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THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

Quality Property Information

A Critical Success Factor

Robotization of precise levelling measurements

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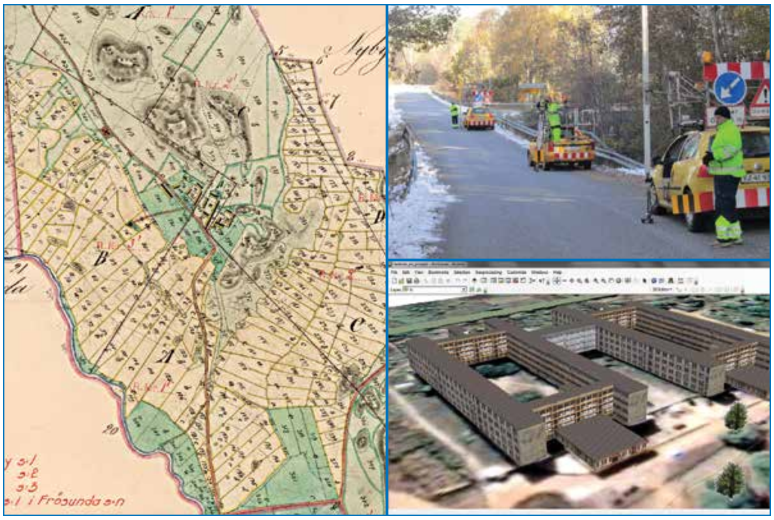

In this issue

Coordinates Volume 14, Issue 05, May 2018

Articles

Columns

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Editor Bal Krishna
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This issue of Coordinates is of 52 pages, including cover.

DÉJÀ VU

According to the Survey of India website

(http://www.surveyofindia.gov.in/news/view/103)

One may see the New Map Restriction Policy- 2017

for Sale, Publication and Distribution of Maps and Data

released by Ministry of Defence. India

It states that "the renewal of the guidelines

is necessitated so as to bring them

in tune with the liberal economic regime

and to accommodate the technological changes…

However, is the use of word 'restriction' itself

Should be good enough to reignite the debate?

Please share your opinion and feedbacks.

Bal Krishna, Editor
bal@mycoordinates.org

Information Quality
A critical success factor

The Swedish approach to Property Information 2025, has an objective that information quality can meet the requirements from both the society in general, for the built environment as well as to secure the rights for property owners

Anders Svensson
Head of section Real Property Information, land register, Lantmäteriet, Gävle, Sweden

Historical review of property information in Sweden

Sweden has a long tradition in registration of land. We therefore have long experience in the field of real properties and how to handle the information.

However, the fact that we have been doing this for so many years is not just an advantage. The transformation and changes that have been made over the years also entails a legacy that complicates the work with the information. To get a glimpse of where we stand today, the following is a very brief description of what has happened over the centuries until today.

It all started as far back as the 13th century and the way of registration has changed, for understandable reasons, many times over the centuries. The oldest document about land transfer is from the year of 1227. In 1628 on April 4, The King of Sweden, Gustaf II Adolf gave the instruction to Anders Bure to conduct a systematic survey of the country. The main objective of the work was to describe the country's property boundaries, geography and who owned the properties. This information would be the basis for raising taxes and developing society, but also for making political decisions in crisis situations. The maps also showed farms, villages, towns, factories, ports and mines.

Figure 1. 1227, The earliest document for land registration in Sweden

In the 18th century Sweden had a big land reform where plotty small fields were consolidated into fewer and larger ones, with the aim of achieving more efficient farming.

In the 19th century Sweden started several land reforms to optimize the land use further which continued until the middle of the 20th century.

In 1935 Sweden introduced the aerial photo technique to improve the map coverage. A map in the scale of 1:10 000 was created which was based on cadastral survey maps.

In the end of the 60s we introduced orthophoto technique which contributed to the improvement of quality.

In 1968 a governmental authority was created to build a computerized textual system for registration of all real property information in the country. The task of transferring the information from cadastre and land register books continued until 1995 when the whole of Sweden had been entered in the Real Property Register.

In 1992 a work to create a National digital map data base started where the land use map (1:10 000) were used as foundation. To get the information maps were scanned or digitized manually.

After the two data capture activities were completed we had two digital records, one textual and one vector based that was visualized in the cadastral map. That is the Real Property register that we use today in Sweden.

From signal system towards decision-making systems

When the data capture for the Real Property Register was completed, the register could, inter alia, be used as a basis for the handling of property transfers. The fact that Lantmäteriet had a map part and a text part that did not always match was not so important at the beginning as the registry was mostly used in Lantmäteriet's own activities where additional information from acts etc. was available. For those who used the information outside Lantmäteriet, the map was used to get an overview of the properties, but to find out the exact location, markings were used on the ground or Lantmäteriet was contacted.

As information, nowadays has begun to be used more and more in other activities than in real property development in Sweden, the requirements have increased as to the quality of the information in the register.

In the community and in the governmental world there is a transformation going on. The activities range from working on a paper-based workload with digital elements to a completely digital management, where the entire decision-making processes takes place digitally.

The Real Property Register in Sweden has good faith and reputation, which is positive, but it also leads to the fact that everyone does not know that the information in the registry has to be handled correctly in order to make the right decision. Many believe that everything in the registry is correct just because it is stored digitally.

> We carry out a number of measurements to check that the targeted quality efforts provide improvements in the registry

Examples of the changing demands that society today has on the information

The property boundaries in the map were collected by scanning or digitized from old map substrates of varying quality, which resulted in a lot of errors in the registry at the time of collection. With today's GPS technology, it is very easy to insert coordinates that a forestry machine can use in connection with harvesting. There are currently examples in the forestry industry, using the Lantmäteriet map to set these coordinates, which can be very wrong.

In Sweden today, there is a high demand on new developments for housing but the planning and building process often can take a long time. By digitizing the whole process where different authorities interact with each other, the time it takes for someone to build housing until the residence is in place can be reduced. However, this puts great demands on the quality of the information in order to use the information in an uninterrupted digital flow and to make correct decisions.

Lantmäteriet has for a number of years had a long-term goal of increasing and widening the use of information that we provide. In that area we have succeeded very well, information today is used much more than before.

Two years ago Lantmäteriet released maps over Sweden for the computer game Minecraft. The intention was to expose the information in a simple and small playful way to get media interest around the area of open data. It got a very large exposure in the media where schools, individuals etc. built new worlds with Sweden's map data as the basis. After the release of Minecraft, there has been a lot of interest in the information that Lantmäteriet provides without saying that the maps that

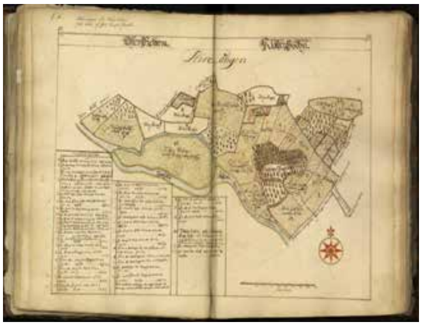

Figure 2. 1628, The mission to map Sweden started, Lantmäteriet was born

Figure 3. 18th century, Land reform there smaller fields were consolidated into bigger ones

Figure 4. Example from the 19th centuries land reforms

Figure 5. End 60s, Introduction of orthophoto technique

were released to Minecraft contributed entirely to this. But for each new user of our information, the requirements for getting correct information are increased.

Technological developments have made it easier to create services, applications and apps for our mobile phones, which means that the use of information has increased drastically.

There are many more examples of where fast and accurate information is needed to make quick decisions that have not been listed in this brief description above. This is just a summary description to get a picture of the challenges we are dealing with today.

Let us try to summarize the examples above, what has happened in the last decade?

The need from society and those who use the information has gone from being a signal system where the need before was to get overall information to decision-making systems where the need today is to get fast and accurate information that can be used in a digital uninterrupted flow of information.

Property Information 2025

As described above, society's requirements have recently changed because it now works to digitize and automate processes. The demands are constantly increasing and everyone strive to get a more cost-effective business.

But what do we do to improve the quality of the information we store in the register? The answer is that we do many things, but before we go into them, a description is given below of how we value the information we have in our records.

The information is our greatest asset

It is the good quality of the information that helped us in Sweden over the years to have, and still have, a stable and secure real property market. In the Real Property Register it is the dossier that is legally valid which decisions is based on. You can feel safe in Sweden in terms of ownership. The stable real property market helps society to continue to evolve, where the properties often stand as collateral for borrowing money from credit institutions.

It is therefore easy to make a comparison with the banks regarding the information. If we do not care for the information entered in the register, the interest rate and the return on the stored information (insured capital) will be low. The total value of the information would therefore decrease in the long run unless the information is constantly maintained and improved.

Another example from Sweden taken from another business is the tracks that the trains run on, where the maintenance has suffered for a long period of time. For several years it worked quite well but eventually the tracks and the traffic volume reached a limit where maintenance needed to be performed. Then major disruptions have occurred in traffic and the maintenance that now started will be done at very high costs.

The return on invested capital generally exceeds the cost involved, and especially in the information area. Therefore, we consider the information as our greatest asset!

Activities in order to raise quality of the property information by 2025

After the property information was digitized, we have been constantly working to improve and enhance the quality of the information we have in the register. This has been done as a continuous improvement work with targeted efforts to raise the quality of the register. However, a large part of the work performed has been a reactive work carried out when errors have been detected in the register.

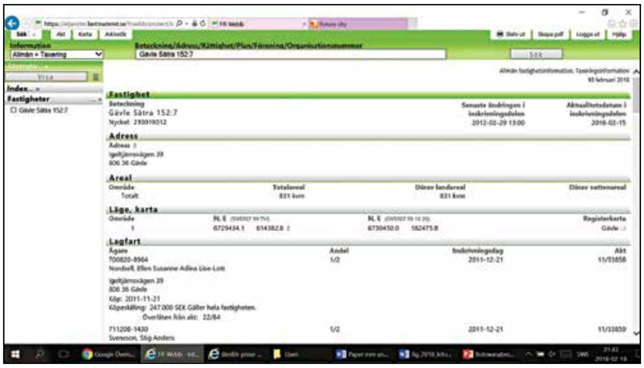

Figure 6. Textual part of the Real Property Register

Since 2006 we have been working on quality development projects aimed at improving the quality of the register. During these years, we have invested quite large sums every year. Despite the cost we think we have contributed to a clear improvement in the register well worth the effort put down.

Now it is time to take the next step in this work to better meet the needs of society for the information stored in the Real Property Register.

We have set long-term goals regarding information quality and made a plan for how we will work to achieve these goals. Some of these goals can be seen as quite forward thinking where we by 2025 may not have fully achieved them. It is important to aim high where great benefits for society can be given if we succeed in this work.

The long-term goals we will be working on are as follows:

- The quality of the Real Property Register is described.
- The property information is uniform across the country.
- Property boundaries have such a quality that they can meet

Figure 7. The map part of the Real Property Register

important society and user needs.

- The presentation of contractual rights, official rights and joint facilities is complete.
- The introduction of new real property information needed for the development of society as well as the discontinuation of information that no longer needs to be kept in the register.
- Other property-related information needed for the development of society and a clear division of responsibility between Lantmäteriet and other information-based authorities. Lantmäteriet are responsible for linking the property information.
- The information transferred to the Real Property Register is correct (Data from processing Cadastral procedures, property transfers etc.)
- Text and geometry in the real property register is managed as a cohesive object with the ability to manage 3D.
- There is awareness among users about how to use the property information properly.

Under each goal there are a lot of activities that all aim to reach as close as possible to the achievement we have planned for until the year 2025. It will not be easy but we will work hard to be there.

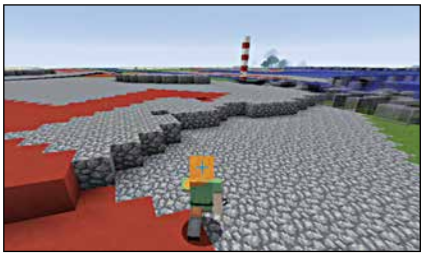

Figure 8. 2016 Sweden is released to the computer game Minecraft

Figure 9. The Real Property Register stands for a stable and secure real property market

How to make it all great

How, then, do we work in a structured way to make the Real Property Register ready for the demands that society now puts on us and what is the secret to accomplishing this? Here is an overall description of how we work in Sweden to improve the quality of our information.

Property Information 2025, as described above, is the long-term plan for quality work with the information in the Real Property Register. On a short-term basis we have 1-year plans for the activities we will do to improve the quality of the registry during the year. We also have a quality improvement project that we work with on a long-term basis in which we have 3-year plans.

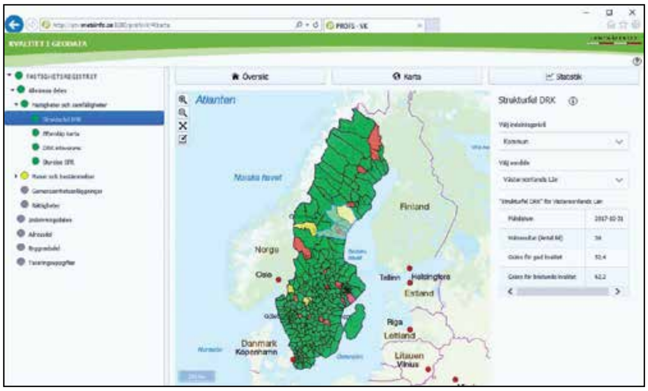

Figure 10. System for visualization of quality information for the Real Property Register in Sweden

An expression we usually use in Sweden is "Together, we are strong." This also applies to the planning for and implementation of measures in the register. The experts on the details are usually the ones who work operatively in the business.

By giving the experts space to grow and taking their own initiatives within the given limits innovative and good suggestions on how to work with the challenges increases. We follow up the plans but we do so with moderation.

An additional success factor for delivering valuable benefits in quality development work is to have clarity regarding roles and responsibilities. In Sweden, we have "information owners" who are the ones responsible for the information we store in the register. It is also the information owners who decide which quality measures will be performed in the register during the year. The information owner decides the quality development plan and follows up the progress of the plans.

Errors discovered in the daily life is handled immediately. An assessment is made if an action needs to be carried out directly or if the rectification can be planned in the structured work being carried out on a regular basis. A change that is made in the register is always logged and documented. The tool Jira is used today for multiple information layers for the handling of errors detected to digitally handle documentation that is not logged directly in the system.

At the moment, discussions have begun in the area of crowdsourcing to improve the quality of the register. It is a change from today when Lantmäteriet does everything by ourselves. However, it is important that that kind of collections complies with current legislation in the area.

Ensure quality through measurements

In order to ensure that the quality is improved, in recent years we have worked a lot with measurements of the existing quality. In that work, we carry out a number of measurements to check that the targeted quality efforts provide improvements in the registry. We also measure the existing quality to ensure that no new information stored is incorrect or inadequate.

The parameters we measure are:

- New registered data from Cadastral

procedures and property transfers
- The actuality of the map
- Information quality overall

However, it is a big challenge to develop the measurements and to find measurements that best describe how the quality of the information really are. But It is worth the effort cause the information quality increases with help from the measurements. For example, when it comes to proactive measures, such as when you want to minimize new errors the measurements are helpful.

In autumn 2017, we developed an internal system to visualize the quality of the information, which will be implemented shortly. In this application, those who work with information, information owners, decision makers and other stakeholders can easily see how the situation is with a specific information layer. The system will be further developed, and what have been developed up to now will work as a basis for continued work.

Suggestions

This was just a bit of overall information about the background and work done in Sweden to work with and improve the quality of the real property information.

Finally, here are some tips and suggestions to succeed in improving the quality of the information stored:

- Think long-term, set up challenging goals / visions.
- Plan, but not just for the sake of the plans. Make sure something is happening too.
- Define roles and responsibilities for the work with the information
- Look at the information as one of our greatest assets where value increases when we make investments in quality.
- See it as positive that the information is used but also count on getting help from users when it comes to finding errors.
- Working with the quality of information takes time.
- Do measurements to improve and describe the quality.
- Be transparent to those who use the information. Better to say that the quality is poor than anyone believing that the information is completely correct.
- Work together to find constant improvements
- Work in a structured way, plan for both reactive and proactive measures that need to be undertaken.
- Have fun!

Lastly, what's at all worth doing is worth doing well!

References

www.lantmäteriet.se The biography of Lantmäteriet

The paper was presented at FIG Congress, 2018, 6-11 May 2018, Istanbul, Turkey

Package of approved ITU-R recommendations on RNSS systems

All these ITU-R recommendations provide characteristics and protection criteria for generic types of RNSS receiving earth and space stations

Nelson MALAGUTI
Counsellor, ITU-R Study Group 4 and CCV, Radiocommunication Bureau, International Telecommunication Union

The ITU Membership considered and approved a package of eight ITU-R Recommendations on radionavigation-satellite service (RNSS) systems as listed below.

Recommendation ITU-R M.1787-3 - Description of systems and networks in the radionavigation-satellite service (space-to-Earth and space-to-space) and technical characteristics of transmitting space stations operating in the bands 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz

The information on orbital parameters, navigation signals and technical characteristics of systems and networks in the radionavigation-satellite service (RNSS) (space-to-Earth, space-to-space) operating in the bands 1 164-1 215 MHz, 1 215-1 300 MHz, and 1 559-1 610 MHz are presented in this Recommendation. This information is intended for use in the assessment of the interference impact between systems and networks in the RNSS and with other services and systems.

Recommendation ITU-R M.1901-1 - Guidance on ITU-R Recommendations related to systems and networks in the radionavigation-satellite service operating in the frequency bands 1 164-1 215 MHz, 1 215-1 300 MHz, 1 559-1 610 MHz, 5 000-5 010 MHz and 5 010-5 030 MHz

This Recommendation is intended to provide guidance on other ITU-R Recommendations related to the technical characteristics and protection criteria of radionavigationsatellite service (RNSS) receiving earth stations and characteristics of RNSS transmitting space stations planned or operating in the frequency bands 1 164-1 215 MHz, 1 2151 300 MHz, 1 559-1 610 MHz, 5 000-5 010 MHz and 5 010-5 030 MHz. In addition, this Recommendation gives a brief overview of those Recommendations.

Recommendation ITU-R M.1902-0 - Characteristics and protection criteria for receiving earth stations in the radionavigation-satellite service (space-to-Earth) operating in the band 1 215-1 300 MHz

Characteristics and protection criteria for radionavigation-satellite service (RNSS) receiving earth stations operating in the band 1 215-1 300 MHz are presented in this Recommendation. This information is intended for performing analyses of radio-frequency interference impact on RNSS (space-to-Earth) receivers operating

The timing and synchronisation community is facing many challenges linked to an increased need for resilience, reliability and security. The frequency and severity of threats to RNSS systems is evolving from unstructured experiments to more organised attacks that are better funded and more motivated in the band 1 215-1 300 MHz from radio sources other than in the RNSS.

Recommendation ITU-R M.1903-0 - Characteristics and protection criteria for receiving earth stations in the radionavigation-satellite service (space-to-Earth) and receivers in the aeronautical radionavigation service operating in the band 1 559-1 610 MHz

Characteristics and protection criteria for radionavigation-satellite service (RNSS) receiving earth stations and aeronautical radionavigation service (ARNS) receiving stations operating in the band 1 559-1 610 MHz are presented in this Recommendation. This information is intended for performing analyses of radio-frequency interference impact on RNSS (space-to-Earth) and ARNS receivers operating in the band 1 559-1 610 MHz from radio sources other than in the RNSS.

Recommendation ITU-R M.1904-0 - Characteristics, performance requirements and protection criteria for receiving stations of the radionavigation-satellite service (space-to-space) operating in the frequency bands 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz

The characteristics and protection criteria for radionavigation-satellite service (RNSS) spaceborne receivers are presented in this Recommendation. This information is intended for performing analyses of radio-frequency interference impact on RNSS receivers operating space-to-space in the bands 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz from emissions of non-RNSS sources.

Recommendation ITU-R M.1905-0 - Characteristics and protection criteria for receiving earth stations in the radionavigation-satellite service (space-to-Earth) operating in the band 1 164-1 215 MHz

Characteristics and protection criteria for radionavigation-satellite service (RNSS) receiving earth stations operating in the band 1 164-1 215 MHz are presented in this Recommendation. This information is intended for performing analyses of radio-frequency interference impact on RNSS (space-to-Earth) receivers operating in the band 1 164-1 215 MHz from radio sources other than in the RNSS.

Recommendation ITU-R M.1906-1 - Characteristics and protection criteria of receiving space stations and characteristics of transmitting earth stations in the radionavigation-satellite service (Earth-to-space) operating in the band 5 000-5 010 MHz

Characteristics and protection criteria for radionavigation-satellite service (RNSS) receiving space stations, and characteristics of RNSS transmitting earth stations, planned or operating in the band 5 000-5 010 MHz are presented in this Recommendation. This information is intended for performing analyses of radio-frequency interference impact on systems and networks in the RNSS (Earth-to-space) operating in this band from radio sources other than in the RNSS.

Recommendation ITU-R M.2031-1 - Characteristics and protection criteria of receiving earth stations and characteristics of transmitting space stations of the radionavigation-satellite service (space-to-Earth) operating in the band 5 010-5 030 MHz

Characteristics and protection criteria for radionavigation-satellite service (RNSS) receiving earth stations, and characteristics of RNSS transmitting space stations planned or operating in the band 5 010-5 030 MHz are presented in this Recommendation. This information is intended for performing sharing and compatibility analyses of radio-frequency interference impact on systems and networks in the RNSS (spaceto-Earth) operating in the band 5 010-5 030 MHz from radio sources other than in the RNSS.

As mentioned above, all these ITU-R recommendations provide characteristics and protection criteria for generic types of RNSS receiving earth and space stations as well as transmission characteristics of all RNSS systems and networks in the bands 1 164-1 215 MHz, 1 215-1 300 MHz, 1 559-1 610 MHz, 5 000-5 010 MHz and 5 010-5 030 MHz, some with safety of life service provisions. All these ITU-R recommendations are freely accessible online at http://www.itu.int/rec/R-REC-M/en. The related studies are continuously evolving based on contributions to and participation at the meetings of ITU-R Working Party 4C, the responsible group where all the related work is currently being conducted, so that those ITU-R recommendations can always reflect the most recent developments related to systems and networks in the RNSS.

Timing aspect of GNSS and its critical importance

Systems and networks in the radionavigation-satellite service (RNSS) provide worldwide accurate information for many positioning, navigation and timing applications, including safety aspects for some frequency bands. The RNSS continues to evolve, as new systems come on line and additional applications are developed.

Global Navigation Satellite Systems (GNSS) operate in the RNSS, and in particular in frequency bands allocated to that service, and provide coverage on and above the entire Earth's surface. Examples of GNSS systems include China's Compass/Beidou system, Europe's Galileo system, Russia's Global Navigation Satellite System (GLONASS) and USA's Global Positioning Satellite (GPS) system.

Although the globally installed base of RNSS devices is greatly dominated by smartphones, followed a distant second by automobiles, the number of RNSS devices in use for professional applications continues to grow and serve a critical role in national economies, public safety, science, etc. Billions of people globally benefit from these high-end RNSS devices on a day-to-day basis, e.g. enjoying the produce of sustainable and cost-effective agriculture, using efficiently coordinated transport networks, and leveraging RNSS-synchronized telecommunication networks.

RNSS receivers measure radionavigation signals delivered by satellite. They are

Precise positioning requires sub-nanosecond measurement of bit edges and effective multipath rejection. Both, in turn, require wide receiver bandwidth

very different from receivers used in radiocommunications systems, where the incoming message is not known to the receiving device whose goal is to find the message and determine whether each signal bit is a one or a zero using sophisticated methods to correct errors. The RNSS incoming signal sequence (ones and zeros) is known to the RNSS receiver. The primary measurement in RNSS systems is the precise timing of bit transitions in the navigation signal. Precise positioning requires sub-nanosecond measurement of bit edges and effective multipath rejection. Both, in turn, require wide receiver bandwidth.

The extreme precision in the clocks required for accurate positioning can be transferred to an RNSS timing receiver and utilized wherever accurate frequency or absolute time is required. RNSS timing is used across a range of civilian and government activities due to its ability to reliably transfer precise time synchronization to global standards over very large distances with low-cost, very low maintenance user equipment.

RNSS provides precise timing and synchronization for most critical infrastructures. Telecommunication networks use the RNSS timing function for handover between base stations in wireless communications, time slot management and event logging. The main applications are:

- Satellite Communications,
- Professional Mobile Radio,
- Digital Cellular Network,
- Public Switched Telephone Network.

Telecommunication networks are continuously evolving toward higher capacity, increased transmission speeds and exploitation of higher frequencies. Consequently, the request for timing and synchronization requirements continuously gets more demanding.

Power grids use RNSS timing in systems providing measurements relevant to the network status. Smart grid development is underway all over the world. Phasor Measurement Units (PMUs) are pivotal to the development of network automatic protection systems. PMUs are deployed across remote locations of power networks requiring microsecond-level accuracy. The internal time references are currently based on RNSS receivers.

The finance sector, i.e. banks and Stock Exchanges, uses RNSS to timestamp financial transactions, allowing tracing of causal relationships and synchronizing financial computer systems. The main applications are financial transaction timestamps.

There is an increased RNSS interest for small cells synchronisation. Small cells are low-powered radio access nodes that operate in licensed and unlicensed spectrum that have a range between several meters up to 1 or 2 kilometres. Small cell base stations can be deployed at street-level or within buildings and are key elements of the LTE deployment. The small cells market is therefore growing very rapidly to support the need for greater coverage and increasing mobile broadband traffic. LTE small cells networks synchronisation can rely on RNSS. This is a potentially promising RNSS market as the outdoor small cells market is expected to grow by 43% CAGR from now until 2020.

The timing and synchronisation community is facing many challenges linked to an increased need for resilience, reliability and security. The frequency and severity of threats to RNSS systems is evolving from unstructured experiments to more organised attacks that are better funded and more motivated. The technology to disrupt RNSS has become much more accessible. Examples include increases in websites selling low-cost “personal protection” jammers and GPS starting to gain attention at hacker conventions.

Some RNSS systems use coordinated universal time (UTC) while others operate independent of UTC by using their own internal time, i.e. a continuous time scale.

A UTC change (i.e. use of a continuous reference time scale) may not have significant impacts or consequences on the operation of RNSS systems that use a continuous time scale, but will affect the operation of RNSS systems that use UTC. With this it should be noted that the RNSS systems disseminate time signals used for navigation and for synchronization of other radiocommunication systems, especially navigation applications associated with safety (for example, usage of the navigation signals for aircraft approaching a runway). There is wide usage of RNSS systems all over the world and a large amount of the current equipment employs various synchronization procedures. Taking this into account, if the UTC change is implemented there are possible negative consequences to the operation of some existing services and systems of the RNSS.

In case of UTC change, some RNSS systems would require update/change. However, in some cases, for example, spaceborne receivers, it is not feasible to modify the navigation equipment throughout the operational life. The necessary updates and changes will lead to high financial expenditures and also require update of all authorized technical documents, carrying out of complete cycle of retests and recertification of these systems and objects (for example, aircrafts, launch vehicles, etc.).

In case of the change of UTC, from the technical point of view, the duration of the required transition time period for those affected operating RNSS systems to be modified is at least 10 years. However, the actual duration of the required transition time period will depend on the financial, legal and arrangement consequences which can significantly extend this period (more than 10 years) and will be individual for each State.

Robotization of precise levelling measurements

The central idea of the proposed method is that robots move and control levelling instruments and rods. The observer's work is helped in the aiming of rods and the recording of observations

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Precise levelling is a traditional method to measure height differences. Currently work stages are performed by hand. In this paper the challenges of robotizing precise levelling measurements are discussed. The difference to the existing solutions would be that robots handle the levelling instruments and rods, and rod readings are remotely recorded via Bluetooth connection.

An automated levelling system would be possible to construct due to the improvement of levelling instruments and robotics. During previous decades, Zeiss Ni 2, Ni 002 (Hüther, 1973) and Wild NA 2000 (Ingesand, 1990) have been major advances. The first automatic levelling instrument, Ni 2, was presented in 1950. It has a compensator pendulum which automatically keeps the instrument's line of sight horizontal. The description of the level is presented, for example, by Schomaker and Berry (1981). An automatic level Ni 002 is ideal for the motorized levelling method. Due to its aiming solution, observers can read rod readings without leaving their vehicles (Vestøl et al., 2014). A digital level, Wild NA 2000, was presented in 1990. Digital levels record rod readings using images of barcode scales. The aforementioned instruments do not have aiming or focusing properties. The Sokkia SDL1X level (Sokkia, 2009) has an autofocus but the aiming of the rod has to be solved. Using machine vision techniques the aiming problems can be solved. Levelling instruments could be like robotic total stations, which have perfect target searching properties. A robotic total station, Geodimeter 4000, was presented in 1990 (Cheves, 2007) and a total level station, Dini 10 T, was presented in 1995 (Feist et al., 1996).

Robotized levelling would be a developed version of today's motorized levelling, where expeditions have an instrument car and two cars with rod transporting systems, like in the Danish motorized levelling for example (Figure 1). A review of motorized levelling in Nordic countries is presented by Vestøl et al. (2014). The early developments were made in the former German Democratic Republic and the USA (Poetzschke, 1980). To speed up measurements, not only cars but also motorbikes and bicycles have been used as vehicles.

Robotized levelling would be a developed version of today's motorized levelling, where expeditions have an instrument car and two cars with rod transporting systems

A description of precise levelling measurements

Precise levelling measurements are performed between two stable benchmarks, which are typically placed at the distance of 1–1.5 km. Levelling instruments can reliably record rod readings if the sight distance is less than 50 m, so the measuring has to be made in successive setups. If the team is moving on foot, then it takes about an hour to measure an average length benchmark interval.

Precise levelling observation is the difference between the back and fore rod

Figure 1. A Danish motorized levelling team in Sweden in 2010. Photo: Per-Ola Eriksson.

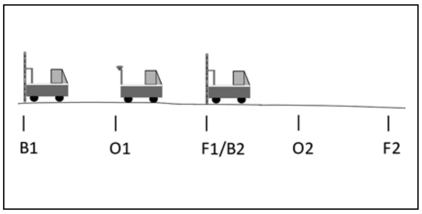

Figure 2. During the movement from one setup to another, the observation car moves from position O1 to O2 and the back rod car moves from position B1 to the fore rod position F2.

Figure 3. A Sokkia SDL1X digital level ©2015 by the Sokkia Corporation. All rights reserved.

readings. Typically, four readings are recorded. For example, the order can be BFFB, where B is a reading from the back rod and F from the fore rod. After readings, the fore rod keeps its position, but the instrument and the back rod are moved to the next position (Figure 2). At the recording moments rods are in a vertical position and invar bands are towards the instrument.

On the equipment in the robotized method

The Sokkia SDL1X (Figure 3) levelling instrument has an autofocus property and its Bluetooth modem enables remotely controlled wireless operations. According to Sokkia (2009), rod readings are recorded in 2.5 sec and it has a precision of 0.2 mm as the standard deviation on a 1 km double-run levelling. A dual-axis tilt sensor alerts the user and disables observations at ± 8.5'. A pendulum compensator with a magnetic damping system has a working range of ± 12' and a setting accuracy of ± 0.3''.

Table 1. The collaborative robots which could be suitable for robotized levelling.

Robot	Payload	Reach	Weight	Protection class
KUKA LBR iiwa 7 R800 KUKA LBR iiwa 14 R820	7 kg 14 kg	800 mm 820 mm	23.9 kg 29.9 kg	IP54 IP54
Mabi Speedy 12	12 kg	1250 mm	35 kg	IP54
Universal Robots UR10	10 kg	1300 mm	28.9 kg	IP54
Yaskawa Motoman HC10	10 kg	1200 mm	45 kg	IP54/67

The Sokkia SDL1X and most collaborative robots have a protection class of IP54. In this class devices are protected against dripping, sprayed and splashed water. Protective covering is needed on the rainy days that provide the optimal weather conditions for levelling. If the protection class is IP67, then robots can be used every day without problems.

The robot selection criteria are payload (carrying capacity), reach, the robot's weight and its protection class. All suitable robot models have a good repeatability (approximately ± 0.1 mm), so the exact values are not presented in the table 1. The payload criterion for an instrument robot is dependent on the weight of the levelling instrument SDL1X (3.7 kg). Sokkia levels are used with Sokkia BIS30A super-invar rods, which weigh 5.5 kg.

The robots carry a gripper and possibly a rod supporting system, so a payload of 10 kg is reasonable. The cheapest robots could cost less than €35 000, but the prices vary strongly. Some robot candidates are presented in Table 1. A top-end robot for the work would be a LBR iiwa (Figure 4). For the summary of the collaborative robots, see Bélanger (2015) and Williamson (2015).

Collaborative robots can work safely alongside humans. The collision detection system stops movements if an obstacle is detected. In practice, safety requirements can be satisfied with industrial robots using area scanners or safety fencing. The disadvantage is that more complicated solutions can be more vulnerable in field conditions. The outcome is that lightweight collaborative robots are the best candidates for the levelling work.

If lightweight robots are placed onto a car's roof-rack, then measurements can be performed without any special levelling cars. This would be an important benefit of the method. In principle, it would be possible to change any car into a levelling car. The solution could replace today's complicated structures (Figure 1).

Figure 4. The collaborative robot LBR iiwa © KUKA Roboter GmbH.

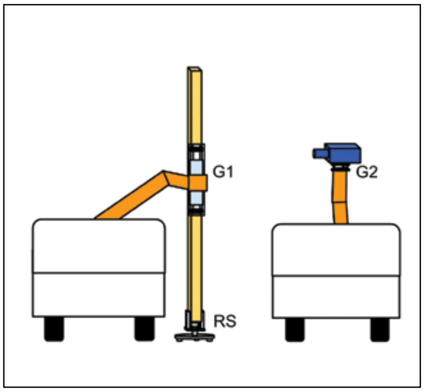

Figure 5. Rod and instrument cars in robotized levelling. The preliminary solutions for rod grippers (G1), instrument grippers (G2) and rod supports (RS) are presented in Figures 6, 7 and 8.

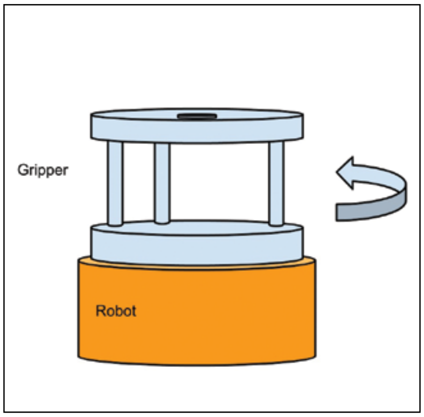

Figure 6. A sketch of the instrument gripper. The instrument is fastened to the uppermost disk of the gripper.

The robotized precise levelling method

Basic ideas for how robots could control the position and orientation of instruments and rods are presented in this chapter. The gripper (end-of-arm-tooling) is installed on the wrist of the robot arm. The exact gripper design is dependent on the technical properties of robots. For a mathematical introduction to robotic manipulation, see Murray et al. (1994).

Three robots would be required in the robotized levelling expeditions. One would operate with a levelling instrument and other two with rods. Sketches of levelling cars for robotized levelling are presented in Figure 5.

The challenges in the instrument gripper design

In the proposed method, robots are used as supports for instruments during recordings. Measuring without any extra support is a tempting option, but it is possible that a solution with a pole or more complicated supporting structure is needed. In today's measurements, instruments are mounted on tripods, but this solution is unlikely to work well with robotized levelling. A gripper sketch is presented in Figure 6. In the gripper, an instrument is mounted on the uppermost disk and the second disk is connected to the robot.

Recording is started when the instrument is aimed at the rod and the barcode scales are aligned to the instrument. The aiming could be based on robot camera solutions. In a manual solution, the camera view can be seen on the controller screen and the target rod can be selected manually. A better solution would be based on machine vision technology (Turek, 2011). Before aiming, it would be possible to compute approximate rod positions. In most cases rods are placed in opposite directions, so that after rotation of 180°, an instrument is approximately aiming at the other rod. After being aimed, the instruments can automatically perform the focusing and recording of rod readings.

Some preliminary solutions for how robots could move rods

Robots can easily move rods between the transporting and observing positions. As a problem is that due to an uneven ground surface, the height difference between the ground and the robots varies in every observing location. There are two points of view on how to solve this problem: the surface can be detected by weight sensors or the collision detection system stops the downward movement.

Rod gripper ideas for collaborative robots are presented in Figure 7. The solution is based on round shaft linear motion technology, which is applied for example in the Simplicity linear slides (PCB Linear, 2013). In the solution, there are rails behind the rods and slides affixed to robots. If the slides can move back and forth 10 cm in rails, then most locations could be measured without problems.

Robots could stop the downward movement when a rod reaches the ground. If weight sensors are used, then the movement is stopped when the weight of the carried load vanishes. Without weight sensors the movement is continued until a slide and a lower stopper collide. Due to the collision detection system the movement is stopped quickly. When rods are on steel plates the only force in a vertical direction is the rod's weight. It is possible that on rough terrain some human-controlled operations are needed.

In the rod support solutions there is a locking system which fixes together a rod and a steel plate (Figure 8). The idea is that during observations rods can be rotated freely on the plates. In the first solution, the extension can move through the plate holder. In the second solution, the extension is fastened to the rod and it can move through the toroid construction. The extension is on the lower toroid when the rod readings are recorded.

The determination of observing positions

If an expedition moves on foot, then a distance measurer goes on ahead of the other team members and marks the positions. The motorized levelling cars are equipped with measuring devices. In the robotized method, approximate distances and height differences between the cars could be used in position determination.

Sight distances from the levelling instrument to the back and fore rods should be as equal as possible. The maximum allowed sight distances are dependent on weather conditions. On cloudy days sight distances of 45 m can be used.

The line of sight is oriented horizontally, so the visibility of rods has to be checked carefully, especially on sloped roads. Naturally, measuring is slower on hilly roads, where more setups are needed.

In order to decrease the refraction effect, a minimum accepted rod reading is about 0.5 m above the ground. In the Danish motorized levelling method (Figure 1) there is an extension below the rod that makes impossible to make observations near the ground. To record rod readings reliably, digital levels need some 0.3 m of visible rod. Therefore a suitable maximum height difference between the rod positions is approximately 0.7 m less than the length of the used rods (Figure 9.).

Equal sight distances remove the collimation error from observations. The error is possible if the instrument's line of sight is not equal to the horizontal plane. Levelling instruments measure distances and it is possible to check the cumulative sum of the distances after every setup. Therefore, it is not dangerous to have different sight distances in a setup if the distance error is corrected during the next setups.

Levelling observations could be used as an independent data set in the calibration of the locating method. The heights and distances can be computed using the rod readings, distances and the instrument's height above the ground. A distance error in Sokkia SDL1X levels is 1 cm if the distance is less than 10 m. For the distances from 10 to 50 m, it is 0.1% of the distance.

Productivity

The measured distance is dependent on the number of setups and sight distances. In the following example time difference is computed between two successive setups. Rough time estimates are used for the moving, recording and transferring of equipment between the transporting and observing positions. These work stages are repeated in every setup. In the example the sight distance of 35 m is the average sight distance in Swedish motorized levelling (Vestøl et al., 2014). It is assumed that the average speed of cars is 25 km/hr. Between two successive setups observation cars move 70 m in 10.5 sec and rod cars move 140 m in 21 sec. After movement, the equipment is ready for the observations in 5 sec. The instrument records one rod reading in 2.5 sec. Robots change aiming directions in 2 sec.

One setup could be measured in 40 sec. The computation is presented in Table 2 and the movement of cars in Figure 2. In the example about half of the time is used for observations and the handling of equipment at the observing positions.

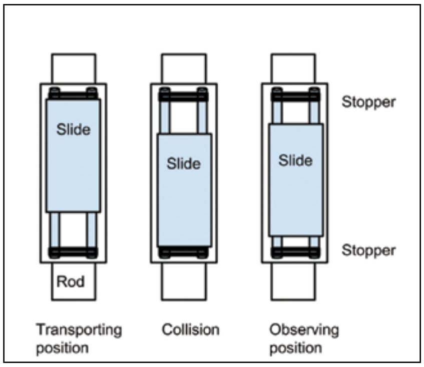

Figure 7. The rod gripper, consisting of a slide and rails. The slide is fastened to the robot. The slide can freely move up and down in relation to the rod.

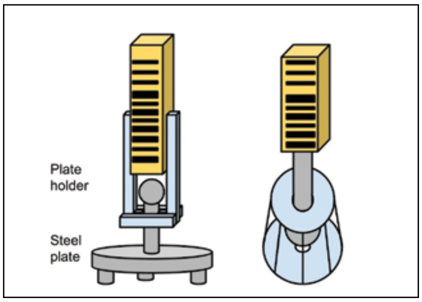

Figure 8. The rod supports have a locking system and an extension.

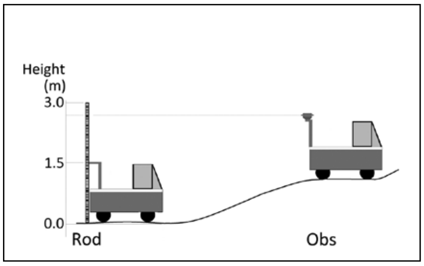

Figure 9. An expedition is measuring on a hilly road. In the example, the instrument is 1.5 m above the road surface, so the observing car is located 1.3 m higher than the rod car.

Table 2. The work stages during setup and the computation of the elapsed time.

	Work stage	The needed time for the work stage (sec)	The elapsed time after the work stage (sec)
1	The instrument car moves to the next setup	10.5	10.5
2	The instrument is ready for observations	5	15.5
3	The instrument records a reading from the back rod	2.5	18
4	The robot rotates the instrument towards the fore rod	2	20
5	The rod car moves to the next fore rod position	21	21
6	The fore rod is ready for observations	5	26
7	The instrument records two rod readings from the fore rod	5	31
8	The robot rotates the instrument towards the back rod	2	33
9	The instrument records a reading from the back rod	2.5	35.5

The rest of time the cars are moving or the observer is waiting for the rod car which is going to the next fore rod position.

Teams could measure 40 km a day if they only spend 40 sec per setup. During a work day, more than 500 setups could be measured. The productivity can be compared to Swedish motorized levelling. In the third precise levelling of Sweden, the daily average distance was about 13 km, which was measured in 5.5 hr (Vestøl et al., 2014). The average time per setup varied between 1.6 min and 2.4 min. The comparison shows that robotized levelling could be more productive.

In the example, it is assumed that measurements are performed directly from cars. In many cases this is not possible and connecting measurements are observed using a traditional levelling method. In the motorized method, extra rods are used for connecting measurements.

To take full advantage of robotized levelling, benchmark intervals should be longer than they are nowadays. Otherwise fast-moving measuring would be interrupted too often by connecting measurements. A suitable measuring time for a benchmark interval is about one hour. On flat roads the ideal distance for benchmark intervals would be more than 7 km. This is too sparse for local surveying purposes, so some kind of compromise is needed between productivity and local requirements.

Combining the robotized method with self-driving cars would create a fully automated measuring system. In any case, benchmark connections are needed, so robotized levelling would be based on cooperation between humans and robots

Future outlook

At the moment we are heading towards a new era of robotized working environments, and hopefully someday robots and artificial intelligence solutions will help precise levelling work. Combining the robotized method with self-driving cars would create a fully automated measuring system. In any case, benchmark connections are needed, so robotized levelling would be based on cooperation between humans and robots. Robots could repeat work stages more accurately than humans, so it is a realistic scenario that in the future robotized levelling would be not only more productive more but also more precise.

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Realization of a functional photorealistic 3D city GIS

In this paper we present a quality realization of a functional photo-realistic 3D City Geographical Information System of a university campus using Google Sketchup and Arcscene technologies. The realized 3D photorealistic model does not only present the photo-realistic visualization of the objects but also incorporates the objects, semantics, spatial, thematic and aspatial attributes

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Man always has been in progressive search for a platform, scenario and technologies to make reasonable and rational comparisons of the real Earth with a virtual Earth. During this quest, a lot of technologies have been deployed, it is obvious that making this quest a possibility, things will get easier for some establishments that are into environmental management, control and planning.

City GML has long been one of the best approaches to this and it is not written off as this new technology comes onboard. This paper focuses on the technology of combining ArcGIS and Google Sketch-up in creating not just Photorealistic models of the study area, but also 3D GIS that is functional and interactive. This paper gives a breakdown of the technologies applied in this project and how they were applied.

Methodology

Add the image of the study area into ArcMap: If the image has been *georeferenced,* you can start off your work immediately, but if not, *Georeference* it with ground control points obtained in the field. Create shapefiles for all the features you want to make use of in Arc Catalogue, and then add those shapefiles into ArcMap. Use the Editor tool to digitize the features thereby creating footprints of buildings, roads, trees and all other features. Create attributes in the attribute table for all the features in the layer so as to optimize querying. Add the footprints into ArcScene, and extrude it by a few meters. (Note: They will be of the same heights).

Using the 3D Analyst tool in Arctool Box, Use the *'Layer to 3D Feature Class'* tool to convert the layer to a multipath. Use the *'Multipath to collada'* tool to convert to a collada file. Open the collada file in sketch up, click through any warning message. Right click and use explode tool to explode the model. Clear the box, yet, leave only the footprints. Use sketch up tools to redraw the foot prints to maintain perfect straight lines where necessary and perfect curves where necessary. Use the push/pull button to model to Architecture.

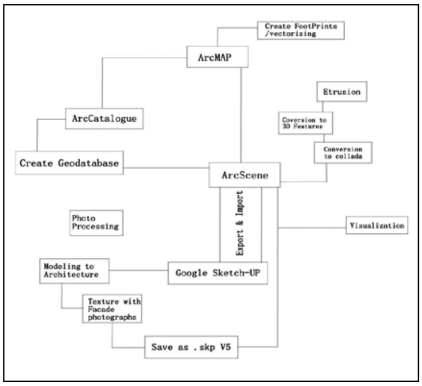

Figure 1. The simple workflow of 3D Photorealistic Modeling

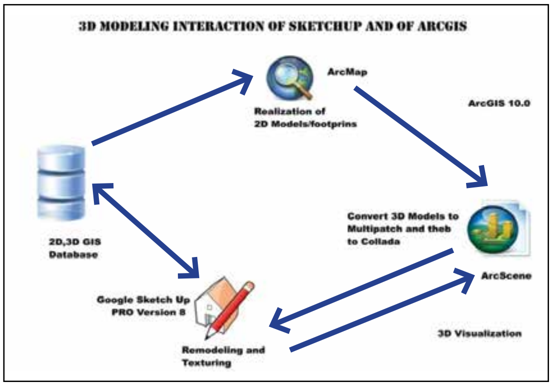

Figure 2: The schema

Import the images that represent the façade and fix them where necessary to give that photorealistic view. Save the Model(s) as

"Sketch up version 5 (.skp)"*. In ArcScene, uncheck the box of layer for the extruded model and leave the only the layer 3D Feature Class. Use the select tool in the Editor tab to select the model you have re-modeled in Sketch up. Then In the 3D editor tab, select from the dropdown *"replace with model"*, then go the location you saved the Sketch up version 5 model and open it. You don't have to reposition it. The advantage to this process is that it retains its geo-registration.

Creating photorealistic models realization of the footprints in arcmap

Figure 3: Extruding the footrints to a certain height in ArcScene

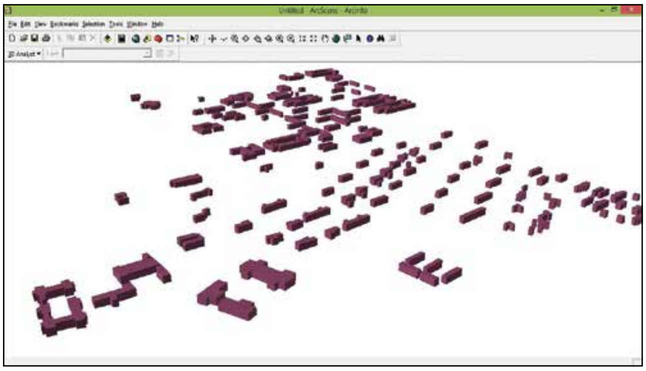

Figure 4: Untitled Arc Scene Foot print of the modeled UNEC building

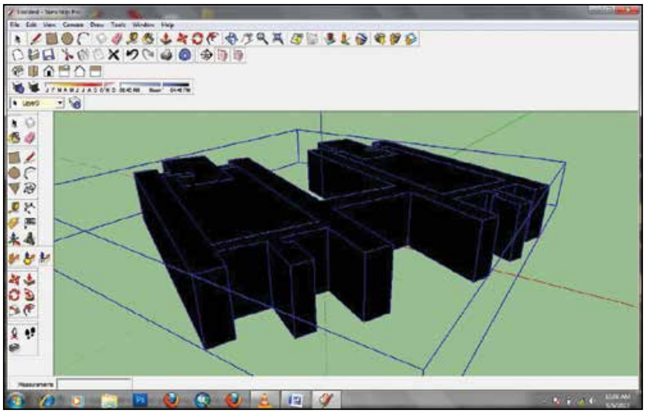

Figure5: Importing the collada file into google sketch up for modeling

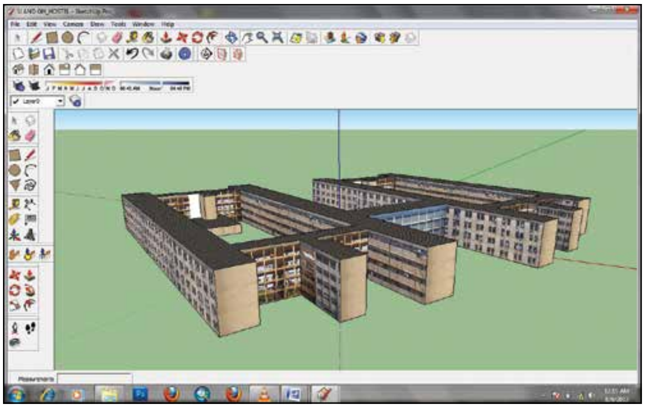

Figure 6: Model to architecture and apply texture

Figure 7: Importing the same model back into Arc Scene for visualization and Analytics

Results

Visualizing the School Library and its Environs in Arc Scene

Figure 8:3D Photo-realistic Model for further Analysis and querying in ArcGIS environment

Summary

The combined technology of ArcGIS and Google Sketch up to produce 3D GIS and 3D modeling of a built environment have been shown in this paper to be a reliable approach of representing the real environment where analytics, real measurements and visualization can be made without fear of blown visible errors. Visualization methods successfully facilitate analysis in many science fields and have played a central role in communication of dependencies in spatial datasets.

From the results of this project, different disciplines in environmental studies can key into this to enhance and upgrade their work. For example, an Urban and regional planner can actualize a neighborhood design, landscaping, layout designs etc.

Building Information Management (BIM) can be incorporated into this technique so as to have a complete virtual environment with attributes like floor plan, window type,

Having an integrated system of Photo realistic Models and Building Information Management, An Estate valuer can as well make use of this technique, since both the spatial and aspatial attibutes are maintained, He can actually, carry out His valuation without necessarily getting to the field.

Conclusion

3D modeling/3D GIS have been shown in this study to be a reliable approach representing the real environment using software applications such as those listed in the course of this work. The combined technology of ArcGIS and Google Sketch up to produce 3D GIS and 3D modeling of a built environment have been shown in this study to be a reliable approach of representing the real environment where analysis, real measurements and visualization can be made without fear of blown errors. Visualization methods successfully facilitate analysis in many science fields and have played a central role in communication of dependencies in spatial datasets.

The approach used in this work presents a simple strategy that is suitable for required spatial applications. The procedure followed is economic based on available databases and can be implemented easily to deliver quick and sufficient results.

An Estate developer needs this same technique in his profession. In situations where the client cannot go to the site due to some reasons, or that the site is very far away, this technique can be used to depict exactly what the client wants to buy.

Recommendations

The advantages of 3D GIS (Modeling) cannot be over emphasized because of its applications in several disciplines. With respect to this work, an Urban Planner can use 3D GIS (Modeling) to present the prototype of what he has conceptualized. An urban Planner can as well produce a virtual city because if this technique was used in an environment like UNEC therefore, the technique can be used to create a virtual City e.g. Enugu City. Having an integrated system of Photo realistic Models and Building Information Management, an Estate valuer can as well make use of this technique, since the positions of a the feature maintained, He can carry His valuation without necessarily getting to the field. City GML is an advanced form of this work. In some developed countries, the effective use of City GML is being made use of . City GML actually has many applications -visualizing the City for various purposes (e.g. tourism, virtual tours), for urban Planning, in Navigation Systems, it is also used in intelligent Transportation Systems. It can be applied for noise modeling of large areas especially industrial sites / buildings.

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The paper was presented at FIG Working Week 2017, Helsinki, Finland, May 29–June 2, 2017.

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Spoofer Detection

With 864 channels and about 130,000 quick acquisition correlators in our TRIUMPH chip, we have resources to assign more than one channel to each satellite to find ALL signals that are transmitted with that GNSS satellite PRN code.

If we detect more than one reasonable and consistent correlation peak for any PRN code, we know that we are being spoofed and can identify the spoofed signals.

When we detect that spoofing is in effect, we use the position solution provided by all other clean signals (L1, L2, L5, etc... GPS, GLONASS, Galileo, Beidou, etc...) to identify the spoofer signal and use the real satellite measurement. If all GNSS signals are spoofed or jammed, then we alarm you to ignore GNSS and use other sensors in your integrated system.

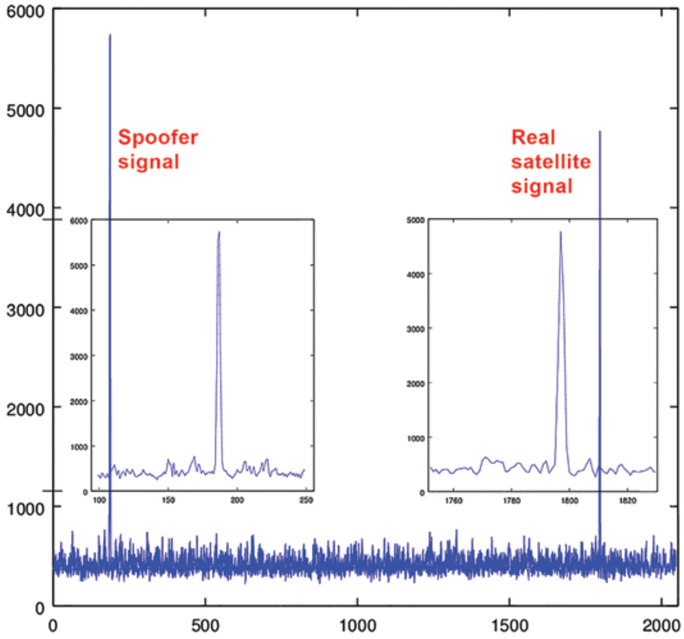


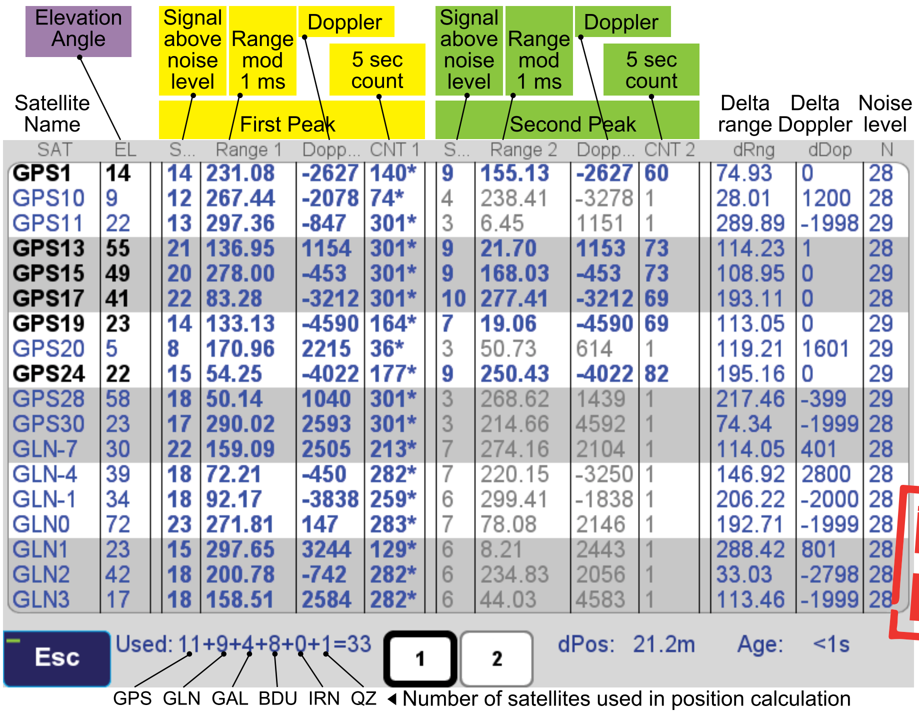
Figure 1
shows an example of a spoofer signal and a real satellite signal received at GNSS receiver.

Satellite and Spoofer Peaks

The screenshots below are from a real spoofer in a large city. The bold numbers are for the detected peaks. The gray numbers represent highest noise, not a consistent peak. "*" symbol next to the CNT numbers indicate that signal is used in position calculation. Each CNT count represent about 5 seconds of continuous peak tracking.

SAT	EL	S...	Range 1	Dopp...	CNT 1	S...	Range 2	Dopp...	CNT 2	dRng	dDop	N
GPS5	33	16	61.14	1382	184*	4	25.95	181	1	29.32	1201	29
GPS7	51	21	14.39	1146	184*	4	18.21	-453	1	2.80	1599	29
GPS8	30	18	65.10	-918	184*	4	4.26	-1318	1	3.68	400	29
GPS9	12	14	40.46	2966	184*	4	2.08	3765	1	26.13	-799	29
GPS13	40	16	46.92	-3525	184*	4	8.21	-4325	1	25.80	800	29
GPS15	12	14	12.46	-4336	30*	5	33.00	-1536	1	19.52	-2800	28
GPS20	24	12	13.19	-1707	107*	4	29.32	-3307	1	15.11	1600	29
GPS27	16	11	10.26	1264	184*	4	43.55	63	1	31.22	1201	29
GPS28	53	19	9.41	-2724	184*	4	7.93	-4724	1	0.46	2000	29
GPS30	81	22	13.79	-332	184*	5	34.16	1266	1	19.35	-1598	28
GLN-4	54	20	62.08	1498	1158*	5	21.72	2697	1	24.16	-1199	25
GLN5	46	20	18.04	-2897	524*	4	26.26	-3697	1	7.20	800	25
GLN0	37	18	30.37	2355	1469*	4	38.37	1554	1	6.98	801	25
GLN-1	82	18	34.92	-776	189*	4	12.54	-1576	1	21.35	800	25
GLN-2	26	12	30.96	-4358	229*	4	11.80	-3158	1	18.13	-1200	25
GLN2	21	10	59.73	288	551*	4	47.55	1087	1	11.16	-799	25
GLN4	22	15	30.59	-3361	208*	4	11.74	-5361	1	17.83	2000	25
GLN-5	21	14	20.17	276	187+	3	25.45	2275	1	4.26	-1999	25

Figure 2 *No spoofer. Only one reasonable peak for each satellite.*



SAT	EL	S...	Range 1	Dopp...	CNT 1	S...	Range 2	Dopp...	CNT 2	dRng	dDop	N
GPS1	14	14	231.08	-2627	140*	9	155.13	-2627	60	74.93	0	28
GPS10	9	12	267.44	-2078	74*	4	238.41	-3278	1	28.01	1200	28
GPS11	22	13	297.36	-847	301*	3	6.45	1151	1	289.89	-1998	29
GPS13	55	21	136.95	1154	301*	9	21.70	1153	73	114.23	1	28
GPS15	49	20	278.00	-453	301*	9	168.03	-453	73	108.95	0	29
GPS17	41	22	83.28	-3212	301*	10	277.41	-3212	69	193.11	0	28
GPS19	23	14	133.13	-4590	164*	7	19.06	-4590	69	113.05	0	29
GPS20	5	8	170.96	2215	36*	3	50.73	614	1	119.21	1601	29
GPS24	22	15	54.25	-4022	177*	9	250.43	-4022	82	195.16	0	29
GPS28	58	18	50.14	1040	301*	3	268.62	1439	1	217.46	-399	29
GPS30	23	17	290.02	2593	301*	3	214.66	4592	1	74.34	-1999	28
GLN-7	30	22	159.09	2505	213*	7	274.16	2104	1	114.05	401	28
GLN-4	39	18	72.21	-450	282*	7	220.15	-3250	1	146.92	2800	28
GLN-1	34	18	92.17	-3838	259*	6	299.41	-1838	1	206.22	-2000	28
GLN0	72	23	271.81	147	283*	7	78.08	2146	1	192.71	-1999	28
GLN1	23	15	297.65	3244	129*	6	8.21	2443	1	288.42	801	28
GLN2	42	18	200.78	-742	282*	6	234.83	2056	1	33.03	-2798	28
GLN3	17	18	158.51	2584	282*	6	44.03	4583	1	113.46	-1999	28

Figure 3
In the screenshot all GPS satellites have two peaks and all are spoofed. We were able to distinguish the spoofer signal and use the real satellite signals in correct position calculation as indicated by the "" next to the CNT numbers.*

PATENTS PENDING

Concepts Behind RTK Verification

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

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

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

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

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

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

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

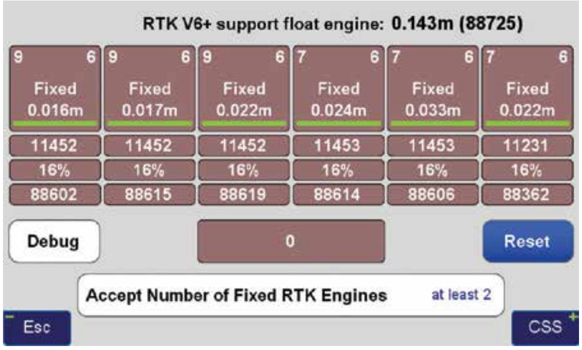


Figure 1 *V6+ six RTK Engines*

User Defined Verification Tools

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

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

Confidence Counter

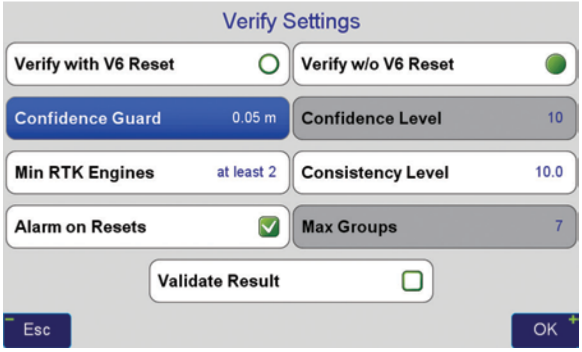


Figure 2 *Verify Settings*

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

Consistency Counter

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

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

Verify with Automatic RTK Engines Resets

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

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

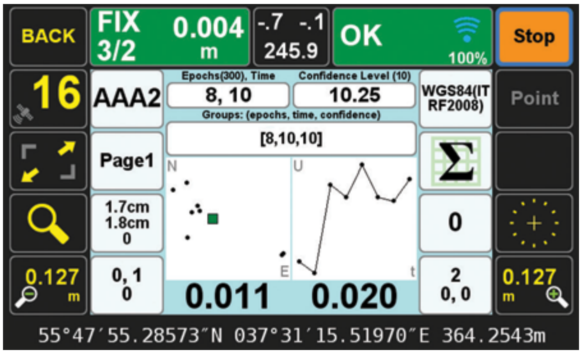


Figure 3 *End of Step one*

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

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

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

You can manually reset all RTK engines via the V6-RTK engines screen (Figure 1), or assign this reset function to any one of the U1 to U4 hardware buttons in front of the TRIUMPH-LS for easy access.

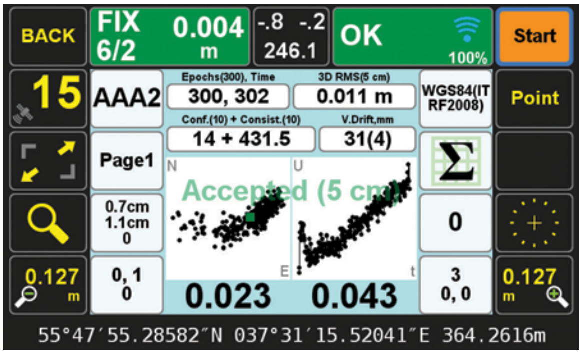


Figure 4 *End of Step 2*

Verify without Automatic RTK Engines Resets:

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

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

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

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

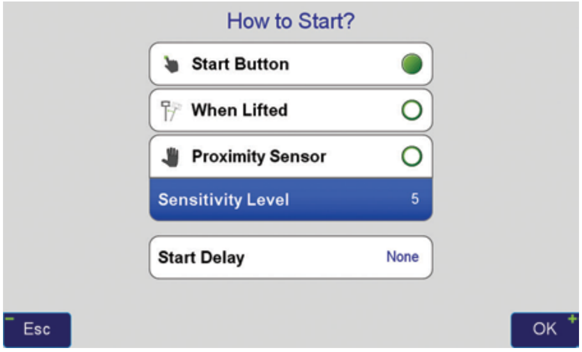


Figure 5 *How to Start*

Figure 6 *How to Stop*

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

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

Screen Shots of Action Screen

Action Screen shows detailed information about each point collected. Screen shots can automatically be attached to each point and saved at the end of each collection (Figure 7). In **Verify with Automatic RTK Engines Resets** screen shots at the end of both Step One and Step Two are saved (Figures 3 and 4). In Action screen there are 8 white boxes that selected items can be viewed on them.

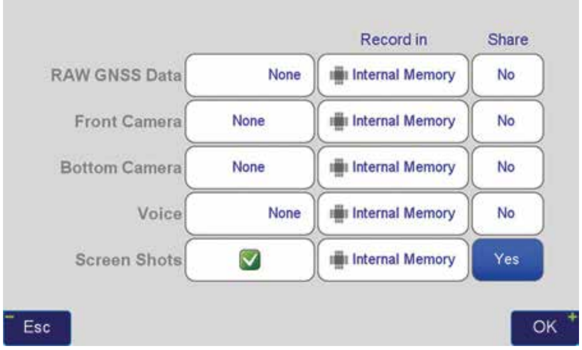


Figure 7 *What to record screen*

Review Screen

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

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

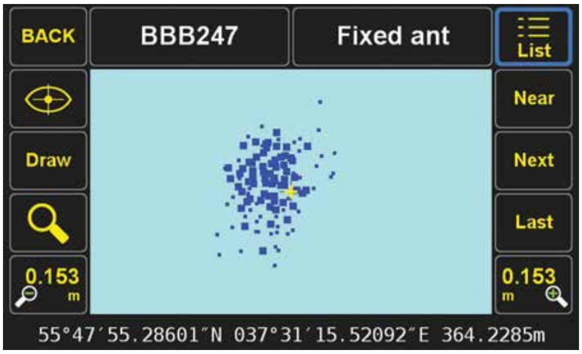


Figure 8 *Review screen shows cluster of 386 points*

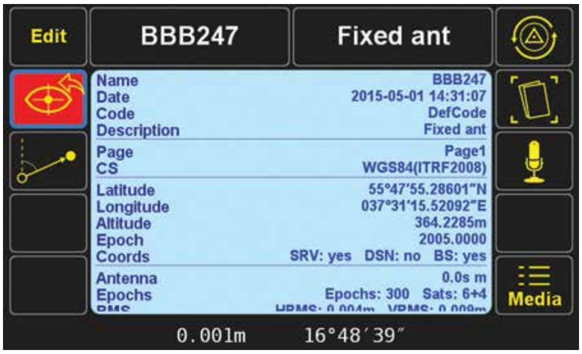


Figure 9 *Detailed information on selected point (scroll to see all information)*

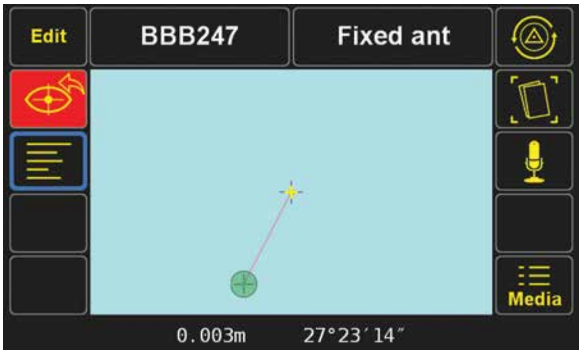


Figure 10 *Distance and direction from the current point to the selected point*

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

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

Instantaneous Multipath charts

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

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

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

SAT	EL	L1	P1	P2	L2C	L5	SAT	EL	L1	P1	P2	L2C	L5
GPS2	29↑	273	281	-76	--	--	BDU11	75↑	362	--	--	--	305
GPS6	44↑	55	201	-60	-5	189	BDU12	36↓	288	--	--	--	200
GPS12	70↑	183	190	-90	-94	--	GPS3	10	--	--	--	--	--
GPS14	25ˆ	281	317	-97	--	--	GPS29	3	--	--	--	--	--
GPS17	23↓	332	364	-74	6	--	GPS32	3	--	--	--	--	--
GPS24	53↓	117	566	67	-64	124	GLN7	3	--	--	--	--	--
GPS25	30↑	243	218	-42	-50	-34	GLN19	12	--	--	--	--	--
GLN1	10↑	305	229	-126	-404	--							
GLN8	16↓	26	87	-484	-617	--							
GLN9	32↑	359	301	-246	55	--							
GLN15	31↓	276	203	-93	-2	--							
GLN16	84↑	235	309	-133	-109	--							
GLN17	39↓	52	-84	-156	-52	--							
GLN18	69↑	190	168	-177	-184	--							
GAL12	68ˆ	680	-121	246	--	32							
SB127	25ˆ	469	--	--	--	319							
SB128	15ˆ	206	--	--	--	322							
QZ193	13↑	550	513	--	56	55							
BDU2	16ˆ	299	--	--	--	275							
BDU5	25ˆ	269	--	--	--	230							
BDU8	25↓	145	--	--	--	143							

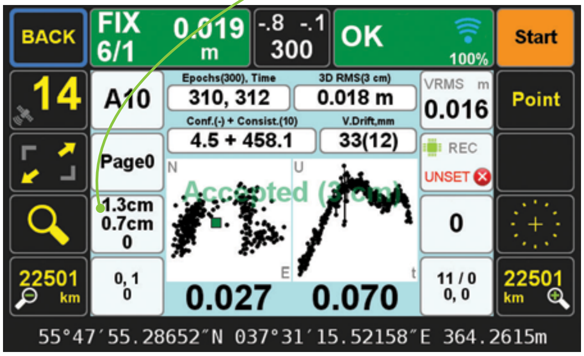
Figure 11 *Code Phase multipath removed (cm)*

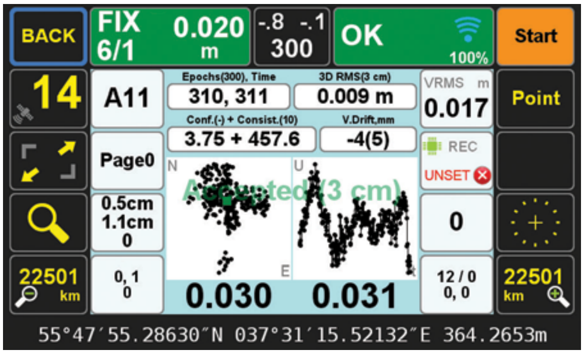
SAT	EL	AZ	L1	P1	P2	L2C	L5	SAT	EL	AZ	L1	P1	P2	L2C	L5
GPS2	29↑	154	7	7	2	--	--	BDU11	75↑	158	-6	--	--	--	-5
GPS6	44↑	98	11	9	2	2	-13	BDU12	36↓	60	-6	--	--	--	-14
GPS12	70↑	282	7	8	-2	-2	--	GPS3	10	26	--	--	--	--	--
GPS14	25ˆ	302	5	8	-4	--	--	GPS29	3	229	--	--	--	--	--
GPS17	23↓	58	6	9	-6	-2	--	GPS32	3	346	--	--	--	--	--
GPS24	53↓	196	1	4	13	1	-12	GLN7	3	297	--	--	--	--	--
GPS25	30↑	282	4	8	7	1	-32	GLN19	12	210	--	--	--	--	--
GLN1	10↑	34	1	4	-15	-23	--								
GLN8	16↓	344	12	15	17	25	--								
GLN9	32↑	316	0	2	-3	-6	--								
GLN15	31↓	142	5	5	0	1	--								
GLN16	84↑	266	2	2	-11	-18	--								
GLN17	39↓	44	-1	-4	-12	-10	--								
GLN18	69↑	188	-1	3	-1	-6	--								
GAL12	68ˆ	108	0	-26	0	--	-14								
SB127	25ˆ	160	7	--	--	--	-4								
SB128	15ˆ	130	9	--	--	--	-11								
QZ193	13↑	68	-3	-1	--	1	-19								
BDU2	16ˆ	132	-7	--	--	--	-17								
BDU5	25ˆ	154	-4	--	--	--	-7								
BDU8	25↓	54	-10	--	--	--	-20								

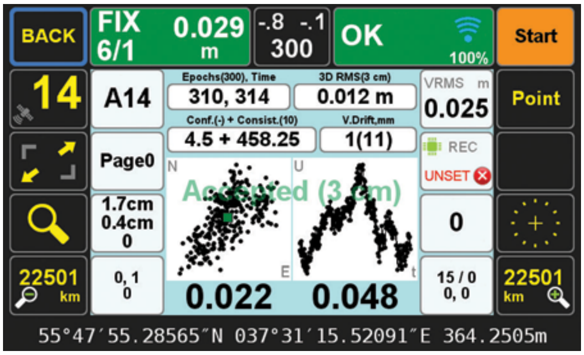
Figure 12 *Carrier Phase multipath remove (mm)*

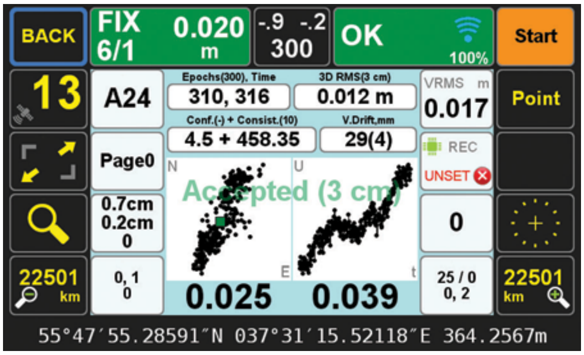
Multipath Showcase

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





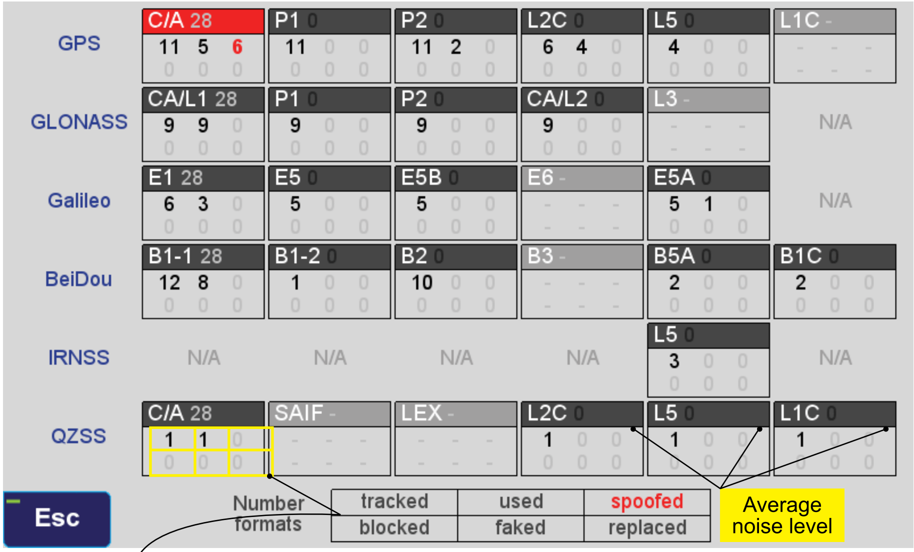




Javad Ashjaee, Ph.D.

GNSS Overall View

The format and the signal definitions are explained below.



GPS L2C: L+M
GLN L3: I+Q
GAL E1: B+C
GAL E5: alboc
GAL E5B: I+Q
GAL E5A: I+Q
BeiDou B2: B5B
QZSS L2C: L+M
QZSS L1C: I+Q

Figure 4
The screenshot shows the status of all GNSS signals.

Definitions for the number of signals:

Tracked: Tracked by the tracking channels and has one valid peak only.

Used: Used in position calculation.

Spoofed: Has two peaks. Good peak is isolated, if existed.

Blocked: Blocked by buildings or by jamming. If jammed, shows higher noise level.

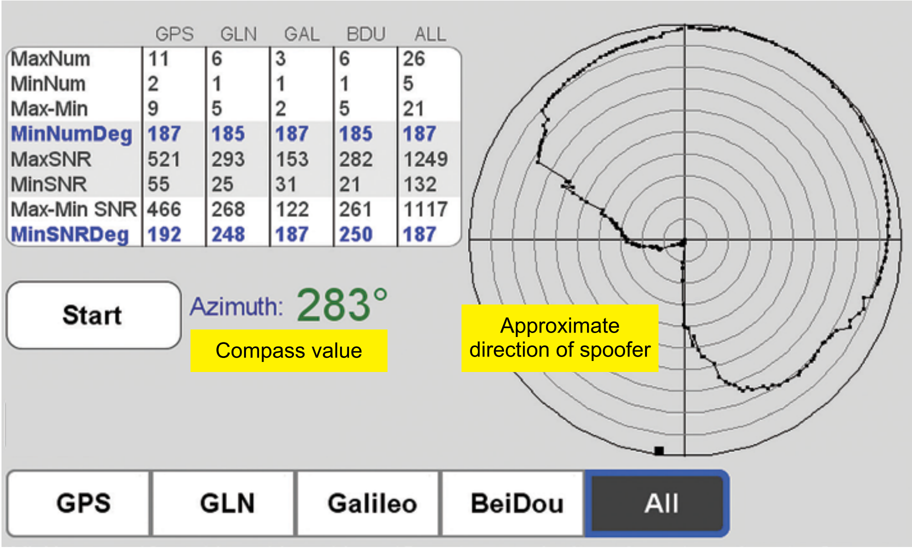
Faked: Satellite should not be visible, or such PRN does not exist.

Replaced: Real signal is jammed and a spoofed signal put on top of it. Because of jammer, it shows higher noise level.

Spoofer Orientation

When you detect that spoofers exist, you can also try to find the direction that the spoofing signals are coming from. For this, hold your receiver antenna (e.g. TRIUMPH-LS) horizontally and rotate it slowly (one rotation about 30 seconds) as shown in the picture and find the direction that the satellite energies become minimum. This is the orientation that the spoofer is behind the null point of the antenna reception pattern.

After one or more full rotations observe the resulting graph that shows approximate orientation of the spoofer as shown in figure 5.

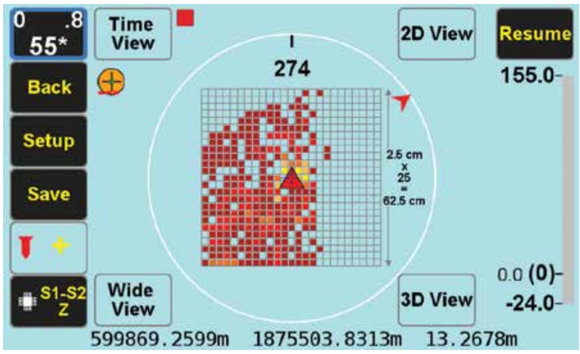


	GPS	GLN	GAL	BDU	ALL
MaxNum	11	6	3	6	26
MinNum	2	1	1	1	5
Max-Min	9	5	2	5	21
MinNumDeg	187	185	187	185	187
MaxSNR	521	293	153	282	1249
MinSNR	55	25	31	21	132
Max-Min SNR	466	268	122	261	1117
MinSNRDeg	192	248	187	250	187

Figure 5
This screenshot is from the experiment within an anechoic chamber. That is why the picture is clean and smooth.

J-Tip

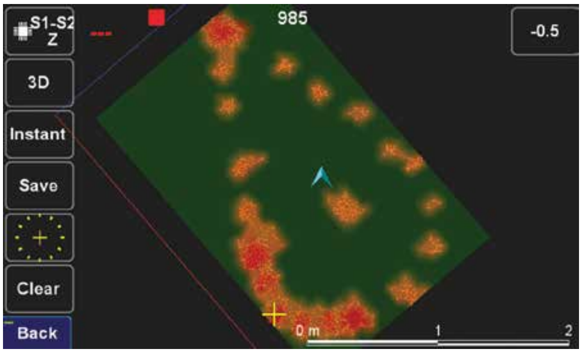
TRIUMPH-LS tags coordinates with magnetic values, It also guides you to top of the item to survey it.

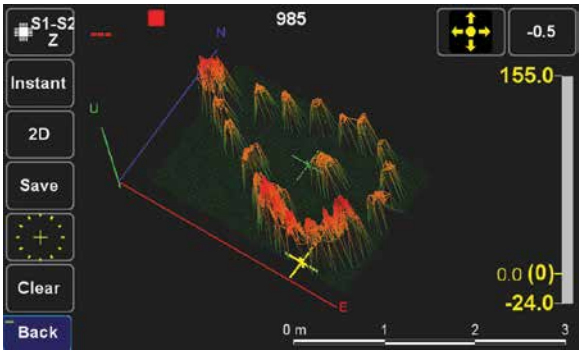


The Mag View focuses only on the mag object with the highest mag value.

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

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





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

Adam Plumley, PLS

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

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

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

Geospatial land governance and management

The present research discover the people's role in land governance and management, and also to see the historical background of land governance in the country. India We present here the first part of the paper

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Geospatial information is forever related to geographic space. It signifies to the immediate geographic world. Geographic space is the space of topography, land use land cover, cadastral, and other landscape features of geographic world. Geographic information systems technology is applied to manipulate objects in geographic space, and to obtain information from spatial facts (Goodchild, 1992). In order to share the geospatial information, the Global Spatial Data Infrastructure (GSDI) facility was set-up for international information cooperation which came into existence in July 2003. The fundamental objective of the GSDI organization is to encourage international cooperation and collaboration in support of local, national, and international spatial data infrastructure developments which will allow all the nations to better address their social, economic, and environmental issues at large. So, the geospatial information is a good definition of the space which is measured, described, and represented in its three dimensions and to be made available over and over again (Burrough and McDonnell, 1998).

Earlier, the geoinformation process could be separated into individual disciplines, such as surveying, geodesy, photogrammetry, remote sensing, and cartography during the analogue mapping era. Presently, there are different data acquisition methods such as terrestrial GPS-surveys, aerial photogrammetry, satellite photogrammetry, laser scanning, photo interpretation, digital processing of remotely sensed images which are themselves competing each other in term of the excellence and expenses (Avery, 1992). In this context, these disciplines and technologies application must have been geared corresponding to the global, regional or local levels geospatial information digitalization for land resources mapping and management for solutions to the real world problems as land governance for betterment of humanity on this planet earth.

Land governance and management

Land governance and management are noteworthy matters of concern in the emerging economies and developing countries of the world like India. In agrarian economies, the land is most important assets of the people as 'to own the land is the highest mark of esteem; to perform manual labour, the lowest' (Myrdal, 1968). There has been recorded continuous decline in the share of agriculture and allied sectors in its gross domestic product (GDP), from 14.60 per cent in 2009–2010 to 13.90 per cent in 2013–2014, which is an expected outcome for a fast growing and structurally changing economy. So, the falling share of agriculture and allied sectors in GDP is an expected outcome in a fast growing and structurally changing economy. In order to keep up the momentum gained during the 11th Plan and achieve the targeted growth rate of 4.00 per cent during the 12th Five Year Plan have focused approaches and schemes.

There is an ever-changing relationship between land, power and people over the centuries in India. Land provides basic necessities like food, clothing and shelter to man. There have been found conflicts over land and resources which are at present a marked feature of the economic growth and development.

The Land Acquisition Rehabilitation and Resettlement Bill 2012's compensation provisions, at four times the market rate in rural areas and twice in urban areas (Chakraborty, 2013). This will raise land prices exponentially and will fundamentally impede economic growth.

Land Governance in Indo-Aryan era

Ancient records as the RigVeda shows that among the Indo-Aryans, arable land was held in individual ownership or family ownership (Muller, 1849). The Land belonged to the person who cleared the forest and woodland and brought the land under cultivation. So, it appears that the principle of private property and private ownership of land has been recognised from ancient times, in India. Throughout the history, during the ancient period 1200 BC– 200 AD as well as during the recent period 1540 AD–1750 AD, the principal unit of land belong to village settlement, in India (United Nations, 1973). Since land returns was the main source of state revenue, the village became the agency for collection and unit of revenue assessment.

Land Governance in British India

The Britisher's governed over land for long time, which is known as the colonial era, for over the centuries 1750 AD–1947 AD over the country, India. The Permanent Settlement Regulation (PSR) in 1793 was introduced to record all rights in respect of land and to maintain an up-to-date record of land rights, which was completely failed to implement in the country. At the time of independence, in the country, India, the land tenure systems preserved in three main categories, namely, the Zamindari, the Ryotwari, and the Mahalwari tenures (Mukherjee and Frykenberg, 1979). Each one of these were accounting for about 57.03 per cent, 38.14 per cent and 5.02 per cent of the total privately owned agricultural land.

Land Governance in Independent India

The India became independent country on the 15th August 1947 of the world and adopted their own constitution which came into effect on 26th January 1950 (GoI, 2007). For all round development of the country, the Planning Commission was set up by a resolution of the Government of India in March 1950. The First Five Year Plan was designed and launched for 1951–56 and thereafter the two subsequent five-year plans were formulated till to present, the Twelfth Five Year Plan, 2012–2017. While keeping this in view, it was assumed that the planning in the country, in general, is that it should increasingly be of an indicative nature. So, since the independence the main emphasis has been on industrialisation of the country, India. Because the agriculture has been treated as a symbol of economic backwardness. Along with the independence, however, the land reforms and agriculture development were paid more attention though the main focus during the plans was on the industrial sector development.

Objectives of the study

The Geospatial land governance and management is a complex matter of discussion and it has been paid a lots of attention since long world widely for the betterment of society. The present research discover the people's role in land governance and management, and also to see the historical background of land governance in the country, India. In view of this, the main objectives of the present study are mentioned as follows:

i. to perceive historical background of land governance, management and digitalisation;
ii. to evaluate geospatial trends of natural resources utilization as land use land cover;
iii. to explore geospatial trends and patterns of agricultural land development;
iv. to examine geospatial trends and patterns of land governance by digitalisation;
v. to suggest suitable lessons learned from land governance and its management.

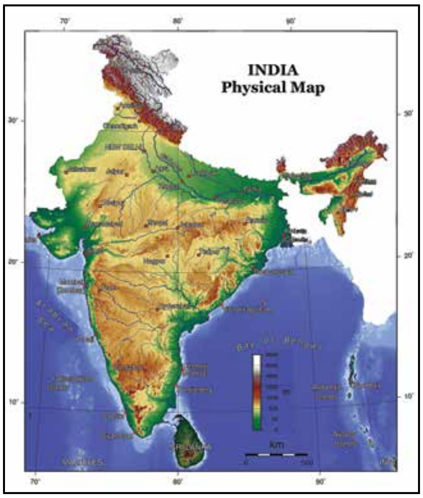


Figure 1: Physical Map, India.

Figure 2: State level Divisions.

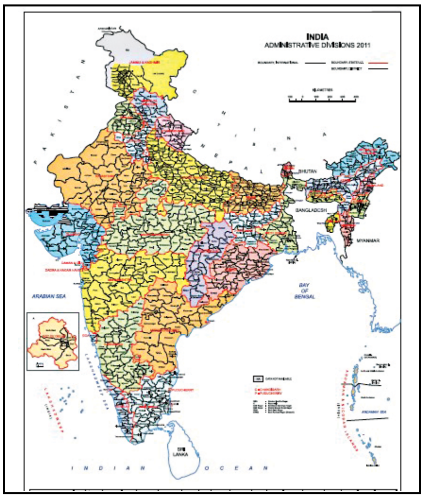


Figure 3: District level Divisions.

Source: CoI (2011) *Census of India 2011*, *Primary Census Abstract*, Office of the Registrar General & Census Commissioner, Ministry of Home Affairs, Government of India, New Delhi.

So, the present research take into account the details of the issues and features of the land governance and management practiced over the periods since the beginning of the ancient time to the present in context to the national land development strategies while dealing with the latest plans and policies of the country, India.

Database of the study

The present study is based on the secondary data available from the different sources as the Agricultural Census, Agricultural Statistics, and Annual Reports etc. which are annually published by the Department of Agricultural and Cooperation, Ministry of agriculture, Government of India, Krishi Bhavan, New Delhi. In addition to this, the present study is also supported by ancillary data available from the Annual Reports published by the Ministry of Rural Development, Government of India, New Delhi. And, the number of volumes have also been taken into consideration of the Five Year Plans published by the Planning Commission, Government of India, Yojana Bhavan, New Delhi. However, the big data have been used in digitalization for real world problems solutions for land governance and its management for the country, India.

Besides this, the National-level Land Use and Land Cover (LULC) mapping at 1: 2,50,000 scale using multi-temporal Resourcesat-1 AWiFS data have also been taken up and analysed using hierarchical decision tree and maximum likelihood algorithm, and interactive classification techniques. Additionally, surface water bodies and snow and glaciers layers for entire country have also been generated for LULC classification and mapping (NRSC, 2006b). While keeping in view for the wider applicability of remote sensing for the land use land cover, a classification scheme has been devised using of 1: 50,000 scale map which consists of Level-I: 9 classes, Level-II: 29 classes and Level-III: 79 classes (NRSC, 2006c and NRSC, 2007). Likewise, the LULC Atlas for India was prepared and released for the use of various departments, central, state and others organisations (NRSC, 2011). Land Cover is defined as observed physical features on the Earth's Surface as forest cover, water body and so on. As soon as an economic function is added into this, it becomes Land Use. The multi-temporal Resourcesat-1, LISS III data for the period of 2005-06 acquired to derive information on the spatial and temporal variability of different land use land cover categories. Such kinds of the multi-temporal datasets were georeferenced with Land Cover Classification (LCC) using the Traverse Mercator (TM) Projection and WGS 84 datum (NRSC, 2007). Besides, the ancillary data consisted of base details namely: the administrative boundaries as international, state, district, tehsil, village and forest boundary, as well as the major roads, railway, drainage, settlements, etc. were taken from available sources. Correspondingly, available ancillary information on wastelands and forests

generated was also quantified during digitalisation of land use land cover mapping for the country, India as a whole.

Research methodology

Geospatial technologies are playing an important role in natural resources mapping, land governance and its management through big data digitalisation for sustainable development, at large. With the advancement of Indian Remote Sensing (IRS) satellite programs over the periods, a variety of remote sensing-based solutions have been provided for all round development of the country as well as to the world. In other words, due to recent remote sensing technological development as the Earth Observation (EO) from space platforms have been largely used in geospatial information digitalisation at spatio-temporal levels. The EO Satellites play an essential role in generation and dissemination of digital information on land use land cover patterns in a timely and dependable manner providing vital inputs required for optimum land use and planning for sustainable development. The Digital Image Processing (DIP) methodology adopted consists of satellite data preparation, onscreen visual interpretation, ground truth data collection, map finalization, quality checking of final maps and databases organization based on recommended standards (NNRMS, 2009).

The Big Data computation requires statistical tools and techniques for summarization in form of final results. The empirical studies shows that there are statistical techniques used for land governance as Gini's Coefficient (GC) is used to measure the extent of concentration. This method measure of inequalities which is commonly used to gain an over-all view of the prevailing geospatial inequalities. In spite of the limitations of this measuring method, it has been used in the number of studies to compute the geospatial concentration of inequalities of various variables (Dorfman, Robert, 1979; Gastwirth, Joseph L., 1972; and John, Weymark, 2003). So, in the present study, in order to eliminate the bias arises due to the changes in the number of each states, the Gini's Coefficient for the different periods have been computed. The statistical presentation of the equation used for calculation of the Gini's Co-efficient is described as follows:

$$G = \frac{1}{100\, x\, 100} = \left| \sum_{i=1}^{n} \text{Xi Yi} + 1 - \left(\sum_{i=1}^{n} (\text{Xi} + 1\ \text{Yi}) \right) \right|$$

Where:

Xi and Yi are the cumulative percentage distribution of the two attributes. In other words, the Xi and Yi are respectively the cumulative proportions of number of operational holdings and area operated up to the j^{th} size class of holdings.

So, the concentration of land holdings

Table 1: Trends of Land Utilisation in India: 1950-51 to 2010-11 and 2011-12.

Sl No	Classification	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2010-11	2011-12
I.	Geographical Area	328.7	328.7	328.7	328.7	328.7	328.7	328.7	328.7
II.	Reporting Area for Land Utilisation Statistics (1 to 5)	284.3	298.5	303.8	304.2	304.9	305.1	305.90	305.81
	1. Forests	40.48	54.05	63.92	67.47	67.81	69.62	70.01	70.02
	2. Not Available for Cultivation (A+B)	47.52	50.75	44.64	39.62	40.48	41.55	43.58	43.52
	3. Other Uncultivated Land Excluding Fallow Land (A+B+C)	49.45	37.64	35.06	32.32	30.22	27.71	26.16	26.10
	4. Fallow Lands (A+B)	28.13	22.82	19.88	24.75	23.36	25.03	24.60	25.38
	5. Net Area Sown (6-7)	118.8	133.2	140.3	140.00	143.00	141.2	141.56	140.80
	6. Total Cropped Area (Gross Cropped Area)	131.89	152.77	165.79	172.63	185.74	185.7	197.32	195.25
	7. Area Sown More Than Once	13.15	19.57	25.52	32.63	42.74	44.54	55.76	54.44
	8. Cropping Intensity *	111.1	114.7	118.2	123.3	129.9	131.6	139.0	138.7
III.	Net Irrigated Area	20.85	24.66	31.1	38.72	48.02	54.84	63.598	65.26
IV.	Gross Irrigated Area	22.56	27.98	38.2	49.78	63.2	75.82	88.630	91.53

Notes:

* Cropping intensity is percentage of the gross cropped area to the net area sown.

i. Figures given in above table are in million hectares.

ii. In 2002-03 there is significant decline in Total Cropped Area and Net Area Sown due to decline in net area sown in the States of Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh Maharashtra, Orissa, Rajasthan, Tamil Nadu, West Bengal and Haryana. This was mainly due to deficient rainfall on agricultural operations.

iii. In 2009-10 there is significant decline in Total Cropped Area and Net Area Sown due to decline in net area sown in the States of Andhra Pradesh, Bihar, Jharkhand, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. This was mainly due to deficient rainfall on agricultural operations.

Source: Above table computed and compiled from the data collected from the MoA (2014) *Agricultural Census (2000-01, 2005-06 & 2010-11),* Agriculture Census Division, Department of Agriculture & Co-Operation, Ministry of Agriculture, Government of India.

in terms of Gini's coefficient among different states have been worked out for the periods 1960-61, 1970-71, 1980-81, 1990-91, 2000-01, and 2010-11 for the country, India as a whole.

Study area

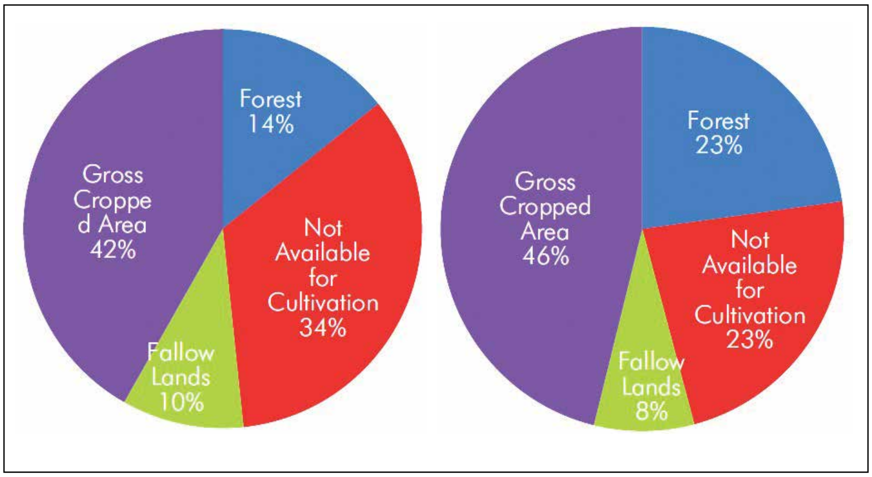
India is situated to the north of equator, between the geographical extent of 08° 04' and 37° 06' north latitudes and 68° 07' and 97° 25' east longitudes. Physiographical features reveals that the lofty Himalayans covered with snow and glaciers are lying in the north. The Great Indo-Gangetic Planes with fertile land drained by navigable perennial rivers are lying below the Himalayas. The Peninsular India is geologically oldest stable landmass rich in mineral resources surrounded by seas as Arabian Sea, Bay of Bengal and Indian Ocean lying in the south as is evidenced by the Figure 1.

Besides this, the States level as well as the districts level latest available administrative divisions at the states level and districts level based on the Census of India, 2011 are also presented in the Figure 2 and Figure 3, respectively. However, the Land information in terms of administrative divisions' statistics showed that there were 28 States which contains about 640 districts in 2011. Likewise, there were around 5,924 sub–districts which comprised by tehsils, talukas and blocks. In addition to this, there was a large number of villages which accounted for about 6,40,930 villages in the country, India during 2011.

Results and discussions

Geospatial trends of land utilisation

The Natural resources in terms of the land use and land cover statistics for the periods beginning from 1950-51 to 2010-11 and 2011-12 is presented in the Table 1. It is evident that there is about 328.7 million hectares of geographical area or the land cover found exist since 1950-51 till to 2010-11, in the country, India. The net sown area is accounted for about



Figures 4 and 5: Trends of Land Use Land Cover in India: 1950-51 and 2010-11.

Source: MoA (2014) *Land Use Statistics at a Glance: 2002-03 to 2011-12*, Directorate of Economics and Statistics, Department of Agriculture & Co-Operation, Ministry of Agriculture, Government of India, New Delhi.

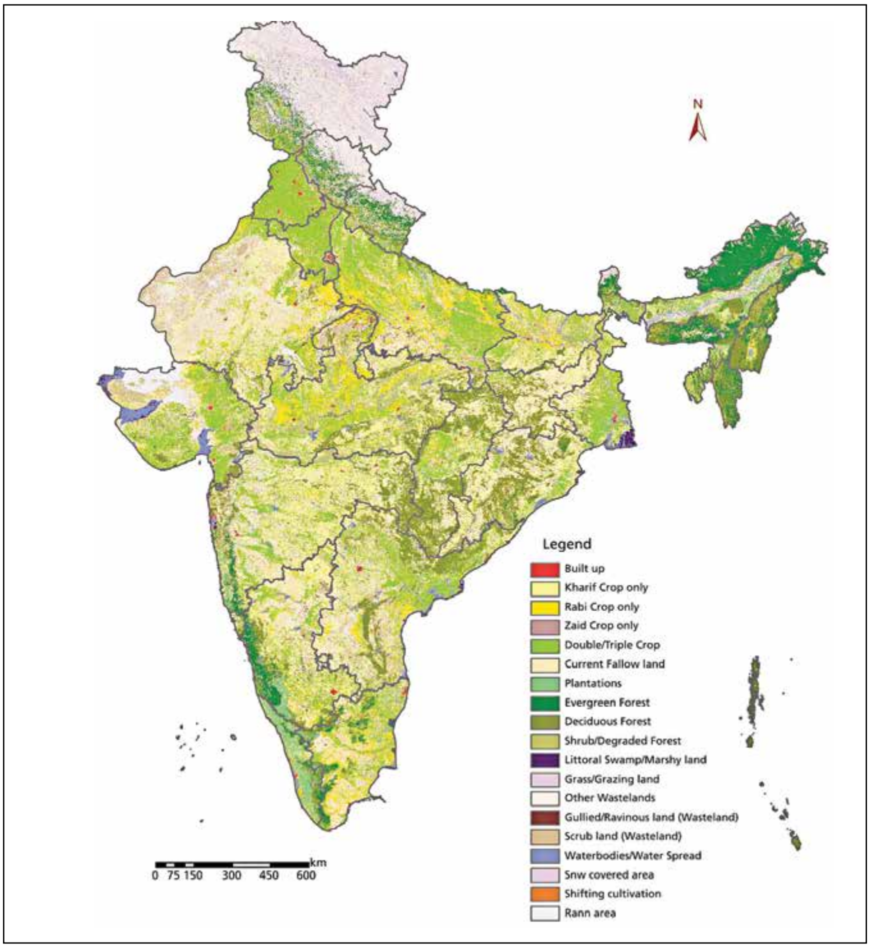


Figure 6: Land use Land Cover, India, 2007-08

Source::NRSC (2011) *Natural Resource Census – Land Use Land Cover Database*, Technical Report – Ver.1, NRSC, RS & GIS Applications Area, National Remote Sensing Centre, ISRO, Department of Space, Balanagar, Hyderabad, India.

46.00 per cent of the total reporting area of the country in the year 2010-11 which has increased from 41.80 per cent in 1950-51. Whereas, the world average is about 32.00 per cent in the same period of 2010-11. The forest cover was increased from 14.20 per cent in 1950-51 to about 22.90 per cent in 2010-11. On the other hand, the barren and unculturalable land was decreased from 13.40 to 5.60 per cent during 1950-51 to 2010-11, respectively.

It is also evidenced from the Table 1 that during 1950-51, the gross cropped area was about 131.89 million hectares, out of which 13.15 million hectares or 9.97 per cent, was as sown more than once and the cropping intensity was 111.10. Thereafter, over the period of about 30 years, in 1970-71 period the gross cropped area was increased to about 165.79 million hectares out of which 25.52 million hectares or 15.39 per cent was sown more than once and the cropping intensity value recorded of 118.2. Furthermore, over another 30 years period, during 2010-11 the gross cropped area was increased to about 197.32 million hectares, out of which 55.76 million hectares or 28.26 per cent was as sown more than once and the cropping intensity further increased to about 139.0 as is evidenced by the Table 1. Besides this, it is inferred from the results presented in the Table 1, that there is found changing patterns of land use land cover over the periods beginning from 1950-51 till to 2010-11 in the country, as a whole which is also graphically evidenced by the Figures 4 and 5.

Geospatial patterns of natural resources and management

Land Use and Land Cover

National–level Land Use and Land Cover (LULC) map at 1: 2,50,000 scale using multi-temporal Resourcesat–1 Multi-temporal AWiFS data have been processed and analysed using hierarchical decision tree and maximum likelihood algorithm, and interactive classification techniques. In addition to this, the surface water bodies and snow cover, glaciers digital layers for entire country, India have also been generated using the satellite imagery. So, the different layers have been merged together and then integrated LULC map produced for the period of 2007-08 which is presented in the Figure 6. Whereas, the Major and medium irrigation command boundary maps were obtained from concerned departments of different states. There are 1,701 major and medium irrigation commands covering 88,896 thousand hectares, which is 27.04 per cent of the geographical area of the country. Number of major and medium irrigation commands are 429 and 1,272, respectively as is evidenced by the Figure 7.

The Vegetation Types in India has been classified based on the IRS–6 satellite imagery for the period 2007–08 which is presented below in Figure 8. The Vegetation type map provides information on spatial extent and distribution of single species dominated vegetation formations, ecologically unique formations, mixed species formations and degraded formations. The spatial delineation of these habitats overlaid with 12,000 field species data in digital domain helps evaluating the regions of bio-prospecting value.

So, the vegetation type map, the first of its kind of systematically organized databases has been developed for India, will serve as a primary database for all types of ecological studies and would serve as benchmark for further environment related studies. The vegetation type maps also provide basic inputs for identification of species habitats.

Land degradation and management

The Figure 9 and 10 shows the waterlogged area within major and medium irrigation commands in different states of the country, India. The perennial and seasonal waterlogged areas have been mapped using the satellite imagery. So, the total waterlogged areas or in other words, the land

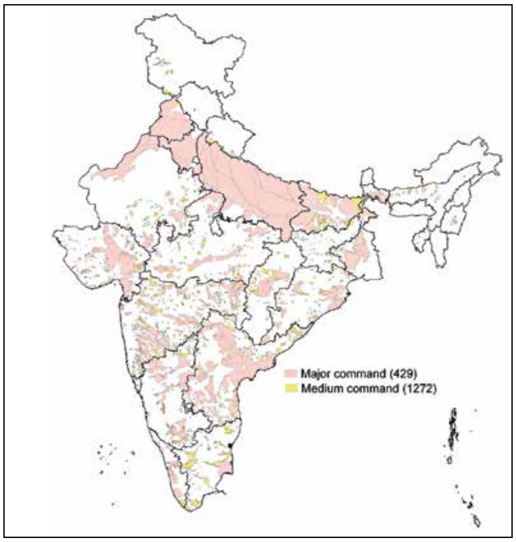


Figure 7: Major & Medium Irrigation Commands, India

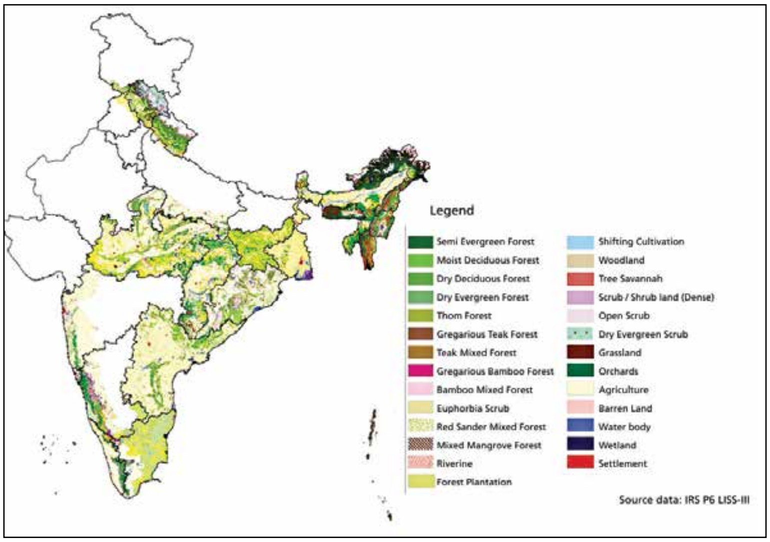


Figure 8: Vegetation Types in India during 2007–08

Source: NRSC (2011) *Natural Resource Census – Land Use Land Cover Database*, Technical Report – Ver.1, NRSC, RS & GIS Applications Area, National Remote Sensing Centre, ISRO, Department of Space, Balanagar, Hyderabad, India.

not available for cultivation due to waterlogging within major and medium irrigation commands in the country is accounted for about 1,719 thousand hectares which is about 1.93 per cent of the command area. Furthermore, the perennial waterlogging covers an area of about 173 thousand hectares, on the one hand. The seasonal waterlogging covers an area of about 1546 thousand hectares, on the other hand. However, the total waterlogged area within major and medium irrigation commands is accounted for about 0.52 per cent of the geographical area of the country, India. There is an urgent need for proper management of waterlogging problems in order to protect thousands of hectares of arable land which is normally caused by the perennial and seasonal running and stored water resources in the country, India as a whole.

The salted affected areas with major and medium irrigation commands for India have been generated using IRS P–6, LISS–III sensor of the satellite imagery for the country, India for the period 2003–05 which is presented in the Figure 10. So, in order to assess the salted affected areas caused by irrigation in the arable lands, the soil testing have been carried out for the country, India.

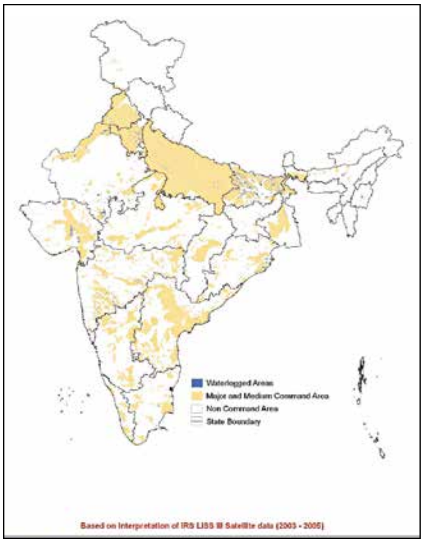


Figure 9: Waterlogged Area within Major & Medium Irrigation Commands in India.

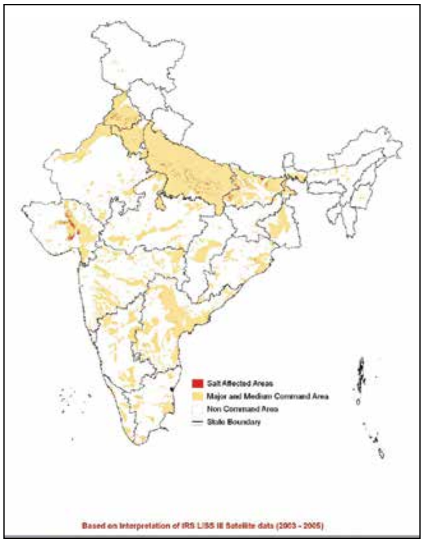


Figure 10: Salt Affected Areas within Major & Medium Irrigation Commands in India.

Source: NRSC (2007) *National Land Use and Land Cover Mapping using Multi-Temporal AWiFS Data*, Project Report 2005-06, NRSC, RS & GIS Applications Area, National Remote Sensing Centre, ISRO, Department of Space, Balanagar, Hyderabad, India.

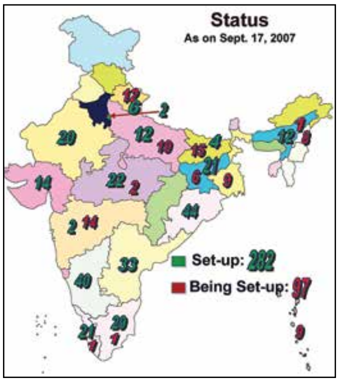


Figure 11: VRCs Centres in India

Figure 12: VRCs Satellite based Services

Source:: NRSC (2007) *National Remote Sensing Centre*, Indian Space Research Organisaiton (ISRO), Department of Space (DOS), Balanagar, Hyderabad, India.

The Soil samples were collected from major and medium irrigation commands of each state. The soil samples were tested for EC, pH and ESP. The salt affected areas are lying in different states in the country within major and medium irrigation commands. The Total salt affected area in the country as per the analysis is accounted for about 1,035 thousand hectares which is around 1.16 per cent of the command area. It covers a marginal land proportion of about 0.31 per cent of the geographical area of the country which is presented in the Figure 10. So, there is an urgent need to reclaim and rejuvenate the degraded land through application of geospatial tools and technologies for land management and sustainability of land resources in the different parts of the country, India.

Village Resource Centres – Cadastral Management

The Village Resource Centres (VRCs) is the unique initiatives that uses Satellite Communication (SATCOM) network and Earth Observation (EO) satellite data in a judicious combination to address the needs of the local people in villages of the country, India. The VRCs use a combination of SATCOM and EO to reach out to the villages and provides wide varieties of services, as agricultural advisories, non-formal education, computer education, skill development and so on. Among the services, the cadastral mapping at the household's level of the villages is one of the important land resource mapping service performed at the VRCs for land governance in the country, India.

At present, there are about 461 village resource centres (VRCs) established in 22 states and union territories which are as Andhra Pradesh (17); Assam (13); Bihar (19); Delhi (2); Gujarat (10); Jharkhand (26); Himachal Pradesh (30); Karnataka (58); Kerala (21); Madhya Pradesh (24); Maharashtra (18); Meghalaya (1);

Nagaland (8); Orissa (44); Puducherry (9); Rajasthan (21); Sikkim (19); Tamil Nadu (54); Uttarakhand (18); Uttar Pradesh (30); West Bengal (10) and Andaman & Nicobar Islands (4) as is evidenced by the Figure 11. The VRCs node also included about 81 Expert Centres set–up in the country, India. The major benefits of VRCs are as the rural empowerment, smart governance, computerised gram panchayats, distance education, remote health care services, employment opportunities, access to products and services available to city dwellers is schematically presented in the Figure 12.

There are more than 6,500 programmes which have been conducted by the VRCs in order to cater the needs of people in the areas like, agriculture and horticulture development; fisheries development; livestock development; water resources; tele health care; awareness programmes; woman's empowerment; supplementary education; computer literacy; micro credit; micro finance; skill development and vocational training for livelihood support etc. So far, more than five Lakh people each year have been benefitted by the VRC services in different parts of the country, India. Now, with the advancement in satellite communication technology, the VRCs are playing an important role in overall development of the country, India. However, the Village Resource Centres (VRCs) programme launched by the Indian Space Research Organisation (ISRO) of the Department of Space (DOS), Govt. of India which disseminates a portfolio of services emanating from space systems directly to the rural communities of the country, India. The programme is executed in association with NGOs and Trusts and the State and Central govt. agencies.

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To be continued in the next issue.

Bentley systems acquires plaxis, and complementary SoilVision

Bentley Systems, Inc has acquired Plaxis, the leading provider of geotechnical software, based in Delft, Netherlands, and the agreement to acquire soil engineering software provider SoilVision, based in Saskatchewan, Canada.

The acquisitions, with Bentley's market-leading borehole reporting and data management software gINT, serve to make Bentley a complete source for geotechnical professionals "going digital." Finally, BIM advancements can be extended to the essential subsurface engineering of every infrastructure project. *www.bentley.com*

Esri releases ArcGIS pro workstation

Esri is releasing the Intelligence Configuration for ArcGIS Pro (ICAP), a workstation for intelligence analysts. ICAP leverages ArcGIS Pro SDK to provide a custom managed configuration and add-ins, offering streamlined user experiences and specialized tools to aid analysts in examining relationships and patterns and determining probabilities relating to the target's most likely course of action.

The scale, complexity, nature, and pace of modern conflicts require a new approach to delivering intelligence capabilities.

Government plans to build national data and analytics platform

After the Central Bank announced that it was planning to start its own digital currency, now the Government of India is planning to build an advanced technology platform in collaboration with private players.

The platform will be used to host and interpret huge amounts of citizen data collected from central ministries and state governments. This interpretation can then be used to factor in the spend patterns of the government. It can also be used to evaluate various government policies. The plan on the national data and analytics platform is being developed by NITI Aayog. The platform will use artificial intelligence to harness the data collected.

Considering that government is looking at a private public partnership, it could see companies such as IBM, Wipro, TCS, HP that offer analytics to be a part of the project. Interestingly, since there are a lot of startups working in the field and as the government is encouraging startups, there could be keen interest from startups as well. The estimated cost of developing the platform would be Rs 50 crore to Rs 100 crore. *www.cio.in*

NavVis launches Autodesk Revit add-in

NavVis has announced a new add-in for Autodesk Revit. The add-in lets its users connect their BIM models to 360 degree immersive imagery and point clouds captured by the NavVis mobile mapping system. This add-in simplifies the process of creating and updating outdated BIM models to reflect the current state of the building. With the Revit add-in, the NavVis IndoorViewer can now easily be integrated with its BIM models.

Integrating Revit and IndoorViewer allows for a side-by-side comparison of the BIM model and the scanned state of the building, remotely from a desktop. *www.navvis.com*

OS and Geovation reveal next wave of GeoTech and PropTech businesses

Seven exciting start-ups will join the Geovation Programme and receive the strategic backing of Ordnance Survey (OS) and HM Land Registry (HMLR).

The Programme, which acts as an accelerator course to new GeoTech and PropTech businesses, will see each of the start-ups receive up to £20,000 in grant funding and a range of resources and services to help them develop their business.

Airbus adds extra precision to Sentinel-3 satellite altimetry

A new highly precise MicroWave Radiometer (MWR) built by Airbus is ready to start operations after the launch of the Sentinel-3B satellite built by Thales Alenia Space as prime contractor for this program. It is one of the essential instruments of the Sentinel3 spacecraft, measuring atmospheric humidity as supplementary information for tropospheric path correction of the altimeter signal. In addition, MWR data is useful to measure surface emissivity and soil moisture overland, surface energy budget investigations which support atmospheric studies and for ice characterization. These corrected measurements along with a digital elevation mode help the radar altimeter to work in SAR (Synthetic Aperture Radar) mode, which is much more precise and provides much better spatial resolution along the track. The data produced will allow scientists to monitor sea-level changes, sea surface temperature, manage water quality,and track marine pollution and biological productivity. It will also provide a land monitoring service with wildfire detection, land cover mapping and vegetation health monitoring. This will provide complementary data to the Sentinel-2 multispectral optical mission.

China launches five commercial remote sensing satellites

China successfully completed its twelfth orbital launch of 2018, sending five small Zhuhai-1 remote sensing satellites into orbit.

Aboard the rocket were one video and four hyperspectral Earth-observation satellites for the Zhuhai Orbita constellation, designated as OHS-01, 02, 03 and 04 (hyperspectral) and OVS-2.

The OVS-2 is an upgraded version of the OVS-1A and OVS-1B satellites launched in June 2017, with spatial resolution of 90 centimeters at an altitude of 500 km and a swath width of 22.5 km. The OHS satellites — China's first commercial hyperspectral satellites in orbit — have a resolution of 10 meters and can complete global coverage in around five days. *http://spacenews.com*

US government considers charging for popular EO data

The US government is considering whether to charge for access to two widely used sources of remote-sensing imagery: the Landsat satellites operated by the US Geological Survey (USGS) and an aerial-survey programme run by the Department of Agriculture (USDA).

Officials at the Department of the Interior, which oversees the USGS, have asked a federal advisory committee to explore how putting a price on Landsat data might affect scientists and other users; the panel's analysis is due later this year. And the USDA is contemplating a plan to institute fees for its data as early as 2019. *www.nature.com*

Chinese space-based RS technology helps discover heritage in Tunisia

Ten new archeological sites in southern Tunisia were discovered using Chinese space-based remote sensing technology. The archaeological sites, dating back to ancient Roman times, are located in three Tunisian provinces -- Gafsa, Tataouine and Medenine, said Tunisian Culture Minister Mohamed Zine El-Abidine at a press conference. *www.ecns.cn*

SimActive automates drone data processing

SimActive Inc has announced increased drone data automation in Correlator3D™. New automated profiles include configurable options with a predefined set of parameters to deliver superior results from the first project onward. As an example, the "Quick Project Overview" enables users to rapidly process and generate results while still in the field for quality control. Additional options include "Standard UAV", "Classic Photogrammetric", and "Fast Ortho." *www.simactive.com*

China to launch two remote sensing satellites for Pakistan in June

China will launch two remote sensing satellites for Pakistan in June, the China Academy of Launch Vehicle Technology (CALVT) said.

It will be the first international commercial launch for a Long March-2C rocket after it carried Motorola's Iridium satellites into orbit in 1999.

The rocket will also carry the China-France Oceanography Satellite into space in September this year, state-run Xinhua news agency reported quoting CALVT. *www.hindustantimes.com*

Belarus eyes launch of its second remote sensing satellite

Belarus is planning to launch its second remote sensing satellite. However, the officials have not yet revealed the exact launch date of the spacecraft.

The satellite, named BKA-2, will be a remote sensing spacecraft, built by the Russian corporation *VNIIEM* (this was confirmed recently by the Belarusian Prime Minister Andrei Kobyakov). *www.spaceflightinsider.com*

Global carbon dioxide maps produced by Chinese observation satellite

An Earth observation satellite called TanSat has produced its first global carbon dioxide maps. TanSat was launched by a collaborative team of researchers in China, and these maps are the first steps to provide global carbon dioxide measurements for future climate change research.

The maps, based on data collected in April and July 2017, are published in the latest edition of the journal Advances in Atmospheric Sciences.

TanSat, launched in December 2016, is the third satellite in orbit capable of monitoring carbon dioxide with hyperspectral imaging, and it is China's first greenhouse gas monitoring satellite. The satellite measures not only the presence of carbon dioxide, but also carbon dioxide flux—the source and sink of carbon dioxide on Earth's surface.

The satellite can measure carbon dioxide's absorption in the near-infrared zone for a better picture of carbon dioxide's behavior on and around Earth. The TanSat maps were completed within a year of the satellite's launch. *https://phys.org*

Boeing and JAXA to Flight-test Technology to Improve Safety

Boeing and the Japan Aerospace Exploration Agency (JAXA) will flight-test Long-range Light Detection and Ranging (LIDAR) technology next year. This remote-sensing technology could help commercial airplane pilots better detect and avoid weather disturbances to improve flight safety.

Boeing and JAXA have been collaborating on the integration of LIDAR technology into a commercial airplane platform since 2010. The JAXA LIDAR technology offers the potential to accurately measure winds as much as 17.5 kilometers in front of airplanes and provide pilots with sufficient time to take appropriate action to avoid wind shear and clear air turbulence, which does not have any visual cues such as clouds. *www.boeing.com*

Deimos Imaging awarded GSA contract

Deimos Imaging and UrtheCast have been awarded a GSA Multiple Award Schedule (MAS) 070 contract by the U.S. General Services Administration (GSA), the procurement arm of the federal government.

This is the first time that a European company in Earth observation services has been awarded such a contract in the U.S., making Deimos Imaging's full portfolio of products and services available to all U.S. government agencies.

Stanford aero/astro professor Per Enge, expert in GPS, dies at 64

Per K. Enge, the Vance D. and Arlene C. Coffman Professor in the School of Engineering and one of the world's foremost experts in global positioning system (GPS) technologies, died April 22 at his home in Mountain View, California. He was 64.

Enge, a professor of aeronautics and astronautics, was best known for his work on GPS. He led deployment of two navigation systems in use today. The first began operation in 1995 and had over 1.5 million marine and land users as of 2014. The second system launched in 2003 and was, at last count, in use in over 100,000 aircraft and by more than 1 million land users. In another notable example, Enge led the team that designed a system that allowed planes to land themselves entirely unaided by human hands, even on the pitching decks of aircraft carriers at sea – in the dark. *https://news.stanford.edu*

EU should keep Britain in Galileo space project despite Brexit

The chief executive of aerospace firm Airbus said Britain should not be frozen out of the European Union's Galileo space programme after Brexit, calling on both sides to find a long-term solution in the interest of security. "The UK's continued participation in the EU Galileo programme will ensure security and defence ties are strengthened for the benefit of Europe as a whole, during a period of increasing threats to our security and geopolitical instability," Tom Enders, Airbus CEO said in a statement.

A spokesman for British Prime Minister Theresa May said that the UK wanted "complete involvement" in Galileo.

Graham Peters, chairman of trade association UKspace, said Britain was already losing work on Galileo as European consortia forming to bid for new contracts were choosing not to include UK companies. Peters said one contract currently up for grabs was the Galileo Ground Control Segment – potentially worth 200 million euros where the prime role may be shifted out of Britain to a site in another EU country.

Among the companies that work on Galileo through UK units are Airbus, which is Britain's biggest space company and the majority owner of SSTL, a Surrey, England-based company which makes satellites for the Galileo project, as well as CGI CGI.N and QinetiQ (QQ.L).

Brexit is already inflicting damage on Britain's space industry as EU officials said in January that a security centre for Galileo satellites would be moved from Britain to Spain as a result.

Asked by Reuters whether it had a plan to set up European subsidiaries to ensure its continued involvement in Galileo, Airbus unit SSTL said: "Due to the enhanced sensitivities and political complexities around the Galileo projects and services at the moment, we are unable to provide input or comment to media at this time on our involvement." Airbus's Enders said in his statement that there was also a need for clarity on Britain's participation in the EU Earth observation programme Copernicus. *https://uk.reuters.com*

Galileo: UK plan to launch rival to EU sat-nav system

The UK is considering plans to launch a satellite-navigation system as a rival to the EU's Galileo project. The move comes after the UK was told it would be shut out of key elements of the programme after Brexit. The UK has spent 1.4bn euros (£1.2bn) on Galileo.

Business Secretary Greg Clark is taking legal advice on whether the UK can reclaim the cash, according to the Financial Times. He told BBC News: "The UK's preference is to remain in Galileo as part of a strong security partnership with Europe.

"If Galileo no longer meets our security requirements and UK industry cannot compete on a fair basis, it is logical to look at alternatives." The row centres around whether the UK can continue to be trusted with the EU's most sensitive security information after Brexit.

Graham Turnock, chief executive of the UK Space Agency, said early feasibility work was under way into a UK system, which he said would cost a "lot less" than Galileo, thanks to work already done and "British know-how and ingenuity". He said the UK had "a lot of the capability that would be needed for a sat-nav system because we developed them as part of our role in Galileo". "We cannot launch yet, although obviously we are trying to address that, but this is something we think is in the realm of the credible," he added.

While Airbus will be able to continue working on Galileo at its continental centres whatever the outcome of the present row, the company said its UK wing stood ready to assist in building a British sat-nav system if asked. "If the UK opts for its own satellite-navigation system then Airbus's space operations in the UK has the skills and expertise to lead the development of it," Andrew Stroomer, a senior British executive in Airbus, told the BBC.

Greg Clark warned that the European Commission's actions could threaten defence and security co-operation with Britain after it has left the EU. *www.bbc.com*

GLONASS becomes financially self-sufficient

The Russian government stopped funding the state-owned operator of the GLONASS satellite navigation system this year as it has become financially self-sufficient, Russian Deputy Prime Minister Dmitry Rogozin said. "This is very important as it demonstrates the success of the decision to commercialize the products created by Russian orbital systems," Rogozin told Russian President Vladimir Putin in a meeting, according to the Kremlin. He said that so far GLONASS equipment has been installed on 107 airfields, 76 ports, 8,791 vessels, 670 aircraft, and more than 1.8 million vehicles. *www.xinhuanet.com*

Glitch in the system correction of the glonass signal

GLONASS is temporarily not providing corrective information via a satellite link. This statement appeared on the virtual online slot – monitoring systems that complement the GLONASS.

The cause of the failure is called failure, which led to the fact that the current has ceased to flow at the point of placing the complex control. Sdcm consists of three satellites of the system "Beam" and stations for data reception and transmission located on Land. These objects receive the signals coming from Russia and other countries. The system constantly monitors the GLONASS satellites and reports malfunctions, and, if necessary, produces the desired correction. According to experts, without the use of sdcm accuracy of GLONASS is equal to 3.1 meters, and when using it it is much improved.

The staff of "Roscosmos" has not yet commented on the situation. Netizens are convinced that accurate adjustment is not interesting to ordinary citizens, so to speak about serious crashing does not make sense. GLONASS is used by the military to locate enemy headquarters. Peaceful this system is used in a variety of areas, ranging from control of movement of vehicles to monitoring of infrastructure. *https://sivtelegram.media/discovered-a-glitch-in-the-system-correction-of-the-glonass-signal/5468/*

DT Research's new military-grade tablet has RTK GNSS

DT Research has released the DT301T rugged RTK tablet (DT301T-RTK), a lightweight military-grade tablet purpose-built for GIS mapping applications. It features real-time kinematic (RTK) satellite navigation to enhance the precision of GNSS position data. The tablet enables 3D point cloud creation with centimeter-level accuracy, meeting the high standards required for scientific-grade evidence in court.

IRNSS-1I up in space

Navigation satellite IRNSS-1I was put in orbit by the Indian Space Research Organisation's (ISRO) PSLV-C41 rocket. Eighth in the series, the 1425- kg satellite completes the first phase of the Indian regional navigation constellation, ISRO Chairman K. Sivan said.

The PSLV-C41 lifted off at 4.04 a.m. on 12th April 2018, as planned, from the First Launch Pad of the Satish Dhawan Space Centre at Sriharikota in coastal Andhra Pradesh, and after a flight lasting about 19 minutes, the satellite separated from it.

The navigation satellites, dubbed India's own GPS (Global Positioning System), are meant for giving precise information of position, navigation and time of objects or people. They were built by a consortium of six Indian companies led by Alpha Design Technologies Ltd., Bengaluru. They have a civilian and a restricted military/security application.

Built for a 10-year job in space, 1I is expected to be ready for work in about a month after routine orbit manoeuvres and tests.

Although 1I is the ninth to be launched in the NavIC navigation fleet, it counts as the eighth, as the previous one, 1H, was lost in a faulty launch last August.

They were planned as backups but became necessary after the three imported rubidium atomic clocks on 1A failed while in orbit. Both 1I and 1H extensively involved the consortium in the assembly, integration and testing in Bengaluru — an exercise that ISRO would replicate in coming missions, Dr. Sivan said. *www.thehindu.com*

ISRO's clock to prop up India's own GPS

Time is running out for the seven-satellite Indian Regional Navigation Satellite System (IRNSS), also known as NavIC (Navigation in Indian Constellation). NavIC, whose seventh satellite was launched in April 2016, was expected to provide India a satellite-based navigation system independent of the US GPS. But India's own 'regional GPS' is yet to become officially operational owing to repeated failures of the atomic clocks on the satellites.

In view of the cascade of failing imported atomic clocks — nine out of the 21 clocks in the fleet have failed — ISRO has decided to add buffers to the NavIC by adding four more satellites. It hopes to have an indigenous atomic clock in each of them. "We are in the process of getting approval [from the government] for at least another four IRNSS satellites," according to ISRO Chairman K.Sivan, confirming the failure of clocks.

"However, they will have some advanced technology, apart from the atomic clocks developed by ISRO." NavIC is meant to give Indian civil and military users reliable location and time information, for which the performance of the atomic clocks is critical.

The indigenous atomic clock is being developed by the Space Applications Centre, Ahmedabad, Mr. Sivan said, adding that once it passes qualification tests, "We will first demonstrate the indigenous clock in an upcoming navigation satellite, along with the imported ones. Work on them is going on in full steam." *www.thehindu.com*

Beidou system helps with spring plowing

Thanks to the new Beidou Navigation Satellite System, Chinese farmers are having an easier time with spring plowing.

In Tawan village in northwest China's Ningxia Hui Autonomous Region, a tractor installed with a vegetable transplanter was slowly moving ahead in the field, while several farmers nearby filled the transplanter with seedlings. The tractor's cab was empty, however, and an antenna and receiver sat atop the machine. "The antenna serves as the eye of this unmanned machine," said Ma Haitao, the original driver of the tractor.

Once a plowing path has been entered, the machine will follow the route precisely, deviating less than three centimeters per kilometer. The unmanned tractor belongs to Yihe Agricultural Machinery Operation Service Co. Ltd. in Wuzhong city of Ningxia. The company's owner, Tan Zhenlong, purchased seven Beidou Satellite Navigation System sets for its agricultural machinery in two years.

Beidou Satellite Navigation System enables the tractor to plow with great accuracy, preventing mis-seeding and reseeding. It not only cuts farmers' workload by nearly half, but greatly improves land use and production output, according to Tan.

The development of China's modern agriculture is gaining speed thanks to technology like the Beidou Satellite Navigation System. *www.xinhuanet.com*

New DARPA challenge seeks flexible and responsive launch solutions

DARPA has announced the DARPA Launch Challenge, designed to promote rapid access to space within days, not years. Our nation's space architecture is currently built around a limited number of exquisite systems with development times of up to 10 years. With the launch challenge, DARPA plans to accelerate capabilities and further incentivize industry to deliver launch solutions that are both flexible and responsive.

The commercial small-launch (10kg-1000kg) industry has embraced advances in manufacturing, micro-technologies, and autonomous launch/range infrastructure. DARPA seeks to leverage this expertise to transform space system development for the nation's defense. Frequent, flexible, and responsive launch is key to this transformation. *www.darpalaunchchallenge.org.*

BeiDou navigation satellite system centre in Tunisia

The China-Arab States BDS/GNSS Center, the first overseas center for China's indigenous BeiDou Navigation Satellite System (BDS), was officially inaugurated in Tunisia.

The center is established as a pilot project between China and the Tunisia-based Arab Information and Communication Technology Organization (AICTO), an Arab governmental organization under the Arab League, to promote the global application of the BDS, said Ran Chengqi, director of China Satellite Navigation Office. *www.xinhuanet.com*

KORE and Telarus partner to drive wireless and IoT

KORE has announced a partnership with Telarus, the largest privately-held Technology Services Distributor in the United States, to offer KORE's IoT connectivity solutions and products.

Telarus partners will now be able to feature the full suite of KORE Power Solutions to meet the wireless and IoT needs of their customers. The supplier partnerships provided by Telarus are based on long-term viability and success, and KORE's unique offering of a single platform, which delivers connectivity globally through multiple carrier relationships, combined with bundled solutions including best-in-class hardware such as routers and tablets, supports the synergistic, sustainable collaboration. *www.korewireless.com*

Spatial DNA joins acuity's atrius IoT partner program

Acuity Brands, Inc. of Atlanta, Georgia USA, reported that Spatial DNA Informatics Inc. joined the Atrius-IoT Partner program. Under the partner program, Spatial DNA will use location-based data from Atrius Platform Services and AtriusTM-Ready Sensory Networks to build mobile applications for enterprise workflows and indoor navigation.

Spatial DNA will integrate data from clients using the Atrius Platform Services. Then its PeopleFlow and AssetFlow Software-as-a-Service (SaaS) platform will present unique insights derived from the data. *www.solidstatelightingdesign.com*

Alibaba confirmed as developing self-driving vehicles

Chinese e-commerce giant Alibaba Group has confirmed that it has been working on autonomous driving technology, China Daily recently reported. Wang Gang, chief scientist at the company's AI Labs, is leading the research team and they have made rapid progress. The company's research aims to reach Level 4, which means the self driving vehicle can fully drive itself without human intervention in certain circumstances, said the report.

Chinese authorities issued regulations on April 12 to allow local road tests for intelligent connected vehicles, which covers different degrees of autonomous driving.

Alibaba has conducted regular road tests of its self-driving vehicles and the company was looking to hire an additional 50 experts to boost the technology.

Alibaba's move follows its rivals, Baidu and Tencent, another two Chinese internet conglomerates, which are also developing self-driving vehicles. *www.xinhuanet.com*

European countries sign a declaration of co-op on AI

European countries signed a Declaration of cooperation on Artificial Intelligence (AI). Whereas a number of Member States had already announced national initiatives on Artificial Intelligence, they now declared a strong will to join forces and engage in a European approach to deal therewith. By teaming up, the opportunities of AI for Europe can be fully ensured, while the challenges can be dealt with collectively.

The Member States agreed to work together on the most important issues raised by Artificial Intelligence, from ensuring Europe's competitiveness in the research and deployment of AI, to dealing with social, economic, ethical and legal questions. The Declaration builds further on the achievements and investments of the European research and business community in AI. AI is already used by citizens daily and facilitates both their personal and professional lives.

The emergence of AI also brings challenges which need to be addressed. An anticipatory approach is needed to deal with AI's transformation of the labour market. It is necessary to modernise Europe's education and training systems, including upskilling and reskilling European citizens. New legal and ethical questions should also be considered. An environment of trust and accountability around the development and use of AI is needed to fully profit from the opportunities it brings. *https://ec.europa.eu*.

HOZON Auto launches research center in silicon valley

HOZON Auto Autonomous Vehicle Research Center (Silicon Valley) officially opened in the United States, marking a crucial step-forward in building out its global strategic R&D layout, and opening up a new path for global autonomous driving technology.

As a global hub of science and technology innovation, the Silicon Valley is the epicenter of autonomous driving, bringing together the world's top R&D institutions focusing on autonomous driving technology, such as Google, Apple, Microsoft, and Baidu.

At the beginning of 2018, HOZON Auto established a global R&D strategy that focuses on building R&D centers worldwide in five cities across four countries, including Autonomous Vehicle Research Center (Silicon Valley), Italy Torino Design Center (underway), German Engineering and Technology Center (underway), and Shanghai and Jiaxing R&D Centers.

Findyr merges with Analytics and Machine Learning Experts

Findyr, the global platform for crowdsourcing of hyper local, street-level data and insights has announced its merger with Leviathan, the big data analytics platform specializing in analysis of cloud ingested big data with leading machine learning models. The merger, which will continue to operate as Findyr, is seeking to solve some of the biggest location-based challenges being faced across the globe by the private and public sectors.

First counter drone technology by IXI EW

IXI EW, LLC has announced that they have entered into a Product Development and a Licensing Agreement with T-Worx Holdings, LLC based in Ashburn, Virginia. The Agreement provide for the integration of the IXI DRONEKILLER handheld counter UAS technology onto the T-Worx Intelligent Rail® ("I-Rail®") system with its Rifle Operating System™. Developed under the US Army Small Business Innovative Research (SBIR) Program, the I-Rail provides both power and intelligent control of electronic devices when attached to an I-Rail integrated Picatinny Rail. Following an extensive competition, the I-Rail also became the NATO Powered Rail standard in 2015.

The current IXI DRONEKILLER is the only standalone handheld counter UAS device that employs software-defined radio technology to detect and affect class 1 and class 2 UAS (sUAS) devices without the use of broadband jamming. *www.ixitech.com*

Foremost UAS test range acquires integrated drone airspace management system

Kongsberg Geospatial, an Ottawa-based geospatial visualisation software company, and the Foremost UAS Test Range, who operate one of only two Transport Canada certified UAS test ranges in Canada, have announced that they have integrated the Kongsberg Geospatial IRIS UAS situational awareness application combined with uAvionix ADS-B receivers into the CCUVS Range Operations infrastructure.

The integration of the Kongsberg IRIS Airspace Awareness application and uAvionix ADS-B system will provide situational awareness safety for Beyond Visual Line-of-Sight (BVLOS) flight operations at the Transport Canada certified UAS Test Range in Foremost Alberta. *www.kongsberggeospatial.com*

First UAS and Automated Guided Vehicle (AGV) certified by UL

Unmanned or automated electric vehicles and systems are now available with UL electrical system safety certification, as UL issues the first UL 3030 certification for unmanned aircraft systems (UAS) to the Intel® Falcon 8+ drone, a professional, unmanned aerial vehicle ideal for inspection and close mapping. Additionally, UL has issued the first UL 3100 certification for automated guided vehicles (AGVs) to Dematic, a leader in integrated automated supply chain technology. UL recently developed these two safety standards that focus on the electrical system safety of the end product with critical safety system components such as the rechargeable lithium-ion batteries and charging systems on- or off-board the product. *www.ul.com*

Large area mapping UAV by Delair

Delair has announced the global availability of its breakthrough Delair UX11 fixed-wing UAV, an innovative hardware-software platform that provides highly accurate images for survey-grade mapping, with onboard processing capabilities and real-time, long-range control. The platform's enhanced centimeter-level precision along with its efficient operational characteristics make it the most cost-effective solution for large area surveying and mapping.

The UX11 is an ideal solution for highly precise and safe mapping in a number of industries such as surveying, construction, oil & gas, utilities, mining, agriculture and transportation.

IAI developing autonomous vehicles

Israel Aerospace Industries Ltd. is unveiling new products that could potentially revolutionize mining and quarrying. IAI's robotics factory has developed technology for utilizing autonomous vehicles in heavy mechanical equipment used in mining and development work.

One of the main developments recently reported by IAI is aimed at the global mining industry through a system named Euphemus based on advanced algorithms that makes it possible to convert huge trucks used to transport dirt in open mines into completely autonomously driven trucks. These converted trucks can be operated independently according to definitions made in advance through commands given to them remotely. *www.globes-online.com*

Singapore plans to beef up laws governing drone use

As more drones and unmanned aircraft take to the skies here, the Civil Aviation Authority of Singapore (CAAS) is proposing enhancements to the laws governing their use in a bid to ensure public safety.

Five changes are being proposed to the existing unmanned aircraft regulatory framework, which was established in 2015.

These include the enhancements of operating guidelines for unmanned aircraft; an online training programme which will be compulsory for those flying unmanned aircraft weighing 1.5kg or more; as well as a pilot licensing scheme to ensure that users have a minimum competency level.

There are also plans for the introduction of training organisation framework to support the proposed pilot licensing.

Another proposed change is the implementation of additional requirements for those flying unmanned aircraft weighing more than 25kg.

Heavier unmanned aircraft pose a greater safety risk.

These requirements could include the partial or full certification of the device, as well as the certification of the operator and maintenance organisation. *www.reach.gov.sg*

India's Mahindra teams with Aeronautics on naval UAVs

India's Mahindra Defense and Israeli drone developer Aeronautics Ltd. have signed a Memorandum of Understanding (MoU) to partner for naval shipborne unmanned aerial vehicles (UAVs). Aeronautics and Mahindra announced that they will offer a UAV system that can be launched and recovered from Indian warships.

Based in Yavne, south of Tel Aviv, Aeronautics provides integrated turnkey solutions based on unmanned systems platforms, payloads and communications for defense and civil applications. Aeronautics is the OEM of the Orbiter series of UAVs which has been sold in many countries globally. *www.globes-online.com*

MRO Drone and Ubisense join forces

MRO Drone and Ubisense are pairing up through the launch of a new Smart Hangar solution, which combines drone aircraft inspection with automated tool and asset management technology. The partnership aims to improve the efficiency and productivity of MROs through reliable staging of work packages, sensor-driven feedback and real-time visibility of tools and equipment.

The Smart Hangar concept starts with Ubisense's Dimension4 tracking system, which uses sensors placed around an aircraft hangar to track assets—including drones—providing real-time location information to control and monitor asset movements.

New drone-based inspection capabilities by Kespry

Kespry has announced new capabilities for significantly accelerating the assessment of roof hail and wind damage for residential, multi-family and commercial buildings. New capabilities include on-site processing of drone-captured roof inspection data, a Virtual Test Square (VTS) to support claims decision-making in minutes, and enhanced automated hail detection, driven by machine learning. Equipped with the updated Kespry solution, insurance adjusters can now make claims settlement decisions in as little as an hour. *www.kespry.com*

New joint effort boosts drone standards for public safety officials

Two of the world's leading safety-standards developers are joining forces to help the growing number of public safety professionals who want to use drones – also known as

The National Fire Protection Association and ASTM International signed a Memorandum of Understanding to support a joint working group (JWG) of about two dozen top experts in public safety and drone technology.

This group, which first met Feb. 23, is working to create "use-case scenarios" to help meet needs of law enforcement, search-and-rescue teams, emergency medical services personnel, and firefighters who want to use drones in various operations. *www.astm.org*

Cyient and BlueBird Aero Systems sign JV to offer UAV systems

Cyient and Israel-based BlueBird Aero Systems, a leader in design, development, and production of micro, mini, and small tactical Unmanned Aerial Systems (UAS) have have entered into a joint venture to offer field-proven UAV systems to Indian defence, paramilitary, security, and police forces. The joint venture, named Cyient Solutions & Systems Private Limited, has 51% and 49% shareholding by Cyient and BlueBird respectively.

DroneDeploy launches drone on demand

DroneDeploy has announced their Drone on Demand solution to unlock actionable drone insights for everyone. The solution lets customers plan a flight mission using DroneDeploy's cloud platform—and then request a certified professional pilot from DroneBase, the largest global drone operations company, who will go to the site, perform the flight, and collect aerial data. It streamlines a complicated drone data collection process—putting instant, high-resolution aerial data into the hands of all.

13 member Task Force in India for fast-tracking UAV technology

The Indian Government has decided to constitute a Task Force under the chairmanship of Jayant Sinha, Minister of State for Civil Aviation for fast-tracking the roll-out of Unmanned Aerial Vehicle (UAV) technology.

The Task Force will develop a roadmap with implementable recommendations for Central as well as State Governments, Industry and Research Institutions.

The Task Force will consist of representatives from the Government, PSUs, industry and sectoral experts and submit report within 6 months of its constitution.

The Terms of Reference of the Task Force are as follows:-

- The Task Force will focus, inter-alia, on research & development, acquisition & commercialisation, application & adoption in specific sectors, regulatory framework, preference for Make in India.
- A roadmap with implementable recommendations for the Central Government, State Governments, Industry and Research Institutions including outcomes, timelines, implementation & review mechanism and measurable metrics will be prepared by the Task Force. The role of the industry will also be clearly delineated.
- The Task Force may study global practices and interact with relevant stakeholders, as required, for preparation of their report.

The Task Force will have necessary consultations and interactions with Industry, Research Institutions and Government Organizations.

Delair UX11 fixed-wing UAV

Delair, a leading supplier of commercial drone solutions, recently announced the global availability of Delair UX11 fixed-wing UAV, an innovative hardware-software platform that provides highly accurate images for survey-grade mapping, with on-board processing capabilities and real-time, long-range control. The newest drone model from the pioneering UAV company passed its final testing phases and is now available from Delair authorized distributors in more than 70 countries.

Hi-Target GNSS Receiver iRTK5 claims Red Dot Design Ward 2018

Red Dot Design Ward released the list of winners recently. Hi-Target next-generation intelligent smart GNSS Receiver iRTK5 overcame competition and stood out from thousands of submissions from 50 countries to claim the award. Established in 1954, the red dot awards are one of the most prestigious design competitions in the world and are an acknowledgment of high quality design. Competition is always very tough and winning demonstrates a high level of creativity, innovation and quality of manufacture.

The use of magnesium alloy materials and electrical coupling corrosion design enable GNSS Receiver iRTK5 with a light weight, anti-drop, corrosion resistance and anti-interference ability. It is the first GNSS Receiver launched in the industry with a high-definition, colored OLED touch screen replacing for the traditional button operation. This transform brings with an intuitive experience and convenience for operators. A 360° omni-directional antenna with innovative design breaks the limit of the distance; multiple radio protocols supporting is compatible with multi-brand manufacturers; upgraded to the new generation controller iHand30 supporting 4G, WiFi, OTG which has greatly improved the operating efficiency.

Handheld devices for mobile applications by Hemisphere GNSS

Hemisphere GNSS has announced the availability of the all-new UT series of GNSS-capable rugged handheld devices to support demanding industries such as construction, survey, GIS, mapping, asset/logistics management, public safety, utilities, military, and other mobile applications. The UT10 6.0" Rugged Phone and UT30 8.0" Rugged Tablet both feature Android™ 8.0 operating systems with Qualcomm® octa-core 2.2GHz processors, 4GB of RAM, and 32GB onboard storage. The UT50 10.1" Full-Rugged Tablet features Windows® 10 operating system with an Intel® Core™ Skylake i5 processor up-to 2.8GHz, 8GB RAM, and 128GB onboard-storage. All three new UT models provide the latest high-resolution, capacitive touchscreen, and direct sunlight-readable display technology for ease of visibility in all situations. *www.HGNSS.com*

U.S. Air Force selects Rockwell Collins

Rockwell Collins has been awarded multiple repair contracts by the U.S. Air Force to support Global Air Traffic Management (GATM) components on the entire KC-135 tanker fleet. These contracts, valued at approximately $27 million over the next five years, will keep the aircraft flying and in compliance with Communication, Navigation, Surveillance and Air Traffic Management (CNS/ATM) mandates. The contract expands Rockwell Collins' existing footprint on the KC-135, which currently provides support for the Flight2™ integrated avionics system and communications equipment on the platform. *www.rockwellcollins.com*

Hemisphere GNSS' flexible & scalable GradeMetrix™ toolkit

Hemisphere GNSS has announced significant achievements with its GradeMetrix OEM toolkit for high-precision GNSS-based machine control and guidance applications and systems. Hemisphere has expanded its portfolio of hardware offerings, including the recently announced A222 Scalable GNSS Smart Antenna, and made significant strides forward with its next-generation GradeMetrix OEM application software platform. Whether it is grading, mining, excavating, drilling & piling, or compaction applications, heavy equipment manufacturers can rebrand the solution and drive feature requirements to sell as their own. *www.HGNSS.com*

Galileo update

Galileo ground segment keeps constellation on track

Galileo's initial services have been running for more than 15 months now, and signals from the satellites in space are routinely serving users all across the world. The functioning of Galileo is dependent on a global network of ground stations.

The constellation in orbit is only one element of the overall satellite navigation system – the tip of the Galileo iceberg. At the same time as satellites were being built, tested and launched, a global ground segment has been put in place, extending to some of the world's loneliest places, from Svalbard in the High Arctic to storm-engulfed Jan Mayen Island, Ascension Island in the Mid Atlantic to Noumea in the South Pacific, Kerguelen in the southern Indian Ocean to Troll base in the Antarctic interior.

Among the latest developments are updated control and mission software for the two Galileo control centres that sit at the heart of this global web: Fucino in Italy generates the accurate navigation messages that are then broadcast through the navigation payloads, and Oberpfaffenhofen in Germany controls the constellation of satellites. A new telemetry, tracking and command station last year arose in Papeete on Tahiti, in the South Pacific.

Establishing Galileo's ground segment was among the most complex developments ever undertaken by ESA, having to fulfill strict levels of performance, security and safety. Formal responsibility for the operations of this Galileo ground segment was last year passed to ESA's partner organization, the European Global Navigation Satellite System Agency, or GSA, but ESA continues to be in charge of its maintenance and growth.

Users don't have to worry about this ground segment, but it is essential to keeping Galileo services running reliably. The atomic clocks aboard the satellites are accurate to a few nanoseconds, delivering metre-scale positioning precision, but they are prone to drift over time.

Similarly, the orbits of the satellites can be slightly nudged by the gravitational tug of Earth's slight equatorial bulge and by the Moon and Sun. Even the slight but continuous push of sunlight itself can affect satellites in their orbital paths. The quality of signals received on the ground can be affected by their transit through the ever-changing ionosphere, the electrically active outer layer of Earth's atmosphere.

Galileo sensor stations, with small omnidirectional receiving antennas around just 50 cm high, are on place around the globe to check the accuracy and signal quality of individual satellites in real time, and work together to pinpoint the current satellite orbits.

Harxon smart antenna provides RTK positioning for agriculture

Harxon Corporation is launching the single-frequency, multi-GNSS real-time-kinematic (RTK) enabled Smart Antenna TS300 series, designed for manual guidance and autosteer agriculture applications that benefit from scalable performance in positioning accuracy.

The TS300 series is a multi-GNSS compatible system using GPS, GLONASS, BeiDou and Galileo for simultaneous satellite tracking to offer RTK positioning.

It is able to track any visible satellites under challenging conditions, ensuring a stable signal quality with higher precision and reliable data. Farm tractors and machines can still receive a healthy signal when the sky is partially visible or there are obstructions around the farmland.

US Geological Survey selects Hexagon

The US Geological Survey (USGS) has selected Hexagon US Federal to upgrade the machine learning-based Land Cover Mapping (LCM) tool. Through more than a decade of success using the LCM tool powered by Hexagon's ERDAS IMAGINE, the USGS has continued to achieve its mission of supplying timely, relevant, and useful information about the earth and the changes experienced by the national land cover.

Since 2005, the LCM tool has generated USGS's National Land Cover Database that collects public domain information on the 3.8 million miles of land cover in the United States and Puerto Rico. This information provides complete, current, and consistent information critical to government managers and officials that seek to understand how land cover changes over time.

The data is used by dozens of federal government organizations, state governments, and private industry to make decisions on wetland ecosystems, urban development, deforestation, agricultural production, climate change and flooding, for example.

Xsens INS module uses GNSS for positioning

Xsens has expanded its MTi product portfolio with the introduction of the MTi-7, a miniature inertial navigation system (INS) module that uses input from an external GNSS receiver to provide an accurate, real-time position, velocity and orientation data stream. The module has a compact 12 x 12-millimeter footprint, weighs less than 1 gram and consumes under 100 milliwatts, making it suitable for use in space- and power-constrained devices such as drones, as well as autonomous or remote-controlled mapping and imaging equipment. Operating at output data rates up to 800 Hz, the MTi-7 achieves very low latency of 2 milliseconds, allowing for real-time operation of dynamic functions such as flight control and camera stabilization, the company said. *www.xsens.com*

DigitalGlobe to map buildings using machine learning

DigitalGlobe (DG) has formed a partnership with Ecopia Tech to use proprietary Artificial Intelligence (AI) algorithms and cloud computing to create building footprints. Customers will now have current information on structures in their areas of interest. Ecopia, a developer in DG's Geospatial Big Data platform (GBDX) ecosystem, established a process to create building footprints quickly and at scale by leveraging machine learning in combination with its cloud-based 100 petabyte imagery library. *www.satellitetoday.com*

Phase One Innovates UAV-based Aerial Imagery

Phase One Industrial has launched the iXM series: an innovative aerial camera platform driven by a fast medium-format imaging sensor. The iXM 100MP is a high-productivity metric camera with a range of high-resolution lenses, especially engineered by UAV-imaging missions. The iXM is ready for integration with a wide range of UAV platforms, including Phase One's DJI Matrice 600 Pro solution.The iXM 100MP metric camera incorporates a medium-format sensor with backside-illumination technology, enabling high light sensitivity and extended dynamic range. Fast, highly responsive, robust, and weatherproof (IP53 compliant), the iXM 100MP delivers the necessary quality aerial imaging and flexible operation to satisfy diverse mapping, surveying, and inspection applications.

First worldwide marketplace for Land Surveying Instruments.

Topotrade to launch the first online marketplace specially designed for selling and buying land surveying instruments. Topotrade.com brings the largest choice of surveying instruments to the market, while ensuring quality of the instrument and protection in every transaction. It brings a strong and safe solution to the market by offering the largest choice of new, refurbished and second-hand surveying instruments.

Optech Galaxy for Mountain and Forestry Surveying

Teledyne Optech recently announced that Asia Air Survey Co., Tokyo, Japan, has taken delivery of an ALTM Galaxy T1000 for use in their forest resource management initiatives, road and railway facility management, as well as slope stability monitoring activities.With 70% of Japan covered in mountains and hillsides, the country can be very susceptible to geomorphic hazards, such as landslides, often caused by seismic activity. To predict and mitigate these hazards, AAS plans to use the Galaxy airborne lidar sensor to collect high-density 3D data to create detailed maps of the country.

Versatile terrestrial laser scanner

The Polaris terrestrial laser scanner delivers accurate, precise data quickly, bridging the gap between small, light-weight, short-range sensors and large, long-range, pulsed time-of-flight scanners. Built with surveyors in mind, the scanner has a user-friendly on-board operator interface with menu-driven operations for quickly collecting and referencing data. With an integrated high-resolution camera, inclinometers, a compass, a L1 GNSS receiver and weather-proof housing, the Polaris can be deployed in many environments and orientations.

New field solutions for land and construction surveying

Trimble® TSC7 Controller is a new field solution for land and civil construction surveyors. Combined with specialized software, it defines the next generation of data collection and computing for mobile workers.

It brings powerful enhancements to the field and was designed based on customer feedback. It provides a tablet experience with a physical keyboard and a sunlight readable 7-inch touchscreen that supports pinch, tap and slide gestures. Users can interact with the TSC7 intuitively, easily zooming, panning and selecting items on the large touchscreen. Front- and rear-facing cameras allow users to video conference their office from the field for on-the-job support, and capture high definition videos and images that provide valuable context to their data and clients.

Trimble's Forensics Solution

Trimble® Forensics SX10 Solution, a hardware and software data collection and processing system for collision and crime scene reconstruction. The solution includes the Trimble SX10 scanning total station, with the Trimble T10 tablet and Trimble Capture field software to enable highly efficient data collection for crime and collision scene investigation and reconstruction.

Marine positioning GNSS receiver

Trimble has debuted the MPS865 marine positioning system multi-frequency and multi-application GNSS receiver. It is a versatile, rugged and reliable GNSS positioning and heading solution for a wide variety of real-time and post-processing applications for marine survey and construction. It features integrated communications options such as Wi-Fi, UHF radio, cellular modem for internet connectivity, Bluetooth and MSS satellite-based correction channels.

The patented GNSS-centric technology uses all available GNSS signals to deliver reliable positions in real time. The GNSS receiver provides for the connection of two GNSS antennas for precise heading. *www.trimble.com*

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www.geosummit.ch/

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5 - 7 June
Anaheim, California, USA
www.spar3d.com/event/

GEO Symposium 2018
11 - 12 June
Geneva, Switzerland
www.earthobservations.org/geoss_wp.php

HxGN LIVE 2018
12 - 15 June
Las Vegas, USA
http://hxgnlive.com

7th International Conference on Cartography & GIS
18 - 23 June
Sozopol, Bulgaria
www.iccgis2018.cartography-gis.com

2018 BGC Geomatics
18 - 23 June
Olsztyn, Poland
http://bgc2018.systemcoffee.pl/index.php?id=1

2018 Baltic Geodetic Congress
21 - 23 June
University of Warmia and Mazury in Olsztyn, Poland
http://bgc2018.systemcoffee.pl

Drones Conference 2018 & Workshop
28 - 29 June
Johannesburg, South Africa
http://www.dronesconference.co.za

July 2018

GI Forum 2018
3 - 6 July
Salzburg, Austria
www.gi-forum.org

Esri International User Conference 2018
9 - 13 July
San Diego, USA
www.esri.com/events

ESA/JRC International Summer School on GNSS 2018
16 - 27 July
Loipersdorf, Austria
www.esa-jrc-summerschool.org

September 2018

Inter Drone 2018
5 - 7 September
Las Vegas, USA
www.interdrone.com

Africa GEO
17-19 September
Johannesburg, South Africa
https://africageo.org.za

INSPIRE Conference 2018
18 - 21 September
Antwerp, Belgium
www.inspire.ec.europa.eu/conference2018

5th EARSeL Joint Workshop "Urban Remote Sensing – Challenges & Solutions"
24 - 26 September
Dortmund, Germany
http://urs.earsel.org

International Symposium and Workshop on A smart sustainable future for all
24 - 26 September
Melbourne, Australia
ssf2018.com

ION GNSS+ 2018
24 - 28 September
Miami, USA
www.ion.org

October 2018

Joint Geo Delft Conference

The 6th International FIG 3D Cadastre Workshop

The 3D GeoInfo Conference
1- 5 October
Delft, the Netherlands
www.tudelft.nl/geodelft2018

39th Asian Conference on Remote Sensing (ACRS 2018)
15 - 19 October
Kuala Lumpur, Malaysia
http://acrs2018.mrsa.gov

Intergeo 2018
17 - 18 October
Frankfurt, Germany
www.intergeo.de

November 2018

Trimble Dimensions 2018
05 - 07 November
Las Vegas, USA
www.trimbledimensions.com

International Navigation Conference 2018 Bristol, UK
12 - 15 November
http://www.rin.org.uk/Events/5185/International-Navigation-Conference-2018

ITSNT 2018
13 - 16 November
Toulouse, France
http://www.itsnt.fr

United Nations World Geospatial Information Congress
19 - 21 November
Deqing, China

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21 - 23 November
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https://www.isgnss2018.com


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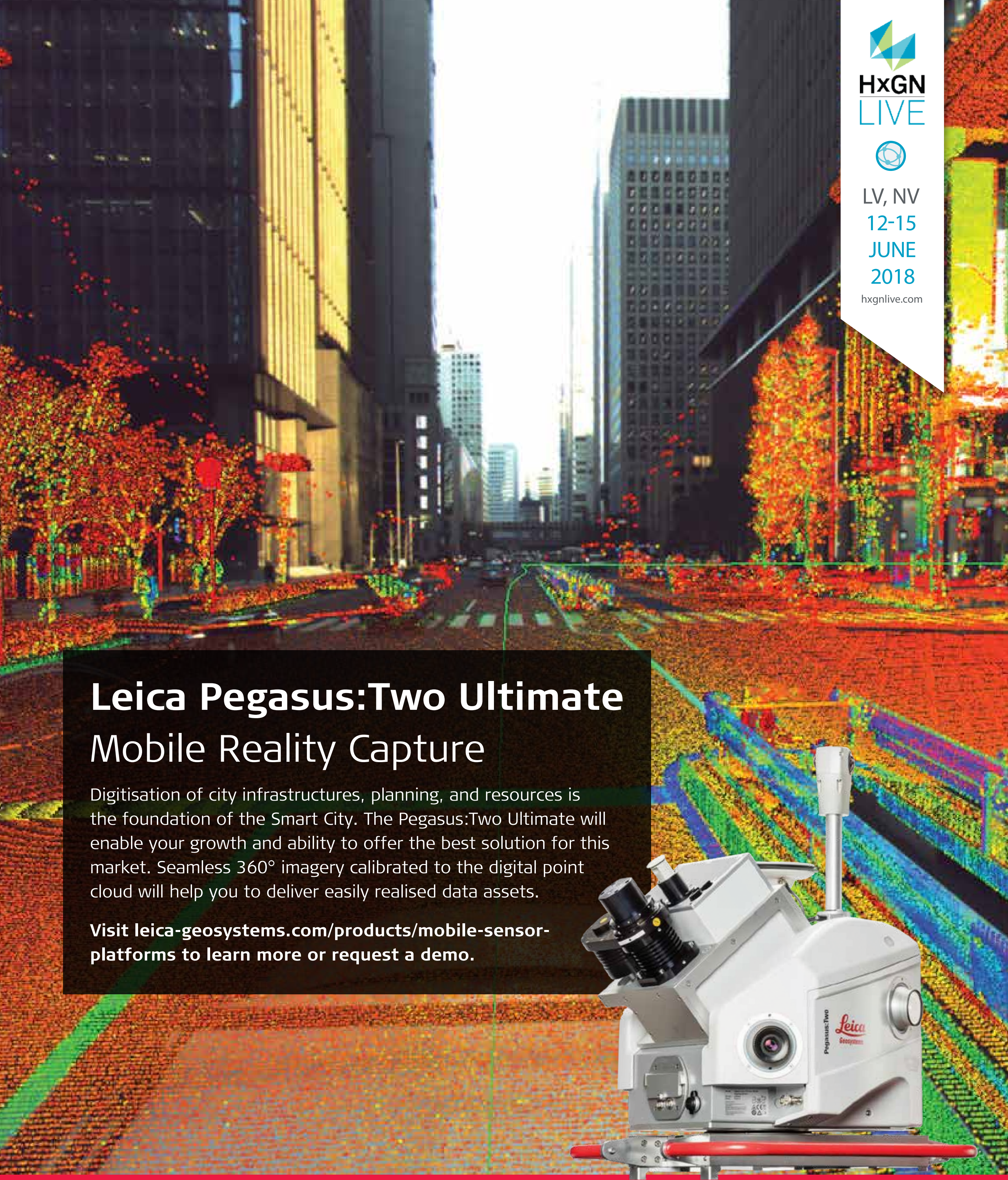
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