managers, operators, and maintenance engineers – who will work on and work with that asset over its lifetime. Comprised of integrated applications and services built on an open platform, each solution is designed to ensure that information flows among workflow processes and project team members to enable interoperability and collaboration.

How does Bentley plan on addressing 'Aging Infrastructure'?

Bentley is committed to providing solutions and services to meet the challenges associated with aging infrastructure. The degeneration of physical infrastructure manifests itself in differing asset types, such as broken water mains, collapsed bridges, decaying roads, and buildings in desperate need of renovation. At Bentley, we are equally committed to ensuring better project delivery on capital projects, as well as improving the performance of existing infrastructure. Implementing better project delivery processes is one way to manage aging infrastructure as it provides a platform for better understanding the infrastructure environment that relies on sustainability. For example, Bentley's AssetWise software is specifically designed to improve asset performance by focusing on the health and longevity of the asset. AssetWise enables users to determine how asset performance can be enhanced, thus mitigating the effects of aging infrastructure. A good example would be a bridge that might require ongoing maintenance. Knowing the asset history and its health can provide options to better manage the life of the asset.

When you use the term 'Intelligent Infrastructure' what are you trying to convey?

Intelligent infrastructure can mean many different things. For Bentley, we are continuously striving to provide smarter solutions for better business outcomes. And, why shouldn't infrastructure be intelligent? With the rise of big data and the Internet of Things, there is a real opportunity to harness the potential. At Bentley, we really see the value in engineering by providing software to interpret the data and offer smarter outcomes. An example of this could be in the water industry. With the large volume of sensors on a water network, there is a real opportunity to collect and analyse data related to a network to provide better insights. This would add a level of intelligence to the network and give water consumers a better experience.

What challenges do you face in the developing world while encouraging the technological solutions?

Emerging economies often have different requirements for technological adoption. Sometimes it can be limited funds, or language issues. We provide software in multiple languages and with much of our software, it is designed to provide an ROI. The reality is, we support nations that look to us to solve an engineering issue, and we've been doing this successfully for over 30 years.

Entire Cities Can Be Captured in 3D (Image courtesy of the City of Helsinki)

India has taken a major initiative in 'smart cities'. What role Bentley can play?

Smart cities are a huge topic in India. It seems all infrastructure projects fall under this umbrella. At Bentley, we see a huge potential in harnessing this and indeed contributing to what will be a very successful initiative. If we look at reality modelling for example, we can realise the potential for capturing and modelling an entire city. The concept of "reality modelling" is concerned with adding real-world imagery to infrastructure projects by capturing, processing, and reusing existing site data with 3D imaging and photogrammetric techniques. The world is moving away from 2D, and the benefits are bountiful. Today, with an application from Bentley called ContextCapture, even simple photographs can be turned into 3D models that are automatically generated to give virtual representations of existing infrastructure assets. This means in cities in India, the professional can capture all the assets within it. By automating the capture-to-process capability, enabled by computational power enhanced by the Cloud, modelling an entire city can now be done in an accurate and efficient manner. It also now supports hybrid inputs; this includes point-cloud data too, so digital photographs and point-cloud data can further enhance these models. The beauty behind these 3D models, is realized by the accuracy of the data and the precise geo-coordination gathered when combined and consumed in geospatial data. These semantically rich models are scalable and less intractable than a point cloud for example. These models can work seamlessly within engineering workflows and provide immersive designs with that real-world context to enliven designs beyond what we're used to experiencing and will go a long way in helping India realize its smart cities objectives.

"We look for innovative, cutting-edge solutions"

Robert Mankowski
VP, Product Development, Bentley Systems

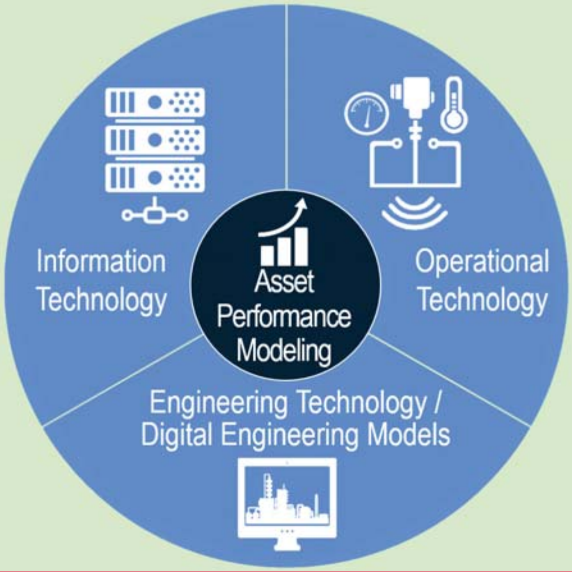
What are the key factors you keep in mind while conceptualising technological solutions?

First in our minds are the benefits the solution provides to the intended audience. Cutting-edge technology that doesn't provide sufficient benefits is just "cool." With that said, we do look for innovative, cutting-edge solutions to the problems we see in the market. It is one way in which we differentiate our solutions from our competitors.

What are the features of asset performance software?

When we describe our asset performance software, we categorize it into sets of capabilities targeted at specific market problems. Some examples include:

- **Asset Lifecycle Information Management** – allows owner-operators to understand the current state of their assets, the work that is planned for those assets, and what the future state of the assets are supposed to be. When we get to that future state, we want to be able to validate that it meets the performance and regulatory criteria. The supporting features for asset lifecycle information management are document and records management, workflows, and desktop, mobile, and Web publishing.
- **Asset Reliability** – provides the features to monitor and track the condition and performance of their assets, develop, and execute advanced maintenance and reliability strategies, and plan and perform inspections using Web and mobile data collection features.
- **Compliance and Safety** – provides the features to help ensure the assets, the use of the assets, and the processes around operating and maintaining the assets are all in compliance with the regulatory and safety criteria.
- **Operational Analytics** – a lot of data is collected over the lifecycle of an infrastructure asset, and this data can be used to gain deeper understanding into the "as operated" performance of the asset, and what changes are required to make the asset perform more efficiently and with less risk. The features of operational analytics provide the analysis and insights into the operational data, and the modelling capabilities to support decision making.
- **Enterprise Interoperability** – asset performance software is rarely deployed in isolation, but rather it is almost always integrated into an overall information system architecture in an organization that may include third-



Bentley's AssetWise IT-OT-ET Convergence party financial software, materials management, workforce automation, and GIS. Asset performance software, therefore, must include a robust interoperability framework to integrate the workflows and information across these systems. This can be particularly interesting in cases of a hybrid cloud computing environment where some servers and services are provided in the public cloud and others in a private cloud or on premise.

The potential for machines to help decision makers understand the data, the trends, and create actionable intelligence is exciting

Would you like to share the success and prospects of hydrological modelling?

Yes. I've been involved with hydraulic and hydrologic modelling for over 20 years. I have seen many great examples of success using these technologies, as well as the continuous transformation of these applications from offline master planning studies to real-time operational decision making. Bentley users have been successful in providing a continuous, 24x7 water supply to entire populations of cities that previously did not have one. And, they have been successful in using these tools to rebuild water supply systems after natural disasters. We have also seen successful implementation where there is an aging infrastructure crisis to identify the highest priorities for replacement and rehabilitation plans. I think prospects include more broad use of hydraulic and hydrologic modelling in real-time or near real-time decision making.

As an inventor of several patented technologies, what gives you a sense of achievement and what leads to disappointment?

While it is very satisfying to develop a new technology and release it to the market, the real sense of achievement accompanies the use of the technology to solve real-world problems. As an engineer, I like to see how other engineers are applying my work in innovative ways. Bentley's annual *Be Inspired* Awards, for example, are a great way for me to see the fantastic achievements of the infrastructure community and know that my work and the work of my colleagues has really paid off.

I think the most disappointing thing is when exactly the opposite occurs. In other words, when we've worked hard to solve a particular problem, and introduced a new capability or feature into the software, but few people are using it. We know that not every user will use every feature, but it's still a disappointment, so we try to understand why it is not being used. It may be that users don't know the feature exists, or maybe the user has alternative solutions, while not as efficient, that get the job done, and don't feel it is worth switching workflows. Ultimately, we want everything we do to add value, and if something isn't being used, it is not adding value.

Which direction do you see the technology is moving in near future?

Like many others, I see great opportunities in the continued use and growth of analytics and machine learning. Like I said earlier, a lot of data is collected over the lifecycle of an asset, and in today's world of increasing sensors and the Internet of Things (IoT), the amount of data is growing rapidly. The potential for machines to help decision makers understand the data, the trends, and create actionable intelligence is exciting, and I think we'll see some advances in this area soon.

"Reality modelling is part of our strategy for advancing infrastructure"

Francois Valois
Director of product management,
Bentley Systems

Explain the importance of 'reality modelling'?

Reality modelling is part of our strategy for advancing infrastructure. Not only are we focused on producing the best possible reality mesh output from photos and point clouds, but we are also looking at the downstream consumption of that data in mapping, design, construction, operations, and inspection. We are making those reality models available through different form factors, into all our applications from mobile, desktop, and the Internet.

Please share some key features of your reality modelling software ContextCapture?

ContextCapture is fundamentally capable of turning ordinary photos into 3D models consumable downstream supporting a range of applications in many industries. Although this is not unique, we are very proud of the quality of the output we are producing, our reality meshes are crisper and more detailed because our approach to mesh generation is unique. In addition to the quality of the output, ContextCapture Center will scale to any size and enable users to tackle the largest projects with the highest resolution of input images. With our latest release in November 2016, we now support combining terrestrial laser scanners with standard photos. Again, our unique approach to meshing is helping us leverage point clouds to augment the quality of the 3D reconstruction.

Which are the key application areas of ContextCapture?

Our users leverage the output of ContextCapture in different applications ranging from road and rails design and any other design that requires in-depth knowledge of the existing conditions, to inspection of bridges or communication towers and other assets, to industrial asset documentation in oil and gas or other asset classes where accurate as-built conditions are lacking.

Would you like to share any example where drones are utilised?

We have been working with a large utility company in France on their substation. They have flown a DJI drone and combined the aerial capture with ground images allowing them to capture many substations, to document the information and use it for brownfield design. We have also worked with large owner-operators in the oil and gas business that have used ContextCapture with drones to document their plant. In the transportation industry, multiple DOTs have leveraged UAVs and ContextCapture to survey a site prior to design.

What solutions do you have in the field of surveying and mapping?

Bentley ContextCapture and Bentley Descartes are applications that can be used by surveyors and mappers to document small or large areas and offer their services to a wider variety of new users.

"Reality Modelling goes mainstream"

Ted Lamboo
Senior Vice President, Reality Modelling, Bentley Systems

Explain 'Reality Modelling goes mainstream›?

For several decades, engineers have had to plan, design, and manage the newly engineered infrastructure in a void, since the "reality" of the existing landscape and the old infrastructure was not available at all or was only available schematically. With reality modelling, the entire 3D representation with all its details are available to them in their engineering applications, while they design the refurbishment or expansion or new infrastructure that they are planning. The availability of reality modelling information will subsequently find its way to many disciplines that want that realistic representation at their fingertips.

What kind of technologies are used for reality modelling?

The data capture sources can now be any method that captures either photos, or laser scan data, or a combination of the two. This can be aerial photography, terrestrial photography, from a UAV, from a smart phone, and from a variety of laser scanning devices. So, with advances in reality modelling come new ways to capture the data. On the photo capture side, we have seen the quality of images improve, as there are new laser scanning devices coming to the market.

Would you like sharing some success stories of 'reality modelling'?

One of my favourite success stories is the city of Helsinki, which has used aerial photography to generate a 3D model of the entire city and its surroundings, and has made this data publicly available. The great vision here is that a) what they generate is shared back for public consumption and b) they proactively help other departments and organisations.

How do you see the difference in the developed world versus the developing world?

There is more information available in the developed world to combine with the 3D data and, hence, the chances of building a richer information system may appear to be higher. But, on the other hand, is there the possibility for the developing world to totally leap into the future by having aging infrastructure photographed and converted to a 3D model. This will bring them right up to date with the actual status of the infrastructure that is out there in the field. So, both the developed world and the developing world can benefit tremendously.

How to make technologies viable to those users who may not find it feasible due to financial constraints?

The cost of capturing a 3D reality model is much lower because of this new technology than it is with older methods, such as surveying and reconstructing, or laser scanning. But the cost can be further controlled since handheld quality cameras or a quality camera on a drone is much more affordable now. For processing, we offer our users the ability to purchase licenses and do their own processing when they have continuous longer term projects, and the possibility to rent the software for shorter periods, or to process in the cloud, if they don't have their own hardware infrastructure. This allows companies to find the best financial solution that suits their needs, based on their projects.

Enhancement of 3D monitoring networks' sensitivity by low cost innovative implementation

The special Portable Metallic Pillar (PMP) that is presented can be used for marking accessible points

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Monitoring is the fastest growing discipline in the survey market. Surveyors undertake the difficult task to answer: What is moving? How fast? In what direction? Is it accelerating? The answers come from reliable, precise measurements from this modern instrumentation (Brooks O. (2011).

Also structural health monitoring is one of the important components in the maintenance technology for civil infrastructures (Hongwei L., Jinping O. (2006)).

For these reasons monitoring sensors' networks were established all around of bridges, tunnels, dams, railways, nuclear power stations, high buildings and cultural heritage monuments in order to collect any spatial and qualitative information concerning the specific constructions (Nicaise Q., Cranenbroeck J. (2015)).

All these constructions benefit from implementing monitoring systems. Such systems are expected to provide multi-dimensional alarms, visualization of results in near-real time, and millimeter accuracies. (Danisch, L. et al (2008)), (Wilkins R. et al (2003)).

> Thus the main goal is to devise an innovate fabrication for the implementation of high precision 3D networks, not permanent, with low cost and without any visible interference to the environment

Thus the data are acquired continuously and are sent to central servers to be elaborate, to be adjusted and to extract the results (Singer J. et al (2009)).

3D geodetic monitoring networks and instrumentation as total station, GNSS receivers, retroreflectors ect., consist part of these sensors collecting spatial information for the health of the construction.

A main parameter is the monitoring network's sensitivity, which was defined as the minimum displacement that could be detected by a network for a concrete confidence level (usually 95%). To be more specific if it is needed to detect displacements of ±5mm for confidence level 95%, generally the points coordinates ought to have rms about ±2mm.

In most cases, accuracy of the order of ±1mm is required (Delikaraoglou D. et al, 2010), (Lambrou E. et al (2011)), (Pantazis G. (2015)), (Chounta I., Ioannidis Ch. (2012)), (Huang T., et al (2010)).

Today the evolution of the technology provides the possibility of accurate geodetic measurements. The modern total stations adjust automatically and electronically in real-time the errors of the line of sight, of the tilt axis, of the z and Hz compensator, of the V-index and of the ATR collimation if it is available (Uren J., Price B. (2010)).

Thus the displayed measurements are free of them and considerable accuracy is provided for angle and distance measurements reaching the ±0.5” and ±0.2mm correspondingly. Also the embedded compensator ensures their accurate levelling. (Lemmon T., Jung R. (2005)) (Zogg H., et al (2009))

Nevertheless the measurement errors that still remain are:

- the centering error of both instrument and targets
- The error in the measurement of both heights of instrument and targets.

These errors are significant and surcharge the measurements and the calculated coordinates with remarkable inaccuracies (Lambrou E. (2013)), (Doukas J. (1984)), (Lambrou E. et al, (2011)), (Nikolitsas K., Lambrou E. (2015)).

This paper aims to propose techniques in order to clear or eliminate these errors.

Usually the monitoring networks are implemented by permanent instrumentation which is established at permanent positions namely cement pillars, metallic arms or other permanent constructions. In these cases the centering and levelling error of the instrumentation are totally removed as all the measurement phases are referred to the initial point where the instrument was set and levelled.

This instrumentation consists of tens or hundreds of Total Stations (TS), or GNSS receivers and thousands of retroreflectors and other sensors. *(http://www.ipcmonitoring.com/portfolio/the-London-crossrail-project)*

It is obvious that such a permanent 3D network is of high cost which isn't always feasible to afford. Additionally cement pillars, metallic arms or other permanent constructions which are appropriate for the instrumentation set up aren't always allowed to be established at every site such as the archaeological ones. (Telioni E., Georgopoulos G. (2006)), Georgopoulos G., Telioni E. ((2008)).

So there are cases where the permanent establishment of this instrumentation is banned for cost reasons or for environmental circumstances or for another special status quo.

Thus the main goal is to devise an innovate fabrication for the implementation of high precision 3D networks, not permanent, with low cost and without any visible interference to the environment. Additionally this implementation should ensure the force centering and the proper levelling of the instrumentation in order to erase the above mentioned fundamental errors. The successful results of the use of the Portable Metallic Pillars (PMP), in two sensitive 3D monitoring networks, support the above statement. The PMP permits the establishment of high sensitivity networks with minimum cost. Additionally PMP allows the quick instrumentation set up, so it eliminates the time for the network measurement.

Outline of the Portable Metallic Pillar (PMP)

The PMP (picture 1) is composed by two separate parts: The pole and the ground - base.

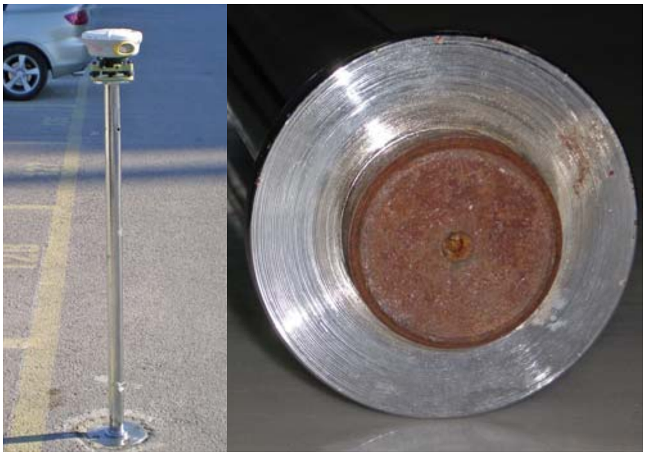
The pole is a cylinder, which was made by nickel-plated heavy duty steel in order to be protected of the corrosion. It has length 118cm, diameter 5cm and it weights about 8Kgr. The length of the pole should be such as to not be oscillated during the measurements. Also, an observer of medium height must be able to use it and the line of sight of the instrument must overcome common obstacles as cars, motorcycles, etc.

The top of the pole is a flat circular disk of 12cm diameter and 7mm width. It has a projected screw at the center in order to put on the tribraches at a unique position. The center of this screw defines the network's point.

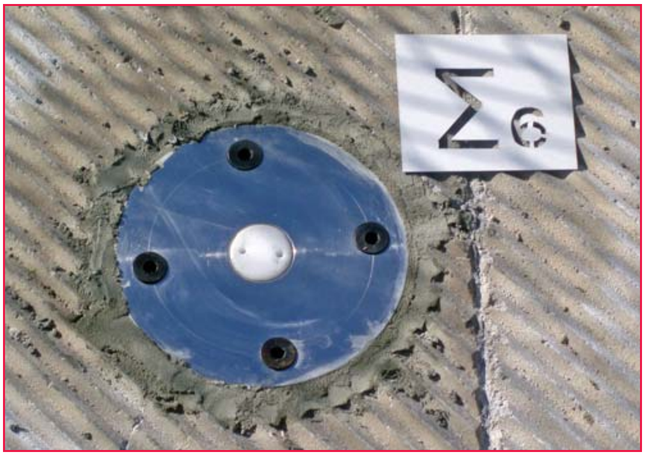
The bottom of the pole has also a flat circular disc and the projected part of its body is formed so as to be also a screw (picture 1) in order to screw in the ground - base accurately at a unique position.

The manufacture of the poles should satisfy the following requirements in order to be used at every network's point:

- the poles must have the same length (The distance between the top and the bottom circular disks).
- The center of the top screw and the center of the bottom screw



Picture 1: The Portable Metallic Pillar



Picture 2: The ground – base

must belong to the axis of the pole (cylinder). Also the axis of the pole must be perpendicular to both circular disks (top and bottom bases of the cylinder) (Lambrou E. et al (2011)).

- Each pole must be screw exactly by the same way on every ground - base.

The ground - base is circular with 20 cm diameter and 2cm thickness; it has a hole with turns of screw in the center of 5cm diameter where the pole screws (picture 2). Also it has four holes at the circumference where special porps are put to firm it in the ground. The base was made by inox in order to protect it from rusting. A pole costs about 250 euros as 300 euros are enough for the ground – base.

Implementation of Portable Metallic Pillar (PMP)

The ground base is incorporated in the ground at the selected position. It is stabilized by concrete. Special attention must be paid for the proper levelling of the ground-base. The ground base should be horizontal in order to force the pole to stand at vertical position when it is screwed on the ground base. This could be realized by using a digital level during the establishment procedure.

As long as the pole is screwed on a ground base and a tribrach is also screwed and leveled on the top of the pole so a TS or a GNSS receiver or a retroreflector could be put accurately at the same position at every measurement campaign. Thus the centering error is totally removed. When a measurement campaign finish, the poles are put off from the ground bases. Nothing remains at the site except the embedded bases in the ground.

It is obvious that the base will permanently remains at the ground position as it is almost impossible to be removed. Thus the number of the ground bases which are needed is equal to the number of the network's control points. On the contrary, the poles are mobile. So any pole can be put on every ground base as they are exactly suchlike to each other. Therefore the same poles can be used in several of such networks. So, in order to eliminate the total cost, the manufacture of so many poles as ground–bases does not need.

Accurate measurement of instrument height (IH)

The measurement of the height of TS, targets and GNSS antenna is the second significant error. The following methodology ensures accuracy of ±0.1mm to ±0.2mm for instruments height measurement. A digital level and a rod are required in order to apply the procedure.

On a point A, which is situated close to the TS's station B, about 5-6m, the rod is put. The reading e on the rod is taken by the TS, under the presupposition that the line of sight is horizontal (namely z=100g). Two readings are taken in 1st (e^I) and 2nd (e^{II}) telescope position (namely z= 300g) (Figure 1a). The mean value is calculated as

$$e = \frac{e^I + e^{II}}{2} \qquad (1)$$

Then the TS is removed and the level is put at the middle between A and B. Both readings backward O (to point B) and forward E (to point A) are taken. (Figure 1b).

The high difference between the points A and B is calculated as

$$\Delta H_{AB} = O - E \qquad (2)$$

Thus the IH comes out as the sum of e and ΔH_{AB},

$$IH = e + \Delta H_{AB} \qquad (3)$$

As the level's reading accuracy on a digital rod is ±0.1mm. The total

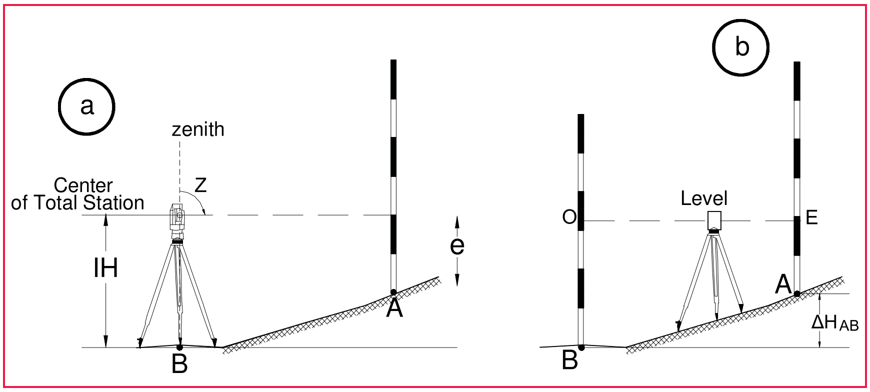


Figure 1: Accurate measurement of instrument and target height

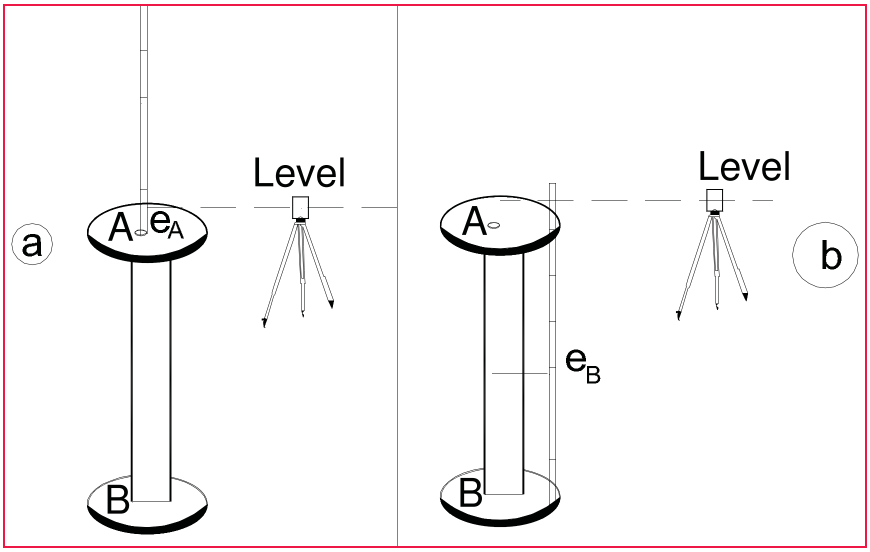


Figure 2: Accurate measurement of GNSS antenna height

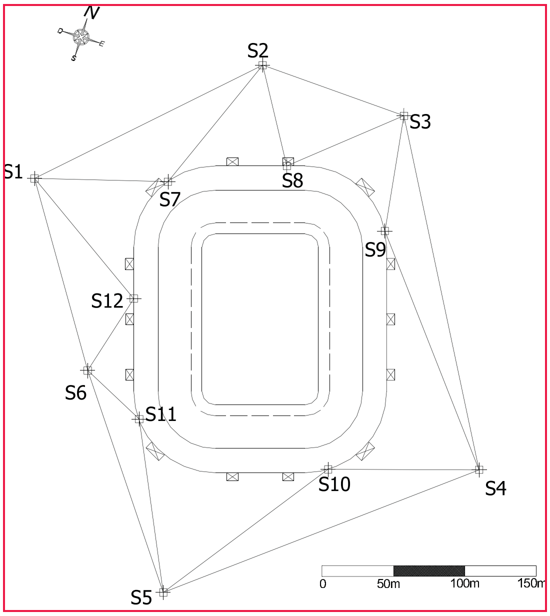


Figure 3: The control network of "Karaiskaki" football stadium

accuracy succeeded depends on the observer's reading skill on the rod (e), that could be ± 0.2 mm.

A simpler procedure is applied for the accurate measurement of a GNSS antenna height. The level is put close to the network point. The rod is put firstly on the surface where the antenna's bottom is seated where a reading e_A is taken (Figure2a). Afterwards the rod is put on the surface where the height of the point should be referred (i.e. the bottom of the pillar) where a reading e_B is taken (Figure2b).

The antenna's height comes out as

$$IH = e_B - e_A + FCH \quad (4)$$

Where FCH (Face Center Height) is the distance from the antenna's bottom to the antenna's face center (is given by the manufacturer). The total accuracy succeeded is of the order of ±0.1mm.

Applications by using PMPs

"Karaiskaki" football stadium

The "Karaiskaki" football stadium, of a capacity of 32000 people, was constructed on a very unstable area close to the sea. The stadium was built on 2004, in order to support the Athens Olympic Games. For monitoring the behaviour of the structure, a 3D control network, which consists of twelve points, was established at the surround area of the stadium (Figure 3). (Bisbilis K. (2007)). The six accessible points of the network were implemented by using PMPs. The rest six inaccessible points were put on the supporting body of the stadium. These points were also marked permanently by small circular targets. The distances between the points fluctuate from 45m to 220m.

The network was measured three times, December 2006, May 2007 and March 2010. In the two campaigns (December 2006, May 2007) the total station Topcon GTS 3003 was used for the measurements, which provide accuracy $\pm 9^{cc}$ for the direction and ±2mm ±3ppm for the distance measurements. In the third campaign (March 2010) the total station Leica TCRM 1201^{+} was used, which provide accuracy $\pm 3^{cc}$ for the direction and ±1mm±2ppm for the distance measurements.

It is remarkable that the time needed for the measurements from each station was maximum 20 minutes, namely 2 hours were totally needed. This was achieved as the PMPs facilitate the placing and the levelling of both instrument and targets.

The adjustment of the network was carried out in an arbitrary local reference system.

The mean rms of the determined coordinates x, y, z is of the order of ±3mm. That means that displacements less than 1cm can be detected for confidence level 95%. Table 1 presents the points displacements between three measurement periods. The time period December 2006 – May 2007 there aren't vertical displacements but there are horizontal ones at the points S4, S5, S9, and S11. The next period May 2007 – March 2010, almost 3 years, later, there is a vertical displacement at the point S5 as well as horizontal displacements occurred at the points S4, S5, S6, S10 and S11.

The church of Megali Panayia in Samarina

Samarina, reportedly the highest village in Greece, at an elevation of some 1450 m, is situated on the wooded slopes of Mount Smolikas in the Pindos Mountains, approximately 70 km west of Grevena in northwestern Greece. Samarina's post Byzantine church of Megali Panayia (Great St. Mary's church) has been built in 1816 and is the area's main religious landmark, as well as a wonder of nature. The church is famous for its painted ceilings, frescoes, and a finely carved

Table 1: Horizontal and vertical displacements between three measurement phases

	December 2006 – May 2007		May 2007 - March 2010	
Point	Horizontal displacement δr (mm)	Vertical displacement δH (mm)	Horizontal displacement δr (mm)	Vertical displacement δH (mm)
S1	0.0	0.0	0.0	0.0
S2	0.0	1.0	0.6	-1.7
S3	2.2	1.0	3.1	-4.9
S4	13.0	-1.0	11.5	-1.8
S5	10.0	1.0	14.1	-9.2
S6	7.1	1.0	10.3	-0.1
S7	2.2	1.0	1.7	-0.2
S8	3.2	-1.0	2.3	1.2
S9	8.6	0.0	5.9	-4.8
S10	6.1	0.0	10.3	-1.7
S11	14.1	3.0	13.7	-4.7
S12	4.1	-1.0	6.1	0.1

Picture 3: Samarina's Megali Panayia

Picture 4: Damage caused by structural deformation

iconostasis (templon), but also that the roof of the altar, covering the apse, in the east side of the 40m long building, “accommodates” a big pine tree with no sight of the tree’s roots to be found within the church or outside the wall (picture 3).

The church is constructed of local stone and has very shallow foundations sitting on unfavorable ground, composed mainly of clay, silt and peat, with the solid rock found in depths of more than 15 m from the surface (Delikaraoglou, et al (2010)).

As the church suffered from extensive structural deformations systematic monitoring should be started. The establishment of permanent concrete pillars was forbidden as it would destroy the sight of the monument. Additionally the accuracy of the network’s points was to be at the level of a 1-2mm in order to detect every displacement up to 5mm for confidence level 95%.That means a high sensitivity network. (Delikaraoglou, et al (2010)), (Georgopoulos, et al (2010)).

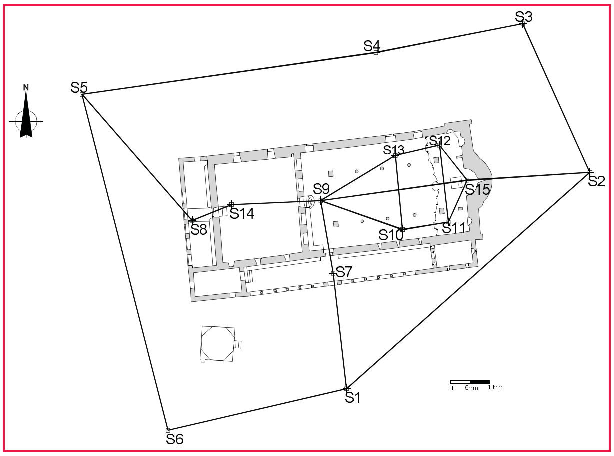


Figure 4: The control network of Megali Panayia

A main 3D network was established inside and outside the monument, which consists of 15 station points. Six of them are located outside of the church and nine more in the interior (figure 4). Also many points were put on the church’s body namely on the walls. These points are implemented by special self-adhesive retroreflectors.

The external six points, with inter-station distances ranging from about 19 to 69m, were implemented by using PMPs.

The network was measured four times, in intervals of about 45 days, June 2009, July 2009 September 2009 and October 2009. In all campaigns the total station Leica DTM 5000 was used which provide accuracy ±1.5^{cc} for the direction and ±0.5mm±1ppm for the distance measurements. (http://www.leicageosystems.com/media/new/product solution/L3_TDA5005.pdf)

The measurements from the six PMPs were carried out in about 4 hours ensuring the simultaneously of the procedure providing time efficiency.

The network adjustment was carried out in an arbitrary local reference system. The point S2 was considered stable as was placed at more stable ground. However its stability was checked by an external network of the wide area.

Thanks to PMPs the total accuracy of the determined coordinates x, y, z is of the order of ±0.2mm. That means that even displacements of the order of 1mm could be detected. As it is presented

Table 2: Planar (Δr) and vertical (ΔH) displacements of the network’s points

	Sep - Oct 2009		July - Sep 2009		June - July 2009	
Point	Δr (mm)	ΔH (mm)	Δr (mm)	ΔH (mm)	Δr (mm)	ΔH (mm)
Points outside the Church						
S1	4.8	+10.4	16.1	-2.9	18.3	+1.8
S2		0	0	0	0	0
S3	3.1	6.7	1.0	-7.0	1.2	-1.6
S4	2.7	-4.9	4.6	-1.5	14.3	1.5
S5	5.9	-3.7	8.6	0.1	18.3	-1.8
S6	8.5	-4.9	12.2	-3.2	15.6	-2.2
Points inside the Church						
S7	7.1	-9.3	9.4	5.0	14.6	-0.3
S8	7.2	-2.6	14.1	1.6	6.3	-1.9
S9	13.5	-2.7	17.9	2.2	23.9	-3.1
S10	3.8	-3.2	6.7	2.4	18.2	-3.4
S11	10.0	-4.0	23.1	1.0	25.4	-2.3
S12	4.3	-1.6	12.6	0.1	18.4	-5.2
S13	6.2	-3.4	9.2	1.6	19.7	-2.5
S14	7.9	-4.5	15.7	-0.1	12.2	0.9
S15	8.6	-4.0	10.4	0.9	11.5	-1.9

in table 2 almost all the points have horizontal and vertical displacements.

Conclusions

As nowadays the number and the requirements for 3D monitoring networks are augmented the proposal of low cost and high sensitivity network seems to be attractive. The two erroneous crucial parameters that still remain at the geodetic measurements, namely the centering error and the measurement of the instrument height, cause significant uncertainties to the results of the impermanent 3D monitoring networks.

A prototype way for the implementation of network's points is being implied which ensures precise centering for the instrumentation. The special Portable Metallic Pillar (PMP) that is presented can be used for marking accessible points. The PMP provides forced unique instrument's centering less than ±0.1mm. It is light enough to carry, it accelerates and facilitates the centering and levelling of the instrumentation as well as it eliminates the time needed for the measurements.

Additionally PMP is environment – friendly as it is invisible but for ever permanent.

Additionally two simple procedures for the measurement of both TS's and GNSS antenna's height are presented, which provides accuracy of ±0.2mm and ±0.1mm correspondingly. This permits the total 3D network solution to be achieved at the same order of the rms for x, y and z coordinates.

Both applications were proved to be successful. The PMPs use provides exceptional accuracy ±0.2mm at the Megali Panayia network where a first order TS was used. Also the duration of measurements was fairly shortened.

At the "Karaiskaki" football stadium PMPs allow for super quick measurements which are needed for this application and satisfied accuracy according to the used TS.

Consequently the use of the PMPs it is recommended for the implementation of monitoring networks. Also if they combined with the accurate instrument height determination, provide low manufacturing cost, easy establishment, no environment intervention, quick instrument setting and measurement acquisition and finally high coordinates' accuracy. Thus they allow the high sensitivity 3D network achievement in order to detect displacements of the order of 1mm.

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Galileo update

Galileo launched for ship positioning and navigation

The Galileo satellite constellation has begun providing positioning, navigation and timing information for shipping, offshore and search and rescue operations. The European Space Agency (ESA) has officially begun open services over the first 18 satellites in the Galileo constellation. The official opening ceremony was held at the European Commission's buildings in Brussels, Belgium. *http://www.marinemec.com*

Galileo launch to reportedly benefit Fugro G4 service users

Fugro said that users of its G4 satellite correction service will be among the first in the world to benefit from Galileo's much anticipated "initial services" launch.

The company said it began taking "full advantage" of Galileo's operational milestone last week. The launch of Europe's satellite navigation system's new "initial services" capability should allow the satellite correction service users to benefit from greater accuracy and reliability.

Fugro's G4 service, launched in February 2015, claims to be the first to use all available global navigation satellite systems (GNSS) – GPS, GLONASS, and BeiDou. From its launch date, the service was prepared for Galileo, and Fugro's G4 users now have access to almost 80 satellites from the four GNSS systems – an advantage when line-of-sight to certain satellites is obstructed by offshore structures.

Two more galileo satellites transmitting navigation signals

After months of testing, the European Space Agency (ESA) has announced that Galileo satellites 13 and 14 are transmitting healthy navigation signals and ready to relay distress calls to emergency services.

The satellites, launched from Europe's Spaceport in French Guiana on May 24, went through lengthy testing that included receiving and uplinking signals through specialized antennas, ESA said. Some of the tests included navigation and search and rescue payloads methodically switched on, the agency said.

The test phase was conducted at both the Galileo Control Center in Oberpfaffenhofen, Germany, and from ESA's Redu Center in Belgium. The Oberpfaffenhofen and Redu centers were linked for the entire test campaign, allowing ESA to compare Galileo signals with satellite telemetry in near-real time, the agency said.

The test campaign measured the accuracy and stability of the satellites' atomic clocks, which is essential for the timing precision to within a billionth of a second as the basis of satellite navigation, ESA said.

Both satellites were visible above the Redu facility for three to nine hours each day, allowing personnel to schedule tests accordingly, ESA said.

The next four satellites, launched on November 17 from French Guiana, are beginning the same in-orbit testing activity, ESA said. The agency hopes to have the four satellites operational in the spring.

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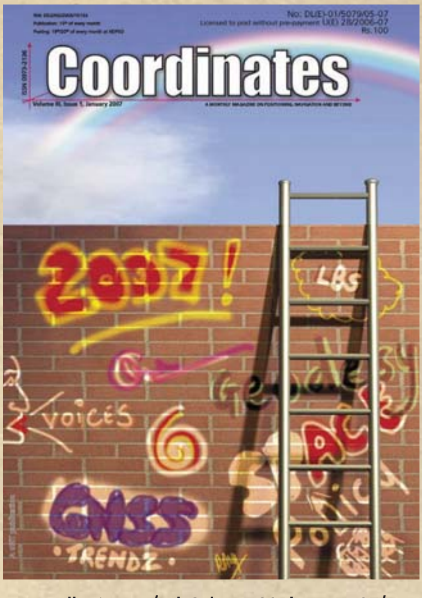

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VOICES

A cross section of views by leading experts on the possibilities and priorities in Geomatics and GNSS in the year ahead

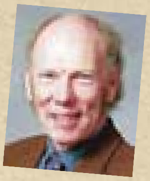
The cell phone GPS market is growing huge

Akio Yasuda
Professor
Laboratory of Communication Engineering, Tokyo University of Marine Science and Technology, Tokyo, Japan

Competition and harmonization is expected in GNSS

Prof Sang Jeong Lee
Chungnam National University, Korea

Geomatics education needs attention



Ian Dowman
President,
International Society for Photogrammetry and Remote Sensing (ISPRS)

More cooperation between providers

Dick Smith
President
International Association of Institutes of Navigation

Emerging wireless applications

Professor Gerard Lachapelle
CRC/iCORE Chair in Wireless Location, Dept of Geomatics Eng, University of Calgary

A transitional year towards larger accomplishment

John W Lavrakas
President
Advanced Research Corporation and President, Institue of Navigation for 2007 **John.Lavrakas@advancedresearchcorp.com**

Customer demand to drive geomatics

Vanessa Lawrence
Director General and Chief Executive, Ordnance Survey

New GLONASS interface control documents released

Russian Space Systems has released draft versions of the GLONASS interface control documents (ICD) for the future code division multiple access (CDMA) signals in the L1, L2 and L3 bands.

Parameters of the subsystem interfaces between the spacecraft and GLONASS navigation consumer equipment are determined by the GLONASS Interface Control Document. The ICD is only available in Russian, but an English translation is expected soon.

PDF files of the documents for each signal can be downloaded here: *http://russianspacesystems.ru/wp-content/uploads/2016/08/IKD-L1-s-kod.-razd.-Red-1.0-2016.pdf*

Synchronization of GLONASS and BeiDou

Russia and China have achieved a significant progress in the synchronization of GLONASS and BeiDou navigation systems, Roscosmos head Igor Komarov said.

"All contracts have been signed, and the work is proceeding. There are prospects, there is great interest on the part of the partners in different fields: the engines, the joint development of launch vehicles, manned space programs, conducting of experiments at the low-Earth orbit," said Komarov. In May 2015, China and Russia signed the BeiDou-Glonass system compatibility and interoperability cooperation agreement, marking a new stage of navigation cooperation between the two countries. *https://sputniknews.com/*

GLONASS ground-based station made operational in South Africa

A ground-based station of the GLONASS satellite navigation system has been made operational in South Africa."Assembling and pre-commissioning work was completed on Nov. 25 to set up a measuring station on the premises of the Hartebeesthoek Radio Astronomy Observatory (HartRAO) as part of the agreement signed between Russia's High-Precision Instrument Systems Company and South Africa's HartRAO on Oct. 29, 2015," acoording to the press office said.

The station has already been made operational and has begun transmitting information to the Global High-Precision Positioning and Ephemeris Time Measurement System's Control Center for commercial subscribers. *Source: TASS https://rbth.com/news*

Broadcom and Qualcomm top GNSS IC vendors

A new reports says that the GNSS market landscape is growing because of rapid growth of satellite technology-enabled wearables, unmanned aerial vehicles (UAVs), new innovation opportunities, and low-cost precision receivers.

ABI Research's new GNSS integrated circuit (IC) vendor competitive analysis says that Broadcom and Qualcomm remain the two top companies for the fourth straight year.

Micro satellites with GNSS receivers for remote weather sensing

Surrey Satellite Technology's Space GNSS Receiver Remote Sensing Instrument (SGR-ReSI) is the primary payload onboard NASA's CYGNSS constellation, launched on Dec 15, from Cape Canaveral Air Force Station in Florida.

The Cyclone Global Navigation Satellite System (CYGNSS) mission is part of the NASA Earth System Science Pathfinder Program that aims to improve extreme weather prediction by studying how tropical cyclones form.

The CYGNSS space segment consists of a constellation of eight micro satellites, each carrying the Surrey SGR-ReSI as the observatory payload in the form of a delay Doppler mapping instrument (DDMI). Making use of reflected global positioning signals, the DDMI collects ocean surface roughness data using a technique called GNSS reflectometry, providing CYGNSS with a new method for looking inside hurricanes. Wind speed will be estimated from this reflectometry data.

U.S. Air Force GPS ground control update

Work on the U.S. Air Force's GPS ground control is complete, Lockheed Martin announced. The recent update, known as the Commercial Off-The-Shelf Upgrade 2, or CUP2, marked the latest step in the multi-year plan to upgrade the technology. The update improves the system's infrastructure, allowing operators to manage 31 GPS IIR, IIR-M, and IIF satellites more efficiently. The Ground Control Segment is a network ground-level facilities responsible for managing transmissions, performing data analysis, and issuing commands to GPS satellites. The network is comprised of a master control station, 11 command and control antennas, and 15 monitoring sites. *http://www.upi.com*

u-blox GNSS Module Featured in Tracking Device

u-blox has announced that two of its products have been used by Cobilsys to create a small, battery-powered asset tracking device.

Cobilsys' ATPACK tracker measures 53 by 48 by 15 millimeters and can be used to track the location of cars, motorcycles, and pets, the company said. The product uses a u-blox EVA-M8M, the industry's smallest GNSS module, which works with GPS, Galileo, GLONASS, and BeiDou, the company said.

SXPad 1000P by Geneq inc

Geneq inc. has announced the SXPad 1000P, a feature-packed, rugged handheld GPS data collector and at an affordable price. It is specifically designed for mobile GIS users in applications ranging from water/electric and gas utilities; transportation; mining; agriculture; and forestry. It is optimized for GPS/GIS field data collection using its 1-3 meter accuracy internal GPS receiver or one of Geneq's high-performance SXBlue GPS receivers for sub-meter and centimeter-level accuracy.

New Esri ArcGIS release Transforms Spatial Analytics

Esri has announced the release of Esri ArcGIS 10.5, the next-generation analytics technology for innovative organizations. It arrives at a time when organizations worldwide are challenged to make sense of real-time digital information. The release helps them glean insight from enterprise data, big data, and the Internet of Things and share that insight in intuitive ways.

The new release is powered by Esri ArcGIS Enterprise, a significant evolution of the technology formerly known as ArcGIS for Server. *www.esri.com*

NTSB wants rail crossing alerts added to navigation apps

The National Transportation Safety Board (NTSB), USA is recommending that technology companies such as Google incorporate grade-crossing GIS data into their navigation applications to provide drivers with alerts when they're approaching crossings. The NTSB made its recommendation in a recent report on its investigation into a February 2015 Metrolink train crash. In the incident, the commuter train collided with a truck stuck on rail track near a grade crossing in Oxnard, California.

Last year, the Federal Railroad Administration (FRA) announced that Google had agreed to integrate FRA-supplied GIS data on 250,000 public and private railroad crossings into its mapping and navigation applications, which would provide drivers and passengers with additional alerts when they're approaching a grade crossing.

NTSB is now recommending that Google, Apple, Garmin, HERE, TomTom, INRIX, MapQuest, Microsoft Corp., Omnitracs, OpenStreetMap US, Sensys Networks, StreetLight Data, Teletrac and UPS of America incorporate grade crossing related GIS data, such as those being prepared by the FRA, into their navigation applications to provide drivers with additional safety cues to reduce the likelihood of crashes at or near public and private grade crossings. *http://www.progressiverailroading.com*

Karnataka GIS portal

The Karnataka Geographic Information System or K-GIS portal was recently launched by IT Minister Priyank Kharge and the department's Principal Secretary V Manjula.

The portal, developed by the Karnataka State Remote Sensing Applications Centre (KSRSAC), was unveiled at BengaluruITE.biz has been visualised as a single gateway-integrated platform to access, acquire, process, store, distribute, and improve the utilisation of geospatial information through intelligent web services generated and published by various agencies; advanced tools for GIS-based analysis; web and mobile apps; and spatial information for further integration with other enterprise applications. *https://yourstory.com*

FARO acquires MWF-Technology GmbH

FARO has announced the acquisition of MWF-Technology GmbH. MWF's technology enables large, complex 3D CAD data to be transferred to a tablet device and then used for mobile visualization and comparison to real world conditions. This enables real time, actionable manufacturing insight for in-process inspection, assembly, guidance and positioning. *www.faro.com/india*

Iran urges Russia to start building remote sensing satellite

The Iranian minister for Communication and Information Technology, Mahmoud Vaezi, urged Russia to start work on constructing the remote sensing satellite both countries agreed upon earlier this year. The remote sensing satellite that Iran and Russia agreed to build will likely be the National Remote Sensing Satellite (NRSS) that the Iran Space Agency announced, along with the National Communications Satellite (NCS), this past summer. A number of companies from China, France, Russia, and South Korea have expressed interest in building Iran's NCS, while it would appear that Tehran has opted for a Russian-built NRSS. *http://spacewatchme.com*

China's overseas remote sensing satellite station starts operation

China's first satellite station overseas was put into trial operation.The China Remote Sensing Satellite North Polar Ground Station is above the Arctic circle, half an hour's drive from Kiruna, a major mining town in Sweden. An inauguration was held in the Esrange Space Center, where the station is located.China has ground stations in Miyun in Beijing; Sanya in Hainan province; Kashgar in the Xinjiang Uygur autonomous region; and Kunming in Yunnan province. The four ground stations receive satellite signals covering 70 percent of the Asian continent.

Domestic stations can receive a signal from each satellite five times a day when it passes overhead, while the new station can receive signals up to 12 times a day. In addition, the new station can acquire satellite data in any part of the world within two hours. *http://usa.chinadaily.com.cn*

SpaceX to launch Ocean-Surveying Satellite

Despite its recent anomaly, the explosion of a Falcon 9 rocket, Elon Musk's SpaceX still landed a deal with NASA to launch an innovative Ocean-Surveying satellite. The project is under NASA's Earth science satellite program that is expected to launch within the next five years. SpaceX will launch the Surface Water and Ocean Topography spacecraft or SWOT. SWOT is designed to scan the Earth's ocean and will perform the first global survey of the planet's surface water. *http://www.natureworldnews.com*

Japanese satellite launches to study earth's radiation belts

A Japanese spacecraft designed to help scientists better understand the radiation environment of near-Earth space has made it to orbit on Dec 20. The Exploration of energization and Radiation in Geospace satellite, or ERG, lifted off atop an Epsilon rocket from Uchinoura Space Center in southern Japan.

If all goes according to plan, ERG will set up shop in a highly elliptical orbit, getting as close to Earth as 215 miles (350 kilometers) and as far away as 18,640 miles (30,000 km). This path will take the 780-lb. (355 kilograms) satellite through the Van Allen radiation belts, where the planet's magnetic field has trapped huge numbers of fast-moving electrons and other particles.

These particles can damage the computer systems aboard satellites and pose a radiation danger to astronauts, Japan Aerospace Exploration Agency (JAXA) officials said. *http://www.space.com/*

China launches satellite to monitor global carbon emissions

China has launched a global carbon dioxide monitoring satellite to understand climate change, hours after it lifted nearly a week-long red alert for the worst smog that engulfed about 40 cities in the country. The 620-kg satellite TanSat was put into orbit by Long March-2D rocket from Jiuquan Satellite Launch Centre in northwest China's Gobi Desert. This was the 243rd mission of the Long March series rockets. Besides TanSat, the rocket also carried a high-resolution micro-nano satellite and two spectrum micro-nano satellites for agricultural and forestry monitoring.

China is the third country after Japan and the US to monitor greenhouse gases through its own satellite. *http://indianexpress.com*

Bluesky Geospatial aerial photos update Irish tourist maps

EastWest Mapping has purchased detailed aerial photography and height data from Bluesky Geospatial to update and enhance its recreational maps. The data, of Counties Wicklow and Dublin, will also be used to update EastWest Mapping's current 1:30,000 and 1:25,000 scale topographic maps, providing more up to date ground cover information and more detailed height measurements. *www.bluesky-world.com*

Trimble launches VerticalPoint RTK system for agriculture

Trimble has announced that it has launched a world-first, patent-pending VerticalPoint RTK system for grade control in agriculture. VerticalPoint RTK provides significantly enhanced vertical accuracy and stability of standard single-baseline RTK systems reducing the downtime and costly delays experienced by many agriculture land improvement contractors today.

VerticalPoint RTK is currently available in North America and Australia as an unlock on the Trimble FmX integrated and TMX-2050 displays and works in combination with the Trimble FieldLevel II system, which streamlines the surveying, designing and leveling steps required for land leveling projects. The VerticalPoint RTK system also includes two stationary supplemental rovers for live, dynamic data collection.

UK startup Focal Point offers smartphone positioning technologies

U.K.-startup Focal Point Positioning has unveiled two new positioning technologies. S-GPS and D-Tail represent step changes in consumer GPS processing and smartphone indoor positioning, the company said.

S-GPS is a new signal processing, sensor fusion and machine learning scheme that dramatically improves the accuracy and availability of satellite-based positioning signals. The patent-pending S-GPS technology provides increased sensitivity and multipath mitigation capabilities that allow modern smartphones to maintain accurate GPS fixes deep indoors and in complex urban environments.

D-Tail is a human motion modeling system that can accurately track users in three dimensions using the inertial sensors in their smartphone or wearable devices. The result is a precise trace of the user's motion, better than the detail and accuracy provided by dead-reckoning and Wi-Fi fingerprinting techniques. It is designed to improve the performance and accuracy of activity tracking apps and LBS analytics.

TomTom and Microsoft join forces to bring LBS to Azure

TomTom and Microsoft have formed a partnership that aims to bring enterprise-grade location-based services to Microsoft's Azure platform, based on TomTom's maps, traffic and navigation software. *http://www.itsinternational.com*

Parkopedia launches Premium In-Car Parking Service with Mazda China

Parkopedia, the world's largest parking service provider, announced that it has launched its premium in-car parking service with Mazda China.

This new premium parking service is provided in partnership with MXNavi, China's leading in-vehicle navigation system and location based service provider. It includes space availability information, which allows drivers to go directly to an open spot as opposed to circling the block searching for an opening. *http://www.parkopedia.com*

Twitter cuts off geospatial data access for police intelligence centers

Police across the US will now have a harder time singling out individual Twitter users. Twitter announced today that it has cut off all geospatial intelligence data being sold to police intelligence centers, also known as fusion centers.

The geospatial intelligence tool was being provided by Dataminr, an analytics firm partially owned by Twitter, which has exclusive access to the company's live data feed or "firehose." Dataminr introduced the system in March, and the ACLU of Northern California found evidence that at least one center had access to it for months afterwards. After a review, Twitter confirmed that the tool is no longer in use by any such agencies. *http://www.theverge.com*

ISRO drones help map disasters in NE India

The Shillong-based North-Eastern Space Applications Centre (NE-SAC) of the Indian Space Research Organisation has tested unmanned aerial vehicles (UAVs) to assess several regional problems, ranging from measuring diseased paddy fields to damage caused by frequent landslides, according to the space agency. A fixed wing aircraft was test flown on November 1.

Drone-based studies are new and currently confined to the north-eastern States. Depending on demand from other States, they could be extended to other places. Based on the images given by the drones, NE-SAC has created a land use map of Meghalaya's Nongpoh town and a 3D terrain model.

MicroSurvey and Pix4D partnership

MicroSurvey and Pix4D have entered into a global partnership which will provide end-to-end solutions to a wide range of customers. By combining products and competencies, the companies bring expert solutions to customers adopting unmanned aerial vehicle (UAV) and photogrammetry technology.

The combined solutions for both forensic and land surveying markets will be available online and through existing MicroSurvey distribution channels.

Drone Services Market Worth 18,022.7 Million USD by 2022

The report "Drone Services Market by Industry (Infrastructure, Agriculture, Entertainment, Logistics), Application (Aerial Photography & Remote Sensing, Data Acquisition & Analytics), Type of Drone, Duration of Service, and Region - Global Forecast to 2022", published by MarketsandMarkets, the market is estimated to be USD 705.3 Million in 2016 and is projected to reach USD 18,022.7 Million by 2022, at a CAGR of 71.62% during the forecast period.

Key factors expected to fuel the growth of the drone services market is the increasing demand for high quality and real time data, favorable changes in policies and regulations pertaining to the use of drones in civil aerospace and rising demand of drones in the commercial sector.

The aerial photography & remote sensing application segment is expected to dominate the market during the forecast period.

Intel acquires MAVinci

Intel has acquired MAVinci, a drone company serving the commercial UAS market with fixed-wing aircraft.

MAVinci team shall continue to focus on supporting current customers and growing the business. The team will collaborate with Intel's Ascending Technologies team to provide a wide range of UAS offerings.*www.mavinci.de/*

Iranians develop firefighting drone

Engineers at a knowledge-based company affiliated to Sharif University of Technology, has been able to build a firefighting drone that relies on indigenous technology.

The unmanned aerial vehicle which is named Hodhod3 is a multirotor drone capable of performing vertical maneuvers. The drone has been designed to help put out forest fires. It can also be used for inspection by firefighters and assessment of power lines. *https://financialtribune.com*

DJI introduces new tools to develop drone apps

DJI has introduced a major expansion of its software ecosystem that allows developers to create drone apps and control drone operations that will bring aerial technology into a wide range of professional activities.

By opening and simplifying the software that operates drones, DJI wants developers to build on each others' accomplishments to develop custom solutions for their own businesses or broadly distribute solutions for entire industries. *http://www.dji.com*

GeoSLAM and Blackdog Robotics sign partnership agreement

GeoSLAM Ltd, the UK based pioneers of SLAM based mobile indoor mapping systems, and Blackdog Robotics, a leading US manufacturer of modular robots, have joined forces to offer law enforcement and first responders a unique rapid indoor mapping solution. Through a combination of the Blackdog mobile platform (which can be remotely operated at distances of more than 500m without line of sight) and the GeoSLAM ZEB-REVO mobile indoor mapping system it is now possible to quickly map in 3D a hazardous or dangerous environment without putting personnel at risk. *http://geoslam.com*

Ford studies using drones to guide self-driving cars

Ford Motor Co. is studying a system to use drones to help guide self-driving vehicles, including on off-road adventures, company officials said.

Drones launched from an autonomous vehicle would help guide it by mapping the surrounding area beyond what the car's sensors can detect. Vehicle passengers can control the drone using the car's infotainment or navigation system. *http://phys.org*

SimActive enables processing in the cloud

Photogrammetry software developer SimActive has announced that processing in the cloud is now officially supported by Correlator3D. Users can subscribe to an online computing service, such as Amazon EC2, and run Correlator3D on a virtual machine.

The main advantage of procesing in the cloud is the capability to use multiple licenses as required.

GMA Land Navigator selects Sensonor STIM210 as inertial engine

The STIM210 provides high accuracy inertial data for the AXD-LNS Land Navigator Solution. Sensonor is currently in serial deliveries supporting the Land Navigator which went into regular production in late 2016, following 5 years of development.

The GMA AXD-LNS is a high performance Navigation system intended for a wide range of applications, such as advanced navigation displays and advanced Navigation Control Systems in Armored Vehicle programs. Due to its High Stability MEMS sensor based architecture, the AXD-LNS equipment is easily configured for platform stabilization applications. In a GPS-denied environment, the system exploits the velocity aiding with help of the high accuracy inertial data in order to provide a continuous navigation solution.

STIM210 is a small, lightweight and low power, ITAR free high performance tactical grade gyro module with 3 gyros. The STIM210 is closing the performance gap to FOG (fiber optic gyro) and is a powerful alternative to current solutions in the market. *www.sensonor.com*

Farlin Halsey named President and CEO and Member of the Board of Directors at Hemisphere GNSS

Hemisphere GNSS, Inc. announced that Farlin Halsey has been named President and Chief Executive Officer, effective January 2, 2017, replacing Xinping Guo, the Interim President and Chief Executive Officer. Mr. Halsey has also been appointed to the Hemisphere Board of Directors, where Mr. Guo will continue to be a member.

NS Groep N.V. to Deploy Real-Time Diagnostic System

Trimble has announced that NS Groep N.V. (NS), the Dutch state-owned rail company, will be deploying the Trimble® R2M real-time remote diagnostics monitoring system. As a core component of NS' overall real-time monitoring architecture, the system allows railway operators to streamline maintenance costs and provide efficiencies across their fleet by automating manual tasks.

Trimble R2M processes diagnostic data from rail vehicles in real time. It provides a comprehensive view of the overall fleet's status including specific vehicle faults. The system also identifies potential faults that may arise while analyzing and detecting anomalies in on-vehicle component behavior to identify component health and the possible impact this behavior may have on the vehicle and overall fleet. *www.trimble.com/rail-assets*

LizardTech unveils GeoExpress 9.5.3

LizardTech has unveiled lossless compression of Harris Geiger-Mode LiDAR data in the newest release of its GeoExpress software. Users of GeoExpress 9.5.3 can now convert massive Geiger-Mode point clouds directly from their native Binary Point File (BPF) format to industry-standard MrSID files without losing data.

Harris has provided airborne Geiger-Mode LiDAR data to the U.S. government for two decades and recently rolled the technology out to the commercial sector for a variety of large-area mapping applications. *www.lizardtech.com/*

CARIS Onboard™ 1.1.

Teledyne CARIS™ has announced the release of CARIS Onboard™ 1.1. CARIS Onboard enables users to process data in near real-time resulting in minimized data conversion and processing times. Designed with autonomous operations in mind, CARIS Onboard will save valuable time as less interaction is needed for automated survey activities.

This release introduces several new processes including the incorporation of the SIPS™ Backscatter engine. Backscatter mosaics can now be generated alongside surfaces in near real-time. This version also presents the ability to compute GPS tide, and apply observed depth and attitude filters. *www.teledynecaris.com*

Honeywell supplies laser navigation to British 'Ajax' tanks

Honeywell's TALIN inertial land navigation technology has been selected for installation on the British Army's new Ajax armored fighting vehicles currently in development by General Dynamics Land Systems UK. TALIN is a battle-tested navigation solution said to be able to "improve mission success in difficult terrain by providing users with a lightweight and highly accurate laser guidance system".

Featuring three-axis inertial sensors and weighing under 6kg, TALIN is already in operational use on certain military and commercial platforms worldwide. Honeywell states that it is smaller and lighter than other available navigation solutions, it can be mounted in different ways and it offers "more reliable performance". *http://optics.org/*

Adv distribution management system for electric utility companies by Hexagon

Hexagon Safety & Infrastructure has announced to offer a fully integrated advanced distribution management system (ADMS) solution to better enable utilities to manage their complex electrical distribution infrastructure and take advantage of real-time operational data. The ADMS solution will aid utilities in improving their network reliability and resilience by streamlining operations and expediting critical actions and decisions. Leveraging Hexagon's strategic alliance with ETAP, the single-vendor ADMS solution features Hexagon's Intergraph InService with embedded distribution management system (DMS) engine from ETAP.

The solution includes comprehensive network analysis tools to perform distribution state estimation, dispatcher power flow and fault calculations; the ability to operate telemetered and non-telemetered devices for ad-hoc operations or planned switching; fault location identification, volt-var control and fault-isolation service restoration; and increased efficiency of field crews and restoration activities.

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NRSC USER INTERACTION MEET 2017 (UIM 2017)
January 23-25
HICC, Hyderabad

February 2017

17th annual International LiDAR Mapping Forum (ILMF)
13-15 February
Denver, Colorado, USA
www.lidarmap.org

March 2017

2017 GIS /CAMA Technologies Conference,
6 - 9, March
Chattanooga, Tennessee
www.urisa.org

Munich Satellite Navigation Summit 2017
14 – 16 March
Munich, Germany
www.munich-satellite-navigation-summit.org

International Forum GEOSTROY
16-17 March 2017
Novosibirsk, Russia
http://www.geostroy-sib.ru/en/

April 2017

ISDE10 & Locate17
3 - 6 April
Sydney, Australia
www.digitalearthsymposium.com

UNMANNED WORLD
5 - 7 April
Doha, Qatar
www.unmanned-world.com

International Navigation Forum / Navitech'2017
25 - 28 April
Moscow, Russia
www.navitech-expo.ru/en/

GISTAM 2017
27 - 28 April
Porto, Portugal
http://gistam.org

May 2017

MMT 2017: The 10th International Symposium on Mobile Mapping Technology
6 - 8 May
Cairo, Egypt
http://mmt2017.aast.edu/index.php

XPONENTIAL
8 - 11 May
Dallas, USA
http://xponential.org

11th Annual Baska GNSS Conference
7 - 9 May
Baska, Croatia
www.rin.org.uk

The European Navigation Conference 2017
9 – 12 May
Lausanne, Switzerland
http://enc2017.eu

GeoBusiness 2017
23 - 24 May
London, UK
http://geobusinessshow.com

FIG Working Week 2017
29 May - 2 June
Helsinki, Finland
www.fig.net

June 2017

10th International ESA Conference on Guidance, Navigation & Control Systems (GNC)
29 May - 2 June
Salzburg, Austria
http://esaconferencebureau.com

TransNav 2017
21 - 23 June
Gdynia, Poland
www.transnav.eu

July 2017

IGS 2017: International GNSS Service Workshop
3 - 7 July
Paris, France
www.igs.org

IEEE Frequency Control Symposium and European Frequency and Time Forum
9 - 13 July
Besançon, France
www.eftf-ifcs2017.org

Esri User Conference
10 – 14 July
San Diego, USA
http://www.esri.com/events/user-conference/papers

September 2017

Interdrone 2017
6 - 8 September
Las Vegas, USA
www.interdrone.com

ION GNSS+ 2017
25 - 29 September
Portland, USA
www.ion.org

Intergeo 2017
26 - 28 September
Berlin, Germany
www.intergeo.de

October 2017

ACRS 2017
23 - 27 October
New Delhi, India
www.acrs2017.org


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