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TOWARDS A MODERNIZED GEODETIC DATUM FOR NEPAL

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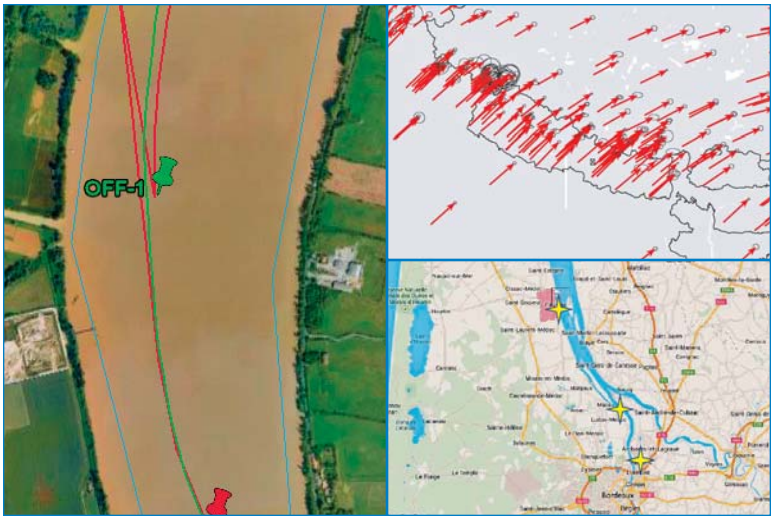

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April 25, 2015.

Major Earthquake in Nepal.

More than 300 aftershocks.

9,000 died and 25,000 injured.

Affecting one third of the population of the country.

Much has been done,

And, much could have.

Since, a year has gone.

Let's remember.

And gather, together.

Whatever we can.

Bal Krishna, Editor
bal@mycoordinates.org

We endeavor to serve the world with the best of the surveying technologies

Says Steven Xu is CEO of Hi-Target Surveying Instrument, in an interview with Coordinates

Hi-Target catch-phrase is 'Surveying the world, Mapping the future'. Could you please elaborate the thought behind it?

Hi-Target has been a leading brand in the Geo spatial, GNSS, and allied technologies market. However, our ambition is to be the leading and professional provider of high-precision Survey & GNSS instrument and solutions in the world. We work for the development of the same all across the globe. We focus not only on the current development but also keep innovating and increase investment in R&D. We endeavor to serve the world with the best of the surveying technologies for a better future. That is our objective and that is our business. The catch phrase 'Surveying the world, Mapping the future' very well summarizes our ambitions, plans, business and more importantly – our vision.

Mention a few achievements in the field of surveying & GNSS from the house of Hi-Target.

In the journey of last 15 years, there are several accomplishments we would like to share.

Hi-Target has gone through the several stages of development - from an instrument manufacture to the integration of devices to data services and now as a solution provider. The transformation from a 'manufacturer' to a 'service provider' not only highlights the responsive approach of the company but also emphasizes the organizational capability and adaptability to evolutionary technological developments in our related techno ecosystem. This is further reinforced in our entry and expansion, in due course of time, to various technology and application areas such as GPS/ GNSS, photoelectric surveying, GIS data managing, marine surveying, UAV, 3D laser systems instrument, BDS high-precision applications, precision agriculture, precision machine control, Indoor localization solution, etc.

The other achievement worth mentioning is the wonderful human resource we have developed. Our team is competent, knowledgeable and highly qualified. HI-TARGET employs more than 1,600 employees. As a company, we understand very well the importance of Research and Development (R&D) and we invest heavily on that. This is visible by the fact that the 30% of our workforce actually constitute our research team; and over 10% of them are professors or they hold PhDs.

We have established several R&D centres and cooperate with many domestics and overseas universities for the research in the field of satellite navigation technology, high-end marine application, 3D laser scanning, etc.

Hi-Target has also launched its self-developed BDS compatible and high-precision BDS motherboard. We have made breakthroughs in the Ultrasonic and 3D laser key technology. In fact, our high-end Marine Survey equipment and 3D Laser Scanning system have totally changed the high-end survey equipment market in China. We have also realized the centimeter level accuracy in indoor positioning.

> The economic uncertainty in both China as well as in international market is presently quite high

What are the key factors kept in mind while developing a new product? What kind of R&D is carried out while designing the same?

We are very much aware of the fast pace of evolution of the technologies and accordingly changing customers' needs and approach. We understand that our customers need high quality products with excellent performance. In addition, we track the market trends, comprehend challenges and analyze economic viabilities and realities. There are many new application areas emerging. We keep many such factors

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In next two years, Hi-Target products will finally realize the support of BDS/GPS/ GLONASS/GALILEO and regional navigation system like IRNSS and SBAS systems

under consideration while developing new products. To facilitate this, we heavily focus on R&D, have developed great human resource and interact with other leading Chinese and international research institutes. Our objective remains to provide our customers best of the products and services.

How do you see growth of UAV business? What are the challenges that it faces? What kind of offering does Hi-Target have in this segment?

UAV is making serious inroads in our domain. The technology is promising and prospects are bright. The technology is being applied to many application areas including agriculture, survey, exploration, forestry, etc. Just like smartphone, it is set to revolutionize this industry. According to a report from Frost & Sullivan, the total value of UAV estimated to be around 7.3 billion dollars.

In 2015, Hi-Target has acquired Tianjin Tengyun Zhihang Tech Co., Ltd to enter into the UAV market. This company is specialized in UAV core technology and product development, and has a strong R&D team, which has designed more than ten types of UAV products. With this acquisition, Hi-Target is dedicated to provide customers with good product and good service at a good price in this segment. This year, Hi-Target will release its first UAV products. In future, Hi-target will make investments in Fixed-wing UAV and Rotor UAV and promote its application in agriculture, survey and other areas.

We are developing our understanding of the dynamics of UAV market, market demands, consumer needs, emerging application areas and the kind or solutions being sought. However, we should also realize the growth of UAV may be hindered in some countries due to restrictions imposed by aviation and security agencies.

How is your collaboration with the China GNSS system, Beidou? Would you like to comment about other GNSS systems – both existing and under development and Hi-Target product's compatibility with them?

Hi-Target always pays close attention and support to the Chinese Beidou system construction and development. We are the authorized manufacture of Chinese Beidou Management department. Since 2012, our products are totally compatible with Beidou. In fact, not only Beidou, most of the products support GPS and Glonass also. In next two years, Hi-Target products will finally realize the support of BDS/GPS/GLONASS/GALILEO and regional navigation system like IRNSS, SBAS (EGNOS, SDCM, GAGAN, and WASS). This will enable to us play a larger role in international market.

How will you compare business opportunities in the domestic markets in China vis-a-vis international? What are the key differentiators?

Chinese market and international market is very different. Even the international market is widely diverse. The difference is largely due to the various stages of economic development, and hence requirements for the survey devices and technology are also very different.

For example, some developing countries are still at the early stage of development and there primary need is to establish and build the basic data and infrastructure. Their demands for surveying equipment are still rising, however, in developed countries, the urban constructions are almost complete and here the need is more of surveying and mapping services and applications.

Though China is a developing country, but it has complicated marketing requirements given the scenario that different parts of the country are at different levels of the development.

Hi-Target will continue to strengthen the development in Chinese market. We promote high-end products in Europe and North America market and will increase investment in Africa and Asia.

Please comment about the growth prospects of business in 2016. What new products or new segments is Hi-Target going to target in 2016?

The economic uncertainty in both China as well as in international market is presently quite high. Given this, our perception is that the growth in traditional survey market may face a slow down. However, for the high-end and new technology areas like 3D Laser scanner and UAV, the demand is likely to grow.

Therefore, we shall look towards increasing our investment for the development of the high-end products and increase our efforts in the international market with the stable 3D Laser scanner products (like Terrestrial Laser scanner and Mobile Mapping System), High-end Marine survey products (like multi-beam echo sounder, ADCP, Long & Ultra Short Baseline Underwater Acoustic Positioning System), Indoor high-precision positioning, UAV, etc.

Towards a modernized geodetic datum for Nepal

Options for developing an accurate terrestrial reference frame following the April 25, 2015 Mw7.8 Gorkha earthquake

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University of Otago,
New Zealand

Niraj Manandhar
Survey Department,
Nepal

Along with the damage to buildings and infrastructure, the April 25, 2015 Mw7.8 Gorkha earthquake caused quite significant deformation over a large area in central Nepal with displacements of over 2 m recorded in the vicinity of Kathmandu. Correcting for this will require a national deformation mode (NDM) that will have the capacity to correct for the earthquake displacements and ongoing tectonic deformation associated with Nepal's location on the India/Eurasian plate boundary. The NDM discussed here contains models of the velocity field and co-seismic deformation. The velocity model for Nepal is based on a compilation of published velocity measurements used to study the boundary between the Indian plate to the south and the overriding Eurasian plate to the north. The co-seismic deformation associated with the Gorkha earthquake and its 12th May Mw7.3 aftershock was modeled using published dislocation models. By combing the velocity and co-seismic models we have developed an NDM that can correct coordinate for both the effect of the earthquakes and continuous deformation associated with Indian / Eurasian plate boundary. Preliminary tests of the model demonstrate that applying the NDM makes a significant improvement when adjusting survey data sets that were acquired both before and after the earthquakes.

It is possible to develop a deformation model for Nepal incorporating the Gorkha earthquake and the variation of the long term (or secular) crustal velocity across the country using published information

Introduction

The current Nepal-Everest datum is a classical datum developed in 1984 by the Military Survey branch of the Royal (UK) Engineers in collaboration with the Nepal Survey Department, (Spence 1987). However, Nepal is located at the conjoint of two converging plates: the Indian plate to the south and the overriding Eurasian plate to the north. Due to the regular convergence of these plates the existing passive geodetic control network has become distorted with time. This combined with the effect of the April 25, 2015 Mw7.8 Gorkha earthquake, which caused significant deformation over a large area centered on Kathmandu means that the integrity of the current Nepal-Everest datum cannot be assured. In this paper we consider options for a modernized geodetic datum for Nepal that will have the capacity to correct for the earthquake displacements and ongoing tectonic deformation associated with Nepal's location on the India/Asia plate boundary.

Semi-dynamic vs conventional datums

Because of the effect of plate tectonic motions, the actual position of points on the earth change continuously. However nearly all users find it difficult to deal with continuous coordinate change. There are two quite different ways that geodetic datums can deal with tectonic motion. Modern semi-dynamic datums are

based on a version of the International Terrestrial Reference Frame. Stable coordinates are produced by projecting each coordinate to its position at a common date called the reference epoch. In order to make this technique work we need a model of how the earth is moving due to plate tectonics. In stable areas, the effect of earthquakes will be small and the motion of the points will follow the motion of the tectonic plates. In areas that are located on the boundaries of tectonic plates, the motion is more complicated because the points are deforming or moving relative to each other in complex ways. In this case a mathematical model, usually called a National Deformation Model (NDM), is used to calculate the trajectory of points. This usually includes a way of estimating the constant or secular velocity of each point and a way of calculating the effect of any earthquakes that may have occurred between the time that the coordinates were measured (epoch of observation) and the reference epoch. The effect of earthquakes is an instantaneous offset while the effect of the velocity increases linearly with time. This process is illustrated in Figure 1, which shows the trajectory of a point effected by a constant velocity and two earthquake shifts.

In contrast, older classical datums, which were usually established before the reality of plate tectonics was widely accepted, establish fix coordinates for a network of control points with no mechanism to correct for tectonic motion. As a result the marks will drift off their true position. However, the relative position of points will not change significantly with time in stable areas such as the interiors of plates since the entire region is moving rigidly. However, for regions on plate boundaries such as Nepal, ongoing deformation means that the relative position of points will change with time due to an inhomogeneous velocity field and earthquakes. Thus the datum will become distorted as the bearings and distances between marks calculated from their coordinates become increasingly different from what we would measure on the ground.

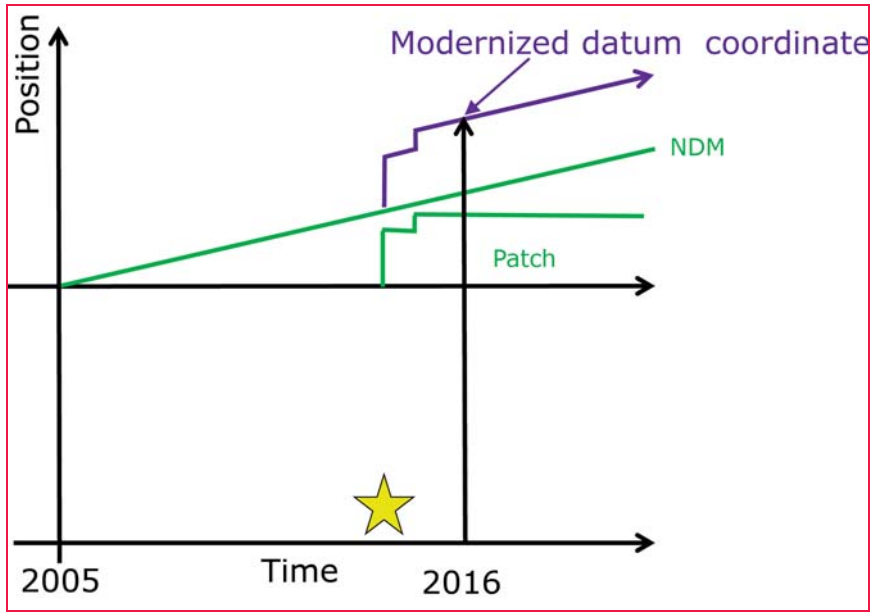

Figure 1: Schematic diagram of a dynamic datum. Green shows the secular velocity and co-seismic contribution to the deformation model. The purple line shows the deformation model with both contributions.

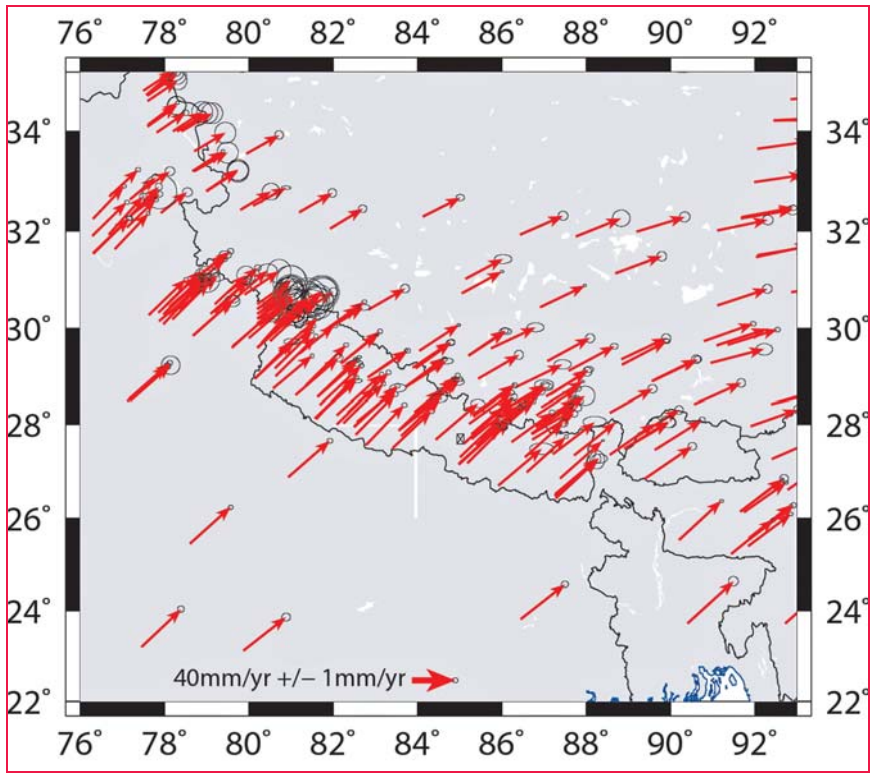

Figure 2: Compilation of velocity measurements for Nepal and surrounding parts of India and China

Semi-dynamic datum for Nepal

Nepal is located at the conjoint of two converging plates: the Indian plate to the south and the overriding Eurasian plate to the north. A significant amount of the convergent component of plate motion is accommodated within Nepal resulting in the crustal velocities changing from a northeast trend in Northern India to an east-northeast trend in southern Tibet. Due to the regular convergence of these plates Nepal has been subjected to a

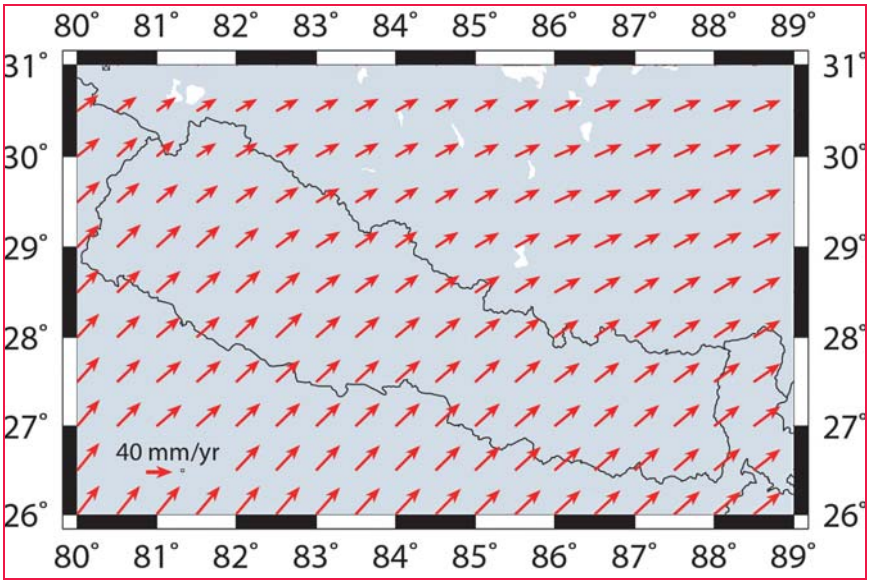

Figure 3: Velocity grid for Nepal

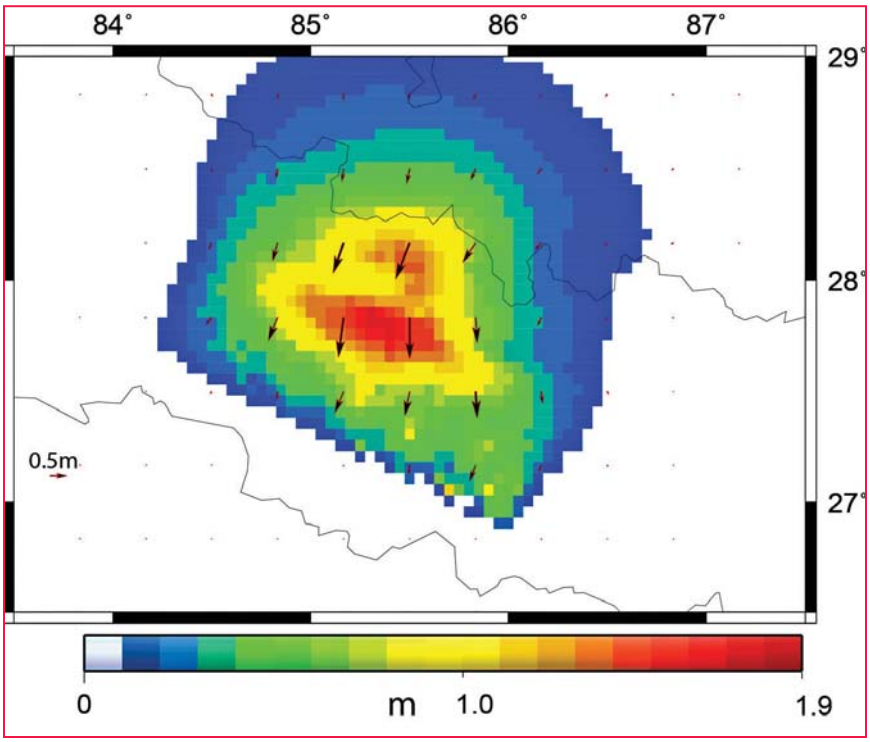

Figure 4: Predicted displacement associated with the 25th April 2015 Mw7.8 Gorkha Earthquake

series of great earthquakes including the 25th April 2015 Mw7.8 Gorkha earthquake. Thus, correcting coordinates to a reference epoch requires that a semi-dynamic datum for Nepal incorporates a National Deformation model . In Nepal's case the NDM must contain a model of the variation of the long term (or secular) crustal velocity across the country and the co-seismic deformation associated with the April 25, 2015 Mw7.8 Gorkha earthquake and the 12th May Mw7.3 aftershock. Both the velocity model and the co-seismic deformation models are grid files so that the estimates of the velocity or co-seismic shifts can be determined using a process of linear interpolation (Stanaway et al. 2012).

Our model of the velocity field for Nepal was developed by combining published velocities for Nepal and adjacent parts of China and India from four geodetic studies in the Nepal region (see Pearson et al 2016 for a detailed discussion). The velocities are shown in Figure 2.

Using these velocities we developed a grid file that covers the region from 80°E to 89°E and 26°N to 31°N (Figure 3). While Figure 3 shows velocity vectors on a half degree spacing the actual gridded velocities have a spacing of 20 points/degree (0.05°).

An NDM also must include patches or gird files that can be used to predict the earthquake deformation at any point. We are currently working on developing patches for the co-seismic part of the 25th April 2015 Gorkha Earthquake and the 12th May Mw7.3 aftershock using published dislocation models (Galetzka et al., 2015). Figure 4 shows the co-seismic slip from the 25th April 2015 Gorkha Earthquake. Note that the Kathmandu Valley has moved by up to 1.9 m.

The deformation model would form a key part of a semi dynamic datum for Nepal which could be based on be ITRF2014 with a reference epoch set some time after the end of the current sequence of earthquakes.

In order to test the effectiveness of a semi-dynamic datum to correct for the deformation from the April 25, 2015 Mw7.8 Gorkha earthquake, we adjusted GPS data that contained both pre and post-earthquake measurements. These test points define a polygon extending about 40 km in the NW SE direction centered on Kathmandu. Between these points there are nine GPS baselines, three of which were recorded in April 2013, before the earthquake and six of which were observed on 08 May 2015, in the period between the 25th April 2015 Gorkha Earthquake and the 12th May Mw7.3 aftershock. The first adjustment was conducted without using a deformation model while, in the second adjustment, the deformation model was used to correct all the measurements to pre-earthquake values. The Standard error of unit weight for the adjustment which does not apply the NDM is more than a factor of 3 times greater than the SEUW for the model

which does apply the NDM. This difference demonstrates that the deformation model is effective in correcting for crustal deformation between the two surveys.

Control

It would be desirable if top level control for Nepal semi-datum was be based on a CORS network with coordinates being rigorously aligned to the ITRF. In Nepal, this network could make use of stations from the Nepal GPS Array (a network established by Caltech and run by UNAVCO to study earth deformation). A preliminary evaluation of the stations in the array indicates that 20 of these sites may be available to act as a CORS network for Nepal. However, four sites download only sporadically due to problematic data links, which results in long latency periods. The distribution of potential CORS stations is shown in Figure 5.

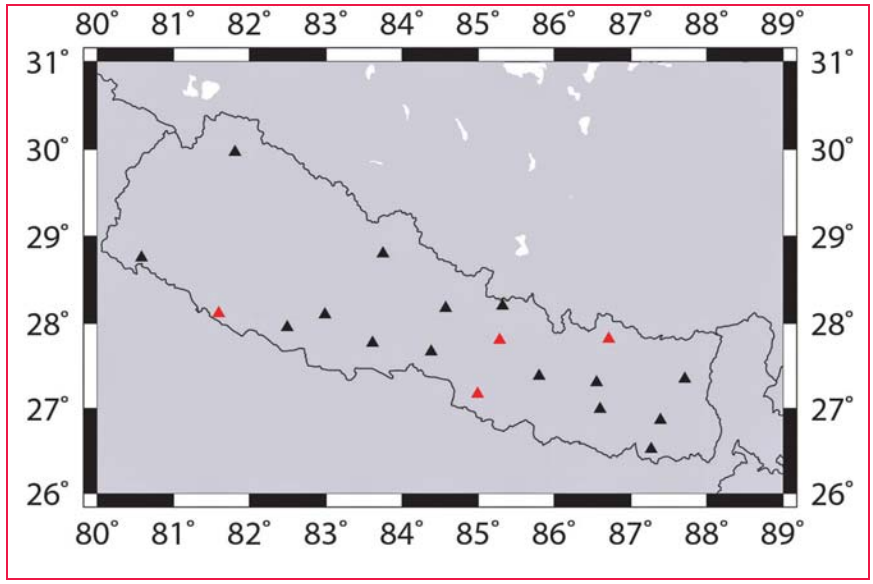

Figure 5: Location of stations from the existing Nepal GPS Array that are potential stations for a Nepal CORS network. Black triangles show the location of triangles with near real time downloading while red triangles show stations with latency of several weeks to several months

Coordinates for existing lower order coordinates would be determined by readjusting existing measurements combined with new surveying data, particularly in the Kathmandu area. Least square adjustments must use packages that can apply the deformation model correctly. This will require that observation dates are available for all historic measurements and it will require that the data is available in a digital form stored in a suitable geodatabase. Comparing the old and new coordinates from existing control will allow a series of correction grids to be developed and these will provide the basis of an accurate datum transformation between the modernized and original Nepal datums. The correction grid will be used to transform coordinates and spatial references in geodatabases into the new system.

Tools for surveyors to connect to the new datum

Nepal will need a mechanism to allow surveyors to realize coordinates in the new datum. This can be done by establishing a network of control coordinates. In Nepal, topographic maps are published in sheets covering 7.5 arcminutes of latitude and longitude in the densely populated regions. The less populated high mountain regions are mapped on 15 arcminute sheets. If high level control points were established at a density of one per topographic base map sheet, this would give a density of about 1 station per 10-15 km in the populated regions of Nepal and one per 25-30 km for the mountainous areas. High level passive control marks, which have been used in previous earth deformation studies, should be resurveyed as a matter of urgency as they can contribute to the velocity model. For points that will contribute to the velocity field, processing must be done using techniques that provide coordinates and velocities that are aligned rigorously to the ITRF such as Bernese GAMIT or GIPSY.. For new static control points which are not intended to be used for measuring velocities, processing using commercial software will be adequate. Once the new stations have been established and surveyed, the data will be adjusted relative to the CORS to determine coordinates in the new datum. This requires the use of adjustment software that supports the use of deformation models, for example SNAP from Land Information New Zealand (LINZ 2013) or HTDP (Pearson and Snay 2012). Sufficient points with existing Nepal Everest coordinates should be included to allow the transformation grid to be developed.

In addition to the network of passive control marks, Nepal could consider developing web based products and other infrastructure to allow surveyors to connect their surveys directly to the CORS network. At its simplest this might take the form of hosting RINEX files from the CORS on its own website, or even training Nepali surveyors to use the existing UNAVCO web interface for this purpose. However, the UNAVCO web interface has some limitations for providing data in the form that surveyors can use easily. For this reason, it would be desirable to have RINEX data served locally in Nepal on a server under the control of the Survey Department.

Eventually, it may be possible to incorporate, at least some of the CORS network in a NetworkRTK facility. In this regard, some of the stations in the Nepal GPS Array are already producing high rate GPS data so incorporating them in a Nepali NetworkRTK should not be particularly difficult although the reliability of communication links and data latency may be a problem. It may also be possible to develop capacity for online data processing along the lines of the existing PositioNZ-PP, AUSPOS or OPUS services.

Conclusions

Because of the effect of the 25th April, 2015 Gorkha earthquake, significant earth deformation has occurred in a large area of Nepal centered on the Kathmandu Valley. As a result, the geodetic control in this region is significantly distorted with published geodetic control coordinates being displaced from their true position on the ground by up to 2m. Correcting these distortions will require a new geodetic datum. In this paper we consider the possibility of Nepal adopting a semi-dynamic datum, which would be based on ITRF2014 and include a national deformation model capable of correcting for the recent earthquakes and normal tectonic motion. We demonstrate that it is possible to develop a deformation model for Nepal incorporating the Gorkha earthquake and the variation of the long term (or secular) crustal velocity across the country using published information. While this model is preliminary our test shows that its use does a good job of correcting survey measurements for the effect of the earthquake.

References: and Further Readings

Galetzka, J. et al., (2015). Slip pulse and resonance of Kathmandu basin during the 2015 Mw 7.8 Gorkha earthquake, Nepal imaged with geodesy, Science, 349(6252): 1091-1095. doi: 10.1126/science.aac6383.

National Geodetic Office LINZ (2013) SNAP Guidelines for GNSS Geodetic Control – CSV files SNAP version 2.3.60, Wellington New Zealand http://www.linz.govt.nz/system/files_force/media/file-attachments/Guidelines-SNAP-v1.0_0.pdf

Pearson, C., Manandhar, N., and Denys, C., (2016). Towards a modernized geodetic datum for Nepal: Options for developing an accurate terrestrial reference frame following the April 25, 2015 Mw7.8 Gorkha earthquake, Online Proceedings of the FIG Working Week 2016, Christchurch New Zealand, in press.

Pearson C and Snay R. (2012) Introducing version 3.1 of the Horizontal Time-Dependent Positioning utility for transforming coordinates across time and between spatial reference frames, DOI 10.1007/s10291-012-0255-y GPS Solutions doi:10.1061/(ASCE)SU.1943-5428.0000013

Spence F S. (1987) Himalayan Survey, The Geographical Journal, Vol. 153, No. 2, pp. 223-230

Stanaway, R., Roberts, C., Blick, G., and Crook, C., (2012). Four Dimensional Deformation Modelling, the link between International, Regional and Local Reference Frames, Online Proceedings of the FIG Working Week 2012, Rome, Italy, 6-10 May 2012.

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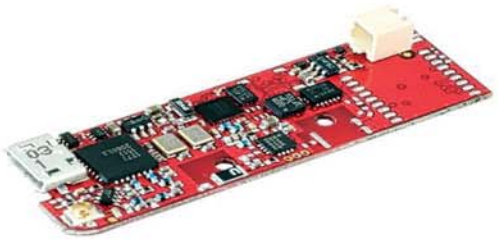

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The module is equipped with multiple on-board sensors, low-level I/O-connectivity and a solar (*) rechargeable integrated battery. It offers accurate location based position data to be connected to any existing worldwide server application.

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- Excellent GPS accuracy, internal antenna.
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  - Short range, up to 30m (*)
  - Long range, over 1 km range, line of sight
- LoRa™ technology, up to 10km, line of sight
- Excellent indoor and outdoor performance with accuracy up to 1.5m
- 3 LEDs for user interaction.
- 1 switch for user interaction.
- Onboard sensors:
  - Temperature sensor (±0.5°C)
  - 3D accelerometer up to 16g.
  - Humidity sensor (*)
- Wide operating range: -20 °C … +85°C
- Multiple watchdog levels for maximum stability.
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  - Digital I/O
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The TM-901 / N1C2 is a budget product line member of KCS' advanced TraceME track and trace modules. The TM-901 is targeted for remotely tracking and tracing a variety of objects, even livestock, and for personal use.

The TM-901 offers excellent long range RF coverage and is equipped with a low-power GPS receiver.

The module is equipped with multiple on-board sensors, low-level I/O-connectivity and a solar (*) rechargeable integrated battery. It offers accurate location based position data to be connected to any existing worldwide server application.

Key Features

- Excellent satellite coverage
  - o GPS
  - o Glonass/GPS (*)
- Very small, only 53 x 15mm
- Lightweight: 3 grams for a fully equipped PCB
- Standby battery lifespan of more than 10 years.
- OEM version
- Excellent GPS accuracy, internal antenna.
- Integrated 2.45GHz. radio for special functions and peripherals.
  - o Short range, up to 30m (*)
  - o Long range, over 1 km range, line of sight
- LoRa™ technology
  - o 868MHz. / 915MHz. (*)
  - o Up to 60km line of sight at 25mW and with integrated antenna.
- Excellent indoor and outdoor performance with accuracy up to 1.5m
- Up to 3 LEDs for user interaction.
- 1 switch for user interaction.
- Onboard sensors:
  - o Temperature sensor (±0.5°C)
  - o 3D accelerometer (up to 16g) Optional: (*)
  - o Humidity sensor (±2%RH)
  - o Baro-/Altitude meter (±10cm)
  - o Compass/Magnetometer(1-2°)
- Wide operating range: -25˚C … +85˚C
- Multiple watchdog levels for maximum stability.
- Solar cell powered (*)
- Versatile interfacing:
  - o Digital I/O
  - o Analog input
  - o Serial, 3V
  - o iButton™ / 1-Wire™
- Buzzer (*)
- Event based free configurable module to fit any job.
- Remote maintenance. Both firmware and configuration files can be updated over the air.
- Supports integration into third party networks.

Applications

- Object protection, up to 10 years of standby on a single lithium AAA-battery.
- Logistics, M2M
- Animal tracking, asset monitoring
- Security and surveillance
- Remote control and diagnostics
- Anti-theft

Ordering information

- TM-901F -
  Full version (Long-range RF, optional Solar-charger)
- TM-901B -
  Basic version (TM-901F without: GPS, Buzzer, Sola-charger, ANT/ANT+)

(*) Optional, please contact sales for more details

Product Summary

Equipped with a state-of-the-art GPS receiver, the KCS TraceME TM-901 / N1C2 module provides reliable and accurate navigational data.

The full version module (TM-901F) is equipped with different technologies for traceability (e.g. GPS/Glonass, LoRa™, Bluetooth LE, ANT/ANT+ and proprietary RF), which can all be combined dependent of the application. The low-budget basic version module (TM-901B) is equipped without GPS while still offering the highly intelligent traceability functionality.

The combined LoRa™ and 2.4GHz. RF technologies offers tracing of the module over a wide area up to 60km. The rough tracing from 60km down to 300 meters is done by LoRa™, while the short-range tracing is done by the proprietary RF-

KCS TraceME

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technique. This technique offers excellent indoor and outdoor tracing with an accuracy up to 1.5 meters. Traditional national telecom costs are avoided because of the absence of GPRS/SMS.

An intelligent 'Listen before talk' algorithm makes it practically impossible to locate the module which secures the valuable vehicle or asset. It enables stolen object recovery and thereby offers insurance premiums reduction possibilities.

Multiple on-board sensors (temperature, acceleration and optional: humidity, baro-/altimeter and compass/magnetometer) as well as buzzer, LEDs, I/O-functionality and pushbutton enable the integration of TraceME into a variety of custom specific (M2M) applications. With a minimal size of 53 x 15 mm, weight of only 3 grams and a battery lifespan of more than 10 years, the module offers endless OEM integration possibilities.

The functionality of the module can be remotely programmed to fit any job. From basic/general functionality to advanced/low-level application specific detailed functionality.

All of the necessary server-side scripts to process and store data from these units are available for registered distributors and resellers. If you do not want to host data and maps yourself, you can use the hosting services of one of our partner companies.

Specifications KCS TraceME TM-901

Data communication

LoRa™	Semtech SX1272 transceiver
Frequency	868/915 MHz. (*)
Protocol	LoRaWAN 1.0 and custom LoRa™protocol
Transmitting power	up to +20 dBm
Sensitivity	-137 dBm

RF 2.4GHz.	Nordic nRF81422 (BLE only) optional nRF51422 (BLE/ANT)
Frequency	2.45 GHz.
Protocol	BLE 4.0, ANT and custom 2.4 GHz. protocol
Transmitting power	up to +20 dBm (with on-board amplifier)
Sensitivity	-93 dBm (BLE), -90 dBm (ANT)

Navigation (*)

GPS Receiver	Quectel L70 GPS module optional L76 GNSS (Glonass + GPS) module	
Frequency	GPS L1 1575.42 MHz. C/A Code, 48 search channels Glonass L1 1598.0625 ~ 1605.375 C/A Code	
Sensitivity	Acquisition Reacquisition Tracking	-148 dBm (typical) -160 dBm (typical) -165 dBm (typical)
Horizontal Position Accuracy	<2.5 m CEP	

Electrical

Power supply	Internal Lithium AAA primary cell Optional external +5VDC ±10% (micro USB-connector)
Typical power consumption	2mA GPS low power tracking 100mA BLE/LoRa™ transmission 13 uA standby, sensors, timer and I/O active, no transmissions

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External Connections

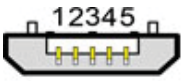
Power connector

Pin	Description
1	3.4 - 4.5V Battery (+) connection
2	Ground

Power connector (*)

Pin	Description
1	3.4 - 4.5V Battery (+) connection
2	Ground
3	External +4.5 … +5.5VDC, or optional: Solar cell 5V

Micro-USB



Pin	Signal	Type	Description
1	USB VCC	VCC	+4.5 … +5.5 VDC Charge input, max 600mA
2	Serial IN	I	Serial input or digital input (2..31V for active high) ~ 50k pulldown
3	Serial OUT	O	Serial or digital output, open collector (max 31V/10mA/100mW)
4	Analog IN	-	Analog input (0..44V)
5	GND	GND	GND for charge and I/O

About KCS BV

KCS BV, founded in The Netherlands in 1984, develops and manufactures electronics in-house for industrial applications, medical purposes, broad- casting solutions, etc.

Support

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Sales

Contact us by email: Trade@trace.me

Final notes & certification

We certify that Kolff Computer Supplies BV, Dordrecht, The Netherlands does not make any hardware or IMEI modifications to the QUECTEL devices as used in the TraceME track & trace device. All software modifications are restricted to official firmware upgrades as provided by Quectel Wireless Solutions Co., Ltd..

Warning

- The device should be turned off in vicinity of petrol pumps, chemical, flammable or hazardous environments where ignition of flammable atmospheres is possible.
- The module and antennas shall be operated at a distance greater than 20 cm from the human body.
- The device is to be operated in accordance with the user instructions or manufactured recommendations.

Disclaimer

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An analysis of the Turkish Cadastre in view of the Cadastre 2014 Vision

The paper carries out an analysis on the Turkish cadastre in view of the Cadastre 2014 statements and then provides some proposals to improve the system

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A well-functioning cadastre is essential for securing rights in land and property, wealth generation, and contributing to better land and environmental management (Jones and Land, 2012). If so, what makes a cadastre well-functioning? Actually the response may change in the course of time because cadastral systems have a dynamic nature especially with the changing technological and changing humankind to land relationship. Therefore, cadastres need to be re-engineered over time to response expectations of the societies in modern ways. Considering this need, the International Federation of Surveyors (FIG) published a vision called "Cadastre 2014" describing characteristics of future cadastral systems in 1998 (Kaufmann and Steudler, 1998).

This vision has become a benchmark to evaluate cadastral systems and directed the re-engineering works in cadastre in many countries. One of those countries where Cadastre 2014 vision has had an important influence is Turkey. As a result of that influence, separation between maps and registers has been abolished in the country. The Turkish Land Registry and Cadastre Information System, combining land registry and cadastre data, and thus a new data model have been developed and implemented. Paper and pencil cadastre has been transformed into the digital one and a new project for renewal of the old cadastre maps was initiated. The private sector has gained importance in cadastre and cadastre works were completed by private surveyors. A new licensing system both for surveyors and offices of surveying and cadastre have been introduced into the cadastre and some parts of the official works in cadastre transferred to those surveyors and offices. The public sector started to concentrate largely on supervision and control of the works.

Although all those developments have been carried out in the Turkish cadastre in the last decade to modernize the system and to response expectations of the society, there are still some works to do in view of Cadastre 2014 statements and modern cadastral trends in Turkey. In this context, this paper, firstly, describes the works carried out in the Turkish cadastre based on the six statements of the Cadastre 2014. Then, it discusses the works needed to be done in the country in the light of modern trends and visions in the cadastre. Finally, it is concluded with some proposals to improve the Turkish way of cadastre.

Cadastre 2014 and the Turkish cadastre

Cadastre 2014 is a vision document published by Federation of International Surveyors (FIG) in 1998. The document provides a vision through six core statements for future cadastral systems. This section evaluate the current situation of the Turkish cadastre based on these six statements.

Mission and Content

According to the Cadastre 2014, "especially after World War II, land use planning, environment protection, noise protection, construction laws, protection against danger caused by natural phenomena, and so on, were regulated by public laws. These laws define areas where certain things are permitted or forbidden. The boundaries of these areas are in principle independent from the private property boundaries, but they have an impact on the possible use of the land. These definitions under public law can have an impact on the property right of the owner, but because they are not part of the official register, they are not subject of the principle of publicity. Although there is in most cases a well-defined procedure for the definition of the respective boundaries of the rights and restrictions, the results are not publicly known. The respective maps are presented during the consultation process of a law-setting before it is put to the vote. Afterwards this documentation is kept with the responsible governmental unit. Interested citizens and organizations can find property information about a piece of land in the land registry. But they must make further efforts to get information about other rights and restrictions that have an effect on the legal situation by making a survey at different governmental organizations. If citizens fail to find out all aspects of the legal situation of a piece of land, they risk the loss of money and time spent for inadequate land use or land use planning. Cadastre 2014 must correct this situation, which is becoming more and more precarious. It must document, in a safe manner, all legal aspects of land. It will be necessary in future for existing and new legal land objects introduced by traditional, private and public law, that the boundary definition and the correctness of this definition are verified carefully, and that the results of the definitions are published in an official public register. In this way the security of land tenure, land use, and resource management will be maintained in view of the land owners and of the societies as a whole." Therefore, *"Cadastre 2014 will show the complete legal situation of land, including public rights and restrictions!"* (Steudler and Kaufmann, 1998).

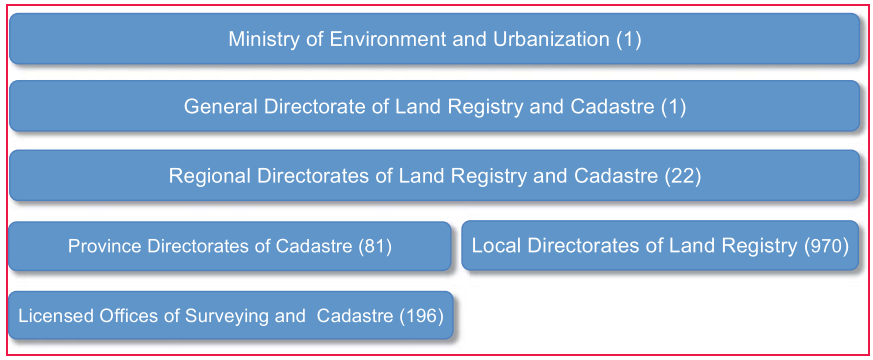

Figure 1: Organizational structure of the Turkish land registration and cadastre system (TKGM, 2015)

In Turkey, main duties of the cadastre organization described in the Cadastre Law (Date: 1987) is property adjudication, construction of boundary markings, surveying of land parcel boundaries, drawing cadastre maps, registration of parcel boundaries and owner information, sustaining land registry and cadastre records and thus providing a basis for land information system. It means main purpose of the Turkish cadastre is building and sustaining land registry and cadastre records to provide security of the real estate ownership. Some rights and restrictions like easements, right of way, usufruct, mortgage, etc. are recorded in the land registry but generally it is not possible to see those rights and restrictions on cadastre maps. There are some academic and institutional studies to show the complete legal situation of land in the Turkish cadastre but these are in very early stages of success. Considering this proposed mission of Cadastre 2014 will be a highly important characteristic of modern cadastres in the future, the Turkish cadastre should more intensively study on realization of this statement.

Organization

Cadastre 2014 states that "most countries have a land recording system consisting of cadastre and land registration components. The cadastral part is normally handled by surveyors, while notaries and lawyers take care of the land registration part. This subdivision has often resulted in two different organizational units dealing with the same matter. Because of the traditionally available technological possibilities, the working procedures of land survey and land registration have been quite different. Cadastre surveying and mapping require special skills to obtain a sufficient result, whereas land registration process was very close to bookkeeping. So the work was subdivided in the past according to the required skills. The correct treatment of the legal aspects of land property transfer matters was ensured by the requirement of a license for land surveyors and by the special education of notaries and lawyers. Advantage of this type of organization is a certain cross-control that can help to eliminate errors. The disadvantages of such solutions are: (i) The system is tiresome, the participants in the land market have to address two different authorities for land transactions; (ii) the information is partly redundant which results with the risk of inconsistencies; (iii) every organizational unit has its own fees to at least partly recover the cost of maintenance of the system." Therefore, *the separation between 'maps' and 'registers' will be abolished!* in Cadastre 2014 (Steudler and Kaufmann, 1998).

Organizational structure of the Turkish Cadastre has some differences from the general structures described above. While cadastre works are carried out by the surveyors in the cadastre directorates, land registration works are carried out by employees in the land registry directorates (Figure 1).

It means, notaries or lawyers do not take part in the Turkish land registration system. The separation between cadastre maps and land registers had been a problem until beginning of the 2000s in Turkey. At the beginning of this century, a new project called as Land Registry and Cadastre Information System of Turkey was developed. The project has targeted to transfer the paper based land registry and cadastre data into a digital environment using a standard framework throughout the country and thus to take land registry and cadastre data use to the next level by spreading its benefits to people, businesses and multiple sectors by facilitating better access to real estate information through the e-government platform (Mataracı and İlker, 2002; Ercan, 2003; Zakout, 2008, Çete et al., 2010). Digitization of land registry data was completed but transferring cadastre maps into digital environment is still continuing. After finalization of the project, land registry and cadastre data will be combined in a unified system in the country. The responsible authorities from land registration and cadastre are local directorates of land registry and cadastre in local level. There is no one agency responsible from both land registration and cadastre but in regional and national levels the responsible authority is one: Regional Directorates of Land Registry and Cadastre (LRC), General Directorate of LRC and Ministry of Environment and Urbanization. Therefore, there is no considerable problem in harmonization of LRC data in Turkey.

The changing Role of Maps

According to the third statement of Cadastre 2014, "the function of cadastre maps must be re-defined. Maps will lose the function of information storage. They will serve in future simply to represent information derived from data stored in data bases. The result of this process is a data model of the real world. The exchange of data models will become common practice in the distribution of cadastral information. This new procedure has several advantages: (i) Type, scale, and content of a representation can be chosen according to the needs; (ii) the information is stored once and different products are derived from the same data; (iii) the digital model is easy to handle, and data representing the model cannot be destroyed physically as can traditional maps; (iv) distribution and publication of cadastral information is easily possible with the help of the exchange of digital data models." Therefore, *the cadastral mapping will be dead and long live modelling will be available* in Cadastre 2014 (Steudler and Kaufmann, 1998).

During introduction of the Land Registry and Cadastre Information System of Turkey (in Turkish abbreviation, TAKBIS), a data model has been developed at the beginning of the 2000s. However, afterwards, Land Administration Domain Model (LADM) has become an international standard (ISO 19152). Considering the LADM supports the implementation of Cadastre 2014, shows the complete legal situation of land, including public rights and restrictions and does not separate maps and registers (Lemmen and van Oosterom, 2014), data model of the TAKBIS should be transformed into LADM to benefit from all these strengths of the LADM in Turkey.

Information technology

Cadastre 2014 says that "the traditional land recording procedures are increasingly computerized. Computer-assisted work has proven to be much more efficient. That is why bookkeeping all over the world is handled with help of computer programs. There is no reason why land recording should not make use of this technology. The handling of spatial objects requires more sophisticated software solutions than bookkeeping, but progress in this domain is accelerating. Spatial objects are nowadays not far from becoming normal objects of information processing. Aside from the bookkeeping information, the geographical information can also be processed easily, and computer-based technology will be the most efficient and cost-effective way to resolve the problem of land recording." Therefore, *paper and pencil – cadastre will have gone!* in Cadastre 2014 (Steudler and Kaufmann, 1998).

Cadastre works have been carried out in digital environment since 1987 when a new Cadastre Law enacted in Turkey. Since initialization of the Land Registry and Cadastre Information System Project, both land registry and cadastre data have been transferred and maintained in computer environment. Surveying data are collected, stored, maintained and delivered in digital form, while legal documents are delivered on paper. Landowners can get property data over the e-government platform.

Privatization

Cadastre 2014 states that "within the worldwide trends of deregulation and privatization, tasks handled until now by the public sector are being transferred to the private sector. Within the framework of New Public Management (Schädler, 1995), public administration units are being converted to private or mixed organizations, doing the work in a flexible and consumer-oriented manner. These trends will also involve the cadastral organizations. In this field we find a lot of operational work that can be done by the private sector as well as or even better than the public sector. The majority of tasks necessary to build up and to maintain a cadastral system can be handled by the private sector without endangering the security of the land recording. Also the preparation of titles and deeds and the registration of titles and deeds may be carried out by the private sector or by mixed-economy organizations. It is not necessary for the public sector to do all the work itself. The public sector nevertheless, plays an important role, because it has to guarantee the legal security of the land recording system. It must be able to implement efficient and powerful procedures for supervision and control of the work. This can be achieved by strict and permanently applied computer-assisted control procedures; by the careful selection, education, and examination of staff; and by the financial involvement of the public sector in

mixed-economy organizations." As a result, *Cadastre 2014 will be highly privatized! Public and private sector are working closely together!* in Cadastre 2014 (Steudler and Kaufmann, 1998).

While all cadastre works had been carried out by Local Directorates of Cadastre until 2004, after that time, technical part of cadastre works has been contracted to private surveyors in Turkey. The General Directorate of Land Registry and Cadastre studied on transferring some workloads of Local Cadastre Directorates to private sector. Then, Licensed Offices of Surveying and Cadastre (LOSC) were introduced into cadastre in 2005 (Official Gazette, 2005). In this context, sub-districts of cadastre throughout the country were designed by taking workloads of the existing cadastre directorates into account. The LOSC have been authorized to carry out many cadastre works. Application of the cadastre maps into the field and showing boundaries of parcels in the relevant area are carried out by the LOSC. These works are not supervised by the cadastre administration. However, the LOSC works on use type change of a parcel, establishment and removal of easement rights and consolidation of parcels are supervised by the Province Directorates of Cadastre (Circular Letter, 2010). The licensed surveyors work as public officials and the losses they caused are compensated by them. As a result, nowadays, public and private sector are working closely together in cadastre works, while land registration works are still carried out by the directorates of land registry in the country.

Cost Recovery

According to the Cadastre 2014, "cadastral systems need considerable investment. But the land documented and secured by the cadastre represents a multiple of the investment. The investment and operation costs have to be paid back at least partially by those who profit." Therefore, "for the land recording systems there should be introduced a controlling mechanism that takes into consideration the real costs and benefits

of the system, separates fees and taxes, and reflects on possibilities of how the cost of the system can be covered by adequate fees. It seems to be realistic that land recording can be organized in such a manner as to achieve a return on investment." It should be provided that *Cadastre 2014 will be cost recovering!* (Steudler and Kaufmann, 1998).

The Turkish land registry and cadastre system is a self-funding even profitable system. As stated above, the country has a dual system in local level of land registration and cadastre. It means, land registration and cadastre directorates work separately. However, in regional and national levels they work under the same regional and national directorates and ministry. Thus, they are thought and evaluated together. This situation prevents to see the cadastre as a costly system. Furthermore, land registration and cadastre is seen as a profitable system in the country. As an example, the yearly income of the land registry serving about 20 million citizens a year was more than 2.5 billion USD in 2013 (TKGM, 2015).

Conclusion

Cadastre 2014 has guided re-engineering processes of land registration and cadastre systems in many countries. It has been also a benchmark during improvements of the systems. Thanks to this vision document, many countries have been sure that their re-engineering processes were on the right way. Turkey is one of those countries. At the beginning of this century, a new project called as Land Registry and Cadastre Information System of Turkey (in Turkish abbreviation, TAKBIS) was developed. The project has targeted to transfer the paper based land registry and cadastre data into a digital environment using a standard framework throughout the country and thus to take land registry and cadastre data use to the next level by spreading its benefits to people, businesses and multiple sectors by facilitating better access to real estate information through the e-government platform. After finalization of the project, land registry and cadastre data will be combined in a unified system in the country. Since initialization of the TAKBIS Project, both land registry and cadastre data have been transferred to and maintained in computer environment. Technical part of cadastre works has been contracted to private surveyors since 2004, and the General Directorate of Land Registry and Cadastre studied on transferring some workloads of Local Cadastre Directorates to private sector. Then, Licensed Offices of Surveying and Cadastre (LOSC) were introduced into cadastre in 2005. The licensed surveyors work as public officials and the losses they caused are compensated by them. As a result, nowadays, public and private sector are working closely together in cadastre works, while land registration works are still carried out by the directorates of land registry in Turkey. However, there are still some needs for improvements in the Turkish land registration and cadastre based on the Cadastre 2014 statements. For instance, a project to provide that cadastre shows the complete legal situation of land, including public rights and responsibilities is needed to be carried out. Land registry and cadastre data must be up-to-date and complete. Data model of the TAKBIS should be revised based on the Land Administration Domain Model (LADM). Accessibility of land registration and cadastre data should be extended to make easier the use of TAKBIS services for the citizens.

References

Circular Letter, 2010, Circular Letter about Licensed Surveyors and Surveying Offices, Official Web site of the General Directorate of Land Registry and Cadastre, http://www.tkgm.gov.tr. (in Turkish)

Çete, M., Palancıoğlu, H. M., Geymen, A., Alkan, M., 2010. The Turkish cadastral information system and lessons learned, Scientific Research and Essays, Vol. 5 (7), pp. 625-633.

Ercan, O., 2003. Geodesy and land information system of TKGM, The TUJK Scientific Meeting, the Workshop on Geographical Information Systems and Geodetic Networks, Konya, Turkey, pp. 75-82. (in Turkish)

Jones, B., and Land, N., 2012. Cadastre 2.0 – A technology vision for the cadastre of the future, FIG Working Week 2012, 6-10 May 2012, Rome, Italy.

Kaufmann, J., and Steudler, D., 1998. Cadastre 2014, A Vision for a Future Cadastral System, FIG Publication.

Lemmen, C., and van Oosterom, P., 2014. LADM and its Role in Establishing Cadastral Systems, Cadastre 2014 and Beyond, International Federation of Surveyors (FIG) Report, Editor: Daniel Steudler, Denmark, ISBN 978-87-92853-12-7.

Mataracı, O., İlker, M., 2002. TAKBİS-Land Registry and Cadastre Information System. The Proceedings Book of the 30th Year Symposium of Geodesy and Photogrammetry Engineering Education in Selçuk University, Konya, Turkey, pp. 544-546. (in Turkish)

Official Gazette, 2005. The Law about Licensed Surveyors and Surveying Offices, Law No.

5368, The Turkish Official Gazette, Date: 29.06.2005, No: 25860. (in Turkish)

Schädler, K., 1995. Ansätze einer wirkungsorientierten Verwaltungsführung, Verlag Paul Haupt, ISBN 3-258-05151-8.

TKGM, 2015. Official website of the General Directorate of Land Registry and Cadastre, http://www.tkgm.gov.tr. (in Turkish)

Zakout, W., 2008. Turkey partners with World Bank for Modernization of Land Management Systems. http://www.worldbank.org.tr.

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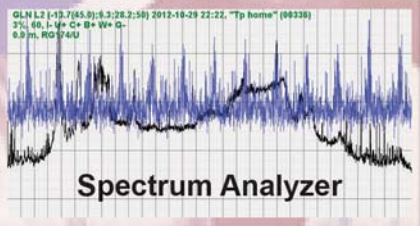

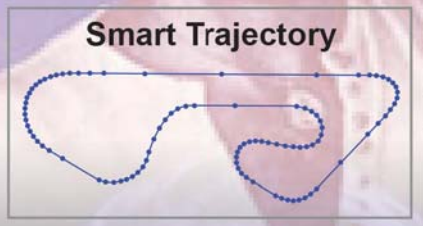

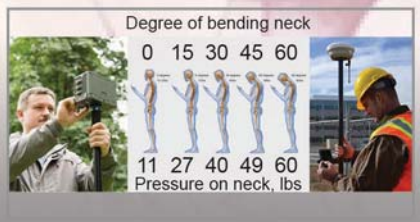

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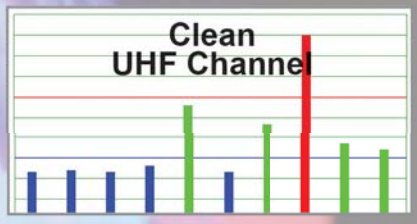

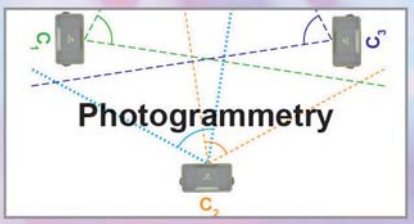

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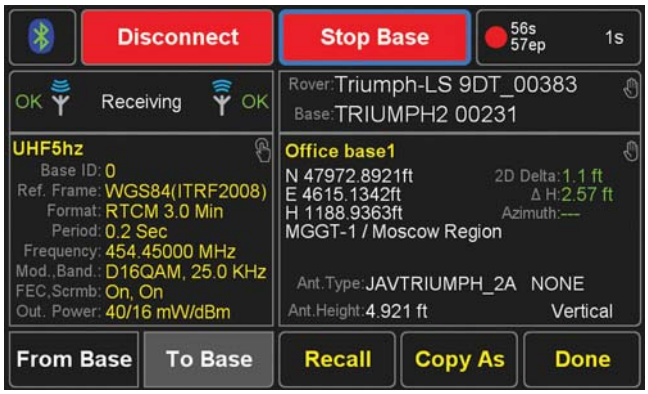
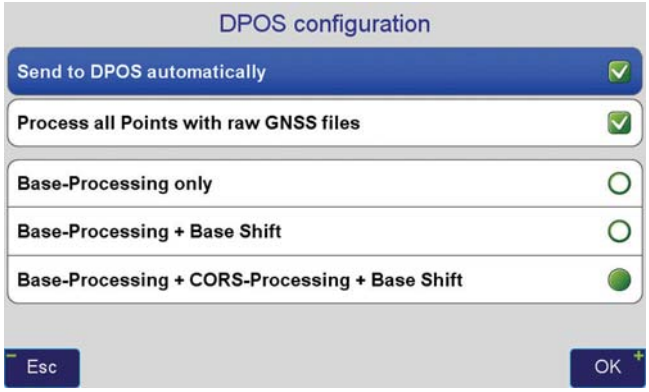


DPOS options



Automated steps

2 Base data downloaded.

3 Awaiting DPOS server connection.

4 Rover points and base data sent to DPOS. Awaiting DPOS to process base-rover.

5 Rover points processed with base (relative).

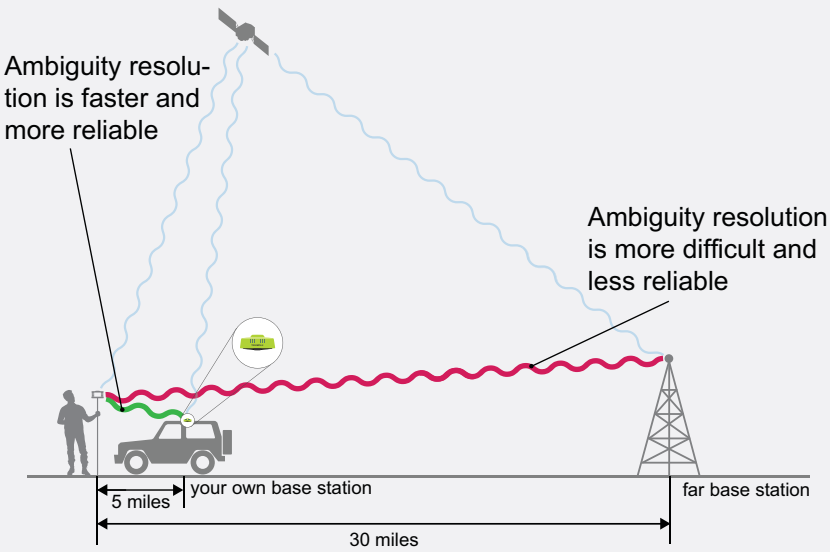
6 Base data sent to DPOS to be processed with CORS data. Awaiting CORS data.

7 Base processed with CORS and corrections applied. (Absolute)

8 Base and rover points sent for CORS processing.

9 Rover points individually processed with CORS data.

Advantages of your own base station and short baselines



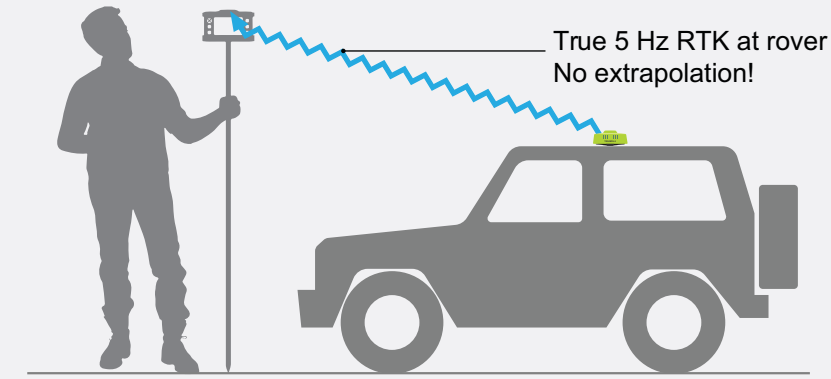
1. Shorter baselines provide significantly better **reliability** because the ambiguities are much easier to resolve and the correct ambiguity solution has an obvious contrast.

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.

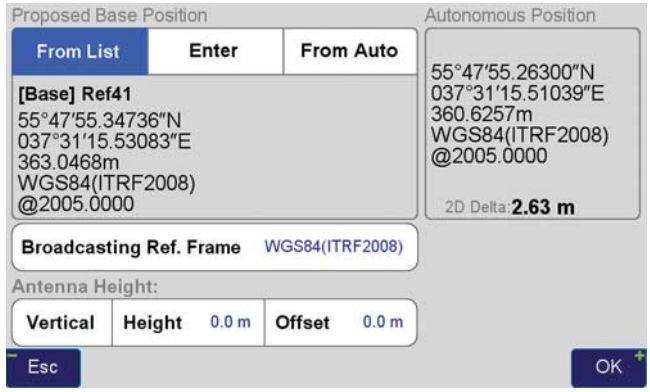
HPT401BT
1W UHF Radio

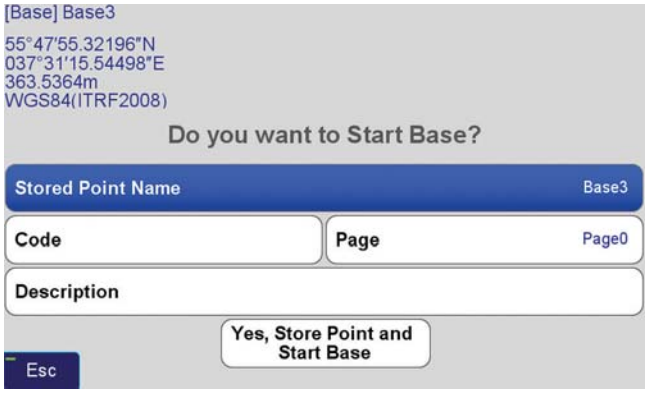
TRIUMPH-2
GPS+GLONASS
L1/L2

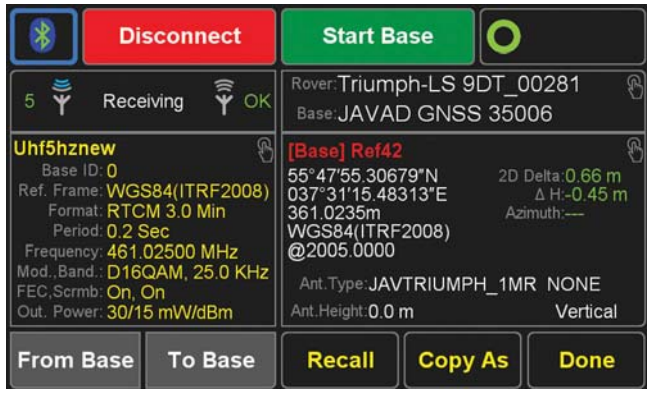
2 Park your car, Start Base

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**.

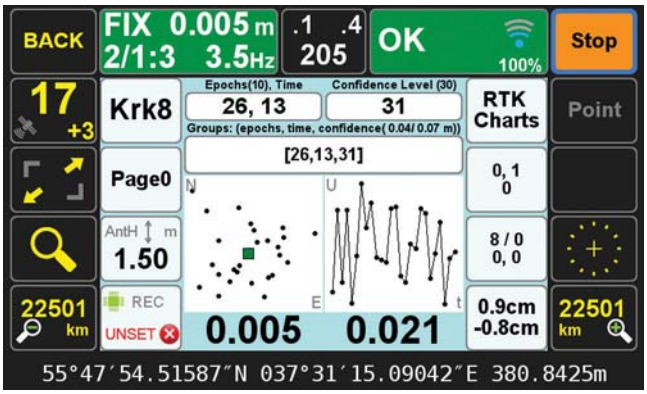




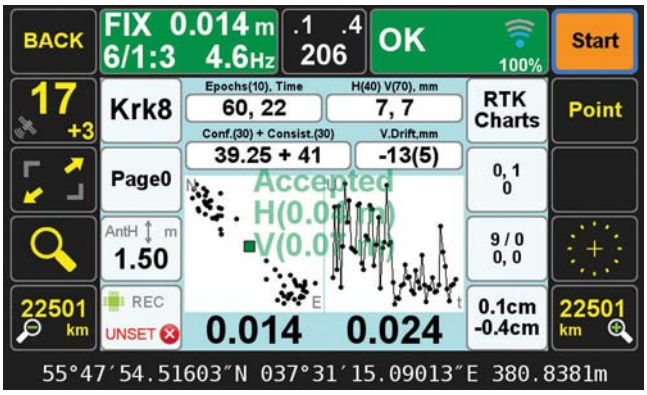


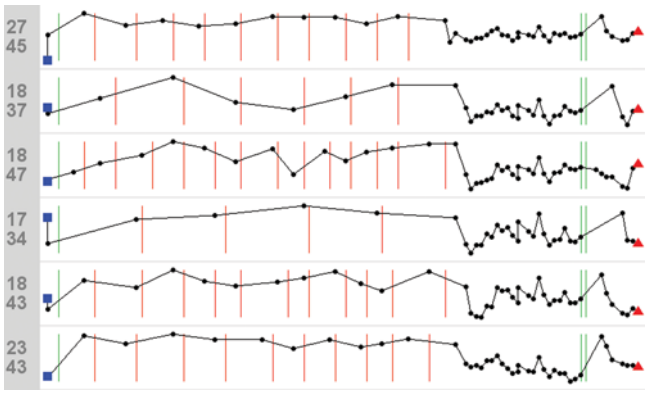
3 RTK Survey

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.

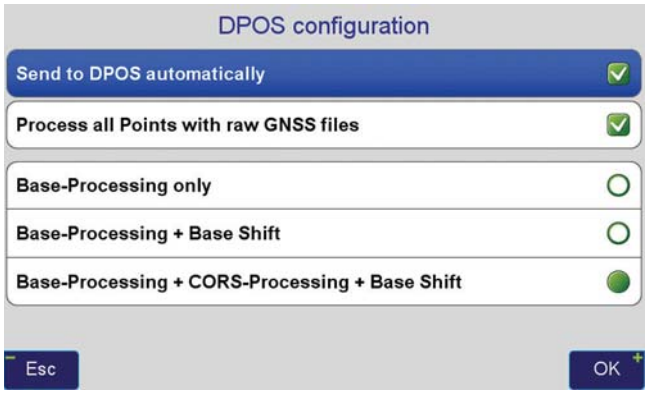


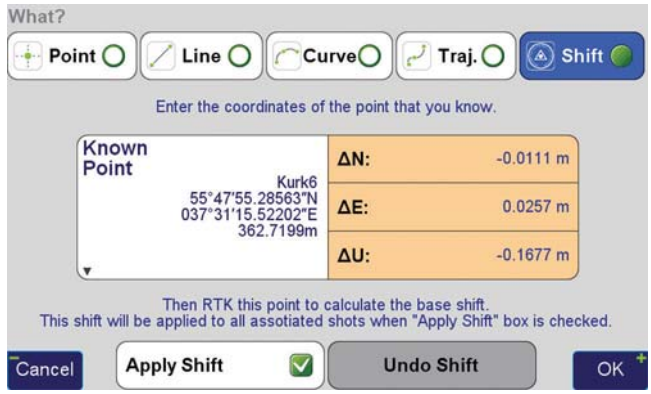


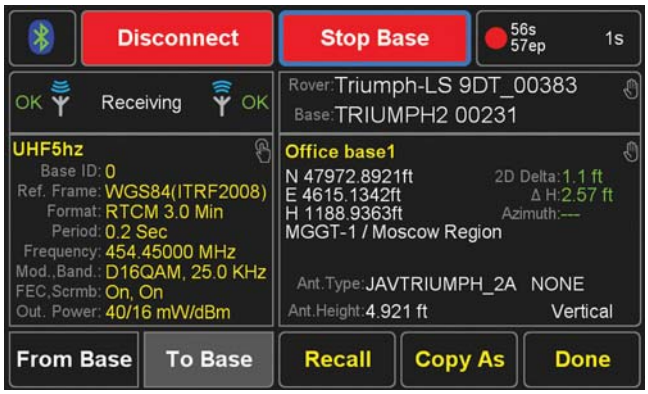
4 DPOS-it, Reverse-Shift-it, CORS Process it, AUTOMATICALLY. See Hybrid RTK too.

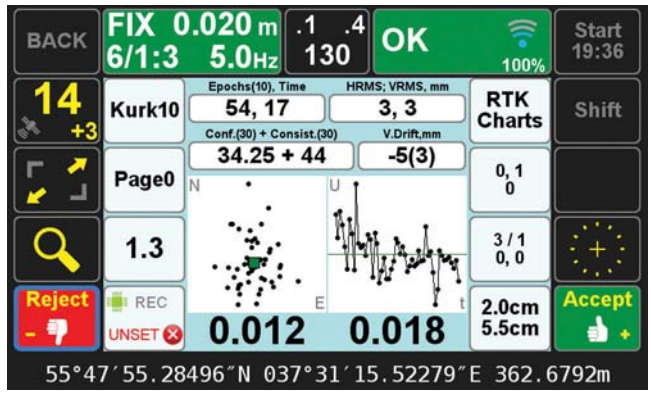
DPOS-it:
Press Stop Base and this will automatically **download** the raw GNSS base data to TRIUMPH-LS and send it to **DPOS** for processing with data from nearby CORS receivers. The TRIUMPH-LS then receives the **correct coordinates** of the base and **shifts** all the rover points accordingly. It can also process your rover points directly with CORS stations too. You can triple check your RTK results.

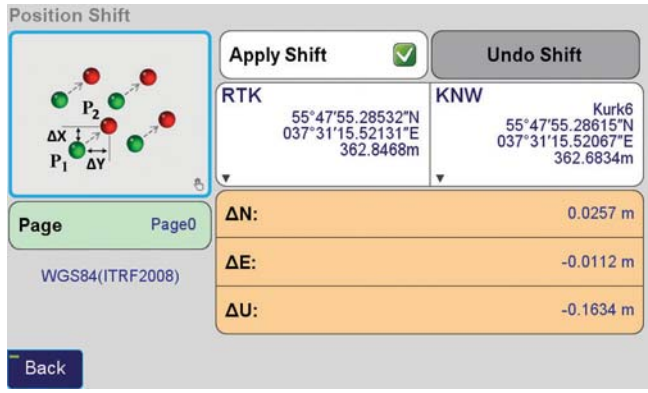
Reverse-Shift-it:
1) Take the TRIUMPH-LS to a **known point** and select the "**Shift**" function in the Setup Advanced screen. 2) Enter the **known coordinates** of that point. 3) Take a **shot** at that point and a base station shift will be **calculated and applied** to all previous and subsequent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



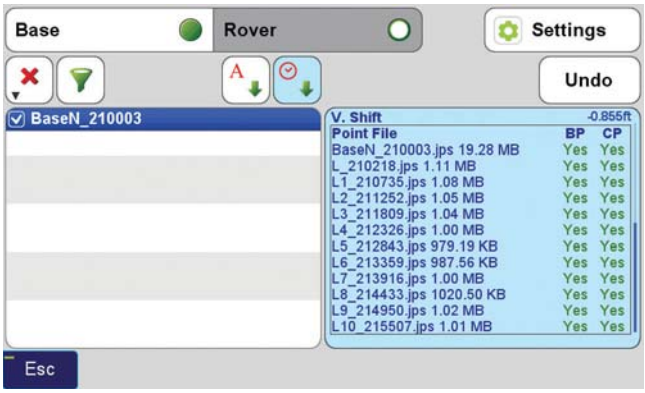




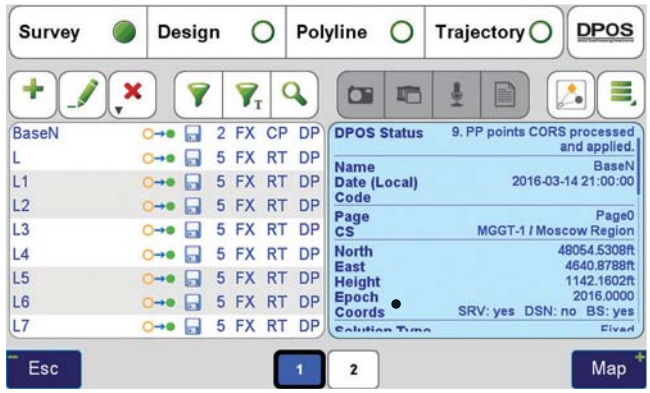




Post-process and CORS process missed points... Automatically!

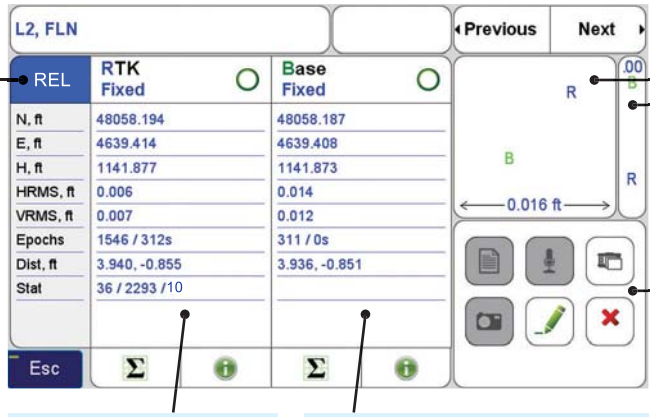


Status of DPOS and Hybrid RTK processing for this session.



Status of each point and indication that base was DPOSed and corrections were applied.

Switch between REL (Relative) and ABS (Absolute) screens.



Horizontal and vertical graph of Relative solutions.

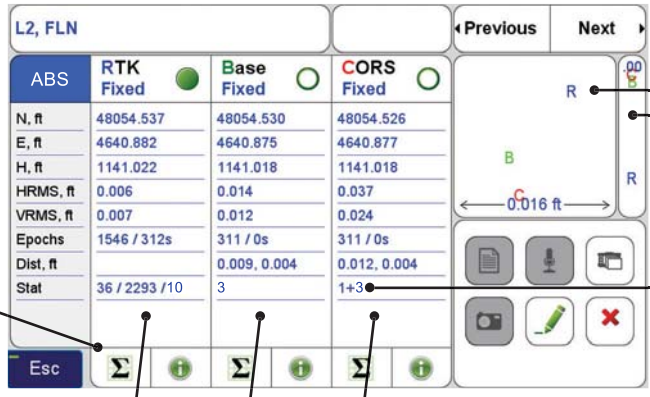
RTK and post-processed rover solutions based on autonomous (standalone) position of the base (Relative).

Access notes, audio, photos and screen shots that are attached to this point.

RTK solution (relative to autonomous position of the base).

Post-processed solution (relative to the autonomous position of the base).

Three types of Absolute rover solutions after autonomous position of the base is corrected with CORS data.



Horizontal and vertical graph of Absolute solutions.

Statistical details.

Number of CORS stations used.

Corrected RTK solution.

Corrected post-processed solution.

Solution post-processed directly with base and with CORS data.

Your thick trees and Our six RTK engines...

"This thing is bad ass!"

"I used "Beast Mode" on a small project yesterday and all I can say is WOW!!!! Did Javad and Red Bull team up to enhance RTK or did my system drink hypercaffeinated coffee when I wasn't looking? Amazing accomplishment/development Javad. I can't imagine using any other GPS equipment."

"the data collection will make your whole body stiff, and quiver from head to toe. It is flat awesome."

"We are considering a third system (these things are awesome)"

"got some shots that he could not get with our gr5's"

"Btw, pardon my French, but holy shit. I got some ridiculous 'fixes' today in some horrible situations. Reset receiver, moved around, etc. Tried to get a bad fix but had a hard time doing it."

"The LS has increased our productivity 2:1."

"On a side bar, the highway contractor had a guy using a Trimble for his as-built shots. My Javad ate his lunch on fixes and the verify routines. He had never seen anything like it. His was stop, drop, and go."

"I've been using BEAST MODE RTK and it works very fine even in heavy canopy. Tremendous application."

"The only bitching now is for the crew that has to take out the Hyper V."

"I often get 2 days of work done, in a day."

"This thing is bad ass!"

JAVAD

...making friends!

Local GNSS Monitoring

The present article describes a promising jamming detection solution developed during the HONTZA project

A Guilloton
Thales Avionics,
Valence, France

B Montagne
Thales Avionics,
Valence, France

Nowadays, GPS are used in many applications such as GBAS, SBAS, EGNOS and WAAS aircraft landing systems, unmanned road or aerial vehicles, wireline and wireless telecommunications networks, financial trading, electricity generation and supply, telematics insurance, tracking of assets, fleet vehicles and people, road user charging, geofenced applications … etc.

GPS applications are vulnerable to jamming and spoofing, the former being intentional or not. Such interferences have a high damage potential. Time spoofing can also help a hacker misappropriating funds from a bank. As example, Table 1 lists some GNSS encountered problems in ATM. The best known example of GPS jamming is the Newark incident, where air traffic was disrupted due to a GPS jammer (PPD, Personal Privacy Device) moving along the airport.

This table highlights that intentional interferences really impact ATM and unintentional interferences effects on ATM should be taken into account. Jamming and spoofing threats draw a growing interest from the scientific and industrial GNSS community.

The article is organized as follows: the first section introduces the context of the HONTZA project and its actors. The second part details the local GNSS monitoring system architecture. The third part shows the results obtained during on-site tests and during the 3 months period. The last part describes future works envisaged.

Table 1: GNSS encountered problems in ATM

Place	Date	Duration	Description
San Diego (US)	01/2007	2h	ATM disruption by Navy ship in exercise
Newark (US)	2009	3 months	GBAS service disruption by personal-privacy device jammer
Korea	23/08/2010	4 days	15 aircrafts impacted by North Korea jamming
Korea	04/03/2011	11 days	106 aircrafts impacted by North Korea jamming
Korea	28/04/2012	16 days	1016 aircrafts impacted by North Korea jamming
Nîmes (FR)	2012	Unknown	LNAV approach disruption by harmonic of analog television
Châteauroux (FR)	2013	N/A	LNAV/LPV approach disruption. Analysis in progress

HONTZA project

Context

The HONTZA project investigated GNSS vulnerabilities for maritime navigation with respect to the issue of voluntary or involuntary GNSS interferences. The aim of the project was to assess the impact of a commercial jammer freely available online on boat onboard equipment and on harbor facilities, and to deploy solutions to mitigate the risks. HONTZA is a collaborative project funded by the Conseil Régional Aquitaine and performed by Thales and its partners within the TOPOS cluster [1].

Whenever a jamming or spoofing event is detected around the harbor of Bordeaux, the solution developed, which will be introduced in next chapter, provides an alert to the master's office.

Actors of the project

The actors of the HONTZA project were:

- GPMB (Grand Port Maritime de Bordeaux): they provided equipment for on-site tests.
- HELILEO: they were in charge of the GNSS sensor tests
- AGUILA: they were in charge of

the GNSS sensor development
- MAXSEA: they were in charge of the server part
- THALES AVIONICS: we were in charge of the system requirements definition and the safety algorithm to detect spoofing or jamming.

Proposed solution for local GNSS monitoring

The aim of the solution is to be able to inform user in real-time:
- Of the GNSS signals availability and quality,
- Of the presence of interference sources,
- Of the origin of interference sources.

This solution could be typically used in transport environment (seaport, airport …) or for guidance operation where accuracy is critical.

Next part will describe the system architecture.

Solution architecture

The local GNSS monitoring system is constituted of 2 main subunits:
- The "GNSS sensor" subunit is spread on the critical zone to monitor. Its role is to collect GNSS signals and GNSS information (level of satellite signals, RF Front End data, position information …) and then to transmit these information to an "web server" via a GSM link and Internet connection.
- The secured server subunit is hosted on cloud, its role is to elaborate and store information data displayed to the user, on a distant PC hosted on the system client, through an HTTPs Human Machine Interface.

Figure 1 illustrates system architecture of the proposed solution.

Simulation test with STK

The HONTZA solution is based on the deployment of sensors on the area to cover along the Gironde River. Jammer is simulated on the Aquitaine Bridge. Jammer simulates a

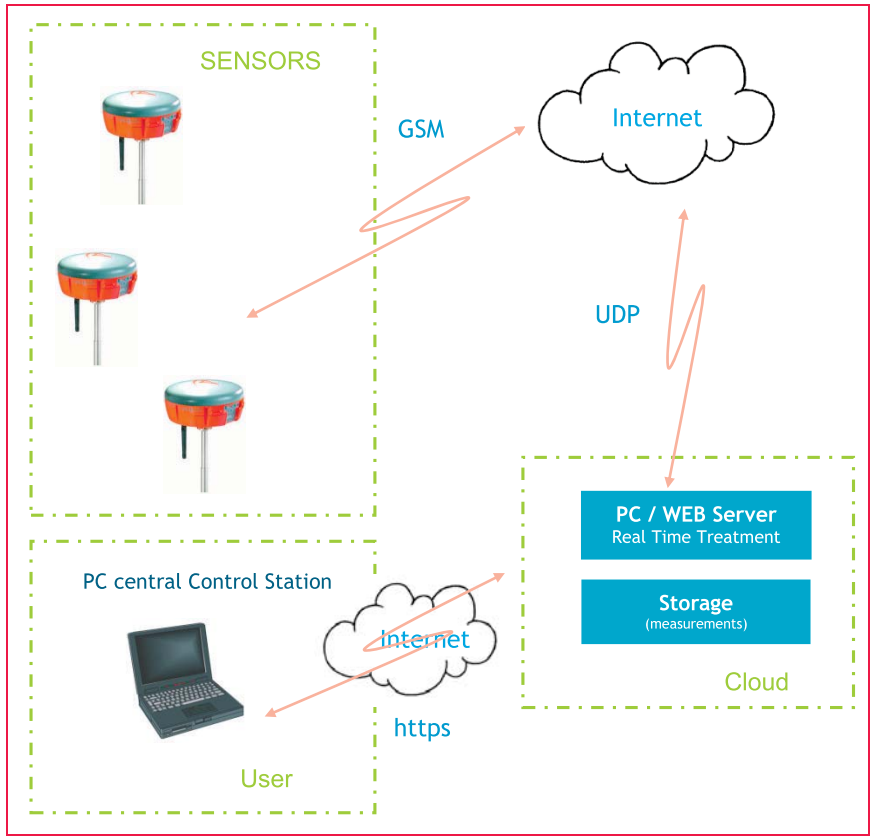


Figure 1: System Architecture

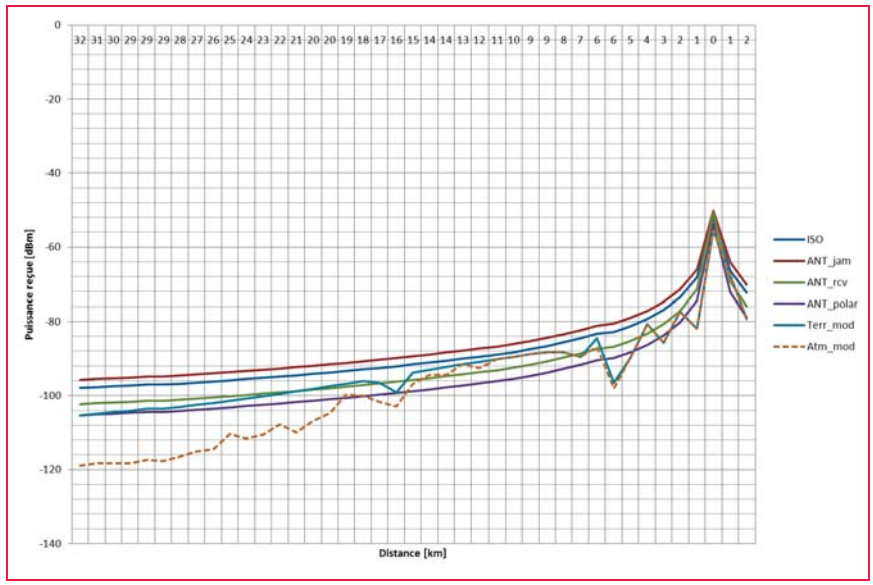


Figure 2: Received power according to the jammer distance

Personal Privacy Device (PPD) with a continuous wave (CW) on L1 frequency (1575.42MHz) with a power of 1W.

According to the number of sensors available for the project (3 sensors) and the area to cover, 3 places to put the sensors have been identified:
- Paulliac: sensor is not affected by the jammer, sensor status is OK,
- Macau: sensor is a little affected by jammer and sensor is in degraded mode,
- The harbor office: sensor is fully affected by jammer and sensor status is KO.

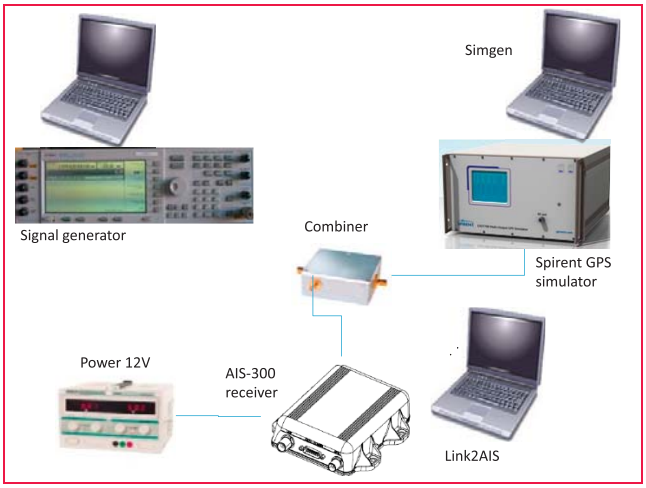


Figure 3: User receiver interference test

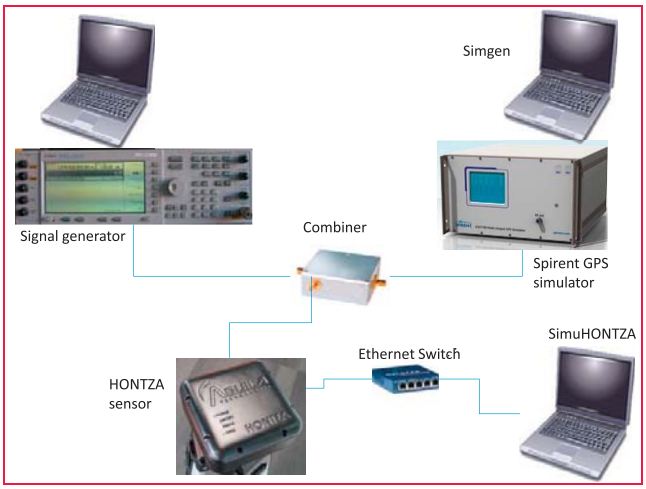


Figure 4: Sensors interference tests

Figure 5: Speedboat trajectory

Figure 6: GPS sensors position

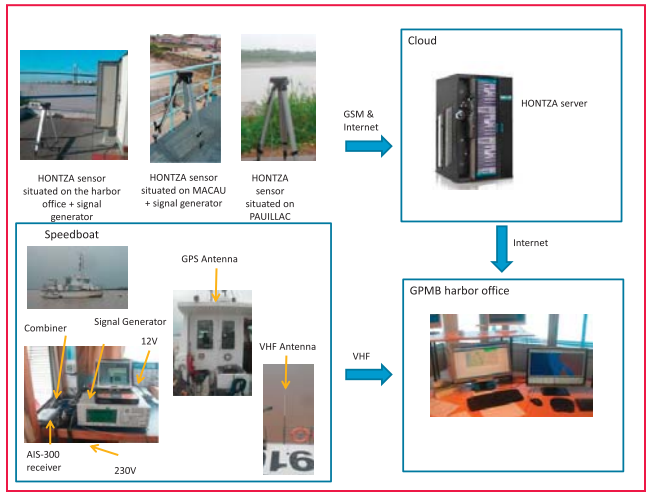


Figure 7: On-site tests

Thanks to the STK software (System Tool Kit) provided by AGI [2], the received power has been modeled for the 3 places identified. Figure 2 provides the received power according to the distance from the jammer (different types of propagation model and antenna are considered). These powers are needed for on-site tests.

Laboratory tests

Laboratory tests have been conducted in order to assess system performance. Tests have been performed on user receiver and on GPS sensors.

User receiver interference tests

The user receiver was an AIS ACR Electronics AIS-300 receiver provided by TOPOS. The interference was generated by a signal generator and then it was combined with a GPS signal simulated with a Spirent, as illustrated in Figure 3.

"Simgen" and "Link2AIS" software are commercial software given with Spirent simulator and the AIS-300 receiver.

Sensors interference tests

The configuration of sensors interference tests was the same as the user receiver interference test, using the GPS HONTZA sensor instead of the user receiver. The RF signal (GPS + interference signal) is injected between the antenna and the receiver.

Sensors interference tests allowed verifying the sensor status according to the jamming level (OK, degraded, KO). After laboratory tests passed, on-site tests have been conducted.

On-Site tests

Tests have been done on GPMB (Grand Port Maritime de Bordeaux). A hydrographic speedboat equipped with a user receiver was used to navigate, along a predefined trajectory (purple trajectory in Figure 5).

The speedboat was also equipped with a GPS receiver that will be used to

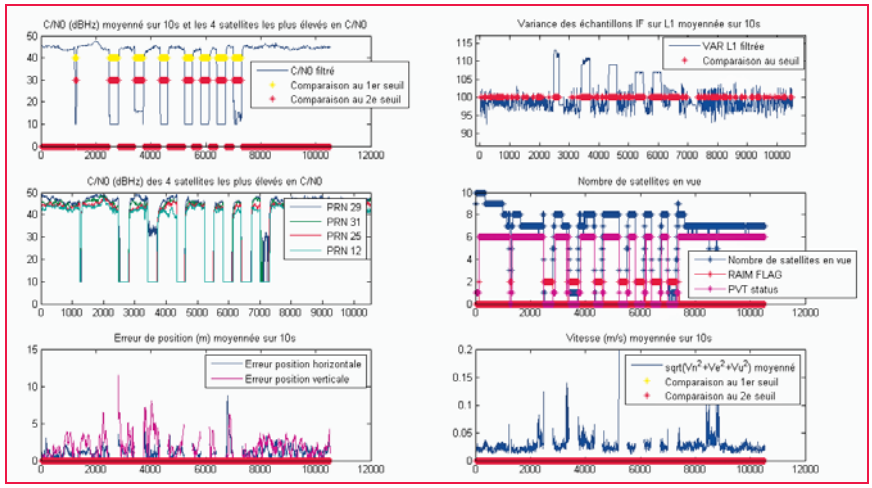


Figure 8: Harbor office sensor: sensor KO

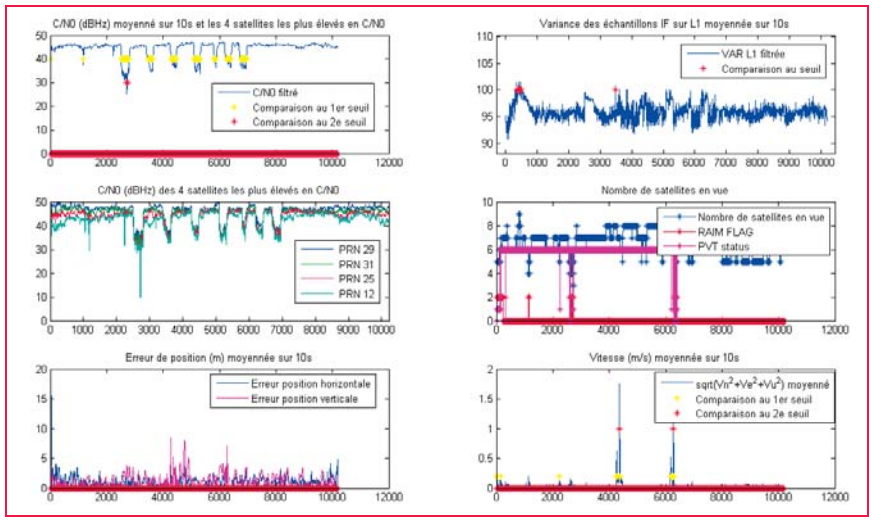


Figure 9: Macau sensor: sensor degraded

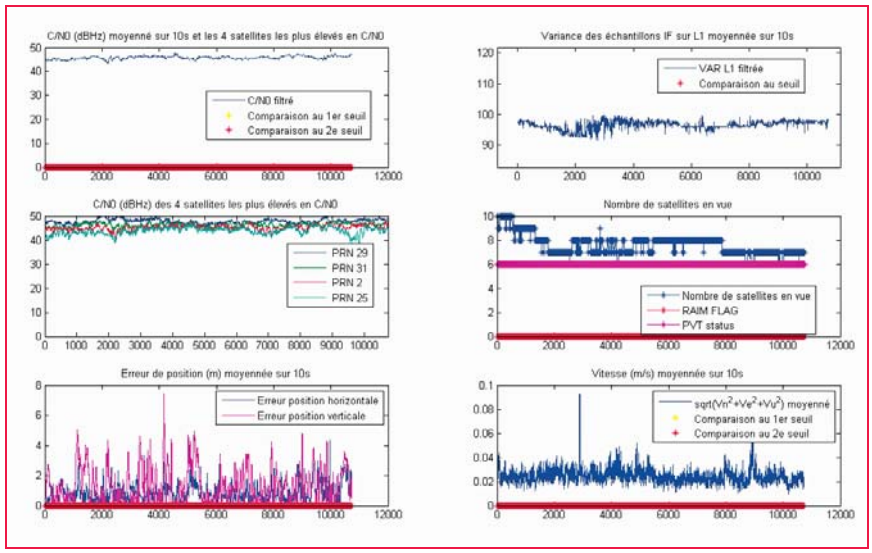


Figure 10: Paulliac sensor: sensor OK

get the reference trajectory. HONTZA sensors were spread on 3 different zones as depicted in Figure 6.

Each of 4 GPS receivers (3 HONTZA sensors and the user receiver) received the real GPS signal coming from its antenna.

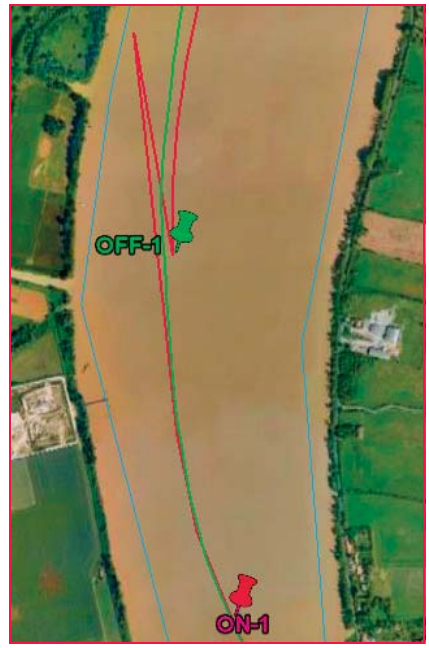


Figure 11: Impact on AIS receiver

As for laboratory tests, interference was conducted after the antenna of each receiver (jamming is switch on 5 minutes roughly after that it is switch off). Interference injected simulates a jammer which circulates on the Aquitaine Bridge.

Server is linked to supervision system of the GPMB harbor office as illustrated on Figure 7.

Results obtained for the 3 HONTZA sensors during the test between Paulliac and the harbor office are given hereafter.

As expected, the sensor placed on the harbor office is affected for each jamming (see Figure 8).

Sensor situated on Macau is only on degraded mode, as expected (see Figure 9).

Sensor placed on Paulliac is not affected by jammer (so no interference was injected) and as expected, sensor is not impacted (see Figure 10).

Impact on the AIS monitoring system is depicted in Figure 11. The green trajectory corresponds to the reference, provided by the on-board GPS receiver not affected by jamming. The red trajectory corresponds to the trajectory elaborated from AIS data. Jamming was activated on step named 'ON-1' and deactivated on step named 'OFF-1'.

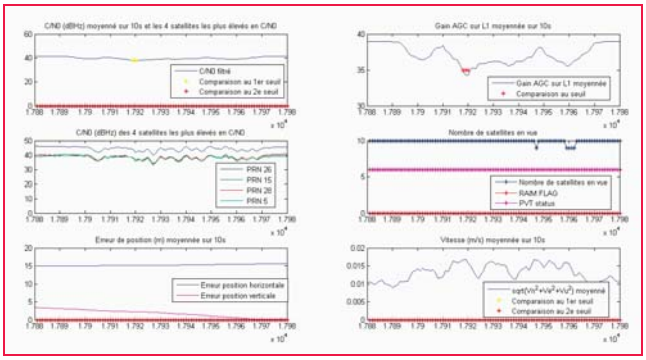


Figure 12: First detected interference

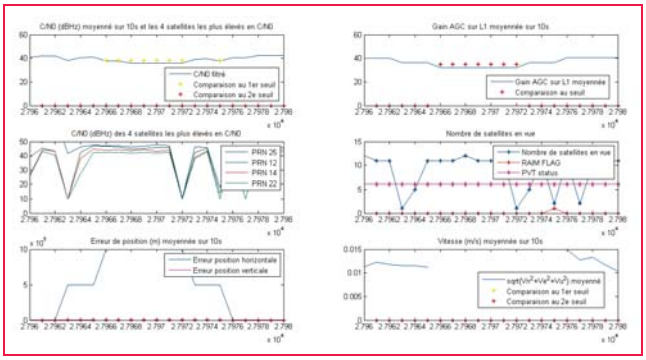


Figure 14: Third detected interference

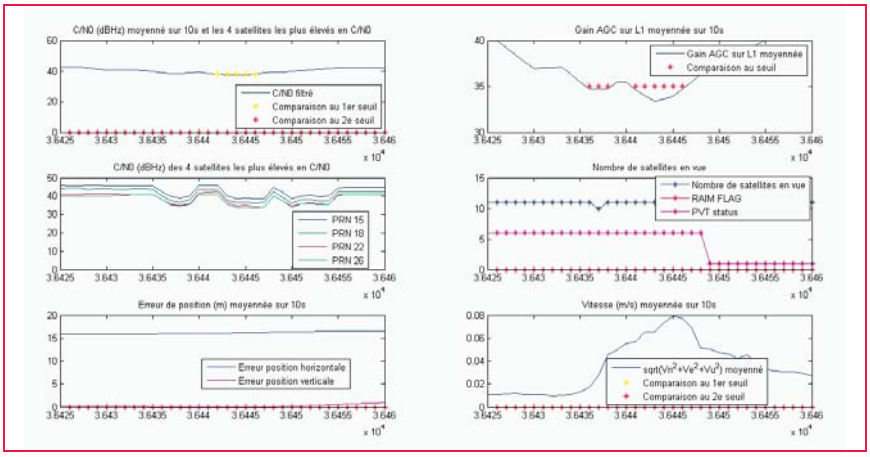


Figure 13: Second detected interference

It can be observed that AIS monitoring system provides an extrapolated boat position during jamming, taking into account parameters available before jamming (speed, heading …). It's why in Figure 11, the boat estimate position is close to the Earth whereas the boat is really in the middle of the river.

First lessons learnt

After the on-site test, one of the sensors was left in place during 3 months on the harbor office, in order to evaluate interferences over a long period. 5

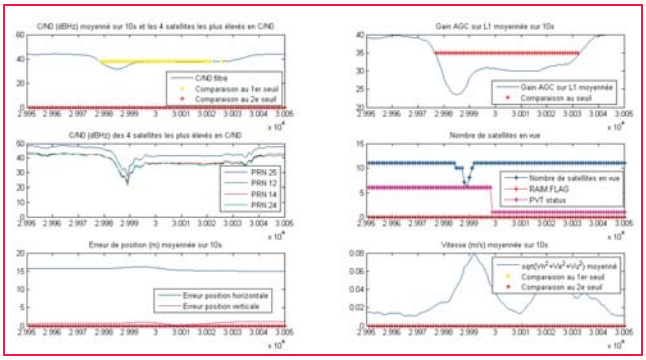


Figure 15: Fourth detected interference

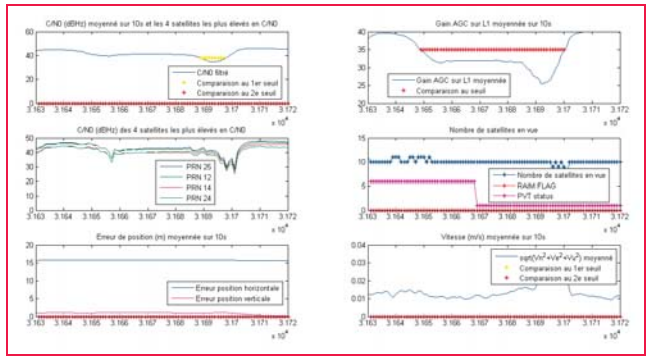


Figure 16: Fifth detected interference

Figure 17: Thales equipment

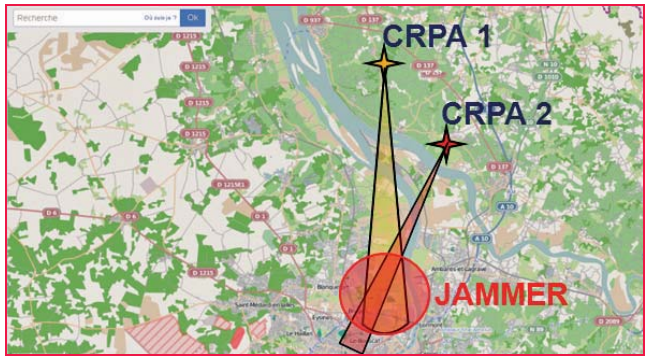


Figure 18: Jammer position representation

interferences have been detected during this period and are illustrated in figures 12, 13, 14, 15 and 16.

The 5 detected interferences in 2014 are summed up in Table 2. Assuming jammer power is 1W, the approximate distance of the jammer from the receiver is 9km for the 2nd and 5th interferences and 2km for the 4th interference.

Future works

The future works envisaged are to detect and also to locate and characterize jammer:

- Power spectrum,
- type of interference: Continuous Wave (CW), Wide Band (WB),
- Duration of the interference,
- Jammer localization,
- Number of jammer.

In order to locate the jammer position, CRPA (Controlled Reception Pattern Antenna) sensors are envisaged. CRPA provides the DOA (Direction Of Arrival) of the jammer.

Thales offers a professional solution to detect jamming of GPS and Galileo frequencies and localize up to 3 sources simultaneously. The solution comprises a digital antenna electronics (DAE) unit, combined with a four-element CRPA, making a versatile solution for any area of usage (see Figure 17).

Table 2: Interference characteristics

	1st	2nd	3rd	4th	5th
Date	10/10	11/8	12/11	12/13	12/13
Time	16h30	10h07	7h46	10h30	11h30
Duration	<10s	10s	10s	50s	50s
Position and speed impact	No	No	Yes(1)	No	No
C/N0 [dB]	N/A	35	N/A	22	33
ΔCAG [dB]	8	7	8	16	9
J estimate* [dBm]	N/A	-95	N/A	-80	-93

(1) Position and speed not available.

* J is estimated at the receiver input from C/N0 and CAG data

Then, jammer localization information is sent to a server in order to provide a representation of the jammer position (as shown in Figure 18).

Conclusion

The present article describes a promising jamming detection solution developed during the HONTZA project. Using this solution, we were able to detect 5 interferences in GPMB during the tests period. When compared to results obtained by other studies which detected up to one hundred events in a month, these results suggest that a fine tuning of detection thresholds is necessary to raise relevant alarms. The solution we propose provides the right alert at the right time and avoids false alarms.

`The next step is to provide the jammer position localization. To do this, CRPA sensors will be integrated in the HONTZA system.

References

[1]: http://www.topos-aquitaine.org/
[2]: www.agi.com

Review of Normalized Difference Vegetation Index (NDVI) as an Indicator of Drought

The present study attempts to review the satellite based Normalized Difference Vegetation Index (NDVI) as an indicator of drought and provide insight into the findings from various research studies that have used NDVI for drought monitoring, detection and assessment

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In remote sensing technology, vegetation indices are considered as a single number that quantifies vegetation biomass for each individual pixel in a remote sensing image. It is basically computed from the spectral bands that are sensitive to biomass and vigor. In other words, they are mathematical transformations usually ratios or linear combinations of reflectance measurements in different spectral bands lying within the visible and near infrared bands (Payero et al., 2003). These indices are used to extract information related to surface characteristics by understanding the spectral differences in the reflectance patterns between green vegetation and other surfaces. Through the years, a number of vegetation indices have been evolved with simple to the most complex band combinations (Perry and Lautenschlager, 1984; Bannari et al. 1995; Payero et al., 2003). Tucker et al. (1979) found that the red (RED) radiance measured above corn and soybean crops decreased as the season progressed, due to increased chlorophyll absorption by increased leaf area index (LAI). The photographic infrared (NIR) radiance, on the other hand, increased with time and LAI. They used five linear combinations of the red and infrared radiance data as radiance normalization techniques to compensate for this variability (Payero et al., 2003). These transformations were later called vegetation indices that includes the Band Ratio (RATIO), Band Difference (DVI), Band Sum (SUM), the Vegetation Index (VI), and the Transformed Vegetation Index (TVI). They found the RATIO, the VI, and the TVI to be the most useful normalization techniques, with preference for the VI. The VI was later called the Normalized Difference Vegetation Index (NDVI) which have become the most widely used vegetation index today. It has been extensively used for assessing and monitoring vegetation dynamics, biomass production, changes in vegetation conditions, soil moisture stress (droughts), carbon sequestration and many more.

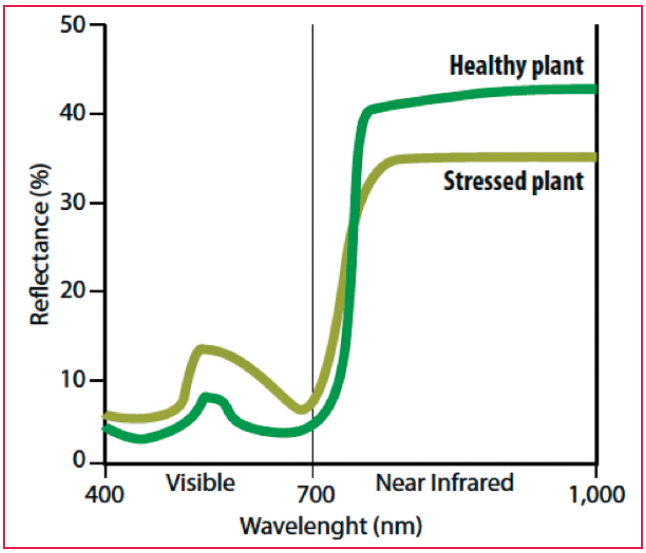

Figure 1: Typical reflectance spectrum of a healthy and a stressed plant (Govaerts and Verhulst, 2010)

However, it is observed that drought monitoring is always a challenge as it is a slow onset natural disaster developing over months and years. The severity of drought also varies depending on precipitation deficit, spatial extent and duration making it difficult to compare one drought with another (Peters et al., 2002). While NDVI has proven useful for timely estimation of vegetation condition, however, it does not allow for relative comparison at a pixel location or time period (Burgan and Hartford, 1993; Kogan, 1995; Peters et al., 2002). NDVI data has been extensively used for more than a decade in classifying vegetation condition. Kogan (1990),

suggested an approach to vegetation condition monitoring based on minimum and maximum NDVI values compiled per pixel over time (Peters et al., 2002). Kogan (1990) states that available moisture and natural resources determine the NDVI minimum while other values, including the historical maximum are determined by the weather (Peters et al., 2002). This NDVI statistical range was then used to develop the Vegetation Condition Index (VCI) which is an indicator of environmental stress. The VCI is NDVI normalized for each pixel on the basis of maximum statistical range over the historical record of available satellite imagery (Peters et al., 2002). With the NDVI playing an important role for agricultural drought monitoring, it is amply felt that a review of NDVI would help provide more insight into how NDVI can be used as an indicator of drought.

Potentiality of Satellite Based NDVI for Drought Monitoring

Development of remotely sensed vegetation indices have been an ongoing process. The basic assumption behind developing such indices is that some algebraic combination of remotely sensed spectral bands can reveal valuable information such as vegetation structure, state of vegetation cover, photosynthetic capacity, leaf density and distribution, water content in leaves, mineral deficiencies and evidence of parasitic shocks or attacks (Yengoh, et al., 2014; Jensen 2007; Liang 2005). The algebraic combinations of these spectral bands needs to be sensitive to one or more of these factors.

NDVI is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum. It is adopted to analyze remote sensing measurements and assess the greenness in the vegetation cover. NDVI has found a wide application in vegetative studies as it has been used to estimate crop yields, pasture performance, and rangeland carrying capacities among others. It is often directly related to other ground parameters such as percent of ground cover, photosynthetic activity of the plant, surface water, leaf area index and the amount of biomass. NDVI was first used in 1973 by Rouse et al. from the Remote Sensing Centre of Texas A&M University.

The NDVI, (Equation 1) is the ratio of the difference between the near-infrared band (NIR) and the red band (R) and the sum of these two bands (Rouse Jr. et al., 1974).

$$NDVI = \frac{NIR-RED}{NIR+RED} \qquad \text{(Equation 1)}$$

where NIR is reflectance in the near-infrared band and RED is reflectance in the visible red band. The NDVI algorithm takes advantage of the fact that green vegetation reflects less visible light and more NIR, while sparse or less green vegetation reflects a greater portion of the visible and less Near-IR. NDVI combines these reflectance characteristics in a ratio so it is an index related to photosynthetic capacity. The range of values obtained is between −1 and +1. Only positive values correspond to vegetated zones; the higher the index, the greater the chlorophyll content of the target (Yengoh, et al., 2014). The use of NDVI is more robust than other indices as many sensors from handheld to satellite provide measurements in the near infrared and the red portion of the electromagnetic spectrum and this holds true as almost all satellites have NIR and RED bands. NDVI has already been extensively used in assessing crop nutrient deficiency, long term water stress, and yield decline in crops (Figure 1).

In terms of drought monitoring, NDVI derived from satellite data can be used to indicate deficiencies in rainfall and assess meteorological and agricultural drought patterns both timely and spatially. Since drought is a slow-onset disaster, therefore, its consequences are immeasurable. NDVI derived from Advanced Very High Resolution Radiometer (NOAA-AVHRR), can calculate the status of vegetation whether healthy, unhealthy or sparse (example: suffering from drought or pest infestations) (Zargar et al., 2011). While NDVI derived from NOAA-AVHRR resolution is high (1 km), it can still cover large areas (Ji and Peters, 2003). Current NDVI algorithms can reduce noise from atmospheric conditions such as clouds and effects of the sun-surface geometry with respect to the sensor. It hence broadly distinguishes vegetated areas from other surfaces. It can measure dryness rather than interpolation or extrapolation (Zargar et al., 2011).

The U.S. Geological Survey's (USGS) Earth Resources Observation and Science (EROS) Center is generating one product called "eMODIS" (U.S. Geological Survey, 2012) based on Moderate Resolution Imaging Spectroradiometer (MODIS) data acquired by the National Aeronautics and Space Administration's (NASA) Earth Observing System (EOS) (Sruthi and Aslam, 2015). The eMODIS NDVI are global datasets at 250 m spatial resolution and available in GEOTIFF format. Using the NDVI data, the changes in vegetation cover in an area along with the trend in occurrence of agricultural drought can be studied (Sruthi and Aslam, 2014). Their study concluded that NDVI due to its simple calculation is largely used for vegetation studies at the regional and global scale. However, it is always advised to combine NDVI along with other parameters to get better results.

Researchers at the National Drought Mitigation Center (NDMC), University of Nebraska-Lincoln has been extensively working on drought monitoring in the United States and they have found that remote sensing has proven to be a useful tool for large vegetation monitoring given the synoptic coverage, high temporal repeat cycle and continuous, moderate resolution observations of satellite based sensors. Researchers at NDMC stated that analysis of time-series NDVI data and NDVI-derived metrics have been an effective means for identifying vegetation condition anomalies such as apparent declines in vegetation health. NDMC has come up with a new drought monitoring tool called the Vegetation Drought Response Index (VegDRI) that integrates satellite based NDVI observations, climate-based drought index data, and several biophysical characteristics of the environment to produce an indicator that expresses the level of drought stress on vegetation. The VegDRI uses concepts from remotely sensed NDVI and climate based drought index approaches to produce 1 km resolution maps that characterizes

the intensity and spatial patterns of drought induced vegetation stress over large areas. The NDVI maps at 1 km resolution provides information on spatial patterns of vegetation which are analyzed by combining dryness information from climate based drought index data to provide the intensity and spatial extent of drought conditions. VegDRI was developed through a collaborative research between the National Drought Mitigation Center (NDMC) and USGS Earth Resources Observation and Science (EROS) Center and its aim is to provide near-real time information as a national drought monitoring tool for United States. The index uses eMODIS NDVI composites while climate-based drought data include the Palmer Drought Severity Index (PDSI) and weekly Standardized Precipitation Index (SPI) data from the High Plains Regional Climate Center (HPRCC).

Further studies have shown that NDVI has been a good indicator of drought. Studies conducted by Owrangi et al., 2011 put forward a fast, efficient and reliable method for producing drought maps from NOAA-AVHRR and comparing it with SPOT vegetation maps which confirms that SPOT vegetation maps can be used as a reliable substitutes for any missing or cloudy NOAA-AVHRR data. The Drought Severity Index (DSI) maps derived from NDVI maps showed reasonable vegetation cover during the years which confirms rational yields. Singh et al. (2003) used NDVI, Vegetation Condition Index (VCI) and Temperature Condition Index (TCI) to monitor droughts as well as estimate vegetation health. In their research, they used both vegetation and temperature condition indices to monitor droughts in India. The NDVI derived from NOAA-AVHRR has been extensively used in vegetation monitoring, crop yield forecasting and drought detection and mapping. The ability to use AVHRR data for drought detection and mapping is based on the higher reflectance generated from moisture stressed vegetation (Unganai and kogan, 1998). According to their research, it is found that NDVI has two characteristics that make it ideal for vegetation monitoring one being that no other surface exhibits higher NDVI values than vegetated surfaces and the second being when vegetation vigor changes due to the nature of the vegetation growth and development cycle or environment induced stress such as drought, that makes the NDVI to change. This gives NDVI its potential for drought detection and mapping as well as climate impact assessment (Unganai and kogan, 1998). Studies conducted to evaluate NDVI and Normalized Difference Water Index (NDWI) for vegetation drought monitoring suggest that continued evaluation of NDVI and NDWI for vegetation drought monitoring using ground observations is crucial to better understand how these indices respond to soil moisture fluctuations leading to drought stress on plants (Gu et al., 2008). Results from the study showed that NDVI and NDWI were found to have comparable sensitivities to soil moisture fluctuations as expressed by Fractional Water Index (FWI) and that both can be used for vegetation drought monitoring. It also further showed that relationship between satellite-derived vegetation indices and soil moisture is highly dependent on the land cover heterogeneity and soil type while in case of homogeneous vegetation cover, both NDVI and NDWI were sensitive to changes in soil moisture which are strongly related to vegetation drought conditions. NDVI and NDWI both exhibited similar relationships with FWI variations, suggesting that both indices are appropriate for monitoring drought stress on vegetation.

Thenkabail et al., 2004 also investigated the historical pattern of droughts in the Southwest Asia using monthly time series NOAA-AVHRR data for 1982-1999. They developed the regression relationships between the drought-related indices obtained from MODIS and NOAA-AVHRR data having different pixel resolution and optical characteristics. This has resulted in the development of a MODIS-AVHRR based drought reporting system. The goal is to make the system available via internet to all stakeholders in the region that includes government agencies, NGO's, research institutions and global research community. The system can be used both as a drought monitoring and decision support tool in regional drought assessment and management. The NDVI data was used to understand the severity of a drought on the basis of its extent of wetness. It was also observed that the departure from the long term mean NDVI is effectively more than just a drought indicator as it also reflects vegetation conditions based on normal and wet months per year. The historical drought interpretation carried out further suggest that the extent of negative deviation of NDVI from its long term mean for a pixel, district or region and the duration of continuous negative deviations are the powerful indicators of the drought magnitude and persistence. Figure 2 shows the long term normal NDVI conditions and relative to it, the driest (1987) and the wettest (1993) years NDVI value for each month for the targeted study area (Thenkabail et al., 2004).

Sharma, 2006 used spatial data mining techniques for drought monitoring in the Karnataka state of India. The study used rainfall data from 1970-2004 to compute Standardized Precipitation Index (SPI) and NOAA-AVHRR NDVI for the period 1981-2003 to calculate Vegetation Condition Index (VCI). The study concluded that NOAA-AVHRR NDVI data has been widely used for drought monitoring and detection effectively and efficiently. NDVI times-series data was used to calculate Vegetation Condition Index (VCI) to estimate the vegetation health and monitor drought. SPI derived drought values were compared with that of VCI for effective drought monitoring. This led to the conclusion that integration and analysis of drought identified areas from SPI and VCI can help in correctly identifying the region affected by drought. The study also observed that rainfall/ SPI and NDVI generally have positive correlations in the study area while data mining technique through association rule was possible to extract the temporal and spatial pattern of drought from 1993-2003 by identifying the relations between climatological and meteorological data.

Scientist from the National Aeronautics and Space Administration (NASA), calculated average NDVI values for an area to find out what is normal at a particular time of year as NDVI images can measure drought when

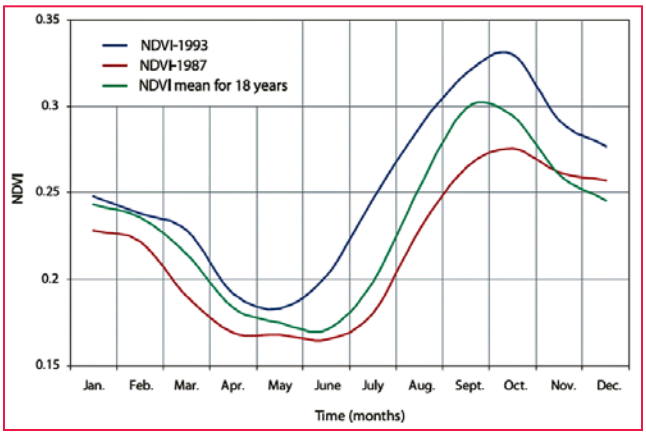

Figure 2: A monthly NDVI time series for a drought year (1987) and a wet year (1993) compared to the NDVI long-term mean (Thenkabail et al., 2004).

compared to normal plant health. This data was measured by the vegetation instrument on Europe's SPOT satellite provided by Digital Globe/SPOT, under the agreement with the U.S. Department of Agriculture Foreign Agricultural Service (USDA/FAS). According to NASA, a region's absorption and reflection of photosynthetically active radiation over a given time period can be used to characterize the health of the vegetation, relative to the norm (NASA Earth Observatory). Therefore, all these information shows the coherency of NDVI during drought period and its potential to serve as an important indicator of drought.

Application of NDVI for Drought Early Warning: A Famine Early Warning System Network (FEWS NET) of East Africa

Generally, vegetation shows a lagged response to drought because of the delayed vegetation response to developing rainfall deficits due to residual moisture stored in the soil (Thenkabail et al., 2004; Senay et al., 2015). Studies have revealed that vegetation response to water stress occurs in two phases: first, the vegetation responds to the initial short-term/temporary depletion of precipitation/soil moisture through plant water conserving mechanisms that would reduce plant water loss (mostly by transpiration) by the closure of stomata (Maselli et al., 2009; Senay et al., 2015) which does not show any external signs of stress as plant biomass is not reduced. However, if there is an extended period of precipitation deficit, it results in reduced photosynthesis leading to reduction in vegetation condition (Maselli et al., 2009; Senay et al., 2015). Such vegetation conditions (drought impact) can be monitored by satellite data through the use of various indices.

The Famine Early Warning System Network (FEWS NET) developed by Senay et al., 2015, uses maximum value composites of NDVI (Figure 3). FEWS NET uses NDVI generated from MODIS known as eMODIS and respond to the operational land monitoring applications that requires near real time NDVI data to compare with the historical data. A time series smoothing technique developed by Swets et al., 1999 was used to smooth the NDVI composites (Senay et al., 2015). The smooth time series was used to derive a 10 year mean NDVI on a pixel-by-pixel basis for a 72 composite period considered per year. This is followed by deriving the NDVI deviations from the 10 year dekadal average and the previous dekads produced for each period. The NDVI anomaly isoloates the variability in the vegetation signal and establishes the historical context for the present NDVI to determine relative drought severity (Anyamba and Tucker, 2012; Senay et al., 2015). The NDVI anomaly, also has the ability to identify any negative anomaly over large areas. Therefore, any small scale changes in land cover did not affect the use of NDVI anomaly for drought monitoring.

The NDVI anomaly used in East Africa was capable of detecting drought conditions since larger regions differs in hydro-climatic conditions with varying rainfall patterns and vegetation cover. The findings from the study suggest that northeastern Tanzania is at greater drought risk than the dry part of northern Sudan despite having low NDVI.

The FEWS NET is a decision support system that provides model derived agro-hydrologic products for drought monitoring such as Crop Water Satisfaction Index (CWSI) or Water Requirement Satisfaction Index (WRSI), Soil Moisture Index (SMI), Evapotranspiration (ET) anomalies and pond water levels. These models are based on the physical principles of energy and mass (water) conservation equations (Senay and Verdin, 2003; Senay et al., 2013a, b; Senay et al., 2015).

FEWS NET Short Term Drought Bulletin

FEWS NET food security analysts rely on a convergence of evidence to make drought and food security assessments (Rowland et al., 2005; Senay et al., 2015). Based on the information generated from multiple indicators, FEWS food security analysts at the NOAA Climate Prediction

Figure 3: The user interface of the Famine Early Warning System Network (FEWS NET) (Source: http://www.fews.net/)

Center (CPC) produce hazard outlooks on a weekly basis. These outlooks serve as short-term drought bulletins distributed to the regional and national partners for efficient hazard management. The hazard outlook maps are generally based on current weather and climate conditions synthesized from multiple indicators.

Need for Crop Monitoring

It is always important to obtain crop condition information during the crop growing season. Sometimes it is even more important than acquiring the exact production after harvest time. Therefore, along with the development of remote sensing applications, satellite data has become the uppermost data source to monitor large-scale crop condition. During the last two decades, various remote sensing methods have been used to monitor crop conditions which has resulted in not only minimizing the crop losses but has also improved the systems adequately. Direct crop monitoring methods with remote sensing indices such as NDVI or other vegetation indices have been adding values in minimizing the risk to the agricultural sector from natural hazards such as droughts and floods. Time series NDVI data have been used during the cropping seasons and deriving the crop growth profiles from the NDVI statistics at the required scales. While satellite data with high frequency and low spatial resolution is still the main source of data, the method of crop condition monitoring with remote sensing data is also developing over the years from qualitative monitoring to quantitative monitoring; development of more and more vegetation indices and the extensive use of NDVI and NDWI to increase the monitoring precision.

References

Anyamba, A. and Tucker, C.J. (2012). Historical Perspective of AVHRR NDVI and Vegetation Drought Monitoring. *Remote Sensing*, Drought: Innovative Monitoring Approaches, 23.

Bannari, A., Morin, D., Bonn, F. and Huete, A.R. (1995). A Review of Vegetation Indices. *Remote Sensing Reviews*, 13 (1): 95-120.

Burgan, R.E. and Hartford, R.A. (1993). Monitoring Vegetation Greenness with Satellite Data. Gen. Tech. Rep. INT-297, US Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, Utah, 13 p.

Gu, Y., Hunt, E., Wardlow, B., Basara, J.B., Brown, J.F. and Verdin, J.P. (2008). Evaluation of MODIS NDVI and NDWI for Vegetation Drought Monitoring Using Oklahoma Mesonet Soil Moisture Data. *Geophysical Research Letters*, 35: L22401. DOI: 10.1029/2008GL035772, 2008.

Jensen, J. (2007). Remote Sensing of the Environment. Pearson Prentice Hall.

Ji, L. and Peters, A. (2003). Assessing Vegetation Response to Drought in the Northern Great Plains using Vegetation and Drought Indices. *Remote Sensing*

Environment, 87 (1): 85-98. DOI: 10.1016/S0034-4257 (03)00174-3.

Kogan, F.N. (1990). Remote Sensing of Weather Impacts on Vegetation. *International Journal of Remote Sensing*, 11: 1405-1419.

Kogan, F.N. (1995). Droughts of the Late 1980s in the United States as Derived from NOAA Polar Orbiting Satellite Data. *Bulletin of American Meteorological Society*, 76: 655-668.

Liang, S. (2005). Quantitative Remote Sensing of Land Surfaces. John Wiley & Sons.

Maselli, F., Papale, D., Puletti, N., Chirici, G., Corona, P. (2009). Combining Remote Sensing and Ancillary Data to Monitor the Gross Productivity of Water-Limited Forest Ecosystems. *Remote Sensing of Environment*, 113 (3): 657-667.

NASA Earth Observatory: NDVI as an Indicator of Drought. http://earthobservatory.nasa.gov/Features/MeasuringVegetation/measuring_vegetation_3.php

Owrangi, M.A., Adamowski, J., Rahnemaei, M., Mohammadzadeh, A. and Sharifan, R.A. (2011). Drought Monitoring Methodology Based on AVHRR Images and SPOT Vegetation Maps. *Journal of Water Resource and Protection*, 3: 325-334. DOI:10.4236/jwarp.2011.35041

Payero, J.O., Neale, C.M.U. and Wright, J.L. (2003). Comparison of Eleven Vegetation Indices for Estimating Plant Height of Alfalfa and Grass. *Applied Engineering in Agriculture*, 20 (3): 385-393.

Perry, C. R., and L. F. Lautenschlager (1984). Functional Equivalence of Spectral Vegetation Indices. *Remote Sensing of Environment*, 14 (1-3): 169-182.

Peters, A.J., Walter-Shea, E.A., Ji, L., Vina, A., Hayes, M. and Svoboda, M.D. (2002). *Photogrammetric Engineering & Remote Sensing*, 68 (1): 71-75.

Rouse, J.W., Haas, R.H., Schell, J.A. and Deering, D.W. (1974). Monitoring Vegetation Systems in the Great Plains with ERTS, Third ERTS Symposium, NASA SP-351, pp. 309-317.

Rowland, J., Verdin, J., Adoum, A. and Senay, G., (2005). Drought Monitoring Techniques for Famine Early Warning Systems in Africa. In: Boken, V.K., Cracknell, A.P., Heathcote, R.L. (Eds.), Monitoring and Predicting Agricultural Drought: A Global Study. Oxford University Press, New York, pp. 252-265.

Sharma, A. (2006). Spatial Data Mining for Drought Monitoring: An Approach Using Temporal NDVI and Rainfall Relationships. M.Sc. Thesis. Faculty of Geoinformation Science & Earth Observation (ITC), University of Twente, The Netherlands.

Senay, G.B., Velpuri, N.M., Bohms, S., Budde, M., Young, C., Rowland, J. and Verdin, J.P. (2015). Drought Monitoring and Assessment: Remote Sensing and Modeling Approaches for the Famine Early Warning Systems Network. *USGS Staff -- Published Research*. Paper 858. http://digitalcommons.unl.edu/usgsstaffpub/858.

Senay, G.B., Bohms, S., Singh, R.K., Gowda, P.H., Velpuri, N.M., Alemu, H. and Verdin, J.P., (2013a). Operational Evapotranspiration Mapping Using Remote Sensing and Weather Datasets: A New Parameterization for the SSEB Approach. JAWRA *Journal of American Water Resources Association*, 49 (3): 577-591.

Senay, G.B., Velpuri, N.M., Alemu, H., Pervez, S.M., Asante, K.O., Kariuki, G., Taa, A. and Angerer, J. (2013b). Establishing an Operational Waterhole Monitoring System Using Satellite Data and Hydrologic Modelling: Application in the Pastoral Regions of East Africa. *Pastoralism*, 3 (1): 1-16.

Senay, G.B. and Verdin, J., (2003). Characterization of Yield Reduction in Ethiopia Using a GIS-Based Crop Water Balance Model. *Canadian Journal of Remote Sensing*, 29 (6): 687-692.

Singh, A., McIntyre, L. and Sherman, L. (2003). Microarray Analysis of the Genome-Wide Response to Iron Deficiency and Iron Reconstitution in the Cyanobacterium Synechocystis sp. PCC 6803. *Plant Physiology*, 132 (4): 1825-1839. DOI:10.1104/pp.103.024018.

Sruthi, S. and Aslam, M.A. (2015). Agricultural Drought Analysis Using the NDVI and Land Surface Temperature Data: A Case Study of Raichur District. *Aquatic Procedia*, 4: 1258-1264.

Sruthi, S. and Aslam, M.A. (2014). Vegetation Stress Analysis Using NDVI at Drought Prone Raichur District, Karnataka. IWRM International Symposium (IWRM2014).

Swets, D.L., Reed, B.C., Rowland, J.D. and Marko, S.E. (1999). A Weighted Least-Squares Approach to Temporal NDVI Smoothing. In: 1999 ASPRS Annual Conference: From Image to Information, Portland, Oregon, May 17-21. Proceedings: Bethesda, Maryland. American Society for Photogrammetry and Remote Sensing.

Thenkabail, P.S., Gamage, M.S.D.N. and Smakhtin, V.U. (2004). The Use of Remote Sensing Data for Drought Assessment and Monitoring in Southwest Asia. *Research Report 85*. Colombo, Sri Lanka: International Water Management Institute.

Tucker, C. J. (1979). Red and Photographic Infrared Linear Combinations for Monitoring Vegetation. *Remote Sensing of Environment*, 8(2): 127-150.

Unganai, L.S. and Kogan, F.N. (1998). Drought Monitoring and Corn Yield Estimation in Southern Africa from AVHRR Data. *Remote Sensing of Environment*, 63: 219-232.

Yengoh, G.T., Dent, D., Olsson, L., Tengberg, A.E. and Tucker, C.J. (2014). The Use of the Normalized Difference Vegetation Index (NDVI) to Assess Land Degradation at Multiple Scales: A Review of the Current Status, Future Trends, and Practical Considerations. *Lund University Center for Sustainability Studies (LUCSUS), and the Scientific and Technical Advisory Panel of the Global Environment Facility (STAP/GEF)*.

Verhulst, N. and Govaerts, B. (2010). The Normalized Difference Vegetation Index (NDVI) GreenSeekerTM Handheld Sensor: Toward the Integrated Evaluation of Crop Management. Part A: Concepts and Case Studies. Mexico, D.F.; CIMMYT.

Zargar, A., Sadiq, R., Naser, B. and Khan, F.I. (2011). A Review of Drought Indices. *Environmental Reviews*, 19: 333-349.

GLONASS-K starts providing service

For the first time, a GLONASS-K next-generation satellite has begun providing on-orbit services for Russia's GNSS system.

Launched December 1, 2014, the spacecraft began regular broadcasts on February 15, transmitting on channel –6 from its orbital location in plane 2, slot 9 of the GLONASS constellation.This GLONASS-K satellite was built around an unpressurized platform, has a mass of 974 kilograms, an electric power supply system's capacity of 1600 watts, and a design for a 10-year lifespan. It transmits five navigation signals in the GLONASS L1, L2, and L3 bands. The satellite also carries a COSPAS-SARSAT payload supporting the international satellite-based search and rescue system. Over the longer term, GLONASS-K satellites are expected to considerably improve the characteristics and capabilities of the GLONASS system, including the transmission of CDMA civil signals. The new-generation satellites will gradually replace the GLONASS-M series that currently form the backbone of the system's orbital constellation.

ICAO Remains Concerned about Russian GLONASS Mandate

The International Civil Aviation Organization continues to be concerned about Russia's plan to require that its GLONASS satellite navigation equipment be installed on certain aircraft starting in 2017. Russian- and non-Russian-built aircraft, including those registered abroad and put onto an operator's certificate issued by the Russian Federation, weighing more than 12,500 pounds (5,700 kg) mtow and used for commercial transportation will be required to install GLONASS by Jan. 1, 2017. That deadline is Jan. 1, 2018, for general aviation aircraft.

According to a 2012 ICAO Working Paper, still the current ICAO thinking, the mandate is imposing new requirements on non-Russian-certified operators, including operators certified by the U.S., although the Russian Federation says it does not have the intention of prohibiting the use of other constellations in Russian airspace. Because there are currently no international standards for such equipment, it will be "extremely difficult" for airframe manufacturers to develop certified receivers and install them on foreign-manufactured aircraft by 2017, ICAO said. *www.ainonline.com*

New GPS satellite begins transmitting to users around the globe

Air Force ground controllers have activated service aboard the newest GPS satellite, achieving that milestone for the final spacecraft in a dozen built in a manufacturing batch to update the constellation. The GPS 2F-12 craft was launched into the navigation network from Cape Canaveral atop a United Launch Alliance Atlas 5 rocket on Feb. 5. It underwent testing and checkout before being "set healthy" by operators at Schriever Air Force Base, Colorado. The satellite was the final one to be launched in a series known as the Block 2F, built by Boeing, with additional signals, improved accuracy, better anti-jamming and longer design lives. The next launch for the program will be the first GPS 3 satellite in 2017. *https://spaceflightnow.com*

GNSS Applications in European Rail Network

The European Space Agency (ESA) has launched a new initiative to support space-based enhancements to Europe's railway network.

Space4Rail will highlight ESA funding programs that could support the use of GNSS in rail applications while raising awareness of the added value that space systems can deliver. GNSS is already being employed within the rail network to monitor trains and check the integrity of rail infrastructure, and ESA, as a research and development agency, has various programs dedicated to supporting such activities. Space4Rail has been set up as a one-stop shop for the rail industry to learn about the agency and facilitate the submission of proposals for partnerships. ESA offers financial and technical support to projects – including access to its specialists and agency laboratories – while acting as a broker between the space industry, the railway industry, and service providers.

3D Laser Mapping Provide the solution for monitoring coastal instability

Durham University purchased SiteMonitor4D to better understand the process of coastal erosion as part of a KTP (Knowledge Transfer Partnership) project, funded by Innovate UK. The project focussed on monitoring the rock faces on the North Yorkshire coast in the UK, near the historic town of Whitby and uses both airborne laser scanning and terrestrial laser scanning to collect the data.

For the airborne surveys, 'StreetMapperIV' was chosen, and was mounted onto a helicopter to perform the job. Terrestrial laser scanning is used with automated analytical software gave a continuous and frequent capture of data. *www.3dlasermapping.com/streetmapper/*

Jason 3 satellite begins surveying world's oceans

Three months after its foggy blastoff from California on a Falcon 9 rocket, a $364 million oceanography satellite has returned the first data from its radar altimeter mapping global sea levels, catching this year's ongoing El Niño in the act.

Engineers are still calibrating the Jason 3 spacecraft's altimeter instrument, but the satellite is already collecting information on the height and roughness of the world's oceans after its Jan. 17 liftoff.

The Jason 3 mission, a joint project managed by U.S. and European weather agencies, will track rising sea levels caused by climate change, help predict the intensity of tropical cyclones, and aid in the forecasting of global weather patterns. *https://spaceflightnow.com*

Isro, Indian Railways to Sign MoU for Remote Sensing

An MoU has been signed between Railways and ISRO, under Department of Space, for developing applications in the field of remote sensing and GIS.

The MoU will enable use of space technology tools in providing passenger information for all trains, indicating next

Galileo update

Septentrio awarded AiRobot

Septentrio, designer and manufacturer of GNSS solutions recently awarded the winners of the Galileo Masters (Flanders Challenge) of the European Satellite Navigation Competition 2015 a special prize of the AsteRx-m UAS receiver for demonstrating the most innovative use of high precision GNSS positioning for their project: "UAV Flight Path Learning through GNSS ".

The judging panel were impressed with AiRobot's Sense and Avoid technology outlined in their proposal. The AsteRx-m UAS GNSS module ensures accurate and robust location information when executing waypoint flying. The sensing technology enables the UAV to create a temporary map of its surroundings ensuring that it will not collide with objects in its path. These combined technologies form a solution permitting safe and efficient horizontal flying in professional working environments.

AiRobot's Sense and Avoid technology compliments their Ranger technology which was developed in conjunction with IMEC - a world leading researcher of nanoelectronics. Ranger is already known in the Benelux region (Belgium, The Netherlands and Luxembourg) for increasing safety, productivity and quality of professional UAV operations.

Ground-based Galileo satellite joins post launch dress rehearsal

The navigation satellite set to become the 16th in the Galileo constellation has been taken through a Europe-wide rehearsal for its launch and early operations in space.

Sitting in the cleanroom environment of ESA's ESTEC technology centre in Noordwijk, the Netherlands, the satellite was recently linked to a trio of sites across the continent: the Galileo control centres in Fucino, Italy and Oberpfaffenhofen, Germany, as well as ESA's ESOC operations centre in Darmstadt, Germany.

"These System Compatibility Test Campaigns (STSCs) occur on a regular basis," explained Liviu Stefanov, lead Flight Operations Director for the next Galileo launch in May.

"Last December saw a campaign using one of the two Galileo satellites due to be launched in May, while our February rehearsal used another satellite from the quadruplet being launched by Ariane 5 later this year.

"So with this most recent task, we have reached a frequency of three system tests in less than four months."

A joint team from ESA and France's CNES space agency oversee Galileo's Launch and Early Operations Phase (LEOP) – the initial switching on and checking and configuration of satellite systems. LEOP is run from either ESOC or CNES Toulouse, on an alternating basis.

ESOC will host the LEOP team for the next launch of two Galileo satellites by Soyuz from French Guiana in May. Then the team will switch to Toulouse for the first launch of four Galileo satellites by Ariane 5, scheduled for this autumn.

station/stoppage, real-time train-tracking, survey of new rail route alignments particularly in hilly and difficult terrains. It will also aid in conducting track vulnerability studies, mapping of assets, audio-visual warning to road users at unmanned level crossing gates and introduction of web-enabled rail user-centric services. *http://gadgets.ndtv.com*

ESA agrees to share Sentinel data with Geoscience Australia

ESA and Australia's national geological survey, Geoscience Australia, have agreed to cooperate to ensure data from the EU's Sentinel satellites are accessible in Southeast Asia and the South Pacific. The agreement supports the Australian government and European Commission's partnership to ensure the EU's Copernicus Earth observation programme benefits their citizens and the broader international community.

A key component of the cooperation will be the establishment of a regional data access and analysis hub managed by Geoscience Australia (GA). This hub will greatly improve access to Copernicus data in a region which is densely populated and experiencing high rates of economic growth, but which faces significant challenges in areas where Earth observation can help. These challenges include the protection of environmental assets, promotion of sustainable natural resource development and risk reduction from natural disasters.

DigitalGlobe awards contracts worth millions of dollars to MDA

DigitalGlobe has awarded two contracts worth several million dollars to MacDonald, Dettwiler and Associates. The contract has been awarded to provide new ground station solutions to two international customers.

The ground stations will receive and process imagery and data from DigitalGlobe's satellite constellation, and are also configurable to receive and process data from the RADARSAT-2 Synthetic Aperture Radar satellite, enabling future integration of electro-optical and radar imagery capabilities.

Now declaration of drones mandatory when entering India

The Government of India has amended the Customs Baggage Declaration regulations to make it mandatory to declare drones in customs forms, for people coming to India. The regulation has come into force 1st of April onwards.

Users carrying drones will have to fill further forms at the red channel, where the item might either be deemed ineligible for entry in India, or have a duty imposed upon it. Note that carrying drones on person was one of the last ways Indian enthusiasts could lay their hands on drones. The custom office has regularly held back or destroyed drone shipments citing that they are a threat to security and are banned from flying in India. *www.medianama.com*

7 million drones by 2020? US projects explosive UAV growth

The number of drones in the US is expected to triple by 2020. According to the Federal Aviation Administration (FAA), a staggering seven million drones will litter American skies in the next three years.

"Unmanned aircraft systems will be the most dynamic growth sector within aviation," the FAA said in its annual forecast for the unmanned aerial sector. The agency also projects the number of drones to reach 2.5 million by the end of 2016. The biggest contributor to this increase will be the consumer drone sector, with purchases there accounting for 1.9 million units by the end of this year. It is estimated that hobbyist unmanned aerial vehicles (UAVs) will account for 4.3 out of the seven million total drones by 2020.

Experts disagree on what implications any impending legal limitations will have on sales and fleet size. One thing is certain: The drone sector will undergo numerous changes in technology, regulations and pricing. The FAA was finding it tough for its legal guidelines to keep up with the constantly evolving technology, but in December issued new regulations requiring any UAV weighing more than .55 pounds (250 grams) and less than 55 pounds (25kg) to be registered.

"This registration rule will aid in investigations and allow the FAA to gather data," the agency said, promising to release a final version of the updated regulations.

The preliminary version has already had substantial effect: Registration of privately owned drones has jumped from 180,000 in early January to nearly 400,000 after the February 1 deadline. Rising UAV numbers have been associated with all kinds of problems, including dangerous encounters where a drone may collide with ascending or descending aircraft. There are also privacy implications of the mini-drone voyeurism fever that has gripped the US.

The more drones are out there, the harder it is to track them. So the FAA has been working to develop its NextGen program to meet the demands of dealing with drones. It seeks to implement newer radar technologies and procedures involving satellite-based aircraft monitoring, and to slowly phase out the aging ground-based systems. *https://www.rt.com*

New Russian law obliges to register drones

"On introducing amendments to the Air Code of the Russian Federation regarding the use of unmanned aerial vehicles" is coming into force on March 30, 2016.

The document regulates the use of UAVs, or drones, and aims to increase the general level of aviation security. In connection with the great popularity of drones and the expansion of their scope of use, the need arose to specify certain provisions of the Air Code of the Russian Federation, as well as to establish a government UAV database.

According to the document, all UAVs whose maximum takeoff mass is equal to or exceeds 250 grams are subject to registration. Thus, the law covers even radio-controlled aircraft mockups and children's toys. Registration of UAVs is not described in the law and will be regulated by an additional resolution of the government of the Russian Federation. In line with the resolution, there are plans to vest the Russian Federal Security Service (FSB) with the functions of UAV registrar. *www.suasnews.com*

3D Robotics ropes in Autodesk to develop a UAV-to-cloud system

Drone manufacturer 3D Robotics has joined hands with Autodesk and Sony to develop a UAV-to-cloud system that can be used for construction, telecom, survey, mapping, energy and infrastructure workers. Once developed, the system will be able to scan the terrain in 3D and will simultaneously create detailed 3D models. *3ders.org*

Juniper releases flight management software for UAV

Juniper Unmanned released its flight management software solution, Sparrow. The system is designed to support commercial UAS program operations. Sparrow provides a shared operational picture of a commercial UAS program by placing tracking, management and reporting at your fingertips. Sparrow's web-based portal features an intuitive dashboard and provides a real-time summary of your aircraft, flight crews, and overall mission readiness.

Malawi tests UAV flights for early HIV diagnosis in infants

The Government of Malawi and UNICEF have started testing the use of UAVs to explore cost-effective ways of reducing waiting times for HIV testing of infants. The test, which is using simulated samples, will have the potential to cut waiting times dramatically, and if successful, will be integrated into the health system alongside others mechanisms such as road transport and SMS.

The first successful test flight completed the 10km route unhindered travelling from a community health centre to the Kamuzu Central Hospital laboratory. Residents watched as the vehicle took off and flew away in the direction of the hospital. UAVs have been used in the past for surveillance and assessments of disaster, but this is the first known use of UAVs on the continent for improvement of HIV services.

FARO 3D cloud-based data management

FARO Technologies, Inc. has released version 2.0 of its well-known web hosting service, SCENE WebShare Cloud. It is the first cloud-based software unleashing the power of fluid 3D viewing of 3D laser scan data within a simple and easy-to-use website. For applications within the fields of BIM, architecture, and construction information management (CIM), user-friendly access to reliable as-is information of buildings, plants and construction sites is essential. Users also need immediate access to this data at the office, on the job-site or in transit. *www.faro.com/webshareclоud/in*

Chandigarh, India to prepare GIS-based master plan

Deciding on land use and planning is set to become easier with the Department of Urban Planning of the Chandigarh Administration planing to prepare the city's master plan using the GIS. The department will convert the existing master plan into a new one using the GIS technology under the plan. The recently approved master plan documents aspects of land use and future planning using paper. But under the new plan, it will be available through digital maps.

The GIS-based master plans will help in urban planning exercises in developing utilities and infrastructure on a zonal basis. All this will be done using IT tools. This will also help planners know the details at a click of the mouse. *www.tribuneindia.com*

Haryana to use 'Udaan' project for detailed digital mapping

With a view to improving urban planning in an Indian state, Haryana government has decided to use experience gained through 'Udaan' pilot project, carried out in Sohna tehsil of Gurgaon, for detailed digital mapping of all the cities. The aim of the pilot project is to improve urban planning and assist administration through the use of modern technology. Under the project, images with resolution of 5 centimetres have been acquired using UAV.

The state government was also developing a geo-portal under the Haryana Spatial Data Infrastructure (HSDI) project, in collaboration with Bhaskaracharya Institute for Space Applications and Geo-Informatics (BISAG), Gandhinagar, Gujarat to make available geo-spatial data to all the departments for their planning needs. *http://articles.economictimes.indiatimes.com*

Pitney announces premium G-NAF solution for businesses in Australia

The National Science and Innovation Agenda (NISA) department of the Government of Australia has publicly released the Geocoded National Address File (G-NAF), which was made available on their website on 26 February 2016. In line with this, Pitney Bowes has announced its premium Geocoding solutions for businesses in Australia. The G-NAF provides comprehensive national address file information for all of Australia. Pitney Bowes' location intelligence technology builds on this, taking the complex structure of G-NAF data and transforming it into a dynamic geocoding solution for a range of industries.

HIPS and SIPS™ 9.1 by Caris

CARIS has announced the release of HIPS and SIPS™ 9.1. This new version includes an alternative method of processing backscatter data which produces high quality mosaics and is based upon industry-recognized algorithms and techniques.

The SIPS Backscatter engine is a single additional step at the end of a traditional multi-beam bathymetry workflow. It is a fresh approach to acoustic imaging by considering both the geometric and radiometric aspects in order to get a fully processed imagery mosaic. It also factors in environmental conditions as well as seafloor topography in the computation. The user can also choose to apply an Angle Varying Gain correction for angular sediment response. In a user friendly way, this new mosaic creation method has been implemented into the standard HIPS and SIPS workflow, with many of the required parameters being captured directly from raw data files. *www.caris.com*

Spectra FOCUS 35 in Night time Topographic Survey

When a topographic survey for the main runway of the East Midlands International Airport was performed during nighttime closure, the Spectra Precision FOCUS 35 robotic total station turned in a stellar performance. Through cold November windy and rainy nights, with no task lighting permitted, the FOCUS 35 total station performed efficiently and flawlessly tracking the prism to 200 meters and beyond to help keep the project on time.

The runway topographic survey of 4,000 points was taken at 7.5m intervals longitudinally and at set locations across the tarmac. The set locations were predefined and uploaded as AutoCAD DXF onto the field controllers prior to commencing the survey. The positions were then located onsite and surveyed in the map screen to ensure the correct location was surveyed. *www.spectraprecison.com*

Poland Chooses MobileMapper 300

The agency responsible for the supervision and control of European Union agricultural subsidies in Poland, the Agency for Restructuring and Modernization of Agriculture (ARMA), has purchased 118 Spectra Precision MobileMapper 300 smart antennas. GPS/GLONASS/SBAS L1/L2 receiver specifically is designed to be combined with a variety of mobile devices, including smart phones and tablets, running any third-party GIS application. ARMA is charged with verifying, through on-the-spot measurement of planted areas during the growing season, that the size of the declared cultivation and cultivated plant species are in line with the request for EU subsidies. The farms are selected for spot checks either randomly or through risk analysis.

The MobileMapper 300 was selected by ARMA because it enabled the agency to choose their preferred tablet solution, the Getac V110, and interface with their

Vexcel Holdings GmbH, Graz, acquires Microsoft's UltraCam Business Unit

Vexcel Imaging GmbH, Microsoft's UltraCam Business Unit, is undergoing an ownership change planned for early March 2016. After ten years contributing to Microsoft as a subsidiary, next month Vexcel Imaging GmbH will again become an independent company upon its expected acquisition by a private investor group.

The new owner will be Vexcel Holdings GmbH in Graz. Following is an interview with Wiechert Alexander CEO of Vexcel Imaging

Please explain the structure of the newly formed Vexcel Imaging GmbH.

Vexcel Imaging GmbH has been under the ownership of Microsoft Corp since the acquisition of the Vexcel companies on May 3, 2006. On March 11, 2016 a share purchase agreement was reached and the ownership of Vexcel Imaging GmbH moved to a newly founded Holding company in Graz, Austria. But these are just the legal details. Of more importance is that behind the Holding company are four private persons who are Erik Jorgensen, former Microsoft Corp. Vice President, Stephen Lawler former BING CTO, Martin Ponticelli who continues to be the CTO of Vexcel Imaging, and myself, continuing as the CEO of Vexcel Imaging. So literally, Vexcel Imaging GmbH is now owned by Erik, Stephen, Martin and myself.

Besides that, little has changed. Vexcel Imaging GmbH, itself, carries on as it was and the business scope remains unchanged with a strong commitment to outstanding UltraCam and UltraMap products for aerial and terrestrial markets and applications. The internal organization of Vexcel Imaging has not changed--we continue to have three units: operations (lead by myself), development (lead by Martin) and application (lead by Michael Gruber).

Does this new entity bring any enhanced value to its existing and potential customers and to its channel partners?

The newly founded Holding is just a legal entity for the share purchase. All the operative business stays within the well-known Vexcel Imaging GmbH. Our time as a Microsoft subsidiary were great--Microsoft brought great value to the company and we did amazing developments for Virtual Earth and BING maps. But it also required a split of resources between commercial development and Microsoft internal developments. Being an independent company now, we can once again focus fully on commercial development and make decisions more quickly. That is of definite benefit to our customers and partners. Additionally, and of major significance, is that we were able to reach favorable and solid licensing agreements with Microsoft and can build on our mutual developments accomplished over the past ten years. That is fantastic for or product roadmap.

What are the new line up of products going to be added to your existing portfolio of photogrammetric products and solutions this year?

We have an aggressive product roadmap. I can't provide all the details but with the share purchase, we received broad licensing rights from Microsoft, with respect to IP that was developed during the Microsoft years. Thanks to that and our own on-going development efforts, the UltraMamp software roadmap includes several new releases that will offer powerful capabilities that we developed for Microsoft. The preview to UltraMap version 4.0, which was just released, offers a first glance as to what is coming. On the camera side, we will see one new aerial camera (UltraCam Condor) for high-altitude mapping and ortho image generation and we will be ramping up our development efforts for new terrestrial sensors such as the UltraCam Mustang mobile system and UltraCam Panther portable system.

existing QGIS-based GIS application. *www.spectraprecision.com*

SkyTraq Low-Cost RTK Receiver

S2525F8-RTK by SkyTraq Technology Inc is a low-cost, low-power, single frequency RTK receiver for applications requiring centimeter-level accuracy positioning. It is a multi-constellation GNSS RTK receiver that can use 12 GPS, 8 SBAS, 6 BDS, and 1 QZSS signal. In situations where RTK fix is not possible, a Float RTK mode can be used for decimeter-level accuracy positioning. A moving-base mode is also supported for precise heading GPS compass application. *www.skytraq.com.tw*

Veripos extends Apex GNSS Positioning Service

Veripos has extended its Apex service with introduction of Apex5 which is capable of securing observations from five available satellite constellations comprising GPS, Glonass, Beidou, Galileo and QZSS.

Using Precise Point Positioning (PPP) methods for correction or modelling of all GNSS error sources, the new multi-constellation service with its access to increased civilian signals via interoperable networks ensures increased levels of observation and redundancy. Other advantages include improved satellite count and position availability, particularly in masked and scintillated environments. Apex5 is broadcast alongside existing Veripos Apex and Apex2 Ultra services via seven geostationary satellites to ensure continuous availability and service redundancy. *www.veripos.com*

ZEB-REVO Laser Scanner

GeoSLAM has launched of the ZEB-REVO – the next generation in our range of mobile, handheld 3D laser scanners. It builds upon the success of its predecessor, ZEB1, with a faster scanner, even simpler operation and greater versatility.

At its core is GeoSLAM's industry leading Simultaneous Localisation And Mapping (SLAM) algorithm, which facilitates rapid mobile mapping of enclosed environments without the need for GPS. *www.geoslam.com*

Seafloor announces the launch of their autonomous surface vehicles

Seafloor Systems has announced the launch of their line of Autonomous Surface Vehicles, developed for hydrographic survey applications. The EchoBoat-ASV is a multi-payload, remotely and autonomously controlled survey boat, featuring portability, improved thrust, and large payload capacity. The HyDrone-ASV is a remotely and autonomously controlled singlebeam survey catamaran platform for bathymetric surveying. Seafloor's range of ASVs combine workhorse utility and capability with modern, advanced microelectronics making owning and operating an ASV affordable to all in the Hydrographic Community.

The survey vehicles can be monitored while under way, in both Auto and Manual modes, while within line-of-sight range. The mission planner application runs on a base station laptop, connected through a radio telemetry link, and displays the vehicle's graphical positioning and progress against a background map of the survey area. Battery voltage, current, and capacity remaining may be monitored via this link. *www.seafloorsystems.com*

iXBlue offers new inertial positioning systems

iXBlue is offering its customers the opportunity to upgrade their fourth-generation Octans positioning reference system to the fifth-generation system. Built on iXBlue's high-performance fiber-optic gyroscope technology, the Octans is an all-in-one gyro compass and motion sensor (attitude and heading reference system) with features such as IMO/IMO-HSC certification. The upgraded system provides extremely accurate real-time output for roll, pitch, heading and heave, as well as acceleration and rate of turns under challenging GNSS-denied environment.

Harxon offers new GNSS helix antenna

Chinese antenna maker Harxon has launched a new GNSS helix antenna for unmanned aerial vehicle (UAV) and geospatial applications.

The HX-CH6601A receives GPS L1/L2, GLONASS L1/L2 and BeiDou B1/B2 signals. It offers exceptional pattern control, polarization purity and high efficiency in a very compact form factor. The antenna is equipped with a high-quality, durable IP65 sealed radome housing and terminated with a SMA connector, which has high gain and wide beam width to ensure the signal receiving performance of satellites at a low elevation angle.

Hemisphere GNSS debuts smart antenna for survey

Hemisphere GNSS has released the S321, its next-generation multi-frequency, multi-GNSS survey smart antenna. The S321 — designed for land or marine survey — combines Hemisphere's Athena and Atlas technologies with a new web user interface offering customer-friendly performance. For professional marine applications — such as marine construction, hydrographic surveying or dredging — using the S321 with Athena RTK (real-time kinematic) enables users to achieve impeccable results and maintain peak up-time. *www.HGNSS.com.*

Kongsberg unveils new DP reference solution

Kongsberg Maritime has introduced a new system that integrates all available GNSS and all correction services. The DPS 432 combines full decimetre accuracy with high integrity and availability of GNSS data, supporting the safety and efficiency of offshore operations that rely on advanced dynamic positioning (DP) systems. DPS 432 integrates signals from GPS, Glonass, BeiDou and Galileo GNSS services, and regional correction signals including SBAS and the new G4 services from Fugro. Because of these combinations, DPS 432 would be ideally suited to complex operations in challenging environments.

Topcon Launches New Local Positioning System

Topcon Positioning Group is launching a new local positioning system (LPS) for concrete paving. The LPS Paving

Trimble News

FieldPoint RTX Correction Service

Multi-constellation Trimble FieldPoint RTX™ correction service offers horizontal accuracy up to 10 centimeters (4 inches) at 1-sigma standard deviation or 20 centimeters (8 inches) at 2-sigma, without requiring the use of a base station or local VRS network. It is now available with the Trimble R2 GNSS receiver and the GIS version of the Trimble Geo 7X handheld for a broad range of applications requiring decimeter accuracy.

Seismic Navigation Systems for Geophysical Exploration

The Trimble Seismic Navigation Systems (SNS) portfolio of advanced hardware and software solutions include two vehicle guidance applications for geophysical exploration contractors to streamline the operation of line clearing equipment as well as provide guidance and precise positioning of drilling and vibroseis vehicles used in land seismic operations.

4D Control Software Supports IBIS-FM Radar Device

Trimble® 4D Control™ monitoring software supports the IBIS-FM radar device, which is manufactured by the GeoRadar Division of Ingegneria Dei Sistemi (IDS). IDS pioneered radar technologies for a variety of applications such as slope stability and structural monitoring in open pit mining. The IBIS-FM radar device continuously scans in all-weather conditions and detects movements with sub-millimeter accuracy for distances up to 4 kilometers. *www.trimble.com/*

System is designed to provide a string-less paving solution in conditions when GNSS signals are blocked or unavailable. It uses multiple Topcon PS series robotic total stations — tracking two prisms mounted to the concrete paver — for steering and elevation control.

The LPS system uses the new MC-i4 receiver with LongLink for local communications between the robots. Multiple robots can be set up ahead of time for seamless transitions and without the need to stop to switch total stations.

Honeywell receives certification for navigation technology

Honeywell has secured a Technical Standard Order from the Federal Aviation Administration for its newest navigation product.

Called the LASEREF VI inertial reference system for helicopters, the product leverages Honeywell's existing inertial navigation products and technology from the civil fixed wing markets and applies them to the commercial helicopter market. LASEREF VI gives helicopter pilots more accurate navigation information such as heading, speed and position, keeping flights safe and efficient, especially when the GNSS is unavailable. *www.verticalmag.com*

VN-360 GPS-Compass by VectorNav

VectorNav Technologies has introduced the VN-360 GPS-Compass heading and position sensor. It is an OEM GPS-Compass module that provides an accurate, True North heading solution for systems integrators seeking a reliable alternative to magnetic-based sensors.

Many systems currently available on the market depend on digital magnetometers for providing heading measurements of a manned or unmanned platform. However, the majority of these platforms (e.g. multirotor UAVs, ground robots or satellite antennas) also include ferrous materials, motors, batteries or electrical components that drastically limit the ability of a magnetometer to provide an accurate or reliable heading solution. VectorNav's VN-360 provides a miniature, cost-effective GPS-based alternative that is unaffected by these magnetic disturbances and changes to the magnetic environment. Incorporating two onboard GNSS receivers, the VN-360 calculates the relative position between its two GNSS antennas to derive a heading solution that is an order of magnitude more accurate than a magnetic compass. *www.vectornav.com*

SBG Systems offers inertial sensors in subsea enclosures

SBG Systems has released the Apogee-M and the Apogee-U, two inertial sensors, to complete the Apogee product line.

The Apogee-M is a motion reference unit (MRU), and the Apogee-U is an inertial navigation system (INS). Both are made of titanium with a depth rating of 200 meters. Apogee Series is an accurate INS based

on robust micro-electro-mechanical systems (MEMS) technology.

Review of Raytheon's GPS control system in 3 months time

The U.S. Defence Department will conduct a widespread review of Raytheon Co's long-delayed ground control system for next generation GPS satellites in about three months. Pentagon chief arms buyer Frank Kendall, Air Force Secretary Deborah James and other officials met with Raytheon Chief Executive Tom Kennedy in Colorado to review progress on the $3.6 billion program after years of schedule delays and technical challenges.

New Leica Geosystems reference servers, monitoring receiver

The new Leica GR30 and GR50 reference servers and GM30 monitoring receiver are primed for the constantly changing requirements of GNSS technology. Now equipped with 555 channels, the new reference stations and monitoring receivers support all global GNSS constellations, such as GPS, GLONASS, Galileo and BeiDou, as well as regional systems such as QZSS and SBAS. Seamlessly working with a multitude of signals, monitoring professionals as well as geodetic research and engineering specialists can be confident they will obtain the highest quality data and continuous, uninterrupted accuracy for outstanding processing performance.

ISS Reshetnev to build 11 new GLONASS-K satellites

ISS Reshetnev has signed a contract with Russian space agency Roscosmos to build 11 new GLONASS satellites, according to the Roscosmos website. ISS Reshetnev is Russia's leading spacecraft developer and manufacturer.

ISS Reshetnev will build nine GLONASS-K1 satellites and two GLONASS-K2 satellites.

MARK YOUR CALENDAR

May 2016

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

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

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

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

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

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

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

June 2016

2016 Baltic Geodetic Congress (Geomatics)
2 - 4 June
Gdansk, Poland
http://www.bkg.geomatyka.eu

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

6th Digital Earth Summit
7- 8 July
Beijing China
www.isde2016summit.org

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

ESA – International Summer School on Global Satellite Navigation Systems
18 - 29 July
Joint Research Centre (JRC)/CCR Ispra, Italy
www.munich-satellite-navigation-summerschool.org

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

3D Athens Conference
18-21 October
Athens, Greece
http://3dathens2016.gr/site/

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

November 2016

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

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

13th International Conference on Location Based Services
14-16 November
Vienna, Austria
http://lbs2016.org

International technical symposium on navigation and timing
15-16 Nov
Toulouse, France
http://itsnt.recherche.enac.fr/index.php


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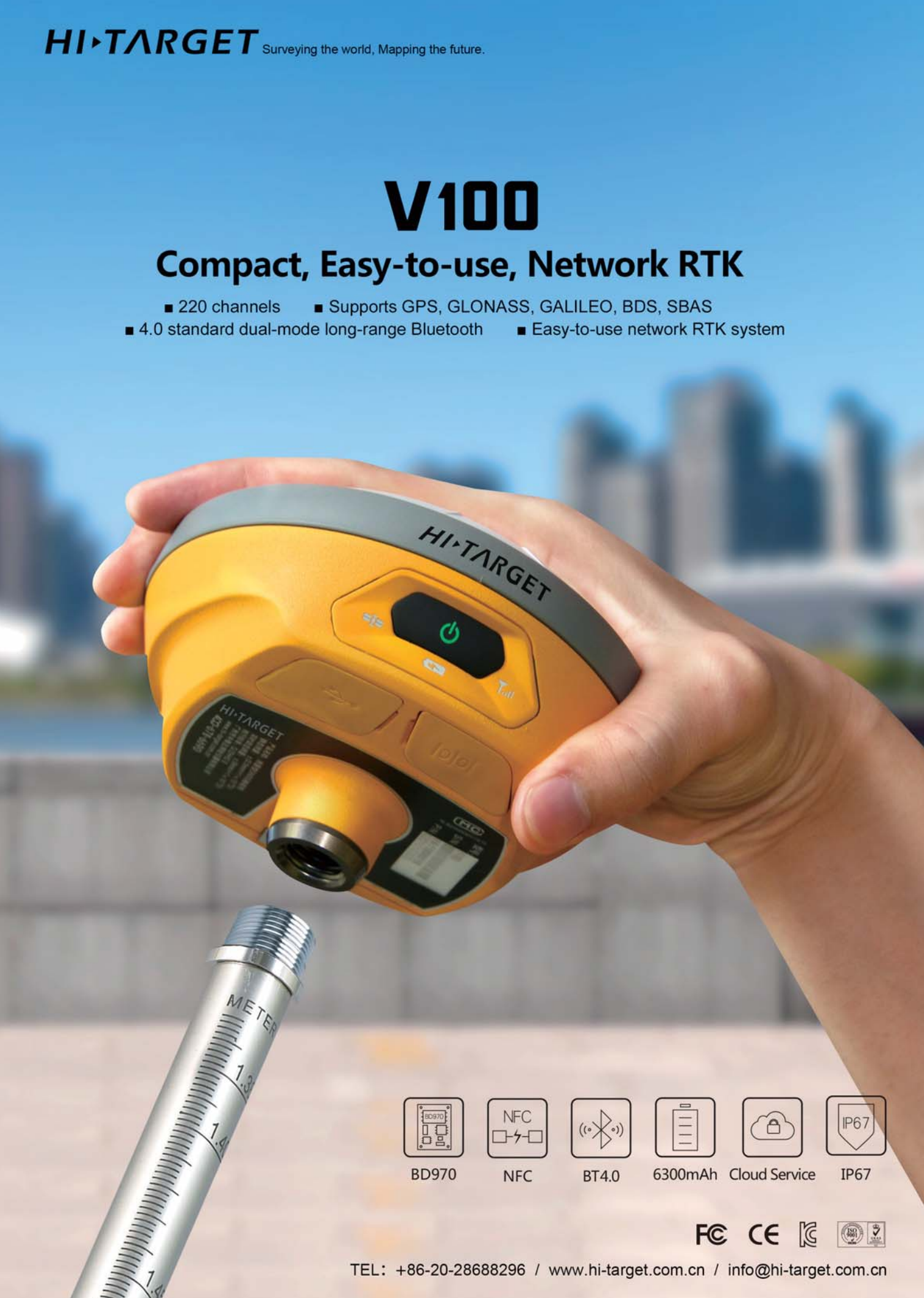

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