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Coordinates

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THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

GNSS threat quantification

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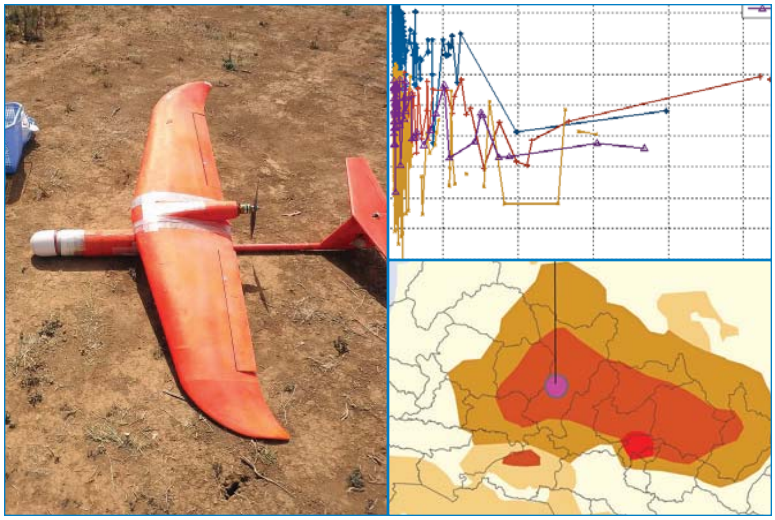

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Coordinates Volume 12, Issue 01, January 2016

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

HI-TARGET Surveying the world, Mapping the future

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GNSS education

India spends less than 1% of GDP

On research and development

Compared to 1.9% in China and 2.75% in US.

Around 90,000 scientific papers

published by Indians compared

to 4,50,000 by Americans

and 3,25,000 by Chinese in 2013.

Even worse: poor citation and a few number of patents.

In general, science education scenario in India

Is not encouraging.

Given this,

GNSS education in India is a long way to go.

Bal Krishna, Editor
bal@mycoordinates.org

"We understand the nuances of the workflows in markets"

says Dave Britton, Global Marketing Director, Surveying and Geospatial Division, Trimble Navigation Ltd. in an interview with Coordinates

Please give us an idea about the structure of Trimble Geospatial Division. What are the broad categories under which it is classified?

The Geospatial Division includes a diverse set of solutions for geospatial data capture and analysis. The solutions range from all types of GNSS devices to total stations and laser scanners, from mobile imaging solutions to aerial cameras, from imagery analysis software to field data collection software, as well as office software for processing and deliverable creation. We have been, and remain, focused on the survey professional as well as GIS professionals but recognize and embrace the fact that geospatial data is playing a more prominent role in many occupations.

How do you approach developing countries vis-a-vis developed countries while marketing your products?

Regardless of geography and market, we always focus on how users can benefit from using our systems. This requires that we understand the nuances of the workflows in markets and geographies we serve and deliver solutions that support and enhance those workflows. We achieve this through close collaboration with our local partners and distribution as well as working directly with end-users. Within developing countries, in some cases we have opportunity to help user develop and define the workflows in ways that may not exist in the developed countries. This is always exciting.

What role do you see of convergence of various technologies in the geospatial domain for the growth of geospatial market?

The convergence of technology will always drive disruption in the market. Being able to determine how to best leverage that disruption will help determine where there is opportunity for growth. There is also increased risk for those that do not embrace the convergence. The potentially most important convergence the domain faces is the capability and function of consumer devices and 'non-professional' tools into the market.

What is your view on UAV/ UAS future trends?

UAS is going to be a critical component of business going forward, and this is true for the geospatial market. Regulations will continue to be an issue in the near future but forward thinkers will continue to leverage the technology. Specifically within the geospatial market, there will be continued emphasis on how to rapidly leverage the data that is created from UAS. The flexibility of the flight systems will only be valuable if the tools used to get to a decision keep up.

Government of India have initiated a program called, 'Make in India'. Do you see Trimble taking advantage of the same in any way?

This represents an opportunity and we already have some production in country. We will continue to evaluate how to best capture the opportunity while balancing the global business.

How does Trimble align itself with its products and services to support Government of India's programmes like Smart Cities and Digital India?

Trimble has many different solutions that support programs such as Smart Cities and Digital India. We believe the breadth of our portfolio positions us well to help realize the promise of Smart Cities and Digital India. Our experience and capabilities in supporting such initiatives in other parts of the world will keep us in good stead in appropriately supporting these programs in India.

How has been the growth in business opportunities in the SAARC region compared to India?

The region is important for Trimble and India sets the pace for growth.

GNSS threat quantification in the United Kingdom in 2015

This paper introduces a summary of the GEMNet system, and presents two sets of results. Firstly, characteristics of interferers observed operationally along with the impact that they caused on two types of operational GNSS receivers. Secondly the results are presented from laboratory tests where jamming "signatures" were played back to two type of GNSS receivers at substantially higher power

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Overview of Project GEMNet

Global Navigation Satellite Systems (GNSS) threats and vulnerabilities have received considerable exposure in open publications and in the press in recent years. Although a number of important studies have been undertaken, several significant gaps were identified in understanding the impact that illegal jammers and other interferers in the GNSS spectrum cause to GNSS users in operational situations. Project GEMNet was initiated as a collaborative activity jointly by the Satellite Applications Catapult and Ordnance Survey (OS) to further the state of knowledge and to begin to address these gaps. After initially assessing the state of knowledge in this field *(not reproduced in this paper)*, the GEMNet operational monitor system was set up with the following core aims:

1. Monitor the GNSS radio spectrum at a number of UK locations in order to quantify the occurrence of jammers in operational environments;
2. Capture "RF signatures" of jammers (both to understand the characteristics of threats, and to support aim 4 below);
3. Assess the impact of jammers and other interference on operational GNSS receivers;
4. Assess the impact that closer or more powerful jammers could have on GNSS receivers, i.e. different operational environments;

GEMNet Sensor System (GEMSS) equipment was set up and deployed

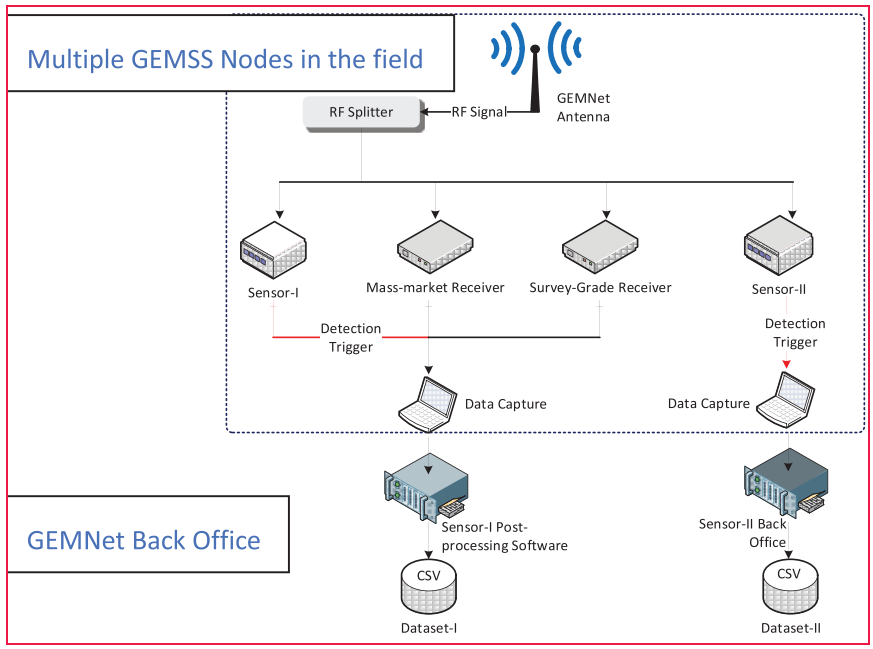

Figure 1: GEMNet System-level Architecture

Table 1: List of GEMSS Devices

Device	Outputs to GEMNet Database
Sensor-1	12-bit In-phase (I) and Quadrature (Q) samples from the A/D Converter, Jammer-to-Noise (J/N) ratio estimation, Received Signal Strength Indicator (RSSI), Plots of the signal spectrum, spectrogram and histogram
Sensor-2	Interference event reports, Interference classification, Normalised signal power, Plots of signal spectrum and spectrogram
Survey-Grade Receiver	Carrier-phase positioning solution (L1/L2), Number of visible satellites, Cycle Slips, Geometric Dilution of Precision (GDOP)
Mass-Market Receiver	Code-phase positioning solution (L1 only), Number of visible satellites, Automatic Gain Control (AGC) voltage level, Jamming strength indicator

in operational situations typical of where Critical National Infrastructure (CNI) equipment is collocated.

This paper introduces a summary of the GEMNet system, and presents two sets of results. Firstly, characteristics of interferers observed operationally along with the impact that they caused on two types of operational GNSS receivers. Secondly the results are presented from laboratory tests where jamming "signatures" were played back to two type of GNSS receivers at substantially higher power.

GEMNet System

System Architecture

Figure 1 illustrates the GEMNet system architecture, which comprised a back office at the Satellite Applications Catapult, and a number of remotely-deployed GEMSS nodes. Each GEMSS Node incorporated multiple sensors and receivers to provide a detailed analysis on the nature and extend of GNSS interference in the vicinity of the Node. Table 1 lists sensors and receivers within a Node, and briefly explains the captured data from each element.

GEMSS utilised an active, Right-Hand Circular Polarised (RHCP) L1/L2 antenna. The radiation pattern for the antenna includes minimal attenuation at low elevations (close to the horizon) since this is the expected direction of arrival of the interference signals. The GEMSS antenna was connected to the sensors/receivers via an active RF splitter. The data from each sensor/receiver are stored locally and also available online through a secure link.

Deployments

Four different locations were used for GEMSS sensors. In all cases the antenna was roof-mounted nearby to existing operational GNSS antennas. The signal from the existing antennas was not taken for two reasons. Firstly, and most importantly, in order to avoid any disturbance to normal operation of those equipments. Secondly, the antennas themselves sometimes implemented technologies that mitigate interference. For example, choke ring antennas are designed to mitigate multipath, but they also attenuate interference emanating from sources at low elevations. Had choke ring antennas been used, the findings would have demonstrated the ability of choke rings to substantially attenuate signals at low elevations, and therefore potential interference sources would have been missed.

The GEMNet antennas were interconnected to the GEMSS platform via low-loss coaxial cable. The GEMSS platform was housed inside secure and weatherproof facilities, and were mains powered.

For this open version of the GEMNet report, locations are not described further since knowledge of their locations could alter the behaviour of those who commonly use GNSS jammers. Since one important element of the study was to assess the real operational situation, it was important to avoid this.

GEMNet Findings On Operational GNSS Interference

Datasets captured from the GEMNet sensors were analysed in detail and yielded over 1800 interference events with Sensor 1 over 100 observation days among four sites. Sensor 2 captured more than 600 interference events over more than 100 observation days among the same sites. The higher number of events with Sensor 1 reflected the higher sensitivity setting used for this device. Each GEMSS node captured a rich set of observables to support analysis of GNSS interference. The GEMNet database consists of two separate datasets. Dataset-1 comprised the raw data captured by three elements: Sensor-1, and the mass-market and survey-grade receivers. It was analysed using bespoke post-processing software developed in-house. Dataset-2 was provided by Nottingham Scientific Limited (NSL), the supplier of Sensor-2, after processing the raw data with their back-office.

Dataset-1 Summary

This section reports interference characteristics logged as Dataset-1. Table 2 provides a summary of Dataset-1 characteristics for the monitoring site designated Site 1. Data captured at other sites was analysed in the same way as for Site 1, and was found to have similar characteristics; due to space limitations it is not reproduced here.

Events in the table are categorised into three groups with respect to their maximum power levels measured by Sensor 1. More than two thirds of observations (69%) were of less than 2dB J/N_0, 29% were between 2 and 5 dB, and only 2% were above 5dB. As well as most interference being of low power, the majority of the captured interference were of very short duration (5s or less). The low power observed was consistent with low power vehicle-borne PPD jammers that were the assumed source of interference, and the separation distance between the GEMSS antenna and the roadways on which vehicles were travelling.

Table 2: Interference Characteristics for Site 1 Monitoring Station (Dataset-1)

Event Statistics		Impact on normal Receiver output parameters				
		Average Change (compared to 90 seconds before the event)				
J/N Ratio [dB], Sensor 1	Number of Events [%]	C/N0 [dB-Hz]	Visible Satellites [%]		Horizontal Accuracy [cm]	
			Mass-market Rx	Survey-Grade Rx	Mass-market Rx	Survey-Grade Rx
≥5	10 [2 %]	↓1.3	↓ 1.9	↓ 8.1	↓ 3.0	↔
2 to 5	169 [29 %]	↔	↔	↓ 1.1	↑ 1.1	↔
1.76 to 2	406 [69 %]	↔	↔	↔	↑ 1.9	↔
Total	585					

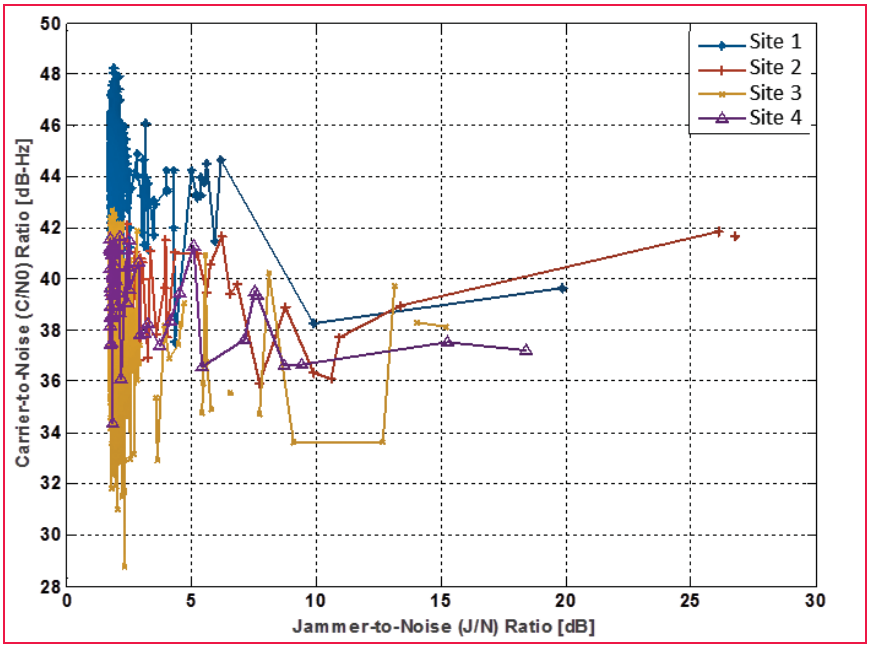

Figure 2: Captured Interference Power (J/N) w.r.t Average C/N0 Recorded with the Mass-Market Receiver during interference (Dataset-1)

The "impact on the receiver" section in the table illustrates the average change in some normally-available receiver output parameters (*The tables with the symbol "↓" indicate a drop, with the symbol "↑" indicate a rise, with the symbol "↔" indicate no significant change in the particular receiver observable*). The low interfering power led to minimal variations in receiver observables. With the survey receiver, no change in horizontal positioning accuracy performance was recorded. This same receiver saw an average 8% reduction of number of visible satellites during the 10 higher-power interference events, but this was not reflected in a worsening of position. The mass-market receiver recorded only a marginal reduction in number of visible satellites (1.9% during the 10 higher power jamming events). Horizontal accuracy with the mass market receiver was almost unaffected by the interference (average of 1.9 and 1.1 cm worse position for lower interference categories), and 3 cm improved horizontal positioning performance during the 10 higher interference power events. There is no physical mechanism in a normal GNSS receiver whereby increased interference power should improve positioning accuracy performance; rather the marginal improvement in these 10 cases is assumed to reflect typical variations in positioning performance when using small statistical samples.

Figure 2 plots interference power with respect to observed C/N_0 output from the mass-market receiver, at four GEMSS monitoring stations. The variations in observed C/N_0 continued to lie within its normal operational range despite the interference. As recorded in the table above, the positioning accuracy also remained within normal operational levels for both mass market and survey-grade receivers.

The vast majority of interference was of very low power and short duration, and caused no significant impact on GNSS receiver performance. The GEMNet sensor sites were between 50m and 200m from roadways (the assumed locale from which interference emanated). Interference at this range would typically be reduced by between 20 and 30 dB relative to the level expected very close to the interferers themselves. Closer separations between interferers and GNSS antenna, and/or higher power interferers, would change this observation and worsen the observed impact of interferers. Intelligent siting of GNSS antennas, or antenna or receiver mitigation technologies could counter the impact of higher interference powers.

Generally interference power was low, typically less than 5 dB jammer to noise ratio (J/N). A peak interference power of about 25 dB (J/N) was observed. This observation is consistent with a close approach (perhaps 10 m or less) of a low power jammer to a GEMNet GEMSS site. This observation might alternatively reflect the rare use of a substantially more powerful jammer, although a close low power jammer appears to have been the likely cause.

Dataset-2 Summary

This section reports interference events logged as Dataset-2 and coming from Sensor 2, the commercial interference detector. Table 3 provides a summary of Dataset-2 characteristics for the monitoring site designated Site 1. Figure 3 and Figure 4 provide ways of visualising certain details of interference characteristics, and are provided as an example of the several outputs from this dataset. At Site 1, 43% of events were

Table 3: Dataset-2 Overview

Station	Dates	# of Days	# of Events
Site 1	13th April – 10th June 2015	59	372

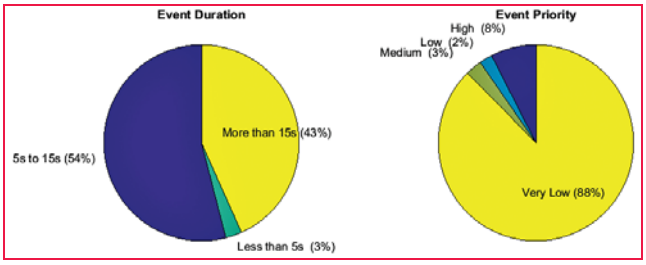

Figure 3: Site 1 Monitoring Station Interference Characteristics (Dataset-2)

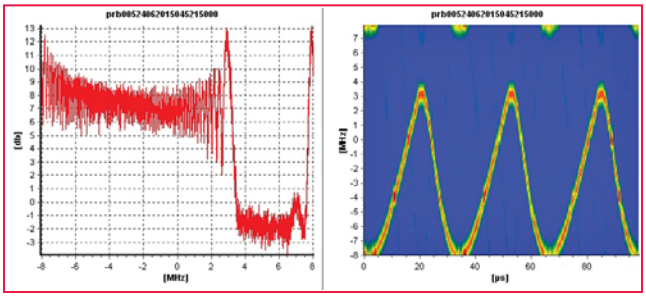

Figure 4: Example Interference Characteristics (Dataset-2) – ChirpTriangular Type, Spectrum and Spectrogram

of 15 seconds or longer duration. "Event Priority" is a parametric assessment of the importance of the observed events, with 88% of Site 1 events recorded as very low priority. Even the 8% of observed events designated as high priority events did not lead to substantive impact on the GNSS receivers, as reported in the previous section. The commercial detector was produced by Nottingham Scientific Ltd (NSL), and included a suite of functionality to process and categorise observed interference, although only a subset was used for the GEMNet work. A full library of event characteristics was captured, an example is shown in figure 4.

The interference characteristics captured by Sensor 2 aligned with the ones captured by the in-house developed Sensor 1, although for research purposes Sensor 1 had been set to be somewhat more sensitive and consequently captured more low-powered interference events. As with Sensor 1, Sensor 2 showed clearly that most events were of low interfering power and had short duration.

Impact of Higher Power Interference on GNSS Receivers

Test Configuration

Operational field measurements showed that many interferers were detected at all GEMNet sites, but that interference powers were of such low power that GNSS receivers were largely unaffected. There are many situations where interference sources (e.g. jammers) could come closer to CNI sites than occurred during the GEMNet trials. This would cause a higher interference power at the CNI GNSS receiver than the powers observed. This approach also addresses the possibility that future jammers might be more powerful than today's. In order to assess the impact of higher levels of interference on GNSS receivers, a non-radiated RF experiment was devised, as illustrated in Figure 5. Two receivers were used for the test:

1) A mass-market receiver (calculates position based on code phase measurements);
2) A survey-grade receiver (calculates position based on carrier phase measurements).

The receivers under test were provided with a simulated GPS signal using a Spirent GSS-8000 GNSS constellation simulator and a reconstituted interference signal. The interference was created using a software-defined radio from the captured I and Q measurement samples of interference from the Sensor 1 database. The captured digital signature was up-converted and "played back" in a loop at the GPS centre frequency. The power level of the played back RF interference signatures could be adjusted to observe the impact of higher jamming power levels on GNSS receivers under test. Figure 6 shows how the power level was varied during the tests.

The satellite simulation was set up and run without any interference. Once the receiver was tracking the simulator signals and calculating positioning satisfactorily, the amplitude of the interference was slowly increased to, and then beyond, the point where the receiver began to lose tracking capability. During the test, position and other observables were logged from the target receiver once per second. From these results it was possible to assess the margin of reliable operation (in dB) with respect to the original incident jammer. This effectively calculated how much closer the jammer would need to be to impact the receiver.

The non-radiating test approach had several advantages over alternatives:

i. The test was repeatable, and could be conducted to compare the performance

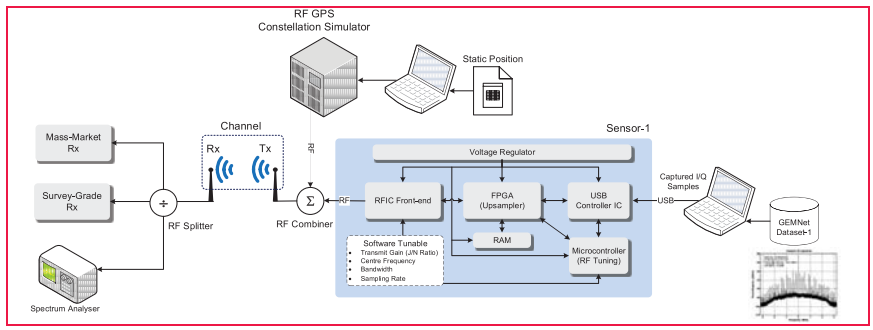

Figure 5: Testbed for Assessing the Impact on GNSS Receivers of Jammer Signatures at different powers

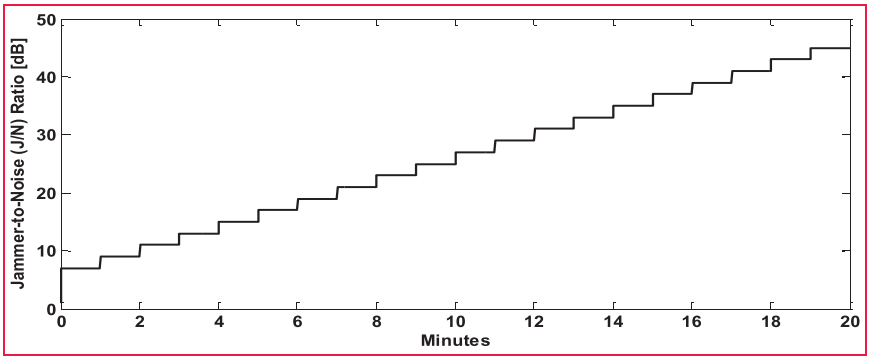

Figure 6: Simulation Jammer Power Profile

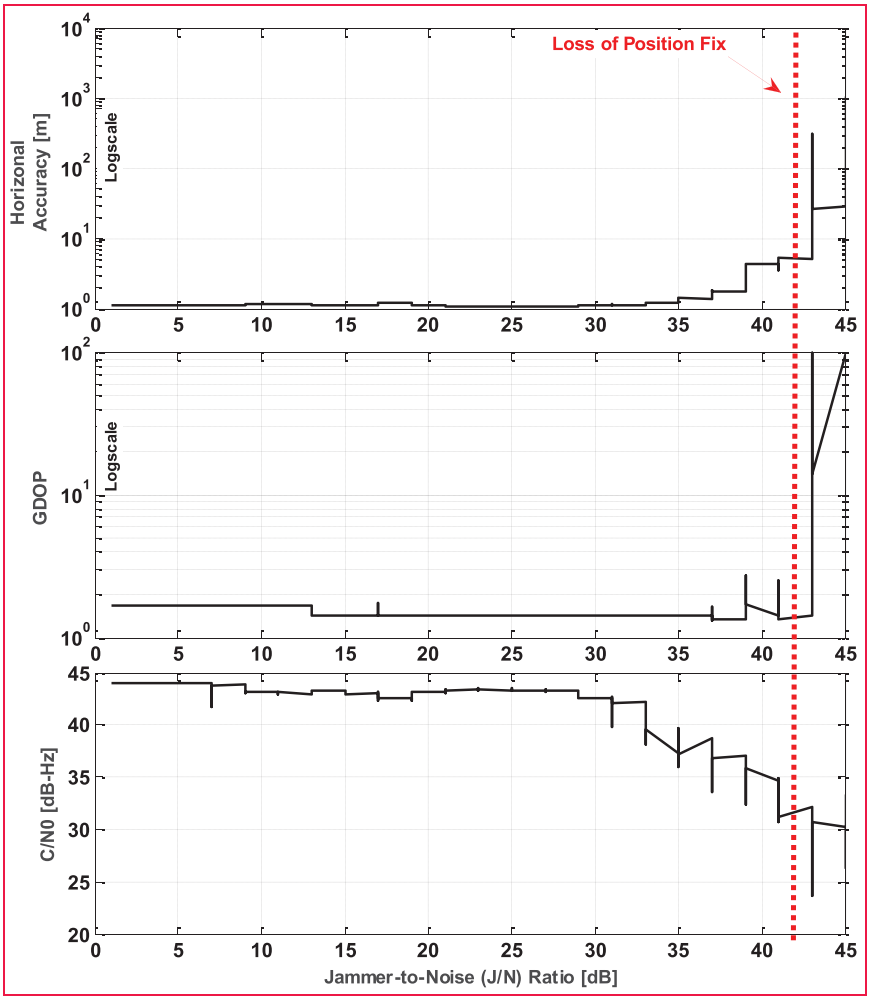

Figure 7: The Effect of High Power Levels of Jammer on the Mass-Market Receiver

of several different receivers against the same threat characteristics;

ii. Sophisticated models could be implemented to investigate different threats and/or combinations of threats;

iii. Different user scenarios could be implemented to assess particular configurations;

iv. No anechoic chamber was needed (although for other tests a TEM cell was sometimes used to address particular receiver configurations where an antenna socket is unavailable);

v. No transmit license was required as would be required for open air trials;

vi. If a receiver were vulnerable to a particular threat, mitigations could be implemented and then tested against the same threat to verify the efficacy of the mitigations.

vii. Generally these tests are much lower cost to implement, repeat, modify, and repeat again than field trials.

Test Results

Figure 7 neatly summarises the results obtained with the mass-market receiver. The receiver lost position fix when the J/N ratio reached 43dB. After this point, horizontal positioning accuracies worsened rapidly up to 1500m. Positioning accuracy had worsened before positioning capability was lost, but only reached about 5m error before failing, i.e. the receiver "knew" that it had lost positioning capability when the output error level was about 5m. It continued to output a propagated position estimate, the accuracy of which degraded rapidly. Geometric Dilution of Precision (GDOP) rose and average C/N_0 (*Average C/N_0 is based on the number of available satellites to the receiver. For example, if the receiver is tracking a single satellite with a C/N_0 of 35dB-Hz, that figure was considered to be the average C/N_0 for the receiver.*) dropped as interference power was increased. These findings were as expected. Broadly similar findings were made with the survey grade receiver, and are not reproduced here.

These tests showed that the particular receivers tested had a high degree of robustness to interference at a distance, but that high power interference, caused by either close proximity to a jammer or potentially to a higher-powered interference source, would cause service denial.

Generally GNSS receivers do not alert users of interference, even when this degrades or inhibits receiver performance. Instead interference may cause either (a) the receiver output (position or time) to become unavailable, (b) the output to freeze at its previous value, (c) the output to become unreliable (propagated solution, unconstrained solution, potentially hazardously misleading information). The impact of interference on equipment, applications, and services for which GNSS receivers provide position or timing inputs depend on the implementation of those complex systems and services. The

lack of GNSS receiver problem alerting is likely to cause consequent equipment, applications, and service problems that are beyond the scope of the present work.

Conclusions

Several conclusions can be drawn from the GEMNet project:

1) Clear evidence of GNSS interference was collected. During 100 observation days, between 600 and 1800 interference events were captured over four sites. The variation in number of observations was due to the different sensitivities of the two different detectors used. This confirms that a potential threat exists to the operations of GNSS users in the United Kingdom.
2) Interference observed was of very low power, with the majority less than 5 dB jammer to noise (J/N) ratio. This is consistent with low-power (less than a few milliwatts) jammers on the roads that were typically 100m or so from the GEMNet GEMSS sites.
3) Very occasional higher interference power (J/N of up to 25 dB) was observed. This is consistent with very occasional close approach (perhaps 10 metres) of a low-power jammer to a GEMSS site.
4) Much of the interference observed had radio characteristics (spectrogram and power level, temporal characteristics) consistent with deliberate (low-power) jamming, produced by devices commonly referred to as PPDs (Personal Protection Devices, or equivalently in-car jammers). Some interference had characteristics that may have been accidental low-power emissions from devices other than jammers. Some interference was of such low power that it was not possible to extract sufficient power above background noise to assess whether it was distant low-power jamming or accidental interference.
5) Building on one of the gaps from previous studies by other researchers, the GEMNet Network collocated a mass market GNSS receiver and a survey-grade GNSS receiver with the interference detection sensors at each of the GEMNet sites.
6) In most cases there was no discernible degradation in GNSS receiver (neither survey grade receiver nor mass market receiver) performance despite detection of interference by the sensors. This is consistent with the commonly reported observation at many sites that, although interference may exist, it generally does not lead to service outage or other problems.
7) In the worst cases, GNSS receivers collocated with the GEMNet interference sensors were marginally affected by interference. This included marginal (cm-level) accuracy changes in the mass-market receiver; no accuracy degradation was observed in the survey grade receiver.
8) If separations between the interferers and operational GNSS receivers were less, or if higher power interferers started to appear, then the risk would be larger. This could potentially cause a receiver to lose its ability to

position reliably. This unreliability could manifest itself as HMI (hazardously misleading information) or denial (loss of positioning).

9) An important second part of the GEMNet work was to replay the captured interference profile at a higher power than observed in the field, under laboratory conditions, and to examine the impact. This part of the study showed that the mass market receiver suffered no significant adverse effect from interference below a jammer to noise ratio (J/N) of about 35 dB. It lost lock and was unable to track satellites at a J/N of about 43 dB. The survey grade receiver was robust to about 33 dB jammer to noise ratio. It lost lock and was unable to track satellites at a J/N of about 39 dB. Should operational jammers with 1000 times higher power than those operating today become common, then both mass market and survey grade GNSS receivers could often be compromised.
10) Low-power jammers (with powers similar to today's levels) can under some circumstances approach to within much closer distances to GNSS receivers at CNI sites. Indeed at many CNI sites there is nothing to stop close approach of such jammers, nothing to detect their presence, and no mechanism to dissuade this from happening, even though transmissions from such jammers are nominally illegal (*It is an offence under the 2006 Wireless Telegraphy Act to emit radio signals in the GPS L1 frequency spectrum (or at other GNSS frequencies*). The enforcement of this Act against low power (PPD-type) jammers is at best weak in the United Kingdom and elsewhere). For the GEMNet work, the distances between the GNSS receivers and nearby roadways was typically 100 to 150 m. A simple radio propagation calculation shows that 30 dB higher power would occur with such a jammer brought to about 5 m from the CNI GNSS receiver. Such a distance is approximately the nominal range of a PPD-type jammer.

Recommendations

Several recommendations are made based on the GEMNet work:

1. Expand GEMNet-like GNSS threat monitoring to cover multiple locations and extend monitoring over a protracted period of time, in order to create a comprehensive database of up-to-date threats, against which to assess potential user impact.
   a. This could usefully be coordinated at National level since the threats experienced are likely to be common across multiple commercial and governmental sectors.
   b. This could also be usefully coordinated internationally since threats experienced are likely to be common across many nations.
2. Standardise GNSS threat recording data parameters nationally and internationally, so that threat characteristics can be captured by platforms and detectors provided by multiple commercial vendors. This will facilitate exchange of information on new and emerging threats across multiple states, thereby highlighting any particular concerns as well as supporting early development of threat mitigation mechanisms.
3. Assess, and create a database of, the impact of identified interference threats on commercially available GNSS receivers. This might, for example, be undertaken by replaying the threats through an appropriately configured Radio Frequency Simulator as was done for the GEMNet work. This will allows users to accurately assess their risk based on the receivers that they use, will support investment decisions for those who rely on GNSS equipment performance, for example for critical infrastructure – i.e. ability to procure GNSS receivers capable of mitigating known threats. In addition this will support improvements in receiver and antenna technologies and augmentations since many mitigation capabilities already exist within the industry, but without an appropriate threat definition the market demand is weak.
4. Create a set of draft minimum performance standards for robust GNSS receivers (i.e. receivers that can mitigate identified operational threats), and in parallel propose performance test methodologies and specifications. Such standards and tests will probably be domain specific because of the diversity of involved bodies; however substantial elements will also be common across multiple domains since the GNSS signals are common; as are many of the threats and vulnerabilities.
5. Extend the work undertaken thus far to encompass other threats to PNT operation, such as atmospheric effects / space weather, and radionavigation spoofing.
6. Examine threats to the radio spectrum at other frequencies where radionavigation systems are implemented or proposed in order to more robustly understand potential threats to such systems. This might usefully include other GNSS frequencies or ground based radionavigation signals

Acknowledgements

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The assessment of the state of the art was based on published material, drawn from a number of openly published sources. This aspect of the work was assisted by helpful insights from a number of experts in the domain. We would like to express particular thanks to experts from the following organisations: Chemring (Roke Manor), InnovateUK, Nottingham Scientific Limited (NSL), Spirent Comunications plc, and the Universities of Nottingham, Westminster, and Imperial College.

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Evolving GNSS threats – just the tip of an iceberg?

If more people knew just how vulnerable GNSS is, and how much today's world depends on it, they would be frightened

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Market Segment Manager- Robust Position, Navigation and Timing Spirent Communications plc, UK

When you think about it, GNSS is miraculous. Actually, like most magic, it is best for most people not to think too much about it. They just accept that today's cars know where they are and how to get where they want, that a cell phone knows how close they are to local restaurants, that planes can land safely in thick fog, and that ATMs and a host of other services can be trusted to deliver.

There are plenty of other miracles around, but they are somehow easier to grasp: television comes by cable or a visible aerial, cell phones rely on towers and signals break up when you get too far from a tower. Most people do have a vague idea that GNSS depends on a satellite, but have little idea of just how delicate is its operation, and that it actually depends on multiple satellites to build its accurate location data.

If more people knew just how vulnerable GNSS is, and how much today's world depends on it, they would be frightened. And that is why we should analyse the possible threats – see Figure 1 – and suggest better strategies to protect against them.

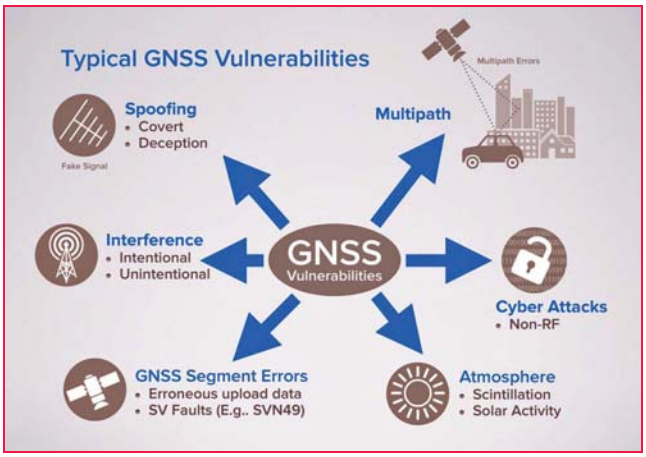

Figure 1: Typical GNSS Vulnerabilities

The threats can be broadly divided into natural and man-made, and the second category includes both accidental threats caused by human error, and deliberate criminal activity, terrorism or acts of war.

Natural threats in the atmosphere

GNSS signals must pass through the atmosphere and all its variations and perturbations. Weather systems can cause small variations in signal delay, while more serious changes can occur in the ionosphere, especially during increased activity from sunspots and solar flares. Over the equator and near the poles small perturbations in the ionosphere – called "scintillation" – can cause the GNSS signals to break up or the receivers see rapid variation in both signal phase and amplitude and, if not designed robustly, they can lose signal lock.

Small variations like this are not uncommon, and some GPS receivers were affected by a couple of solar events in June last year. More serious solar radio bursts during December 2006 were about 10 times larger than any previously reported event and civilian dual frequency GPS receivers were quite severely affected. Experts estimate that once in around 200 years we can experience a "Carrington event" super-storm that would cause severe and long lasting damage: the last one was recorded in 1859. A nuclear explosion in the upper atmosphere would have a similar effect, and cause propagation anomalies for weeks afterwards.

Natural threats on the ground – multipath errors

One effect from scintillation is that the receiver picks up a double signal from two different paths through the atmosphere. A similar "multipath" error

can be caused by reflection: GNSS signals can reflect off relatively distant buildings, and cause gross errors if the receiver locks onto the reflected instead of the direct signal. More subtle errors arise when the reflective objects are closer and the direct and reflected signals merge.

Multipath is a well known problem and receiver manufacturers have introduced all kinds of measures including multipath rejecting antennas, receiver filtering and processing techniques. But multipath can still cause surprising errors of tens to hundreds of metres, and it is also one of the most significant challenges faced by driverless car navigation.

Accidental interference

High power transmitters, ultra wideband radar, television, VHF, mobile satellite services and personal electronic devices can all interfere with delicate GNSS signals – even causing complete loss of lock. In 2002 a poorly installed CCTV camera in Douglas, Isle of Man, caused GPS within a kilometre to be blocked.

Accidental jamming can occur when an older model GPS antenna rebroadcasts the signal on account of poor impedance matching in the amplified signal path from the low noise amplifier, and this interferes with reception in an adjacent antenna. To avoid this risk, antennas should not be mounted too close together.

In April 2005 a military GPS jamming exercise in Southern Idaho was announced in a Notice to Airmen (NOTAM) but a lot of other GPS users never heard about it until too late. Local farmers were caught out and truck and tractor drivers were forced to sit idle waiting for the GPS signals to return. A commercial crop-spraying helicopter company also lost business.

Human error

Such is the "magic" of GNSS location that people soon learn to trust it and ultimately may cease to question its data. But however good the GNSS, human error can still make nonsense of its output.

Pages of data – including the clock predictions and precise orbit predictions (ephemeris) – have to be uploaded to GPS satellites. If bad data were to be uploaded to a satellite, errors could show up as soon as the ephemeris data loads – typically every 2 hours – or they could slowly accumulate over time. It is theoretically possible that bad input could cause all the satellites to transmit bad navigation data simultaneously, causing GPS receivers to fail everywhere. Bad GPS data uploads happened in June 2002, March 2000 and March 1993, for example, but without serious consequences.

At the other end of the data stream, people can be so sure of the GNSS system that they fail to allow common sense to over-ride its data. In March 2014 the 80 metre MV Danio ran aground off the coast of Northumberland and the six crew members were stuck on board for a fortnight because bad weather postponed rescue attempts. The navigator was relying entirely on a low cost, unapproved GPS chart plotter, had not switched on the alarm system and then fell asleep.

Satellite system error

Even without human mistakes, GNSS can generate errors. The satellite's precise atomic clocks sometimes produce errors that accumulate before being noticed. On 1st January 2004, the clock on GPS satellite SVN-23 drifted for 3 hours before the command centre marked it unhealthy, by which time the range error had grown to 300 km.

A fault in the signal modulation or generation process on a satellite, can result in bad signals that confuse receivers. The so-called 'evil waveform' from GPS satellite SVN 19 in 1993 caused an error of up to 8 metres, while a piggy-back L5 signal generator on GPS SVN 49 led to an on board multipath effect that caused variable, sometimes substantial errors in receivers at different elevation angles.

Deliberate signal jamming

The crudest form of jamming simply transmits a noise signal to overload the GNSS receiver and cause loss of lock. Circuits and assembly instructions for simple jammers are widely available on the Internet. Commercial jammers can be bought for less than £20 and are increasingly sophisticated: some are designed to fit into a pocket, some into car lighter sockets; most jammers are designed to block GPS, GLONASS and GALILEO (even before GALILEO is operational), others include cell phone jamming as well, while more powerful jammers, up to at least 25W, are also available.

Short of cyber war or terrorism, why would anyone want to jam a GNSS signal? As an advertisement from Jammer4U puts it: *"If you are sales personnel and delivery drivers, this GPS tracking jammer is a very popular item for you to take lunch or make a personal stop outside of your territory or route off the radar We are a GPS jammer factory! We will check the quality before shipped! Best service!"*

Deliberate jamming is against the law and is used by car thieves, road toll evaders, tracker evaders, lorry drivers bypassing commercial mileage limits as well as those wanting a short respite from the fleet operator's vigilance – as suggested in the above advertisement. The jamming will typically be indiscriminate and both moving and stationary. It may be fairly low power just to defeat the localised vehicle location system but a car thief is unlikely to be concerned with managing power levels to minimise risk to other GPS users.

GNSS spoofing

Spoofing is more sophisticated than simply jamming a signal with noise, because it requires the attacker to

generate realistic but false GNSS signals. Until recently it was assumed that spoofing would require specialist knowledge of GPS, whereas criminals would prefer simple, fool-proof methods. So spoofing attacks were not expected for the near future.

All that changed at last year's DEFCON 23 hacking conference in Las Vegas, when two hackers – neither of whom were GPS specialists – demonstrated how they had created a low-cost GPS emulator using cheap off-the-shelf components and open source code from the Internet.

They made two well-known brands of smart phone show wrong location and timing information – one showed a time and date in the future. They also spoofed a car satellite navigation system into showing its position as being in the middle of Namco Lake. They also showed that they could bring down a drone by fooling its receiver into thinking it was positioned in a forbidden, geo-fenced area. Existing GPS receivers in important devices were all too willing to lock onto these fake signals without sounding any warning. The equipment needed could be bought for less than $1000, and the availability of Open Source software tools meant that the level of expertise needed was a lot lower than previously believed.

A Windward report claims a 59% increase in such GPS manipulation between mid 2013 and mid 2014, with similar motives to those described for jamming, but more typically used by ships rather than lorries. The Automatic Identification System (AIS) is used on ships for identifying and locating vessels by electronically exchanging data with other nearby ships. Vessels fitted with AIS transceivers and transponders can be tracked by AIS base stations located along coast lines or, when out of range of terrestrial networks, through a growing number of satellites that are fitted with special AIS receivers. The International Maritime Organization's International Convention for the Safety of Life at Sea requires AIS to be fitted aboard all international voyaging ships of 300 or more gross tonnage, and all passenger ships regardless of size.

The tip of an iceberg?

There are many reasons for a ship wanting to bypass the system. These include fishing vessels wanting to poach in forbidden territory, for smuggling and people trafficking. Other possible uses for spoofing signals could be for pirates to lure a ship into dangerous waters by issuing fake distress or man overboard signals, to make a stolen ship invisible, to create malicious weather forecasts, and impersonating a port authority. Just how widespread is this form of fraud? Figure 2 shows the distribution of false International Maritime Organisation signals detected in the year to mid 2014.

Figure 2 shows a surprising number of vessels claiming to sail across known deserts and jungles, while Britain is left relatively undisturbed. So it is interesting to note some of the GNSS interference events detected in a very quiet rural location: the Spirent facility in Paignton, Devon – surely an ideal location for GPS testing in an unpolluted radio frequency environment.

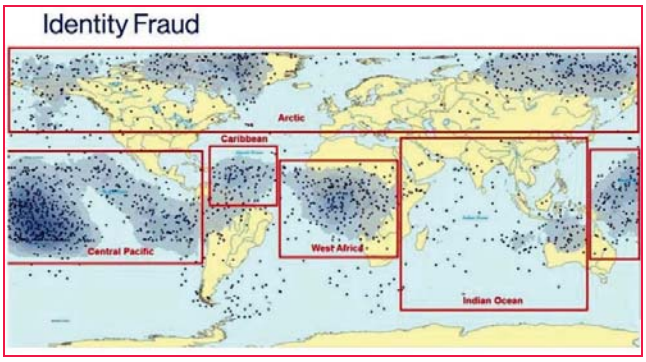

Figure 2: 'Heat Map' showing amount of transmissions detected with invalid IMOs; Darker blue 'clouds' indicate areas with more invalid IMO transmissions (July 2014)

Between May and August 2015 over 100 interference events were detected. Some occurred so regularly by the clock that it is assumed that they could be caused by local machinery, some were quite mysterious, probably from a natural source and not a jammer, and then there was the off deliberate jammer signal – one lasted 3 minutes and was presumably from a van making a nearby delivery.

What should be done?

There is no shortage of incentives for GNSS fraud. Further possibilities could be to avoid GPS based road tolling systems and to outsmart location-based payment authentication services – what if one could withdraw money from an ATM while having a GPS alibi claiming that you were elsewhere when the transaction took place? A recent development has been the use of smart phone tracking as a source of forensic evidence: the police will take a suspect's smart phone to search its movement tracking record. If that record could be falsified, then again it would provide a powerful false alibi.

So we should be mindful of the enormous potential risks and the need for better guidance to help non-specialist GNSS/GPS users to assess the risks, known how much protection is needed, and how much would be truly cost-effective. If there were recognised global standards for robustness levels and types of risk, the buyer could make a more educated choice based on the actual need, relative risk and additional cost.

Controlled testing, under a range of realistic or extreme operating or attack conditions, helps manufacturers to develop more robust systems – standardized tests against set criteria are improving the performance and reducing vulnerability. A recognized set of standard tests will make it easier and quicker for customers to select the best equipment for their application based on performance and levels of protection

The time is ripe for sharing ideas before we hit the iceberg. There is a GNSS Vulnerabilities group on LinkedIn specifically for discussing issues around GNSS jamming and spoofing. Join it.

Development of collision avoidance system for unmanned aerial vehicles

This paper is focused about finding an optimal solution for the collision avoidance of UAV in a busy airspace with both stationary and moving obstacles present in it, using Indian Navigation and Remote Sensing satellites

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Satellite Navigation service is an emerging satellite based system with commercial and strategic applications. To meet the user requirements of the positioning, navigation and timing services based on the indigenous system, ISRO is establishing a regional satellite navigation system called Indian Regional Navigation Satellite System (IRNSS). ISRO is also jointly working with Airport Authority of India (AAI) in establishing the GPS Aided Geo Augmented Navigation (GAGAN) system to meet Civil Aviation requirements. ISRO is already one of the leaders in Remote Sensing satellites. High resolution images received from these satellites are used for various sectors such as agriculture, land and water resources, forestry, environment, natural disasters, urban planning and infrastructure development, rural development, and forecasting of potential fishing zones.

Unmanned Aerial Vehicles [UAV] are complex systems engineered to substitute humans in missions deemed as dirty, dangerous or dull. Advancement in MEMS based low-cost sensor technologies has resulted in the availability of a range of Commercial Off-the-Shelf [COTS] Flight Control Systems [FCS] / Autopilot Systems. It lend them readily to integrate with model scale aircraft and in turn provide excellent platforms to UAV for application enthusiasts, researchers and operators. Due to the increase in UAV applications, the need to develop Collision Avoidance System is becoming a major area of research.

This paper is focused about finding an optimal solution for the collision avoidance of UAV in a busy airspace with both stationary and moving obstacles present in it, using Indian Navigation and Remote Sensing satellites. To achieve this, different algorithms were explored. Dijkstra's algorithm was implemented as a method to avoid stationary obstacles. Automatic Dependence Surveillance-Broadcast (ADS-B) technology and Kalmann filtering was studied for object tracking whereas Inverse Proportional-Navigation [PN] Guidance law was applied as a method to maneuver in collision conditions.

The whole system was simulated in Matlab under different scenarios, and results were found satisfactory.

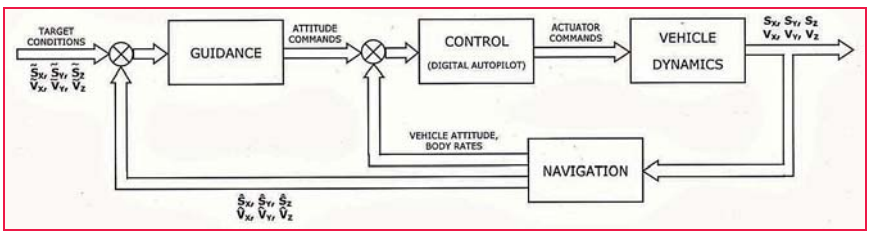


Figure 1: NGC system of an UAV

UAVs

An over-simplistic view of an Unmanned Aerial Vehicle (UAV) is that it is an aircraft with its aircrew removed and replaced by a computer system and a radio-link and is either controlled

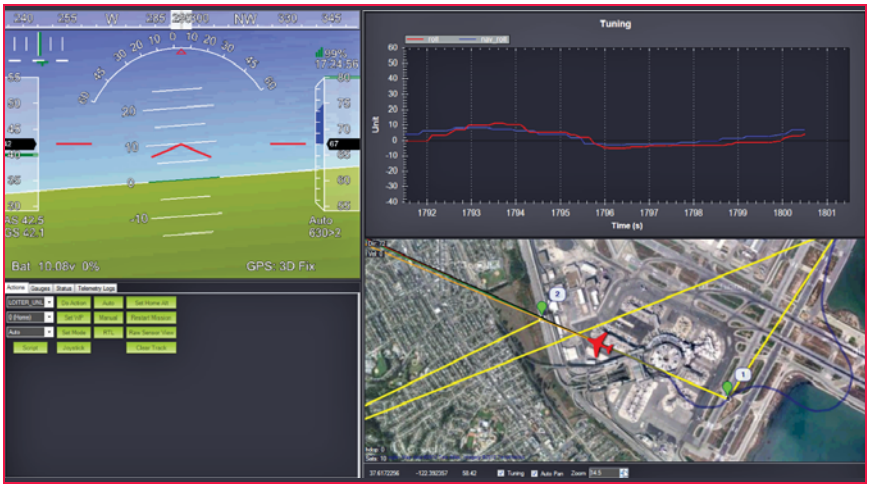


Figure 2: GUI for an Autopilot System

Figure 3: UAV and Post flight Analysis of the trajectory

autonomously by on-board computers, or with the help of a remote pilot.

Today, many different types of UAV are easily available in the market and are used for various applications ranging from defense and surveillance to food and grocery delivery, aerial photography etc.

Working of UAVs

Similar to different aircrafts, Navigation. Control and Guidance constitute the key blocks of UAV, but here the manual pilot is replaced by a Computer or technically a Digital Autopilot, which controls the vehicle. NGC system for a typical UAV is shown in figure 1.

The target points for the UAV is provided either before the flight or in the course of flight. These target points are called Way-points. Now the Guidance algorithm calculates the desired flight parameters i.e. Bearing, Altitude, Airspeed etc. for the aircraft to follow the Way-points in an optimal fashion. Navigation system provides the attitude parameters of the aircraft using different sensors (GPS, Accelerometer, Gyroscope, Magnetometer, Pitot-tube, Barometer etc.). Difference between desired flight parameters (calculated by Guidance algorithms) and input navigation data are fed to the Digital Autopilot for the corrective action. Output of the Digital Autopilot is fed to the Control Surfaces (Aileron, Elevator and Rudder) to make the correction in their actual flight parameters.

Flight and post flight analysis of UAV

The UAV is assembled with all the required navigational sensors, surface actuators and communication tool. If Auto Take Off function is not available for the UAV, then it is flown manually and after securely clearing the ground it is switched into Auto mode. The Autopilot interface shows all the attitude parameters of the UAV as well as the desired and actual path of the UAV. Control parameters of the Autopilot can be tuned offline before flight as well as real-time during the flight using the interface. It also records the attitude parameters for post flight analysis which plays an important roles especially in the case of any flight failure.

Figure 2 shows GUI for an Open-source autopilot system Ardupilot [1]. Figure 3 shows an UAV Slybird and its trajectory data obtained using Xigbee transmitters.

Why collision avoidance system for UAV's are required?

The need for Collision Avoidance Systems (CAS) has come about due to the increasing numbers of Unmanned Air Systems that are being operated now, as well as those that will be operated in the future. In order for commercial entities to be able to operate these vehicles, they must demonstrate a very high level of autonomy, as well as safety. Especially, where these aircraft will be operating in a commercial airspace environment, a greater deal of safety must be ensured.

The collision avoidance system

The proposed UAV Collision Avoidance System works in two steps:

Step1: Calculating the optimal path to reach the target avoiding stationary obstacles only.

Step2: Following the optimal path avoiding moving obstacles and once the obstacle is clear getting back to the optimal path.

Avoiding stationary obstacles

The GIS data derived from the Remote Sensing Satellite imagery is used to predict the stationary obstacles

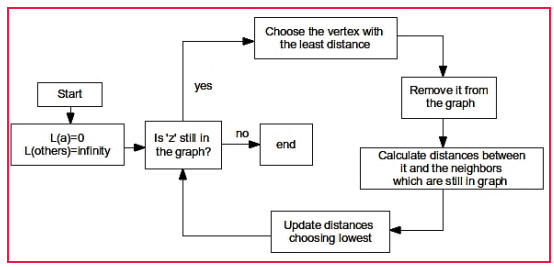


Figure 4: Dijkstra's Algorithm

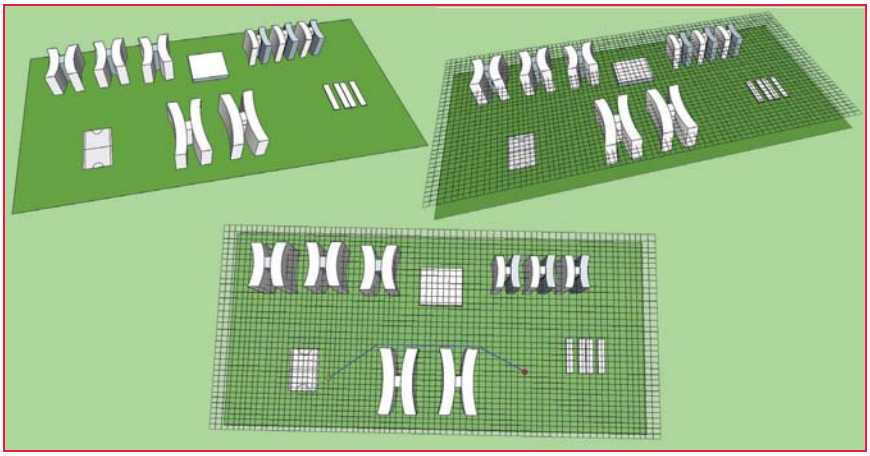


Figure 5: Calculating Optimal path for an UAV in presence of Stationary obstacles derived from GIS data of Remote sensing Satellites

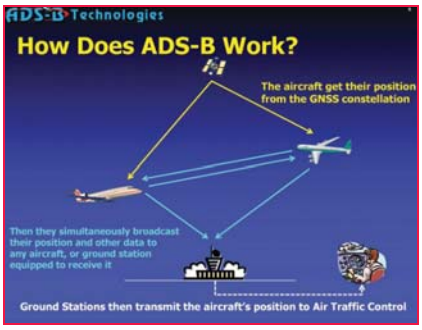


Figure 6: ADS-B technology

coming in the path of the UAV. The Data is used to create a 3D model.

Dijkstra's Algorithm is used to calculate the optimal path avoiding these stationary obstacles. Dijkstra's Algorithm solves the single-source shortest path problem for a graph with non-negative edge path costs, producing a shortest path tree.

If there are several nodes in a mesh with points marked as a, a1, a2……..z, where a is the initial point and z is the final point then Figure 4 shows the flow diagram of Dijkstra's algorithm to get the shortest path from a to z. Figure 5 shows the application of Dijkstra's algorithm to avoid stationary obstacles which are mapped using GIS data obtained from Remote Sensing Satellites.

Avoiding moving obstacles

To avoid the moving obstacle it is required to track them first. For the purpose following two methods are found suitable:

1) ADS-B technology:

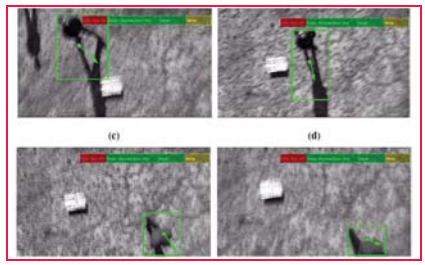


Figure 7: Object tracking using Kalmann Filtering method

2) Kalmann Filtering Method:

ADS-B technology [6] is a GNSS based system, where all the airborne flights transmit their own attitude parameters and receive the parameters of other flights in the given sensor range. Same data is received by the Ground station to monitor all the flights. Working of ADS-B technology is shown in figure 6.

In Kalmann Filtering method the Attitude parameters of the moving object is predicted using continuous still image camera feed [5] as shown in figure 7.

Modelling the airspace

To simulate the CAS, it is required to model the airspace. It is assumed that n number of aerial vehicles are flying in a given area with random velocity of V1, V2…..Vn.

If for an aerial vehicle initial position and final position are P_i and P_f respectively, then the heading angle as shown in Figure 8,

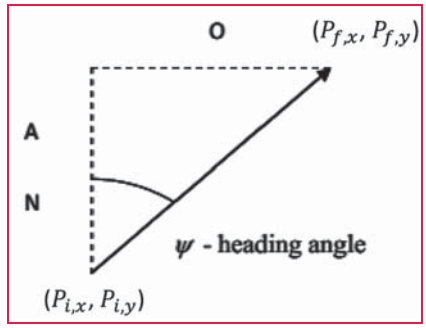


Figure 8: Heading angle for UAV

$$tan\psi = \frac{O}{A}$$

$$\psi = arctan\left(\frac{P_{f,x} - P_{i,x}}{P_{f,y} - P_{i,y}}\right)$$

For an aerial vehicle i, position at any time t,

$$U_i = \begin{bmatrix} x_i \\ y_i \end{bmatrix} + t \begin{bmatrix} V_i sin\psi_i \\ V_i cos\psi_i \end{bmatrix}$$

Distance of two objects at any given time't',

$$s(t) = |U_1(t) - U_2(t)|$$

$$or,\ s^2(t) = (P_0 - Q_0)^2 + 2t(P_0 - Q_0)(u - v) + t^2(u - v)^2$$

Where,

P_0 And Q_0 are the initial positions for the two objects

And, u and v are their velocity vectors

Solving the second derivative of the equation gives the time at which the distance between aircrafts will be minimum or Time of Closest Approach,

$$t_{CPA} = -\frac{([P_0] - [Q_0])([u] - [v])}{([u] - [v])^2}$$

Putting the value of t_{CPA} to distance equation gives the minimum distance of the two aerial vehicles, technically called as Zero Effort Miss (ZEM) distance. If this distance is less than the minimum safe distance between the vehicles, there is a probability of collision and collision avoidance maneuver is applied.

Collision avoidance maneuver

To avoid a probable collision inverse of Proportional-Navigation (PN) Guidance law is used. PN Guidance law is extensively used in Homing missiles to intercept the target. In Proportional-Navigation Guidance law [3] the missile is provided lateral acceleration such that

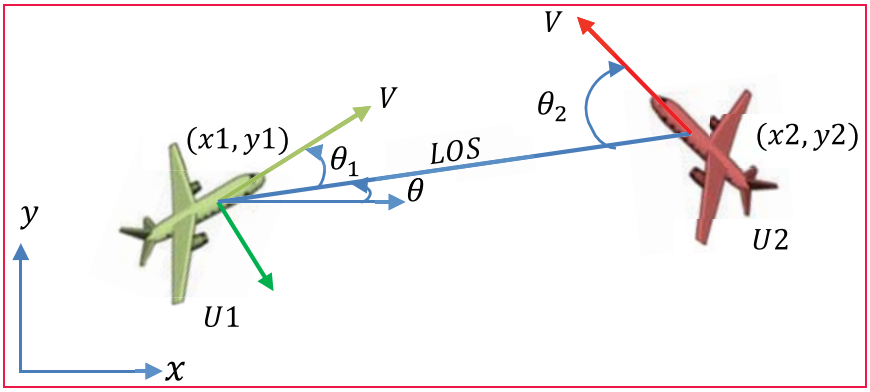


Figure 9: Collision Avoidance Maneuver

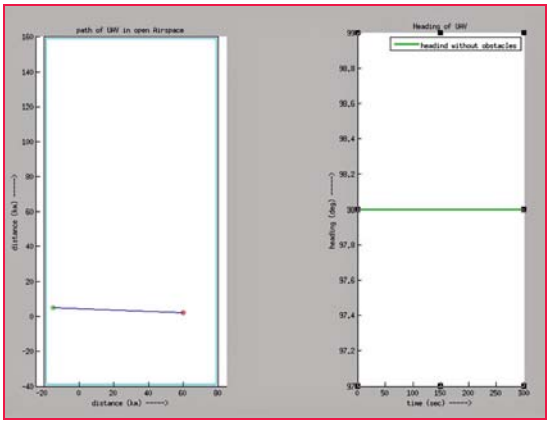


Figure 10: Trajectory and Heading angle of UAV when no Obstacles are present

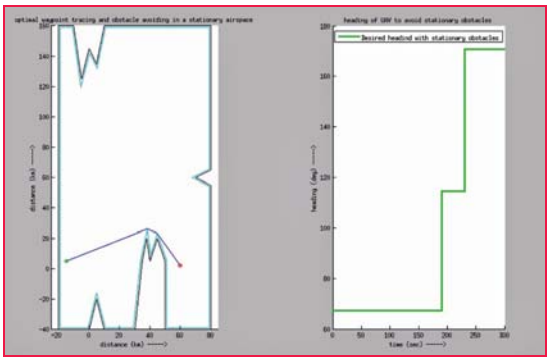


Figure 11: Trajectory and Heading angle of UAV when only stationary Obstacles are present

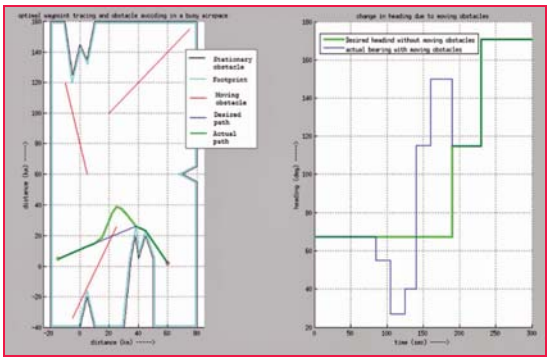


Figure 12: Trajectory and Heading angle of UAV when both stationary and moving Obstacles are present

the rate of rotation of Line Of Sight (LOS) is minimized.

As the purpose here is opposite to the Homing Missiles, i.e. here we want to avoid the probable collision the applied guidance law is inverse of the PN-Guidance law [4] i.e. here the lateral acceleration on the UAV is applied such that the rate of rotation of Line Of Sight (LOS) is increased.

For $\theta_2 > \theta_1$,
Rate of rotation of LOS,

$$\dot{\theta} = \frac{VSin\theta_2 - VSin\theta_1}{r}$$

So, increase the rate we have put a lateral acceleration on the UAV as shown in the figure. If $\theta_1 > \theta_2$ then the lateral acceleration will be applied to the opposite direction.

Results

The proposed system was simulated in Matlab for different scenarios. Figure 10 shows the result when no obstacles were present in the path of the UAV. In this condition, the UAV followed the optimum straight line path from start point to the target point.

Figure 11 shows the result in the condition when only stationary obstacles were present. In this condition the Guidance algorithm applies the Dijkstra's algorithm to calculate the optimal path avoiding the obstacles. Heading angle of the plane is changed accordingly to follow the calculated path.

Figure 12 shows the result in the condition when both stationary as well as moving type of obstacles were present. The guidance system first calculates the optimal path avoiding the stationary obstacles, and simultaneously continues with background execution of algorithm to predict any probable collision with moving obstacles. If any collision is detected the collision avoidance maneuver is applied with the help of PN-Guidance method. Once the obstacle is avoided, Dijkstra's algorithm provides the new optimum path to get to the target point.

The algorithm was simulated with different number of moving obstacles and types of stationary obstacles.

Future work

The algorithm can be integrated with the open-source autopilots like Ardu-pilot for real-time tests. To simulate the moving obstacle scenario different UAVs can be used. GNSS data can be used for tracking different UAVs and post flight trajectory data can be used to verify the algorithm.

References

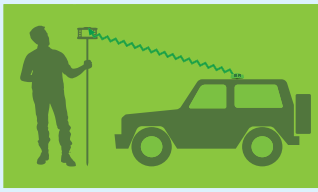
[1] APM Planner*: code.google.com/p/ardupilot-mega/wiki/Mission*
[2] DIY Drones : *http://diydrones.com/*
[3] Neil F. Plaumbo, Ross A. Blauwkamp and Justin M. Lloyd '*Basic Principles of Homing Guidance*'
[4] George J. and Ghose *D., 2009, 'A Reactive Inverse PN Algorithm for Collision Avoidance among Multiple Unmanned Aerial Vehicles', in 2009 American Control Conference, St.Louis, MO, USA, pp.3890-3895*
[5] Mathworks: *http://in.mathworks.com/*
[6] Automatic Dependent Surveillance – Broadcast (ADS-B) Out Based Ats Surveillance Services, Aai/Atm/Ais/09-09/2014

Virtual Roadshow

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

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

This is another innovation that saves you time.



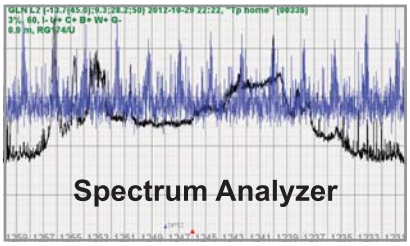
Make more **money** and have **fun** too >>>
Park, RTK, DPOS-It/Reverse-Shift-It

JAVAD
www.javad.com

Some Innovations and features that only we have

Verify, Monitor, record, present and defend your shots. TRIUMPH-LS has six different RTK engines and extensive automatic verification and notification systems to ensure that your shots are 100% reliable. Export results in PDF and HTML formats.

5 Hz BEAST MODE RTK resolves ambiguities up to 5 times faster. This is totally different from up to 100 Hz RTK that is done by extrapolating 1 Hz base data. In 5 Hz BEAST MODE RTK, base transmits correction data 5 times per second.



Interference in the GNSS spectrum exists in many places. Monitor and avoid it with the TRIUMPH-LS. It shows the magnitude and characteristics of the interfering signals and their effect on the GNSS signals.

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

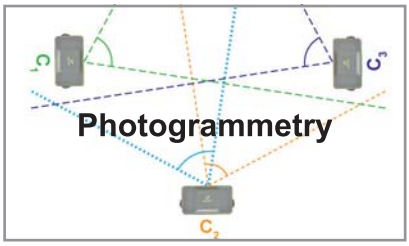
You don’t need to setup your base over a know point. Mount your base on top of your car; park it near your job site and perform RTK survey. Then DPOS-It or Reverse-Shift-it (fast localization on any known point) to correct the RTK points for base offset.

Don’t break out the Total Station! Complete the job with the TRIUMPH-LS only. The built in camera of the TRIUMPH-LS performs a variety of photogrammetry tasks. See the example of surveying a tall tower on www.javad.com

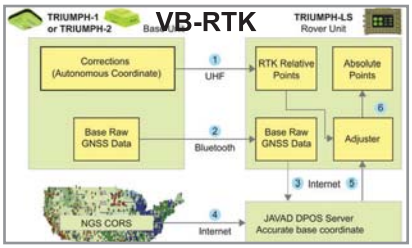
Highly rugged. Gorilla Tested, Surveyor Approved. Gorilla Test = 180 pounds of surveyor driving it into the pavement (Don’t Try This at Home!). Also, check out our concrete drop test on www.javad.com

Bottom camera shows Double Bubble on the screen and documents it. Also, you can use these physical bubbles to calibrate the built-in electronic tilt sensors. You don’t need to level the rod, tilt sensors and compass automatically compensate for tilts.

Don’t Look! Don’t Touch! Survey with Lift&Tilt. Survey starts with you lift the pole (within 5 degrees) and keep it steady for 3 seconds. Survey stops when you tilt it more than 15 degrees. Repeat the process and survey points quickly.



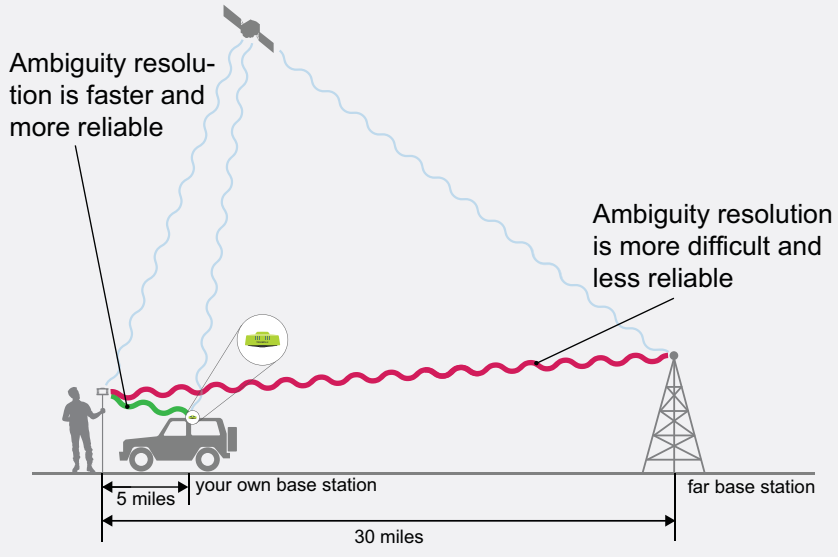
You can survey points that you or GNSS signals can’t reach. Camera Offset Survey (Photogrammetry in the box) with the internal forward facing camera of the TRIUMPH-LS.



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

TRIUMPH-LS has the most comprehensive worldwide Coordinate Systems, transformation and localization, including “time dependent” coordinate systems.

Advantages of your own base station and short baselines



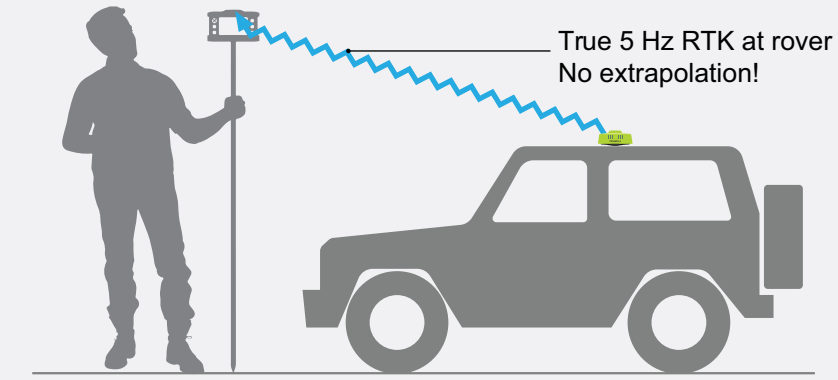
1. Shorter baselines provide significantly better **reliability** because the ambiguities are much easier to resolve and the correct ambiguity solution has an obvious contrast.

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

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

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

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



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

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

1 Equip your car

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

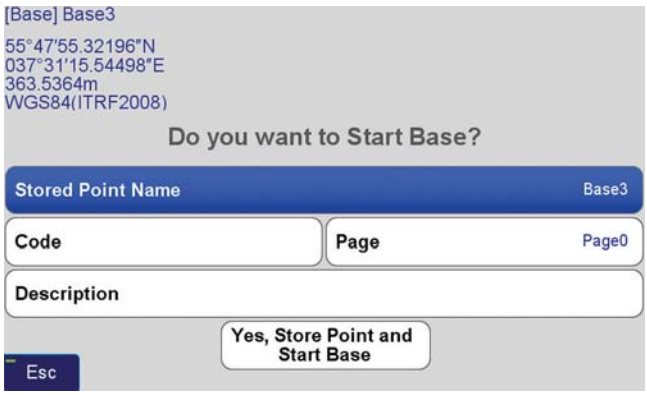
HPT401BT
1W UHF Radio

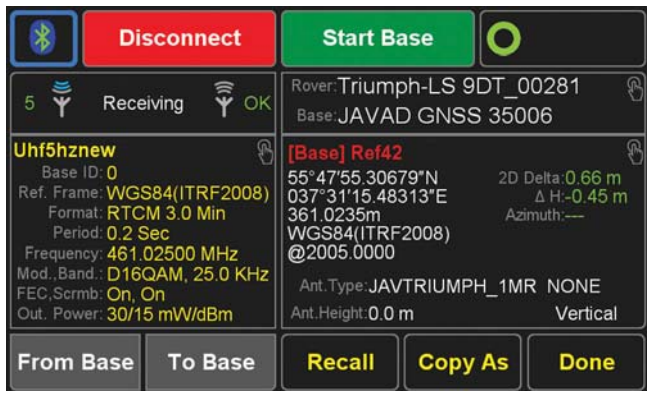
TRIUMPH-2
GPS+GLONASS
L1/L2

2 Park your car, Start Base

Park your car in an open area near your job site. It may be even in the middle of your site job. Engage all the brakes and ensure the car will not move. The Base/

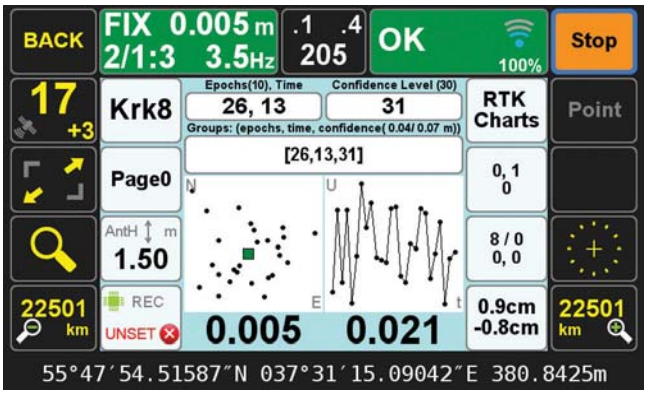
Rover Setup screen makes it easy to configure the base and rover with the same parameters.
Use "**Auto**" for the base coordinate. "Auto" will use an autonomous solution as the base coordinates which may be off by several meters (this will be corrected later). Then click **Start Base**.



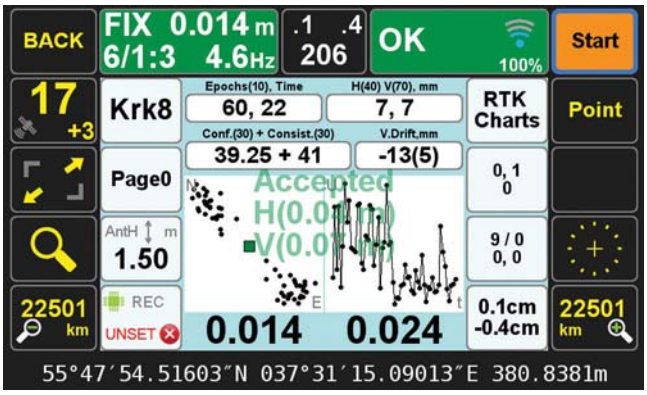


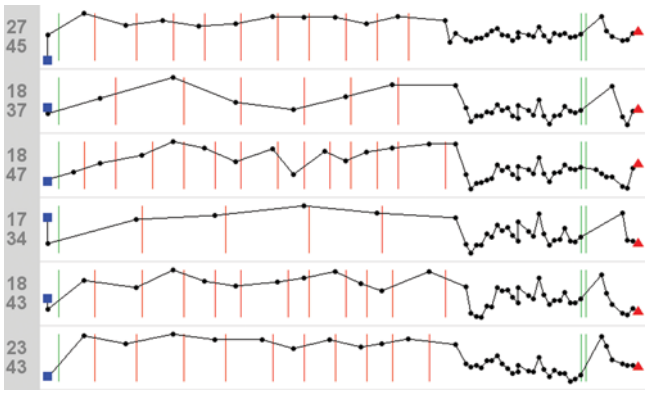
3 RTK Survey

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



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

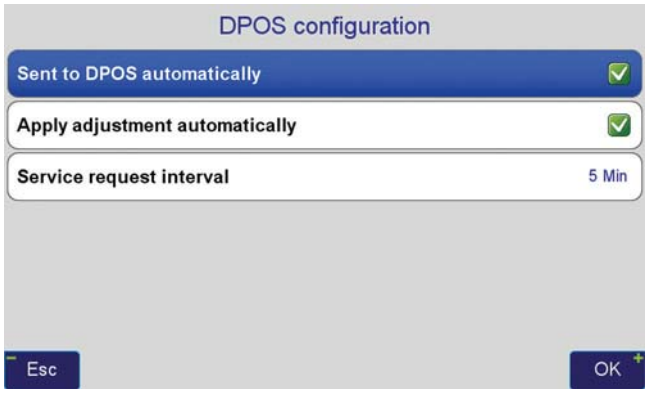


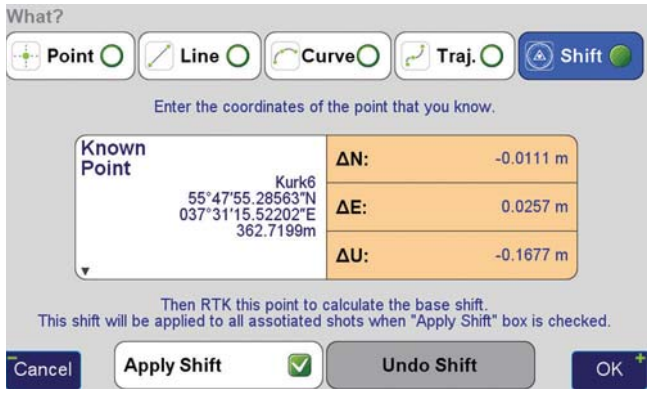


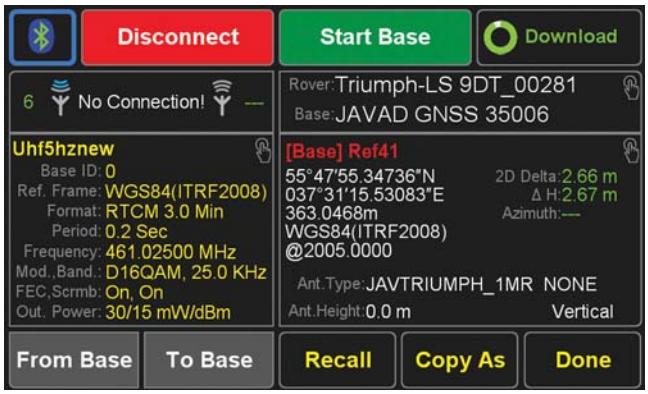
4 DPOS-it or Reverse-Shift-it

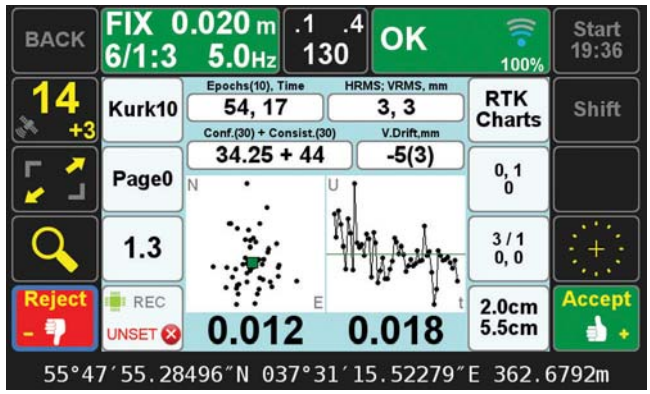
DPOS-it:
Press Stop Base and this will automatically **download** the raw GNSS base data to TRIUMPH-LS and send it to **DPOS** for processing with data from nearby CORS receivers. The TRIUMPH-LS then receives the **correct coordinates** of the base and **shifts** all the rover points accordingly. DPOS,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

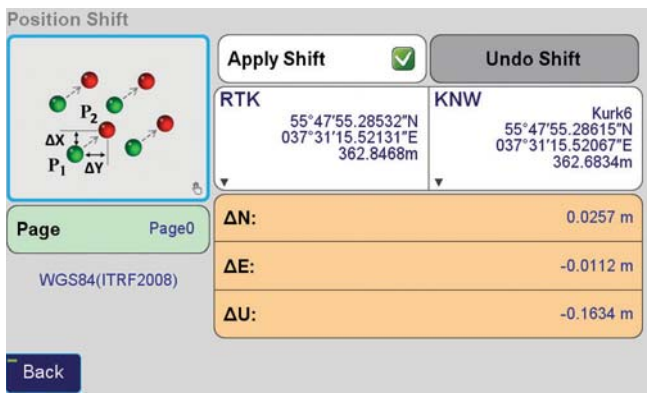
Reverse-Shift-it:
1) Take the TRIUMPH-LS to a **known point** and select the "**Shift**" function in the Setup Advanced screen. 2) Enter the **known coordinates** of that point. 3) Take a **shot** at that point and a base station shift will be **calculated and applied** to all previous and subsequent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











REVERSE SHIFT<<it

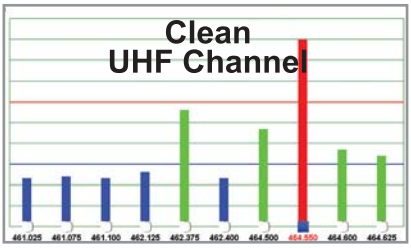
Setup your base anywhere you want. Put the rover on a known point and click reverse “SHIFT”. The base correction will be applied to all past and future points in that session. You can move your base and leap frog using any of the new points that you have surveyed.

the most advanced GNSS chip with 864 GNSS channels, 24 digital filters and 24 anti-jam filters to protect against out-of-band and in-band jammers. We calibrate GLONASS interchannel biases down to 0.2 mm.

RAMS

Remote Assistance & Monitoring Services

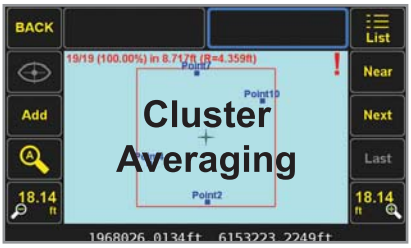
You can monitor and control the activities of your field crews from the comfort of your office via a PC, MAC or iOS/Android device. It is also a great tool for training and receiving support.



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

Six RTK engines plus one support engine provide robust RTK performance, even in challenging environments. The six RTK engines combined with their automatic reset and verification features guarantee that you will never get a wrong solution without notification.

TRIUMPH-LS is a fully integrated system, all antennas, radios, controller, high resolution sunlight readable display, over 20-hours of sealed internal batteries that make “hot swappable” and “removable” jargons outmoded concepts. 2.5 Kg (5.5 lb) including monopod.



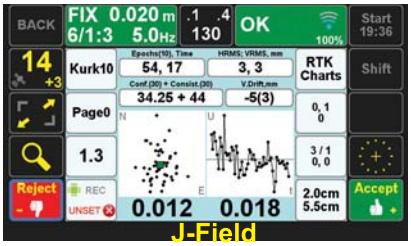
In some instances, you may have a legal requirement to repeat your shots. The TRIUMPH-LS makes this process easy. It finds clusters and averages them. You don’t need to make any attempt to manually tie shots together. The cluster margin is user defined.

DPOS

Data Processing Online Service

DPOS is our Data Processing Online Services. It is similar to OPUS but processes GLONASS and more of your observations if available from the nearest CORS sites. It also applies corrections to the base coordinate and all RTK solution as mentioned in VB-RTK.

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



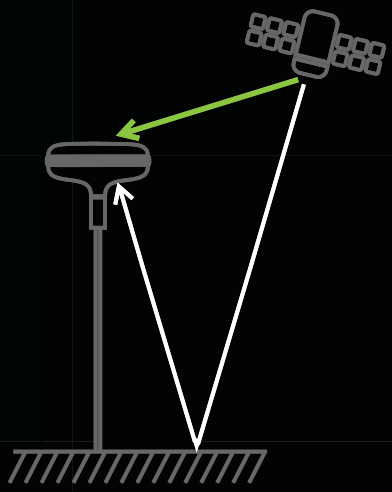
TRIUMPH-LS provides horizontal and vertical graphs of every epoch solution along with statistical data. This screen, along with the final solution screen and several other progress screens, can automatically be recorded with each point for documentation and protection.

TRIUMPH-LS has the most comprehensive COGO functions (grid, ground and geodetic surfaces) in easy to use graphic-assisted interface.

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

All these unique features at price of $12,990

MULTIPATH BUSTERS



Multipath appears like a **ghost signal** that degrades the accuracy of your shots. We **detect and bust** these ghosts by sophisticated signal processing techniques in our **TRIUMPH** chip. We also show the **signature** of these ghosts that we bust. Below are two screen shots from the TRIUMPH-LS.

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
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	--	--	--	--	--

In each column the relative amount of multipath ghosts that has been detected and busted from each signal **carrier phase** is shown (in millimeters). In the carrier phase it is up to a **quarter of a cycle** (wavelength).

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
BDU11	75↑	362	--	--	--	305
BDU12	36↓	288	--	--	--	200
GPS3	10	--	--	--	--	--
GPS29	3	--	--	--	--	--
GPS32	3	--	--	--	--	--
GLN7	3	--	--	--	--	--
GLN19	12	--	--	--	--	--

In each column the relative amount of multipath ghost that has been detected and busted from each signal **Code phase** (range) is shown (in centimeters). In the code phase it is approximately **several meters**.

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The education for cadastral surveying

The involvement of professional surveyors in the educational system of young surveyors is also necessary for them to present and promote the surveying as an attractive profession since it is highly specialized and regarded in society

Kazuaki Fujii
Japan Federation of Land and House Investigators' Associations,
Hyogo, Japan

In this paper, I would like to discuss the current situation of the working environment for young surveyors based on the contents of such reports (Reference Material 1).

Cadastral Survey, Administration and Educational Environment in Japan

Management and Administration of National Land Survey in Japan

The administrative authorities responsible for the national land in Japan are divided: Ministry of Land, Infrastructure, Transport and Tourism holds the jurisdiction over the land, while Ministry of Justice administers matters related to cadastral information used for the registration of title deeds. These ministries are separately handling the spatial information and not able to cooperate with each other as they are sectionalized in parallel (or, as Japanese people call it "vertically divided"), which is a distinct characteristic of Japanese bureaucracy (Figure 1). The cadastral survey conducted by the administrative agencies and local municipalities is wide ranged; national land survey pursuant to National Land Survey Act, cadastral investigation, land readjustment projects, agricultural land improvement projects, Real Estate Registration Law Article 14 map making projects, and so on. In such survey projects, mainly the boundaries of each land lot are surveyed and the area of that land is calculated. The administrative agencies plan a project, which is consigned through a bidding system by private survey enterprises having licensed surveyors who consider the scale and required manpower of the project, and the work is subcontracted to a private firm who wins the bid. With regard to the project of launching Geospatial Information Database, since the time it was completed, it has actually not been widely used until now. Much of the data cannot be accessed unless an application is submitted in compliance to the Law Concerning Access to Information Held by Administrative Organs. The Law of NSDI was also legislated, but in reality its effect is less extensive than we had anticipated. The level of understanding regarding NSDI in Japan is considerably different from that of the United States and Europe, and no education on spatial information is being provided to the working staff in the field at the moment.

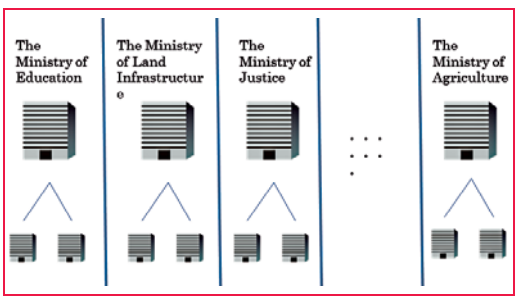

Figure 1: Communication between the Ministries in Japan

Types of Surveyors' Licenses in Japan

The licenses for cadastral survey professionals are designated for the target survey projects, and some licenses are certified by the jurisdictional ministerial agencies and others are certified by non-governmental organizations (Table 1).

There are also additional licenses that are highly specialized in certain fields. Such qualifications can help to evaluate the level of expertise and types of specialty of skilled professionals belonging to public agencies that order projects and survey enterprises that subcontract the projects requiring highly advanced survey skills.

Table 1: Types of Popular Survey Licenses in Japan

Certified	License Name	Jurisdiction
Government Certified	Land Surveyor	Geospatial Information Authority
	Land and House Investigator	Ministry of Justice
	Real Estate Appraiser	Ministry of Land Infrastructure, Transport, Tourism
NGO Certified	Land Readjustment professional	Japan Construction Training Center
	GIS expert	GIS Certification Association

The licensing can also indicate the size of survey enterprises.

The surveyor licenses listed in Table 1 may not be widely known in society, but even a single license holder is highly regarded in the governmental administration and in the market of land transactions.

Land Surveyor

Licensed surveyor who conducts basic survey and public survey carried out by national government, local municipalities, or public agencies. In Japan, each surveyor doing the work is required to be licensed, unlike the license system in foreign countries whereby the quality of cadastral survey results is guaranteed by a licensed firm. For this reason, the number of individual licensed surveyors in Japan is 30 times larger the other advanced nations. When establishing a private survey enterprise, a licensed surveyor needs to be registered as a regular employee of that enterprise (Survey Act).

Land and House Investigator

Specialist of cadastral survey and land parcels investigation. It is an exclusive qualification which authorizes the license holder to accept requests from general citizens for processing the division or merger of land lots (Land and House Investigator Law). The cadastral information of certain areas in Japan is a mixture of the survey results from old days and the latest cadastral information of modern days, and therefore, there was a need for specialists who are well versed in how to handle such information. The predecessors of this license were tax inspectors who conducted investigation on fixed property taxes.

Real Estate Appraiser

Specialized qualification for conducting appraisal or assessment of the price of a fixed property. Investigation on roadside land prices (to be a standard for determining land prices) can also be conducted with this license (Land Prices Public Announcement Law).

Land Readjustment Professional

Expert who readjusts the land in the project area, calculates the price and area for the land owner, and thus enhances the value of the fixed properties in the area (Land Readjustment Law).

Agricultural Land Improvement and Replotting Professional

Expert who readjusts agricultural land by improving and replotting the land for enhancing the productivity and promoting use of agricultural land (Land Improvement Law).

Compensation Management Chief Consultant

Expert who has the expertise for consulting on purchase of roadside land from the title deed owners and compensating for transfers of buildings in connection with road widening projects (Japan Compensation Consultant Association).

GIS Expert

Specialist who has made certain achievements in designing and management of geographic information systems (GIS Association of Japan). The certification system has been set up in reference to the recent qualification criteria of GIS engineers in the United States. Therefore, the license is granted on a point accreditation basis while giving emphasis to the professional achievements of the applicant in the fields of education, work career and contribution.

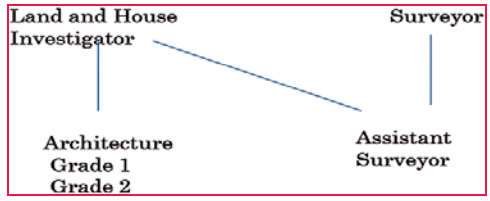

Figure 2: Upgrade License

How to acquire surveyor licenses in Japan

In Japan, specific licenses are required according to the types of survey project to be undertaken. The license system, however, allows assistant surveyor license holders to be exempted from the survey examination required of Land and House Investigators. (Figure 2)

Examination

A license is granted when passing the relevant examination that is held once a year. All examinations are given in Japanese; not available in any foreign languages. Preferential regulations are stipulated for a person who works for an administrative agency that has jurisdiction over such examination for over 10 years while engaging in certain type of work therein to be given the corresponding license.

School education

Students who have completed a specific curriculum provided by civil engineering or architectural department in designated universities or high schools may at times be granted a license. On the other hand, a survey technical school is designed for studying and acquiring knowledge and skills of land survey for a year or two and obtaining a professional license before being employed by a survey firm.

Students who want to acquire practical survey skills attend such a school as completing the curriculum equips them to acquire a license. The education provided therein, however, is simply basics of modern survey techniques due to the limited duration of schooling, so the graduates need to continue to study and learn even after their employment in a firm to be a highly skilled specialist.

Survey license system and surveyors in Japan

The relationship between the license system and actual work undertaken in the business scene is not arranged practically. Not every member of the administrative staff or surveyor working for private enterprises who is involved in the cadastral survey is carrying the relevant license. Especially, the staff engaging in investigation of boundaries with public land is not required to be licensed for such cadastral tasks, and therefore those officials who have never surveyed the land are doing the job.

Since the license system does not require any business experience before taking the examination, many of the license holders simply studied for passing the exam but have never experienced onsite survey work although they are licensed to do the work. For this reason, it can be said that the reliability of license is not really high since business experience is not a requisite for taking the examination. The examination's difficulty level is also said to be high, but the test problems are not mainly on practical knowledge or business processes, as, for example in the examination for Land and House Investigators, the test time is limited and quick judgment is required for passing it. Moreover, the examination topics are quite limited, excluding the recent geospatial information, cadastral principles, or the latest survey information such as GNSS, 3-D scanning, or UAV.

A report on an ideal survey administration in response to the new age of survey (Reference Material 2) comments on the current survey administrative system as follows: "For a while after the enactment of Survey Act, there were few survey

> There are some technical schools in Japan that provide education in surveying to high school graduates, but mainly geodesy is taught therein and the duration of schooling is only one year or two, so the students are given the license as assistant surveyor without acquiring knowledge and skills required of field surveyors

who had a certain level of academic ability could attend universities and higher educational institutions where high-level education was provided, so we could conclude that the survey professionals were equipped with sufficient knowledge." Looking back on the past 20 years, however, there have been a number of studies and researches on geospatial information published by FIG and other institutions, and it has been already 15 years since the announcement of international cadastral policies as typified by Cadastre 2014. Inside Japan, however, the cadastral licensing system today is almost the same as 15 years ago, and this fact only suggests that no meaningful changes have been practically made in this country.

The difficulty level of the examinations is not necessary high as the problems set out in the tests are not covering diverse fields, and thus the preparatory study does not need to go into widely different topics. For this reason, when the license holders begin to engage in field work, many of them are hardly useful for the task.

Some licenses restrict the holders' belonging to a certain company. When undertaking a relatively large project, a work group can be made up of professionals who are not familiar with one another, and thus it can be a very inefficient project.

Educational system for licensed surveyors in Japan

As mentioned earlier, in Japan, every one of the surveyors working onsite needs to be licensed, so the relevant license has to be acquired in the first place regardless of whether the person eventually becomes a professional surveyor or not. Therefore there are license holders who have never conducted onsite survey work. For this reason, survey training seminars are sometimes held or on-the-job training is likewise given to them by the agency or private company where they are employed despite the fact that they are already licensed surveyors. This situation is comparable to a licensed baker having his own bakery learning how to bake bread.

Not all enterprises or agencies that engage in survey work are equipped with a system or curriculum for educating their workers in-house. Since only major companies have established a training system for their own surveyors, such activity is supported by Japan Association of Surveyors or other organizations.

Having said the above, there are two steps in the licensing system: to acquire the license, and then to develop professional skills through taking trainings.

Exchange of cadastral information with associated countries

South Korea, Taiwan and Japan jointly hold survey technical conferences called International Cadastral Surveyor Conference (ICSC) once every two years on a rotational basis as a venue for exchanging practical business information on cadastre. The conferences provide opportunities to introduce

the survey techniques developed or information science studied in the field work and to promote the exchange among young surveyors.

In 2013, the Japanese network of young surveyors supported participation in South East Asia Survey Congress (SEASC) for expanding exchange opportunities with young professionals in Asian countries.

Young surveyors and survey education

Young surveyors and cadastral education

In the midst of such a current situation surrounding survey education, the meaning of the word "survey" is usually never taught in junior or high school unless students attend a civil engineering or architectural course. Unless a person has a parent or relative who is involved in surveying in the work, he will rarely get to know the profession of survey. The promotional activity by surveyors targeting young students is very limited though they may give a lecture on surveying in high school or university, but it is simply a general introduction, far from education in basics of the profession. In addition, there is no academic society that specializes in cadastre in Japan while such researches that are to be categorized as the field of cadastre are actually broken up and conducted separately under geography, sociology, public administration, civil engineering, architecture, information engineering, and so on, thus making up a structure whereby implementation of Land Administration (LA) is quite difficult in Japan.

There are some technical schools in Japan that provide education in surveying to high school graduates, but mainly geodesy is taught therein and the duration of schooling is only one year or two, so the students are given the license as assistant surveyor without acquiring knowledge and skills required of field surveyors. Therefore, as mentioned earlier, these young surveyors are not being trained as useful technical workers in onsite surveying although having certain field experience.

Figure 3: Cadastral Surveyors' Age Composition

Current CPD education system

Survey CPD system which is implemented mainly by Japan Association of Surveyors provides training sessions ranging widely from basic knowledge required of surveyors to more specialized surveying expertise. Point-based evaluation is given to each of the development fields, whereby a surveyor who is often attending various training seminars can achieve more points. Similar lectures or seminars are being held in different localities throughout Japan. As discussed earlier, surveyor is a license to carry out surveying work consigned by governmental agencies, local municipalities or public organizations, and in 2008 the CPD point system was launched for the project ordering body to consign the work according to the acquired points of license holders. As this system has been in operation for a short time yet, it is expected to expand in the future. In recent years, more seminars on surveying are held for students, and ID registration is proactively promoted in schools related to surveying, and such trend also is thought to be growing.

Structuring organizations for young surveyors

In such an environment in Japan where the population is declining and educational systems are not sufficiently organized, it is increasingly important for young surveyors to upgrade their surveying know-how through their own effort. Young technicians can maintain their value as experts by continuously acquiring higher techniques and skills. In our growing information-oriented society, organizations of young surveying professionals are being formed gradually by networking their educational environment through SNS or other media platforms. Among the variety of survey licenses in Japan as introduced in Section 2, the group that is taking the lead in networking young surveyors all over Japan is Land and House Investigators who specialize in cadastral survey. They have organized a network of young surveyors in Sapporo and Sendai from as far back as over 40 years. Also, as the information infrastructure such as the Internet has been developed further, licensed young surveyors have shared their thoughts and worries regarding the current educational environment by means of video messages using facebook, Google Hangout on Air, or similar platforms, and thereby the network of young professionals is rapidly and spontaneously growing at the moment.

There are two kinds of groups of young Land and House Investigators; one that originated from a mother association based in the local area and one that was formed

Table 2: Japanese young cadastral surveyor conferences and theme

Year	Held in	Agenda
2004	Kyoto	Cadastral system and Registration
2005	Tokyo	Cadastral Map (Tokyo, Sendai)
2006	Kyoto	Cadastral system and Registration
2007	Hokkaido	The future of cadastral surveyor
2008	Fukuoka	Alternative Dispute Resolution and Surveyor
2009	Hyogo	Addressing and Spatial Data Infrastructure
2010	Nagoya	Resisted Boundary and Cadastral Surveyor role
2011	Fukushima	Cadastral surveying and Disaster
2012	Hokkaido	FIG Young Surveyors Conference in Rome Report
2013	Osaka	Openstreetmap and Cadastral Surveyor
2014	Okayama	Next Innovation – Create Our Future
2015	Kumamoto	New Evolution

by young members who share the same purpose. As many of the young surveyors are more or less aware of and share similar problems, in their information exchange and close communication, they shared the local customs and example cases in their own area, and such information exchange developed the formation of their associations. Such associations also function as a forum where the young surveyors contemplate their role in the upcoming spatial information society from the standpoint of devising a new type of survey work required in the future and also fundamentally reforming the current cadastral survey system.

Transition of age composition of young surveyors association

Many surveyors are licensed in their 30's: they graduate from university where they study law, architecture, civil engineering or economics, and they join a survey enterprise wherein they continue their study for 3 or 4 years before they can finally pass the surveyor examination. Consequently, it usually takes about 10 years after graduating from university for them to become a licensed surveyor, and therefore there are few license holders under the upper limit age of 35 as qualified to join FIG Young Surveyors Network (Figure 3). At present, such associations are open only to those young surveyors who have already acquired a basic license, and there is no organization in operation for supporting young people who now begin their study to be a professional surveyor. Therefore the association network tends to be composed of members of higher ages.

This situation is not only an issue that the licensing system is facing today but also the general educational system in Japan which is not structured for the purpose of developing human resources useful for society from their teenage years. Therefore, the above situation will not be fundamentally changed or solved unless the Japanese educational structure is reformed entirely.

History of young surveyor conferences

It was 14 years ago that young surveyors began exchanging information using the mailing list about their concerns over the situation in the cadastral associations where the central representatives were busy organizing and steering the national organization's activities but not actively addressing the issue of the organization's aging population in a systematic manner. Initially, the conference was like a summit meeting for considering the future organizational management mainly through discussion, business information exchange and socializing. The keynote addresses are given by experts in Japan as invited by the executive committee in each area.

After the first conference held in 2004 in Kyoto (refer the table), it was subsequently held in Tokyo, Kyoto as the second, Hokkaido, Fukuoka, Hyogo, Nagoya, Fukushima, Hokkaido as the second, Osaka, Okayama, Kumamoto and Kanagawa in order, and then in 2016, it will be held in Kanagawa. The half of the past conferences were held in metropolitan cities and the other half in different prefectures. There are also efforts in launching Association of Young Land and House Investigators, which is under way to encompass the entire country of Japan. The significance of young surveyors' taking action with keen awareness of relevant issues and initiatives for improvement as well as their style of structuring a cooperative network of surveyors working in neighboring areas is well in harmony with the spirit of sustainability. There is no place for imposing anything on their spontaneity.

Association of young land and house investigators and great east Japan earthquake

In 2011, Japan suffered Great East Japan Earthquake that victimized thousands of lives. In the midst of that huge disaster, the nation-wide network of young surveyors who have been spontaneously gathered together as mentioned above fully utilized their own effective, emergency online network for exchanging vital information. They communicated what is needed by the disaster victims, what are the topographical features of the disaster area, etc. The onsite disaster victims first accessed their companions all over the country, who then took actions to check the whereabouts of these victims, realizing that it was the top priority.

Those surveyors who experienced the gigantic urban earthquake in Hyogo Prefecture back in 1995 took the lead in arranging emergency vehicles to travel to the Tohoku disaster area before anything else as they knew what is needed most in such a situation from their own experience wherein many lives were lost in that earthquake. The vehicles were secured only two days after the earthquake, and the procurement of water, food and fuel was organized in the south and it was relayed to the disaster area. Four days after the disaster, the supply was delivered to the earthquake site.

Before the earthquake struck, Young Surveyor Conference was planned to be hosted in Fukushima Prefecture that year, but in the wake of the disaster, discussion was held on whether to cancel the conference. The group of young surveyors in Fukushima area unified their efforts through their network, and as a result, the conference was held as planned.

Young surveyors network and issues of educational environment

Awareness for reformation, land administration policy and cadastral education

The decline in academic ability of students in Japan and the current environment of cadastral education system necessitate certain improvement measures to be taken against the national land management policy. The unique system of Japanese land administration has been maintained basically unchanged over 100 years due to modern history of Japan and the concept of possession with the will to occupy a land lot, a different concept from that of the Western nations. Because of the extremely complicated land administration that has been practiced according to local and others customs not specified in relevant laws, there are some experts who even insist that any reforms would not virtually change anything. As an age of multi-purpose cadastre and spatial information society is soon coming, the national land whose administrative information is kept and shared in the legacy system can be in a vulnerable situation against disasters due to its many flaws.

Proposals for cadastral education reform

The Law of NSDI is supposed to be featured more and more for the effective utilization of the national land, but is has been pointed out that the number of experts who can truly understand the significance of such policy is not large enough. The reducing number of students due to declining birthrate is one of the reasons why the educational institutions are not staffed with teachers who are familiar with information processing technology. This issue needs to be addressed with a combined approach of the integration of educational environments, improvement in vocational counseling in higher education and curriculum designed to draw out the potentials of each student's favorite field, and it is not enough for any one of these elements to be implemented singly to promote the reform but all of them need to interact with one another together.

The surveying education also needs to accommodate a vocational training system for those who want to shift their career to surveying. The study courses and examinations for almost all licenses are open to anyone, but there are limitations for the system whereby training seminars are open only to license holders. Changes have to be made for an extremely unclear structure whereby the work ordering side cannot evaluate the technical capability of survey enterprises or organizations.

The involvement of professional surveyors in the educational system of young surveyors is also necessary for them to present and promote the surveying as an attractive profession since it is highly specialized and regarded in society.

- Preparation of Japanese Surveyor 2.0 (To introduce the standard on what kind of surveyors are needed)
- Obligation of having field experience before a license is granted
- Information sharing with higher education, vocational training or other systems, and liberalization of participation, organizing workshops facilitated by experts
- Formulation of survey education guidelines and systemization of educational levels
- Coordination and liberalization of common basic education environment with foreign countries and cadastral principles
- Improvement of language skills and lexicography of survey related terms
- Structuring and assessment of online educational environment such as e-Learning systems
- Fund management system for supporting studies of young surveyors

It is clear that in order to realize the above measures it is necessary to comprehensively improve the current curriculums of universities and survey technical schools, CPD subjects and operations for experts, and OJT by survey enterprises. To do this, the "vertically divided administrative system" needs to be reformed so as to improve and promote communication and cooperation between the ministries. In the future the international exchange among surveyors in Japan and other counties will be activated, and such information exchange will enable the restructuring of Japanese cadastral environment and the formation of an educational environment beyond the national boundaries. This means we need to look to and learn from cadastral advanced countries while we also try to be useful for other counties where we can, thus creating opportunities for next generation young surveyors to make contributions. It will be a course of wisdom for us to realize and acknowledge that the barriers of international cooperation among young surveyors coming from different countries are lower than aged surveyors may imagine.

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This is an updated paper presented at FIG Congress, Kuala Lumpur, 2014

Roles of geomatic engineers after great earthquake

In this article, it is briefly described the suggestion of immediate survey and future activities of geomatic engineering to meet the immediate and future developments needs of Nepal

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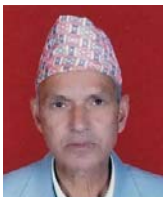

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A strong earthquake (7.8 RS) hit Nepal in 11.55 am Saturday, April 25, 2015 with epicenter in an area near Barpak village, Gorkha district, which followed by many powerful aftershocks, and new earthquake (6.7 RS) on Sunday, April 26, 2015 with epicenter in an area near border of Dolakha and Sindhupalchok districts. It causes extensive damage to buildings and other infrastructures, over 9000 death of people and over 5000 injured. It was felt in India, Tibet, Bangladesh and Pakistan.

Many old villages, historical monuments, and temples ruined, road ruptured and avalanches, landslides or stone falling triggered by earthquake. It was extensive damaged in 16 hill districts including of Kathmandu valley and need to plan and rebuild new towns.

Survey Department Nepal studied the situation of control points around Kathmandu Valley found to move southwest direction 0.99-1.82m in plannimetric position and 0.63- 1.158m increase in height.

Post earthquake precise leveling survey was also conducted after in 1988 in Nepal and some works on minimization of movement of heritage sites were also conducted in the past. Indonesia, Haiti, Japan and China conducted surveying works after recent great earth quakes. Places like Kathmandu valley may be studied better by LiDAR survey and carry out appropriate actions for conservation of heritage sites.

Engineering works need precise ground control points (cm accuracy in plannimetric and fraction of mm in height) to orient and check the quality of work and future deformation measurement of major constructions as well as need of precise BMs for irrigation, hydropower or tunneling work.

Therefore, it is required to check precisely the position of control points at least first and second order control points (trig point, BM and gravimetric point) with GNSS, precise leveling and gravimetric observations. Similarly maps are required to revise new situation on ground and relay the parcels of earthquake effected village blocks.

In this article, it is briefly described the suggestion of immediate survey and future activities of geomatic engineering to meet the immediate and future developments needs of Nepal.

Background

Himalaya was formed due to collision of India plates to Eurasion plates. Indian plate is moving at the rate of 2.0 cm/year as north east direction and Himalaya is rising at the rate of 1cm / year as observed during crustal movement studies/ relevelling. The pressure is built up on collision plates, i.e. about 20 km below the main central thrust (MCT), the boundary line of Himalayan and high mountain regions. The great earthquake occurs every 80-110 years in Nepal to release the built up pressure. Minor earthquakes occur different periods. It will cause the minor movement of land mass few centimetres to few metres.

Many people observed the cracks of up to 0.5 meter size along the road and up lift and sinking of ground few meters are also observed.

Weaker structures will collapse or fall down and loss of lives due to damages of structures. Most of the time, rock fall, dry land slides and avalanche are also triggered in the hill side and Himalaya respectively.

The ground control points (trigonometrical points and bench marks) of known latitude, longitude and heights are determined in cm to mm accuracy. They are also subjected to shift the position with the movement of land masses. In Nepal, Trigonometrical points are established at 5 km interval and height points (bench marks) are established along the road at 2 km interval.

The topographical maps are prepared showing all natural and manmade features like road, canal, building and natural features includes land slide, forest, prominent tree, land form, water bodies. The scale of map in general is 1:25,000 /and 1:50,000 and town and development areas have 1:5,000 or larger scale maps which have better than 2-1 metre positional accuracy. The cadastral map of rural area is at the scale 1: 2,500 and urban areas are at the scale of 1:500. Generally, the movement is relative and is physically measurable at major fault areas.

The origin of survey is based on the fundamental station. The land mass is moving continuously and during the earthquakes, land slips abruptly. Nagarkot, Mahadev Pokhari station of Kathmandu valley, is the fundamental station of Nepal, which is the origin of latitude, longitude, height and gravimetric observations. It is fairly locked on Indian plate or has minor change with Indian points, points of Nepal south of main Boundary Fault (MBF), i.e. points of terai, hill and upper mountain are moving with Nagarkot in normal time. The seculars or annual change on measurement is adjusted based on the position or position of Nagarkot.

Definition of terms

Great earthquake

An Earthquake is the perceptible shaking of the surface of the earth which can be violent enough to destroy major building and other structure and kill the thousands of people and animals.

The magnitude of earthquake is measured in Richer scale (RS). If the magnitude of earth quick is more then 8 RS then it is called great earthquake.

Movement of control point

The movement of control points is the steady and slow motion of a portion of the earth area with relation to each other due to the movement of plate underneath. The abrupt motion of the control points along with ground by earthquakes is called the movement of control points in plannimetric and elevation.

GNSS

The 'global navigation satellite system' (GNSS) refers to a constellation of satellites providing signals from space transmitting positioning and timing data. By definition, a GNSS provides global coverage. GNSS receivers determine location by using the timing and positioning data encoded in the signals from space. The USA's NAVSTAR Global Positioning System (GPS) and Russia's Global'naya Navigatsionnaya Sputnikovaya Sistema (GLONASS) are examples of GNSS. The Galileo of EU, QZS of Japan and Beidou(Compass) of China systems are new systems under operational.

Table 1: Swift of Position of trig points in Eastern Nepal

Name of Station	Lat	Log	dx	dy	ds
Chitretham	27.02006	86.61661	0.001	0.308	0.308
Dhaje	26.8658	87.39478	-0.277	0.307	0.413
Dimba	27.46508	86.36609	-0.002	-0.308	0.308
Hatiyal Danda	27.43475	85.59712	0.268	-0.619	0.674
Laore Danda	27.37215	86.92243	0.000	0.000	0.000
Malangawa	26.85931	85.56981	6.639	1.156	6.739*
Sandakhu	27.10327	88.00063	-14.326	0.502	14.335*
Siranchok Danda	28.08372	84.60306	0.273	-0.005	0.273

* New Satellite station

Table 2: Local Movements of control points at TIA

Point No	Easting	Northing	Elevation*	de	dn	dH
GP03	633149.397	3062731.045	1259.816	-0.286	-1.622	1.288
GP02	633736.054	3065466.860	1282.637	-0.298	-1.544	1.272
GRV	633914.414	3065053.147	1285.067	-0.305	-1.634	1.306
GP14	633384.417	3064441.683	1262.144	-0.272	-1.500	1.162
GP04	633536.904	3065852.215	1281.788	-0.284	-1.587	1.284
GP12	633378.216	3063514.602	1264.534	-0.260	-1.593	1.304
GP10	634025.560	3064723.433	1282.458	-0.271	-1.638	1.354
GP09	634437.738	3064926.318	1287.816	-0.297	-1.666	1.405
GP08	634419.974	3065724.201	1289.630	-0.299	-1.535	1.237
GP07	634660.843	3066148.329	1290.522	-0.283	-1.646	1.307
GP13	633647.027	3064358.870	1276.016	-0.279	-1.657	1.342

Effect of earthquakes on survey data

The trigonometrical points are observed and determined ±5 - 25cm accuracy in latitude and longitude and Bench marks (BM) are observed to determine height better than 1mm accuracy.

After 2045 BS (1988) magnitude 6.9 earthquake in eastern Nepal with epicenter at Udayapur district, the level lines were re-observed in that sector. The different in altitudes were observed and found that they moved irregularly.

During the Eastern Nepal Mapping project1992-96 some of the first order points were re-observed and the different of coordinates from 1982-84 fist order

observation to 1992 Topographical Mapping Survey in dx and dy are found as following table 1 which shows that variation were irregular and up to 67 cm.

The local movements of control points at Tribhuvan International Airport(TIA) are shown as Table 2.

The researchers of Dr. Roger Bilham, Ms. Rebecca Bendick and Mr. Frederick Blume of Colorado University and staffs of Geodetic Survey Branch re-observed the trigonometrical network from Namche to Saptari which was observed in 1948 -52 by Ms. Gulatee in to observe the height of Mt. Everest in Nepal. Regarding to seismic movement of BMs during 1934 great earthquake, they observed that " Repeated leveling revealed that some of them had sunk at least 1m during the event though this would not have change the scale."…

"It is likely that the points in the terai were approximately 1-4m more northward than the surveyors believed,".. (Page 12, Report on Collaborative Geodetic investigations in Nepal, March1991- 1996),

In 26th June 2015, the magnitude 7.8 Earthquake struck Nepal and neighbouring countries and Survey Department re-observed some 5 stations and issued the following press statement on the movement of the points:

"The position of Nagarkot is moved 1.82 m south west direction and ellipsoidal height increased by 1.158m, Phulchoki is moved o.92 m south west direction and ellipsoidal height increased by 1.063m. Similarly, positions of Bungmati, Swambhu, and Kumari moved south west by 0.99m, 1.64m and 1.71m and ellipsoidal height increased by 0.77, 0.98m 1.093 m respectively."

The earth quake affected area map (No.1) was prepared by USGS which is shown as Figure 1.

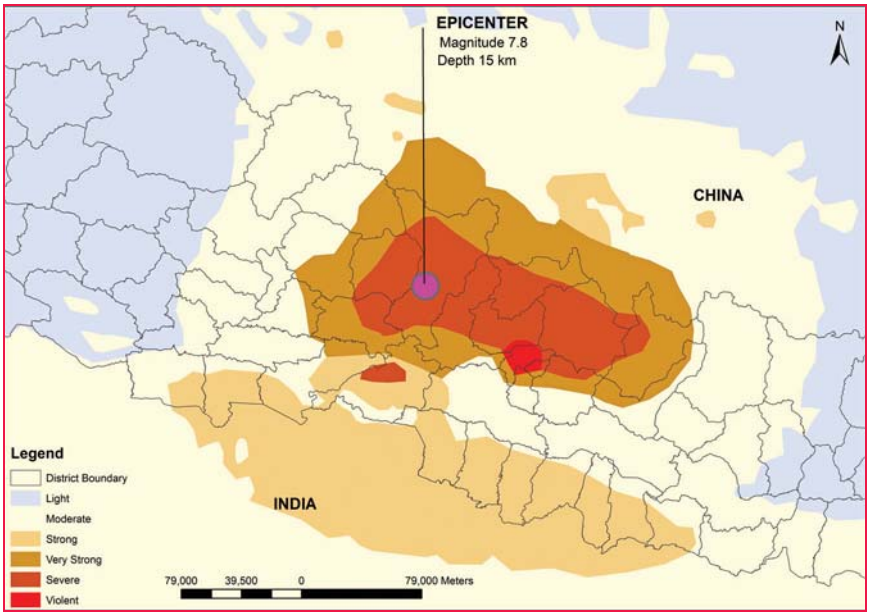

Figure 1: Map No.1: Earth quake Affected Area Map

Figure 2: Ortho photo Before Earthquake Satellite Imagery After Earthquake

During the earth quakes of many building are collapsed and some are tilted. They are all cleared for new construction. People are still leaving tents and temporary houses. New construction will starts after end of rainy season. The comparative situation of Tripureswar, Kathmandu town area is shown on the orthophoto map and satellite imagery of the area as Figure 2.

This shows that there are substantial change details of maps. The situation is worse in the maps of Kabhre, Sindhupalchok, Dolakha and other districts. The damaged buildings which are still standing are also unhabitable, required to remove and need to reconstruct.

The map (No.2) of the aftershocks of earth quakes 2015 in Nepal is shown National Seismological Center map shown in Figure 3. The topographical maps of strong, very strong and severely shacked areas (reddish area) of Map No. 1 need to revise for planning.

The cadastral maps are unaffected as the movement is relative and relative distances of parcel are same, as before except in areas of large cracks on land surface and MBT, MCT.

Monitoring and checking of control points

The engineering works and topographical mapping of large infrastructures need to base on accurate ground control points to check the quality of work i.e. calculate closing error, origin of x, y and height and orientation of survey work i.e. azimuth (bearing) of survey work with coordinates relative accuracy of 5-10 cm and height better than ±7mm.

Therefore, Geodetic Branch, Survey department required to check or re-observe the situation of all first and Second order control points and assess the situation of other control points. The revision of observations of control points will be carried out as per the finding of above observation.

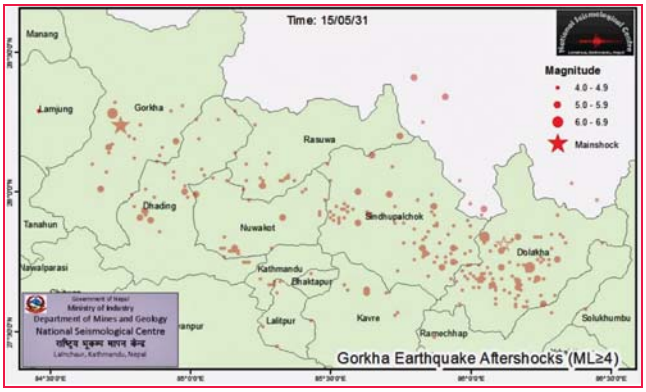

Figure 3: Map (No.2): Aftershocks of Earth quakes 2015

The heights of BMs very strongly shaken area must be revised by relevelling and accordingly data corrected and supplied to users.

Other problems

At 11h 56m on 25 April 2015, a 7.8 RS magnitude earthquake struck Nepal and surrounding nations. Shaking from the earth quake triggered an avalanche from Pumori into the base camp on Mount Everest at after noon. Twenty-two people were killed, surpassing an avalanche that occurred the previous year as the deadliest disaster on the mountain.

After the second earthquake on 12 May 2015, president of the Expedition Operators' Association of Nepal, abandoned climbing on that season which resulted that no one climbed Mount Everest in the spring of 2015, the first time in 41 years that this has happened.

Similarly, Langtang village was completely covered by avalanche and large number of people died including foreign tourists.

Many major roads were disrupted by major landslides and the main roads to Tibet from Kathmandu are recently operational. People also died by crashing the vehicles by falling rocks after earthquake or aftershocks.

Future actions

As described above, it is required to re-observe the control points (trig point and BMs) of severely and very strongly shaken areas in the coming seasons and assess the situation of them and accordingly all the first order/ second order control points and BMs required re-observing. The third order points may be decided either for re-observation, recalculation or maintenance.

All topographical maps are due for revisions of plannimetric features by 15 years. The severely and very strongly shaken areas maps are needed to revise in the coming seasons and publish digitally. Other maps need revision periodically. Government may use private sector for revision.

The development programmes are delayed by 1-2 years due to unavailability of large scale (high resolution) maps, which will increasing project cost 10-20% i.e. billions of rupees every year.

It is required to new digital mapping at the 0.5-2m resolution of the whole country to accelerate the infrastructure development of the country. LIDAR survey may be used for valleys and terai areas to cater the need of development and as well as detect movement of after the great earthquakes.

New settlements and infrastructures are required to plan, construct, and reconstruct and repair in severely affected areas. Lack of fund, land pooling method - the process of planning, development and redistribution of the assigned area, can be used for the development of land in the resettlement area. It evolves large scale topographical mapping, engineering design, cost estimation, land valuation, superimposition of cadastral data and returning the developed plots to the land owners.

Conclusion

The monitoring after earthquakes was carried out in the past for scientific studies. Presently high resolution maps and data are used for infrastructure development; meet the spatial data needs of municipalities and quality control of survey data. It is also required to plan new cities by land pooling process including earthquake damage areas. Therefore it is urgent to evaluate the existing control points.

National mapping organization should also plan to revise survey maps and data regularly as well as programme to create high resolution (0.25- 1m) topographical mapping of the whole country using LiDAR, digital photogrammetric and remote sensing techniques.

It shows that there are vital roles of geomatic engineers from monitoring, evaluating the movement of control points and creation of spatial database for the planning, managing, and reconstruction of development activities after earthquake.

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In Coordinates

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DEFENCE

"Security concerns about maps are at times overplayed"

says Lt Gen Ranjit Singh, SM, Engineer-in-chief and Senior Col Comdt, the Corps of Engineers, Indian Army while discussing the importance and role of geo-spatial technologies in defence

My own perception is that the security concerns are at times over played. Many countries do have the digital maps of their adversaries. In addition, one can get very sensitive information from many other sources. Google earth is one such example. It was not long ago when taking a photograph at airports was prohibited in India. Such rules are silly and ridiculous.

HIS COORDINATES

"India should have its own positioning satellite system"

says K Ramalingam, Chairman, Airports Authority of India (AAI) while discussing the mandate and activities of AAI related to GPS

One fear will be always if US withdraws the GPS signal due some reason, the GAGAN system will collapse. So I feel that India should have its own positioning satellite system like GPS.

GNSS

Advances in GPS/GNSS data processing

Till the year 2015 there will be a constant and radical change in the existing GNSS data processing techniques

SRIDEVI JADE

From now till the year 2015 there will be a constant and radical change in the existing GNSS data processing techniques though the underlying principles will not change much. As a user , one needs to keep abreast with all the latest developments in this field as the current processing software's will be adopting to the new satellite signals, new satellite systems , different reference frames and real time availability of the data and the products

GNSS

An open GNSS receiver platform architecture

The aim of the project is to develop a platform for supporting GNSS research and provide an accessible IP block

PETER MUMFORD, KEVIN PARKINSON AND FRANK ENGEL

Galileo update

Soyuz ST-B booster sends two more Galileo satellites to orbit

European Launch Service Provider *Arianespace* launched two more Galileo navigational satellites (known as "Andriana" and "Liene") on Dec 17, 2015. The firm used a Soyuz ST-B booster to lift the FM08 and FM09 satellites off the launch pad located at the Spaceport in Kourou, French Guiana, at 6:51 a.m. EST (11:51 GMT). *www.spaceflightinsider.com*

Galileo location service to start next year – ESA

ESA director general Jan Woerner announced that the Galileo location service would be able to start next year under its new configuration. Another fourteen satellites are currently in construction or will be so soon in the clean rooms of German company OHB-System, which is producing 22 satellites for the 30-satellite constellation. *www.telecompaper.com*

U.S., Norwegian Paths to Encrypted Galileo Service Open in 2016

The successful Dec. 17 launch of two Galileo positioning, navigation and timing satellites makes it all but certain that the Galileo network will offer initial services by late 2016, including the encrypted, government-only Public Regulated Service (PRS), to which the United States and Norway have requested access.

Both governments have submitted formal requests for PRS access to the European Commission, the executive arm of the 28-nation European Union. The U.S. and Norwegian requests have remained dead letters at the commission not because they are controversial, but because sorting out access to PRS even among the 28 EU nations has been complicated.

EU officials have been grappling with what are called Common Minimum Standards that set rules on PRS access for national government agencies and PRS hardware manufacturers, with a view of ensuring the encrypted signal is not compromised.

The diversity of EU nations' security precautions is wide enough that the commission, with the approval of EU governments, has reserved the right to conduct inspections of agencies and companies working with PRS to verify compliance. Each nation using PRS will create a specialized agency responsible for its use.

The sensitivity of the subject is high enough that the EU has decided not to publish the Common Minimum Standards supporting documents — including technical details on required security measures and PRS distribution — in the EU's Official Journal. The standards were nonetheless approved in November.

The next step on the road to granting U.S. and Norwegian access is for the EU's highest decision-making body, the European Council, to give the commission marching orders for opening negotiations with U.S. and Norwegian authorities. *http://spacenews.com*

UAE signs an MoU with China for cooperation in space science

The UAE has signed a memorandum of understanding with the People's Republic of China concerning defining a framework for collaboration in studies and development in space science, as well as the peaceful exploration of outer space. The signing came during the visit of His Highness Sheikh Mohammed bin Zayed Al Nahyan, Crown Prince of Abu Dhabi and Deputy Supreme Commander of the Armed Forces, to China. The visit aimed at exploring collaboration opportunities in various sectors, including energy, space, financial services, commerce, transportation and education. *https://www.zawya.com*

Russia Reduces Reliance on Foreign Satellite Data

Russia has significantly reduced its dependency on foreign remote sensing satellites, Russia's space agency Roscosmos said.

"A significant reduction has been noted in the use of foreign Earth remote sensing satellites, which is linked to the provision of similar data by Russian space devices," the agency said in a statement.

The United Geographically-Distributed Information System (UGDIS) has also been completed, according to the press release. The system will ensure the distribution Russian satellite data to all those who require access. An Arctic remote sensing center will also be opened in Russia's northern port of Murmansk jointly with the emergency services ministry, Roscosmos said. *http://sputniknews.com*

DigitalGlobe select Raytheon

Raytheon Company has been selected by DigitalGlobe, Inc., to develop the capability to support a September 2016 launch and mission planning of DigitalGlobe's WorldView-4 satellite. Raytheon's Constellation Scheduling System (CSS) is the commercial geospatial mission planning system for companies who want cost and resource efficiencies through automation while

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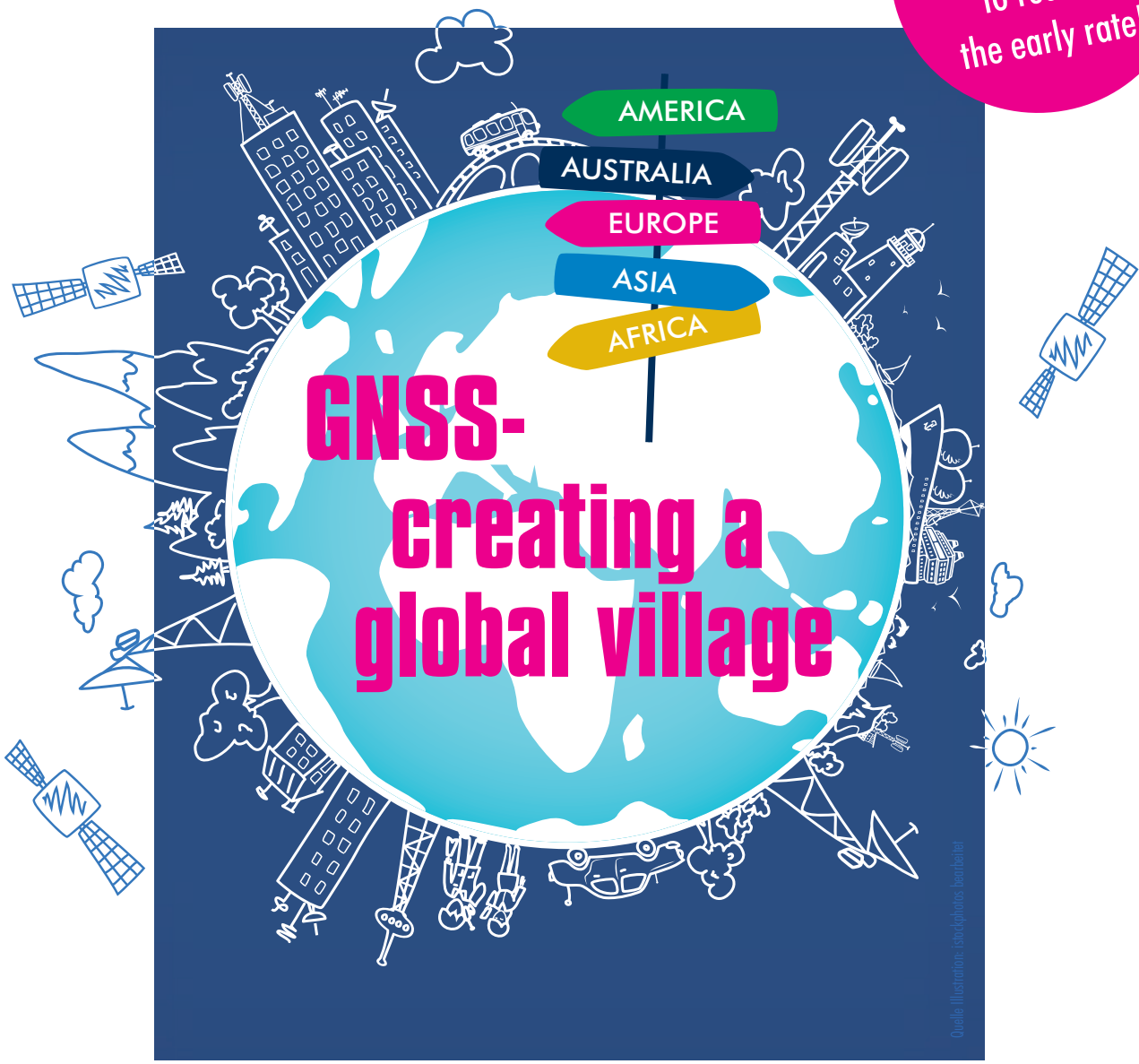

GNSS- creating a global village

Munich, March 1–3, 2016

MUNICH SATELLITE NAVIGATION SUMMIT 2016

www.munich-satellite-navigation-summit.org

increasing satellite utilization and imagery yield. The new competitively-awarded contract to prepare the ground station for WorldView-4 is part of the first phase in the development of DigitalGlobe's next generation ground system, Platform 20/20.

ISRO launches RS satellites for agricultural purposes

Union Minister of State for Space, India Jitendra Singh on 9 December informed the Lok Sabha that Indian Space Research Organisation (ISRO) has launched Remote Sensing Satellites in thematic series - Resourcesat, Cartosat and Radar Imaging Satellite (RISAT-1). The images acquired by these satellites, in conjunction with field observations, are used for various applications in the area of agriculture development, which includes mapping and monitoring of agricultural crops and its condition, crop acreage estimation and production forecast, crop phenology and growth; site suitability for crops, cropping system analysis, watershed monitoring and management, command area management and drought assessment.

He added that Space observatory ASTROSAT, recently launched by ISRO, carried five payloads to study the stars and galaxies in ultraviolet, optical and X-ray wavelength bands. *http://www.catchnews.com*

Google and FAO partnership

Google Maps and FAO have agreed to work closely together to make geospatial tracking and mapping products more accessible, providing a high-technology assist to countries tackling climate change and much greater capacity to experts developing forest and land-use policies.

The three-year partnership between Google Maps and FAO is designed to foster innovation and expertise and sharply broaden access to easy-to-use digital tools. It ushers in a major ramping up of existing collaboration between the two organizations and will boost the visibility and implementation of efforts to encourage sustainable environmental practices around the world. *www.agprofessional.com*

Topcon and Agisoft collaboration

Topcon Positioning Group is partnering with digital photogrammetric solution provider **Agisoft LLC,** in a collaboration set to expand the Topcon solutions portfolio for mass data collection across its many brands and extensive product range. Of particular interest to the two organisations is the growing trend of using Unmanned Aerial Systems (UAS) for photogrammetry.

Russian based Agisoft is renowned for specialising in the processing of digital imagery in order to generate high-accuracy 3D spatial data using photogrammetric and computer vision techniques, and has been developing imaging solutions for nearly 10 years. *www.spatialsource.com.au*

FAA approve CNN for drone flights

The Federal Aviation Administration (FAA) has approved an application from CNN to fly drones. The approval is to use drones "to conduct aerial photography, aerial videography, and closed-set motion picture and television filming." In doing so, it waived requirements for FAA approval of drone flights that are operated outside restricted airspace and below 200 feet.

The FAA has approved more than 2,500 drone flights in the process of developing regulations for allowing a rapid expansion of the use of the devices in the U.S.

The agency has faced tremendous pressure to approve an expansion of nonmilitary drone use from companies such as Amazon, which has said the technology can be used to make speedier online deliveries. *http://thehill.com*

Next Evolution in Drone Technology by UAV-America

UAV-America has launched a new long-duration flight time UAV. The Eagle XF is capable of up to one-hour flight times with a payload of five pounds, leading the pack in the evolution of drone technology. It also boasts features such as:

Molded carbon fiber frame with minimal parts and hardware Fast packing time (less than one minute); packs to small, transportable size Flexible platform capabilities that allow change-out of sensor pods, gimbals and more with quick-disconnect technology. *www.uavamerica.com/eagle.html.*

ATS tells government to ban unapproved drones

Taking note of the fact that no approvals are obtained for the use of most UAVs in the Indian state, Goa police's anti-terrorist squad (ATS) has recommended that the government ban the use of drones for civil purposes. The squad has written a letter to both district collectors requesting them to issue an order to the effect under Section 144 of the Criminal Procedure Code (CrPC).

The squad has reiterated that the formulation of regulations and subsequent law enforcement would play a significant role in monitoring UAV usage by anti-social elements, better enabling the police to thwart any activity that could endanger life and property.

In the event of an individual deciding to sell or buy a UAV, the ATS has suggested that the same be intimated to the authorities well in advance and the registration process adhered to. It has also recommended that owners furnish details of their respective drones, complete with purpose of usage, to the controlling body and that the devices be inspected by technical experts. *http://timesofindia.indiatimes.com*

Drones for postal delivery in Malaysia

Malaysia wants to explore the potential of unmanned aerial vehicle (UAV),

or drones, for the postal and parcel delivery industry. At a recent discussion between Malaysian Communications and Multimedia Commission (MCMC) and the Association of Malaysian Express Carriers, it was concluded that drones can deliver a maximum load of one kilogram, to a distance of 10 kilometers. MCMC's digital ecosystem chief Datuk Mohd Ali Hanafiah Mohd Yunus said, "MCMC as the monitoring agency is prepared to bring the relevant agencies including the Civil Aviation Department to study the use of drones in postal and parcel delivery."

Japanese NPO launches crowdfunding campaign for mapping by drones

Japanese non-profit organization (NPO) Crisis Mappers Japan has started a crowdfunding campaign on Japan's crowdfunding website ReadyFor for a project called Drone Bird, which aims to reflect the damaged states after disasters to maps rapidly and accurately utilizing drones. The team is led by Aoyama Gakuin University Department of Global Studies and Collaboration Professor Taichi Furuhashi, who is well-known as an expert on GIS. Drone Bird was selected out of 139 application entries for a project-collecting campaign on the ReadyFor crowdfunding site last year.

Crisis Mappers Japan has been engaged in activities of mapping the damaged state on OpenStreetMap based on satellite photographs when natural disasters occur, for the purpose of making use as lifesaving or supporting activities. Previously, the first problem of its method was that it takes more than two days to complete mapping although immediacy of information is strongly required upon disasters. Therefore, the team started to form the plan of Drone Bird, which is to arrange state-of-the-art drones and their operators in ten places around Japan in order to collect image data of the damaged state rapidly. The plan aims at aerial photography and publicizing the information acquired within two hours from the time of a disaster occurs anywhere in Japan. *http://thebridge.jp*

Ford in talks with Google to build self-driving cars

Google is said to be in talks with automaker Ford Motor Co (F.N) to help build the Internet search company's autonomous cars, Automotive News reported, citing a person with knowledge of the project.

Earlier this year, Google began discussions with most of the world's top automakers and assembled a team of traditional and nontraditional suppliers to speed efforts to bring self-driving cars to the market by 2020.

In June, Google began testing tiny, bubble-shaped self-driving prototype vehicles of its own design on public roads around Mountain View. The company has also started testing self-driving prototypes in Austin. *http://www.reuters.com*

Kcell launches new location service

Kazakhstan mobile operator Kcell has introduced its new 'Where Is The Child?' location service. The service, based on LBS, enables users to locate their children using their handset. The service, accessible across the country, also enables users to follow the route of their child and to check the route history. *www.telecompaper.com*

Toyota to display new map generation system

To aid the safe implementation of automated driving, Toyota is developing a high-precision map generation system that will use data from on-board cameras and GPS devices installed in production vehicles.

Toyota's new system uses camera-equipped production vehicles to gather road images and vehicle positional information. This information is sent to data centers, where it is automatically pieced together, corrected and updated to generate high precision road maps that cover a wide area.

An understanding of road layouts and traffic rules (including speed limits and various road signs) is essential for the successful implementation of automated driving technologies. Additionally, high precision measurement of positional information requires the collection of information on dividing lines, curbs, and other road characteristics. *http://pressroom.toyota.com*

Flipkart minority stake in MapmyIndia

India's largest ecommerce marketplace Flipkart has picked up a minority stake in CE Info Systems Pvt. Ltd, which owns digital mapping business MapmyIndia as it looks to boost its supply chain. *http://articles.economictimes.indiatimes.com*

Skyworks launches BDS/GPS/GNSS low-noise amplifiers

Skyworks Solutions Inc of Woburn, MA, USA has launched two new low-noise amplifiers (LNAs) for GNSS. Each device integrates all output matching components, and hence requires only a single external input matching component. The LNAs use surface-mount technology in the form of quad flat no-lead (QFN) packaging, allowing for highly manufacturable and low-cost solutions. The SKY65605-21 and SKY65611-21 are both designed for BeiDou/GPS/GLONASS/Galileo receiver applications and are optimized to operate at 1559-1606MHz. *www.skyworksinc.com*

Antenova adds compact GPS and GNSS receiver modules

The two modules are similar, both measuring 9.0 x 9.0 x 1.8mm, with low current consumption, making them suitable for smaller portable devices, such as smart watches, navigation devices, OBD II modules, asset tracking, personal safety, sports cameras and equipment. They are based on MediaTek's processor.

There are two part numbers. The M10578-A2 module operates with GPS, with a 1-5 Hz update rate, and the M10578-A3 operates with GPS, GLONASS, BEIDOU and Gallileo with an update rate of 1-10 Hz.

India launches National Centre of Geo-Informatics

India's Union Minister for Communications and IT, Ravi Shankar Prasad, has recently announced the launch of National Centre of Geo-Informatics. It will be one of its kind GIS platform for sharing and collaborating GIS data source and location-based analytics that will aid central and state governments in planning, decision-making and electronic delivery of services. *http://articles.economictimes.indiatimes.com/*

US$1.5b by WB for India's Universal Sanitation Initiatives

The World Bank has approved a US$1.5 billion loan for the Swachh Bharat Mission (SBM) Support Operation Project to support the Government of India in its efforts to ensure all citizens in rural areas have access to improved sanitation – such as a toilet or latrine with a focus on changing behaviors – in ending the practice of open defecation by 2019.

Specifically, this project will support the rural component, known as SBM – Gramin (SBM-G), over a five-year period using a new performance-based program which links funds directly to results, ensuring that benefits are delivered to the people in need – more than 60 percent of India's rural population.

The SBM-G program focuses on ensuring usage of toilets along with their construction. States and their implementing agencies will be given incentives for meeting performance standards. Performance will be measured against the states' ability to reduce open defecation, sustaining their open defecation free (ODF) status and improving solid and liquid waste management in rural areas. The financing mechanism promotes the leadership of the states, which will have flexibility in innovating and adopting their own delivery models. *www.worldbank.org*

India to track illegal mining with satellites

The government has finalised its plans to track illegal mining in the country using space technology and satellite imagery in partnership with Indian Space Research Organisation (ISRO). This entails states to utilise remote sensing technology to take satellite images of their mines and update them on a regular basis every 15-30 days that will help authorities in ascertaining the extent of mining operations and check illegal extraction of minerals. *http://articles.economictimes.indiatimes.com*

UN and Singapore agree to develop information management tool for peacekeeping operations

The United Nations and the Government of Singapore have signed a MOU to collaborate on the development of an information management tool in support of UN peacekeeping operations that can aid in enhancing situational awareness, trend analysis and early warning capacities in field missions. Under the MOU, Singapore will partner with the UN Department of Peacekeeping Operations (DPKO) and the Department of Field Support to co-develop an information management tool that will add GIS capabilities to existing situational awareness tools. *http://www.un.org*

China tightens control of online maps

In rules released recently, China's State Council announced that all digital maps provided in China be stored on servers within its borders. The rules will also lay out certification standards for digital mapping providers. According to China's state-run Xinhua news agency, the purpose of the new regulations is to "boost development of the geographic information industry" and safeguard "national sovereignty and geographic information security."

The rules seem much heavier on tightening control than on boosting development. In addition to the server location requirements, map providers are prohibited both from displaying or even storing any data deemed to be prohibited by the government. Government officials will be able to regularly inspect data for "errors and leaks of information that threaten national sovereignty," according to Xinhua.

The move is arguably redundant—China has long held mapping services to strict content standards, and blocks those that don't comply.

This includes Google Maps, which has been officially blocked for users in China since 2010, when Google refused to submit to Chinese government censorship. Google has since made moderate concessions in its representation of Chinese borders on maps accessed from outside of the country, changing the names of disputed regions. There has been frequent speculation about when (or if) Google Maps will return in China. The current rule change would seem to make that harder, particularly since it includes a system of fines and penalties—and even potential criminal prosecution—for violations. *http://fortune.com*

Road Mapping Through Satellites in India

Central Road Research Institute (CRRI) has developed several technologies/procedures/methods for construction and maintenance of Indian roads such as cold mix & warm mix technologies for bituminous roads, use of waste plastic, design & specifications for construction and maintenance of roads & bridges, procedures for road safety measures, etc. National Highway Authority of India (NHAI) has initiated steps for use of space technology for preparation of detailed project reports, monitoring of construction and road asset management. NHAI proposes signing MOU with Indian Space Research Organisation (ISRO) & North East Centre for Technology Application and Research (NECTAR) for use of space technology in aforesaid areas. *www.business-standard.com*

Bluesky Partners with FATMAP to Create Interactive 3D Ski Maps

Aerial mapping company Bluesky is working with FATMAP to create ultra-high resolution 3D mobile maps of the world's major ski resorts and other popular outdoor pursuit destinations. It recently completed a pilot project for FATMAP, capturing aerial photography and generating detailed height models in order to create a highly detailed 3D map of the Big Sky Ski Resort in Montana, USA. *www.bluesky-world.com*

Contract awarded to Israeli defense firms by Pentagon

The Pentagon awarded US defense corporation Raytheon and Israel Military Industries with a contract to develop and manufacture GPS-guided mortar shells. The 120-mm. mortar shells will be long-range, precision- guided projectiles.

The guided version of the shell offers "operational flexibility" and "excellent accuracy in striking the target," while "enlarging the existing assistance for these mortars, even in especially difficult weather conditions." *www.jpost.com*

NCA trials e-navigation

The Norwegian Coastal Administration (NCA) has initiated the first full-scale trial of e-navigation technology in Norwegian waters in conjunction with Navtor and ferry operator Fjord Line.

The NCA is using Navtor's NavStation digital chart table to digitally share routing information with Fjord Line's Stavangerfjord, which sails between Norway and Denmark.

First launched in 2014, NavStation gathers all of the information navigators need into a single interface, including weather data, tidal information, digital publications, and other services such as passage planning and route monitoring. This enables the NCA and the ship's crew to seamlessly share accurate and real-time information, enhancing maritime safety, efficiency and control. Routes can then be approved or adjusted instantaneously. *www.cruiseandferry.net*

China builds ground service center for satnav system

A ground data center that will support China's independent satellite navigation system was recently given a go-ahead to offer LBS. Located in central China's Henan Province, the center features 63 data stations that are able to increase the resolution of images downloaded from the Beidou Navigation Satellite System from ten meters to mere millimeters.

"From chips, receivers to servers, all of the center's components are 'Made-in-China,' which makes it the first independent data system under total control of our country. It's of crucial significance to our country's infrastructure and information security," said Beidou expert Li Guangyun. With myriad functions that include satellite navigation, precision time synchronization and speed measuring, the center's services will first be applied in traffic, water resources, agriculture and police affairs, with a project to monitor the province's freeway network soon to go live. *http://news.xinhuanet.com/english/*

Beidou performing well after tests

The three satellites launched this year for China's indigenous satellite navigation system are sending twice as many signals as their predecessors, said the system's designer, after completing tests on the new units.

The 18th and 19th satellites for the Beidou Navigation Satellite System (BDS) were sent into space on July 26, and the 20th on Sept. 30.

While they are less than half the weight of earlier generations, the new satellites' output is greater, matching the best around the world, said the China Academy of Space Technology in its latest newsletter.

After tests of their orbits and key technology, they are working as intended and in all weather, according to the academy. *http://news.xinhuanet.com/english/*

Russian Defense Ministry Conducts Final GLONASS Tests

Russia's GLONASS satellite navigation system has been handed to the Defense Ministry for final tests, the chief executive of the system's developing company said.

"We presented the system to the customer for final tests currently underway," Russian Space Systems (RSS) Director General Andrei Tyulin told. He said tests resumed on Saturday after the company remedied problems previously identified by the ministry. *http://sputniknews.com*

Satnav chip set deal between Russia and China

Russia and China will soon finalize an agreement to establish two joint ventures to develop, manufacture and sell new satellite navigation devices that receive signals from three major navigation systems, the head of Russia's GLONASS Union said.

The Bei-Dou-GLONASS-GPS device will operate under the "BG-Star" brand on Russian and Chinese markets, with plans to expand further. One of the ventures is expected to develop the chip set at Russia's Skolkovo Innovation Center, the other based in China and involved in manufacturing and sales. *http://sputniknews.com*

Trimble Adds Kenai Tablet to its Portfolio

Trimble has introduced the Kenai™ rugged tablet computer, an all-in-one computing solution that can transport a user's office to the field, forest, desert, manufacturing floor or boardroom. Trimble brings durability, reliability and feature-rich design to the Kenai tablet's versatile configuration making it a powerful mobile computing solution for transportation, public safety, field service, forestry, utilities, mapping, insurance and other outdoor or service-related applications. The Kenai tablet features a 10.1 inch capacitive multi-touch screen with WUXGA display technology to provide superior readability in virtually any extreme environment such as heavy rain or the brightest outdoor conditions without compromising performance or efficiencies. *www.trimble.com/mobile*

Leica Geosystems buys Indonesian distribution company

Leica Geosystems has purchase of assets from PT Almega Geosystems, the company which has been representing Leica in Indonesia for the past 15 years. The new company has been rebranded as PT Leica Geosystems Indonesia, and will strengthen the presence of Leica Geosystems in the Asia Pacific region. Located in northeast Jakarta, the new company will provide the Indonesian market with measurement technology solutions. *http://news.xinhuanet.com*

Northrop will bid if Pentagon opens GPS satellite tender

Northrop Grumman Corp said it would bid if the U.S. Air Force opens a fresh competition for next-generation GPS satellites next year, as expected, and perhaps later on a new ground control system.

Tom Vice, president of Northrop's Aerospace Systems division, said he expects the Air Force to launch a competition for new GPS satellites, and Northrop was ready to participate. It already builds satellites for the U.S. intelligence community and is building the powerful new James Webb telescope for NASA.

Air Force officials have said they expect to start early work in 2016 on a competition for a next batch of GPS satellites, followed by a formal request for proposals in 2018.

Lockheed Martin Corp is under contract to build the first eight GPS III satellites, and the Air Force has options for two more. *http://news.yahoo.com/*

Septentrio PolaRx5 – 14/12/2015 receiver

Septentrio has launched a GNSS receiver for precise scientific and geodetic applications: the PolaRx5. It supports applications for the Earth science community, offering a range of advanced features which enable maximum accuracy and functionality. It offers 544 hardware channels for robust and high-quality GNSS tracking. The receiver supports all major satellite signals including QZSS and IRSS.

Northrop Grumman to replace U.S. Navy's INS

The U.S. Navy has awarded Northrop Grumman a contract to replace the inertial navigation system used on most of the Navy's combat and support ships.

The contract is valued at $19.8 million with a total potential value of $47.8 million over five years if all options are exercised. The inertial navigation system, also known as INS-R, supports the new Navy Assured Positioning Navigation and Timing architecture currently in development by the Navy. The new system will increase navigation accuracy. *http://www.upi.com/*

Fugro awarded PGS positioning contract

Fugro has been awarded a three-year contract by PGS for the provision of precise satellite positioning systems for its entire seismic vessel fleet.

Fugro, a provider of precise satellite positioning to the offshore oil and gas industry, will supply PGS vessels with a number of completely independent GNSS. These systems include Fugro's recently launched Starfix.G4 - the

first commercial GNSS service to utilize all available GNSS systems, giving sub-decimeter accuracy - and Starfix.G2+, a global service offering centimeter accuracy in both position and height. *http://www.oedigital.com*

New Beijing Airport Extends Trimble Integrated Construction Contract

Trimble has announced that it has received a contract extension to use the company's technology from Trimble to integrate construction and operations for the high-profile Beijing New Airport Project, expected to be the world's largest when completed at an estimated cost of $13.1 billion.

Trimble won the initial bid to supply the project with a construction information management system. Based on the success of the solution to date, the contract has been extended to include additional machine control systems for soil stabilization.

Beijing's new airport, scheduled to open in late 2018, is projected to handle approximately 72 million travelers, 2 million tons of shipping and 620,000 flights by the year 2025.

KCS Releases Low-Cost Track/ Trace GNSS+ Module

KCS BV has extended its TraceME product line with a low-budget track-and-trace module based on the company's LoRa technology. The TM-900/N1C1 module is the latest development in KCS's TraceME GPS track-and-trace product line. The product is targeted for tracking and tracing a variety of objects, including livestock, and for personal use. The full version module comes equipped with various technologies for to achieve traceability (e.g., GPS/GLONASS, LoRa, Bluetooth LE, ANT/ANT+, and proprietary RF), which can all be combined depending on the application. Compared to traditional track-and-trace modules, the TM-900/N1C1 omits GPRS/ SMS, thereby eliminating traditional national telecom operational costs.

Esri's ArcGIS to Support SAP HANA®

SAP SE recently announced that through a global technology partnership, Esri will commercially support ArcGIS using SAP HANA® as an enterprise geodatabase. This release of ArcGIS, planned for 2016, expands the existing native integration with SAP HANA and allow customers to run all their SAP® Business Suite and ArcGIS applications within an architecture based on SAP HANA. The companies will further enhance the SAP HANA platform by more deeply integrating advanced ArcGIS geospatial capabilities and content across SAP's broader application portfolio. The collaboration between SAP and Esri is expected to harness the power of combining two market-leading platforms, providing the ability to run both GIS workloads and advanced spatial analytics on a single SAP HANA geodatabase. SAP and Esri have been technology partners for a number of years, providing integration of their respective platforms, SAP HANA and Esri ArcGIS.

DAT/EM Systems International Releases 7.2

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

LightSquared settle GPS Spectrum Lawsuit

LightSquared and Deere & Co. have settled a long-running legal fight over whether the wireless venture's GPS network interfered with global receivers made by the farm-equipment manufacturer.

In 2013, Phil Falcone 's Harbinger Capital, the hedge fund which then controlled LightSquared, sued Deere and two other GPS companies---Garrmin Ltd. and Trimble Navigation Ltd. - along with industry groups in federal court claiming their equipment interfered with the LightSquared network.

Under its deal with Deere, LightSquared has agreed to forgo a portion of its spectrum nearest to the GPS signal and instead will use frequencies that are further away from the GPS signal. In return, Deere said it won't object to LightSquared's deployment of its wireless broadband network.

The settlement with Garmin, which comes on the heels of LightSquared's recent settlements with Deere & Co. and Trimble Navigation Ltd., marks the end of a number of disputes between LightSquared and GPS equipment makers over the use of spectrum for ground-based wireless broadband services. The company last week also withdrew its lawsuit against the U.S. government for allowing GPS equipment makers to use spectrum owned by LightSquared. *www.wsj.com/*

Alternative GPS ground system by U.S. Air Force

The U.S. Air Force will continue work on an alternative ground control program and explore outside options to hedge against further cost spikes and delays on Raytheon Co's troubled ground control system for next-generation GPS satellites, according to an Air Force document seen by Reuters.

A "deep dive" review led by the Pentagon's chief arms buyer last week resulted in a further two-year delay in completion of the Raytheon program and potential cost increases. The delays and cost increases are the latest troubles facing a program slammed as "a disaster" by General John Hyten, commander of Air Force Space Command. Raytheon won a contract worth up to $1.5 billion in 2010 to develop the GPS Operational Control System, or OCX, to operate the next generation GPS 3 satellites being built by Lockheed Martin Corp . By December 2014, the program's projected cost had soared to $3.6 billion, including inflation, due to increased cyber security requirements and poor contractor performance, according to Air Force and Pentagon officials. *https://www.yahoo.com*

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3 - 4 February
Hyderabad, India
http://www.nrsc.gov.in/uim2016/index.html

EuroCOW 2016 Workshop
10 - 12 February
Lausanne,Switzerland
www.eurocow.org

March 2016

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

April 2016

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

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

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

May 2016

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

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

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

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

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

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

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

June 2016

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

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

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

July 2016

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

September 2016

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

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

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

October 2016

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

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

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

November 2016

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

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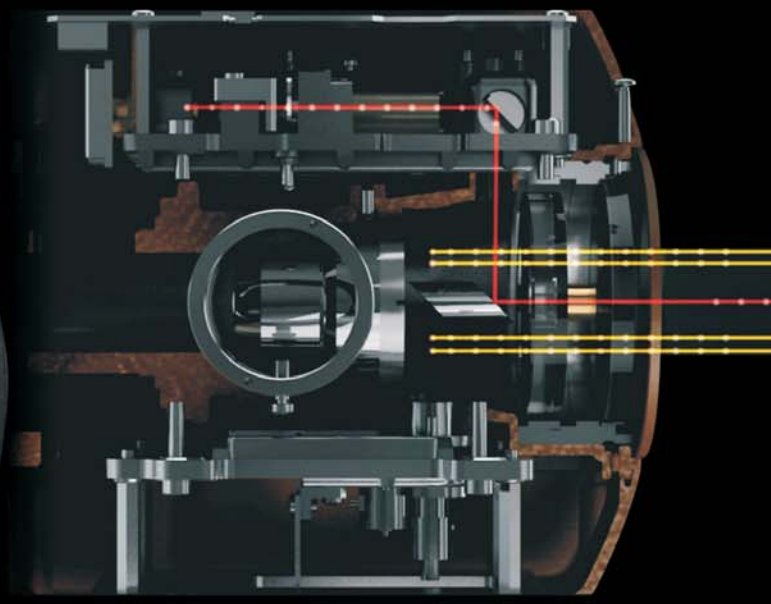

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