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THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

ORTHOMETRIC HEIGHTS DETERMINATION

Also

- Selection of Suitable Matching Area in Gravity-Aided INS
- "Public good" of geographic information
- Cadastre and Land Register Maintenance in Finland


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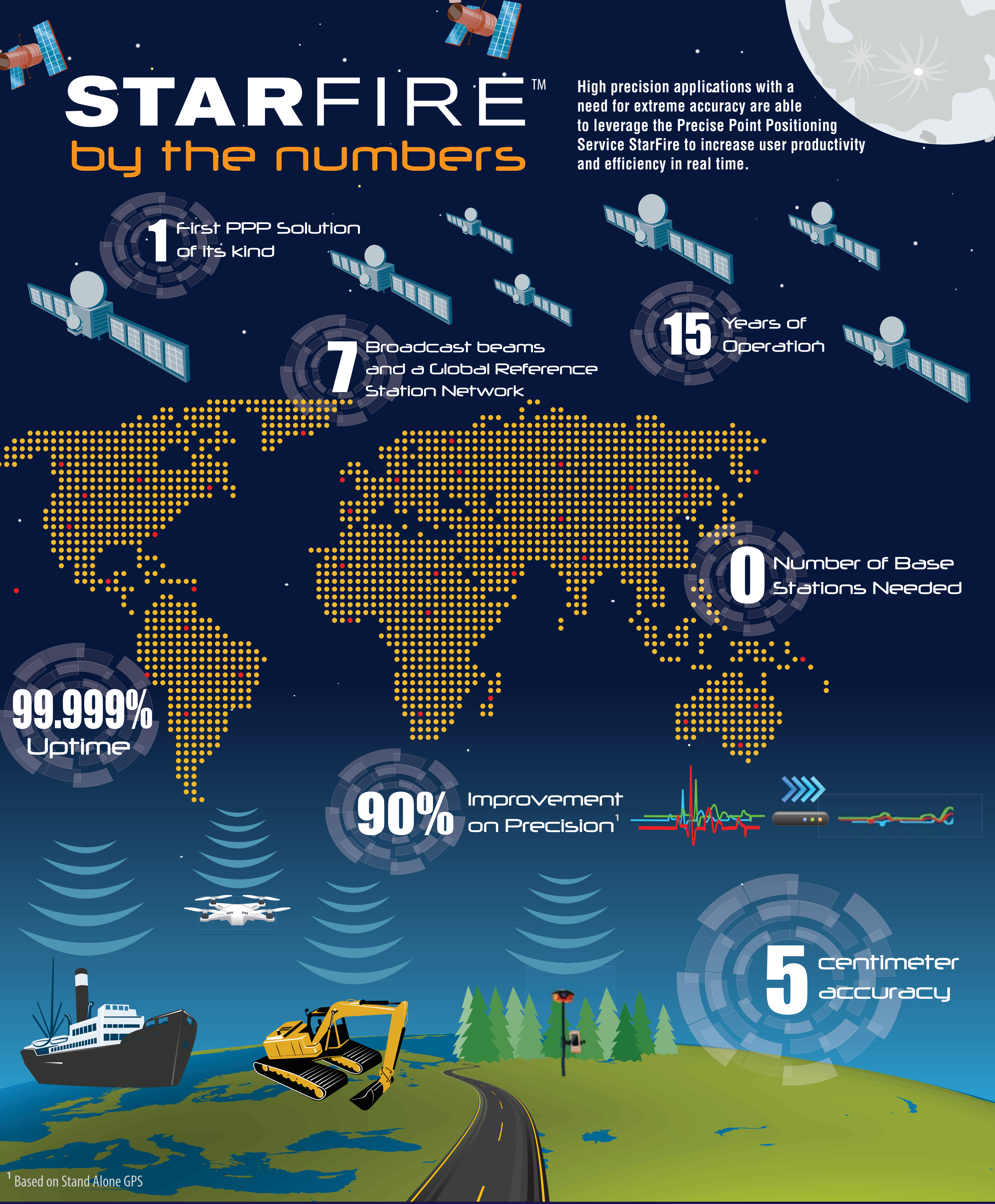

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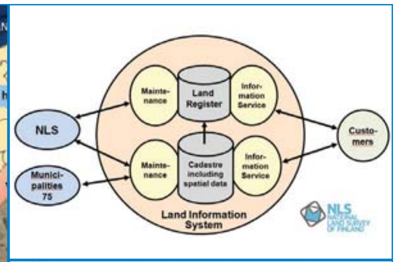

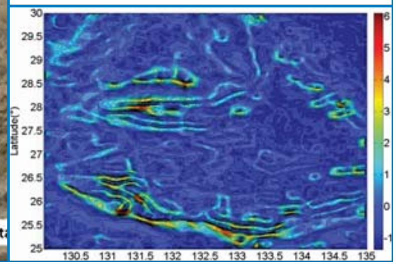

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Mailing Address
A 002, Mansara Apartments
C 9, Vasundhara Enclave
Delhi 110 096, India.
Phones +91 11 22632607, 98102 33422, 98107 24567
Fax +91 11 22632607

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

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

Something is better than nothing

The Director General of Civil Aviation (DGCA) of India

Has issued draft guidelines on operation of Civil Unmanned Aircraft System (UAS) (page no 38).

Drones will be issued unique identification numbers (UIN) so that they can be 'tracked' easily.

All civil UA operations at or above 200 ft AGL in uncontrolled airspace will require Operator Permit.

Earlier there was a blanket ban on flying of UAS by non-government agencies.

Now they can fly provided they meet certain conditions.

A positive step towards UAS policy has been taken.

And, this is a welcome step.

Bal Krishna, Editor
bal@mycoordinates.org

Cadastre and Land Register Maintenance in Finland

The LIS is complex combination of systems consisting of a number of subsystems, which all have to work together

Ari Tella
Chief Engineer,
National Land Survey of Finland Opastinsilta, Helsinki, Finland

In Finland, the Land Information System (the LIS) has for a while already been in a digital format. In recent years, we have developed new maintenance tools that save manpower. We have also developed operational environments to respond to today's needs. Nowadays there is continuous demand to make all activities more efficient.

Maintenance of LIS needs several software and auxiliary systems to work well. The LIS is complex combination of systems consisting of a number of subsystems, which all have to work together.

Well working tools and databases is not enough to ensure that LIS maintenance is efficient. Updating the processes and structures of organisations, to take advantage of the possibilities that the online world has to offer is also necessary. The opportunity to work anywhere and at any time makes it easier to combine working time and leisure time, which in turn contributes to wellbeing at work.

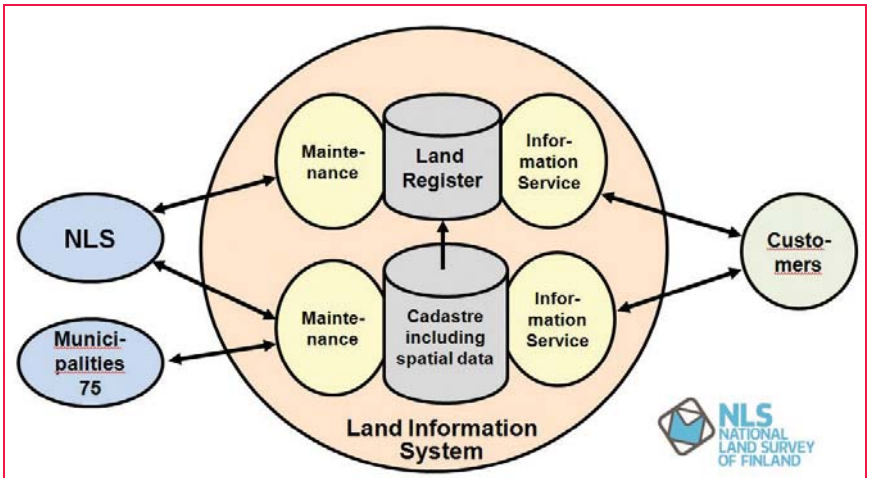

Figure 1: The structure of LIS inFinland

The structure of LIS in Finland

LIS consists of the Cadastre and Land Register and they both have applications to maintain data and give information services (Figure 1). National Land Survey (NLS) and 75 municipalities keep the Cadastre. Municipalities are responsible for recording data on real estates in their town plan areas. These areas are approximately 2% of the area of Finland area and 18% of the total number of real estates. NLS keeps the Cadastre in the rest of the Finnish territory. The Cadastre is nationwide, coherent and contains attribute and spatial data of real estates (Tuomaala, J., Uimonen, M.: Introducing the New Object-Oriented Cadastral Information System (JAKO) of Finland) and have been in today's technical form since 2005 (Tella, A.: The New Land Information System in Finland). NLS has kept the Land Register since 2010. The new Land Register was introduced in 2013 and it contains data on the ownership of real estates (titles) and mortgages and encumbrances that burden the real estates. Both the Cadastre and Land Register are updated around Finland in 35 locations at the NLS's offices.

NLS and municipalities update the Cadastre with changes which come from cadastral surveys using a maintenance application. The biggest municipalities also have real estate information in their own systems. First they update their own systems and from there transfer the changed real estate information using semiautomatic tools to the Cadastre.

After the real estate transaction is completed, the buyer has to apply for the registration of title to the property. Annotating the Land

Register guarantees public credibility of ownership. The owner of the property can apply for a mortgage and use it to guarantee the loan. In the Land Register, the application for title or mortgages is processed by a maintenance application and the information is stored in the Land Register database.

The Land Register uses information from the Cadastre as basic information concerning the real estate, to which titles and mortgages are added. In addition, it is possible to make some annotations directly from legal cadastral surveys to the Land Register.

In the LIS there are three different kinds of information services. The web browser service is primarily used by authorities, banks and real estate agents. Via service interfaces (WFS and REST), several ICT companies have created their own services. From the service interface,it is possible to get via http-request different kind of certificates from the LIS in pdf format.

Third type of information services is data service by order (XML) by which is transferred changed real estate information to municipalities, to the tax authority and to the Population Register Centre.

The maintenance of the cadastre

The subsystems used in conjunction with maintenance of Cadastre

The whole maintenance system that is needed in the Cadastre update contains not only the Cadastre database and maintenance applications, but also several associated systems.

One import system is the electronic archive. Storing documents only in electronic format has been the only archiving form from the year 2009. We continually scan old documents, of which we have in total 15 shelf km and of which under 10 % is in digital format. The oldest maps are from the 1690s and the oldest other documents are from the 1750s.

Here are some examples of other associated databases and applications:

- actual transactions of real estates in purchase price register
- topographic and orthophoto data as background map
- legal surveys billing system
- diary system of correspondence with clients
- statistic information of processes which update the Cadastre

Tools which make Cadastre updating more efficient

Cadastre maintenance is done by storing changes and additions from legal cadastral surveys and from decisions of the keeper of the Real Estate Register. See below some examples of the tools which make doing legal cadastral surveys easier and more efficient and, therefore, also the updating of the Cadastre.

Appointment of cadastral surveyors

NLS complete about 20,000 and municipalities about 4,000 legal cadastral surveys every year. To each new legal cadastral survey a cadastral surveyor must first be appointed. There is a tool in the cadastral maintenance application for selecting the cadastral surveyor. The tool shows where the legal cadastral survey is on the map interface and where the alternative cadastral surveyors are. It also shows the work situation of surveyors, e.g. the amount of incomplete work, which kind of legal surveys he can do and times when he is absent from the work. The surveyor can define his location as his home or, e.g. holiday cottage if he works from there in summer.

The institution of proceedings of legal cadastral surveys has been centralised and covers the whole of Finland. The initiator selects the cadastral surveyor who is best suited to handle the cadastral survey. This helps to minimise the driving and service times.

Initial data for legal cadastral survey

The cadastre is used as the source of initial data for the cadastral survey. Another source is the electronic archive. In Finland we cannot use the Cadastre as the only source of information.

Information from earlier legal cadastral surveys that concern that real estate unit must be checked. In the long run, the aim is that the Cadastre could be the only source of information for pending new legal cadastral surveys.

The locations of boundary markers are measured by GPS, from where they are transferred with their attribute data to the cadastre maintenance application.

Electronic minutes – 'Feather' tool

The electronic minutes of a legal cadastral survey and the electronic notification of meeting make using a dedicated tool, Feather (Figure 2). The idea is that the tool can generate as complete minutes as possible.

Feather is used to fetch the basic information from that particular legal cadastral survey.

The information is located directly to the right place on the minutes. The tool contains a text bank from which text can be selected depending on the type of legal cadastral survey. The user can also select old minutes when starting to write new ones and use the tool to fetch the right information from the database to the minutes.

The electronic signature guarantees the constancy of the document and saves it only in electronic format to the archive system.

Previously, we scanned manual documents into electronic archive. Today, all documents go directly in electronic format to the archive. The change has saved about 5 person years every year.

Sending documents by post – 'Dove' tool

Every year, we send about 550,000 letters to our customers. The customers of legal cadastral surveys receive notifications, invitations, minutes, extracts and other documents from the NLS. We have developed a tool with which those documents can be prepared, sent and archived. The tool is called 'Dove' (Figure 2).

All documents to the client are sending using the Finnish postal service provider Posti's iPost-service. Documents are

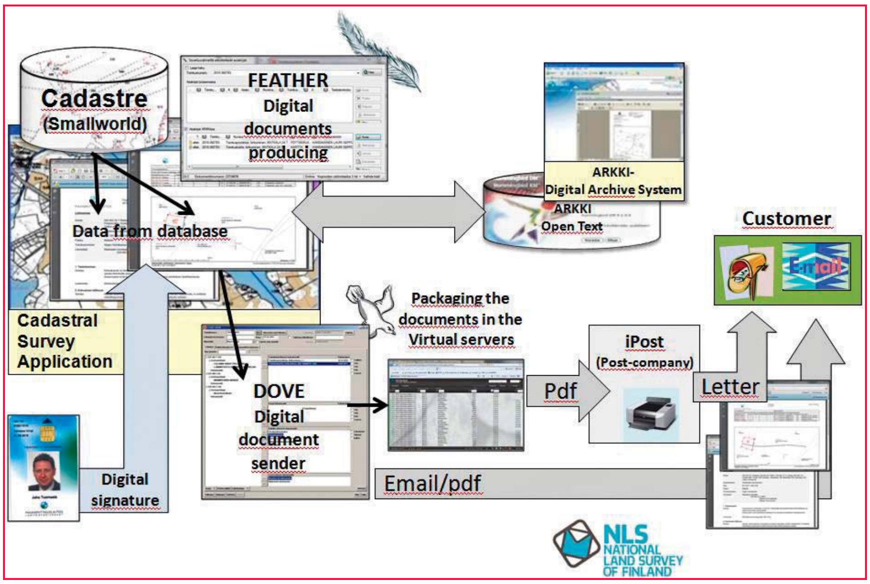

Figure 2: Feather and Dovetools

sent in pdf format, and printed out as iPost documents and put into envelopes by the iPost service, to be delivered to clients. The tool has saved about 10 person years of manual labour each year.

The documents from legal cadastral surveys can also be delivered to clients bye-mail. Especially major customers, such as electricity and forest companies, use this service.

In the summer 2015 we will take into use the citizen's account where the client's official documents will be delivered, instead of delivery by post or e-mail, provided that the recipient has opened a citizen's account. When we send the documents, the application check if the client has account and if there is one, the documents are sent there.

The citizen's account is communication form which makes an electronic connection between citizen and authority possible. Using the citizen's account person can receive announcements from the authorities, decisions and other documents in digital format, in a safe manner and in one place. Accounts can also be used in bidirectional communication.

The last stage of a legal cadastral survey is sending the invoice to client. It is also sent automatically from the billing system. All information is also recorded automatically in the diary system.

The future of the Cadastre

In 2017, the possibility to form 3D real estate units will be added to the Cadastre in Finland. However, the technical solution is in 2D. 3D real estate units can be located above or below ground. 3D real estate units are projected areas to the Earth's surface, whose highest and lowest height is known. The detailed spatial extent is clarified in documents.

Currently we are investigating what kinds of e-services the public needs. We talk about bidirectional services, which help customers to do business online and at the same time help us do legal cadastral surveys.

The long-term aims of the cadastre are being considered. One thing that is being investigated is the possibility to use the cadastre as the only information source, as a coordinate cadastre, without the archive. When developing any system, it is also necessary to think about processes. Those will also be the object of our scrutiny.

The maintenance of land register

The new Land Register

The Land Register which was renewed in 2013 is based on e-documents and the consideration of the cases electronically. The electronic handling of titles and mortgages makes it possible to resolve cases in any one of the NLS's 35 office locations. There is no dependence between location of a real estate unit and the location where the case is handled.

All documents, which we receive in paper format are scanned when we get a new title or mortgage application from the customer. We get those directly in digital format from the new Electronic Property Transaction System, if it is used. In that case the application, with its attached documents, goes to the work queue to await handling.

The land registration secretary takes title or mortgage application from the nationwide work queue for handling, settles the matter and the title or mortgage is stored in the Land Register. Documents are stored in the digital archive. Documents and invoices are sent to the customer using the iPost service.

Both electronic and manual formats of mortgage bonds are used in the Land Register. The electronic mortgage bond is not yet common used, because banks and real estate agents have not yet made changes to their own processes and data systems. In practice, the electronic mortgage bond is an annotation in mortgage information in the Land Register where the mortgage holder is mentioned. If you have a manual mortgage bond, the holder is person who, or typically the bank which has possession of that paper physically.

The new Electronic Property Transaction System

To the Land Register and to its maintenance is associated essentially the Electronic Property Transaction System. In the year 2013 the new service was introduced, which makes it possible to convey a real estate unit by sale, gift or exchange electronically online. With the system, you can also apply for mortgage and transfer a mortgage to another holder.

The System uses the Cadastre to check real estate and the basic information of the target of transaction, the Land Register to check that the sellers have right to make the transaction, the Population Information System to check that the seller and buyer are capable of acting in law and the Register of Enterprises to check that persons have right to make property transactions in that company.

In that online service, the number of completed real estate transfers has been very small, only about 1 000 and the number of mortgages only about 1 500. The reason why so the numbers are so small is that banks and real estate agents have not yet changed their processes and systems so that they are compatible with electronic property conveyancing.

We are now clarifying what the banks' and estate agents' perceived barriers against using the system are and trying to persuade them to use that new service. In the near future, interface to banks will be available, through which a deed or mortgage application can be transferred from the bank's system to the Electronic Property Transaction System as initial information. Our aim is definitely to ensure that the new service will one day be widely used.

Operational environment of cadastre maintenance

One man's legal cadastral survey and mobile work

Not so long ago cadastral surveyors performed legal cadastral survey work in the terrain and with customers, and a different person updated the registers. There were officers whose main task was updating the Cadastre. Times have changed. Today, the most part of updating is done by cadastral surveyors who themselves update the Cadastre to match the changes made during their own legal cadastral surveys. We talk about 'one man's surveys', where is ICT used effectively and efficiently.

Also, some years ago it was general practice for cadastral surveyors to visit their offices every day to fetch and return the documents related to legal cadastre surveys. Journeys to and from work take time and are costly. After doing work in the terrain and with the customers of a legal cadastre survey, the cadastral surveyor drove back to the office or directly home, depending on the time of day. It was usual to update the cadastre with the information of a survey weeks or even months afterwards.

Technological development has changed the story above. Cadastral surveyors have portable computers and all the information systems that are available at the office are also available in the terrain. Surveyors can maintain the Cadastre from anywhere and use any telecommunications network by using Citrix–technology (Figure 3).

A cadastral surveyor can go to the customer straight from home or even from his cottage. With the customer he can store legal cadastral survey information directly using the Cadastre maintenance application. At the end of day he come back to home and stores this day's information in the system. He can e.g. send documents and invoices to customers and update the Cadastre.

This procedure speeds up legal cadastral surveys and affects the quality of work positively, because surveyors can update the Cadastre on the same day, when the day's case is in good memory. It is also notable that information is updated by the same person who has collected and handled it in practice.

This arrangement has contributed to better performance in the cadastral survey process and to time savings. The surveyors have been able to better integrate work and leisure time when they can work in any place at any time. This has meant better wellbeing at work for surveyors. In addition the mobile work is environmentally friendly, because it reduces the need to drive.

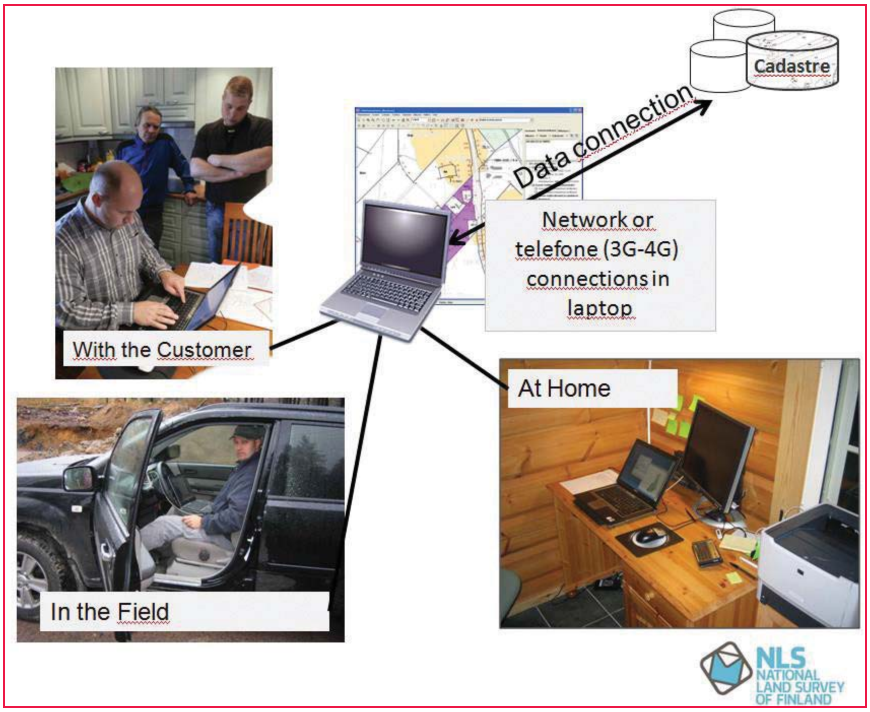

Figure 3: Use of portablecomputer

Activity based work, common working place and flexible working time

Only a small part of working tasks at the NLS is bound by a fixed location; such could be working in customer service or working with special technical instruments like a digital stereo workstation. Almost all other work can be done in any location. A video connection is a natural way to communicate. Workers at the NLS engage in activity based work. Technology has made it possible to work at home, in a hotel, municipal hall, or anywhere.

Office premises cause big costs and the characteristics of the work have also changed, which have made it necessary to investigate office space utilisation. Work is more mobile and can be done anywhere. We work at the customer's home or from home, when we go to our workplace we often sit in meetings or we are absent from the office. At all these times our own office or cubicle is empty. New offices at the NLS are furnished so that no one has his own room or seat. Employees have locker for keeping their work things and every day employees find a free place where to sit. This is the way to reduce offices sizes and save costs of office premises.

In NLS, we do not have fixed working times. Of course we have functions where it is necessary to be present during office hours (8:00 to 16:15) and many others are present at the same time. But we have the opportunity of working between 6:00 and 23:00. This we call flexible working time. It increases the possibilities to arrange the work schedule to fit personal conditions and opportunities.

Structure of organisation

At the NLS the Cadastre is updated in four processes. Basic surveys (parcelling out and private road surveys) are in one process, valuation surveys in another process, land consolidations are in a third and other maintenance of the Cadastre in a fourth process.

Production at the NLS has taken place in processes for the last 15 years, which have ensured a homogeneous mode of action and uniform quality. From the beginning of the year 2014 we develop our process organisation one step further. Now our production operates at a national level without any regional level, and the district survey offices no longer exist. Each national level process is its own result unit which has total responsibility of production regarding result, income, worker resources and quality.

Working in a national level organisation in each process has made it easier to move the work force where it is needed because the borders between district survey offices no longer exist. At the same time many functions are also centralised at a national level. This means that exceptional and rarely occurring cadastral surveys or those which need expert knowledge are done by surveyors with specials kills.

In conclusion

ICT tools are a part of today's working environment. Work flows can be developed quite far so that system users, like cadastral surveyors, work becomes easier, more effective, productive and at the same time the quality improves. Employees can do their work anywhere, which increases the meaningfulness of their work and their wellbeing at work.

Working in an electronic world demands also that working conditions and working environments change to meet the requirements of working in new way. In Finland we have developed our processes and organisation trying to improve our productivity.

Development is a never ending process. Now we consider how we can better serve customers in an electronic world. It is also time to consider the requirements that we demand of the next generation Cadastre, as quite many countries have done in conjunction with the Cadastre 2034 programme. We have to think of the opportunities provided by technical development, but maintenance processes, operation environment and even organisations may require changes.

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The paper was presented at FIG Working Week 2015, Sofia, 17-21 May 2015

"Public good" of geographic information

How important it is for good governance and citizens

Mukund Rao
Member Secretary, Karnataka Jnana Aayoga, India

In just few decades, Geographic Information (GI) has made tremendous and lasting impact on global society – almost every citizen of the world and every government now depends on GI for their day-to-day life and for governance, respectively. GI has become a part and parcel of many human activities and there are many examples of how society have benefited from use of geographically referenced (or geospatial) data.

What has triggered this wide and rapid dependency of society on GI? To me the most significant trigger has been the technological advances brought about by satellite imaging, satellite based positioning and rapid proliferation of digital and computing technologies. Of course, added to these "triad" has been tremendous advances in survey technologies – which have modernised and automated surveying – from ground and aerial (both manned and unmanned) platforms using many new "principles of surveying". In fact, a new "GI Metrics" now allows measuring/collecting varieties of relevant parameters – from below the ground, far away from an object, of insides and outsides of buildings; obtaining nuances of objects (shape, size, angles, height, changes, quality, status etc) which hitherto were un-measured. Every "information" on this Earth and of relevance to humans is slowly becoming "GI" by intelligent geo-tagging and "coordinate-association" – almost without knowledge of average humans. These advances in technologies have caused a "GI explosion". Thus, every census data of demography, every social security number, every credit card transaction, every developmental data, every family data, every enterprise and business, every building/property, every tree and forests, every peak, every civic service and every… is becoming "geo-tagged" and is GI. In coming years, humanity will only know "GI" as every information will be wily-nily geographic/location tagged – a sort of a "GI world" will come upon us and can only entrench into every society and encompass all of humanity.

Is this GI revolution characterised by "orchestration" or "evolution"? It has simply been a process of "evolution" - of advanced technology and human entrepreneurial spirt that is causing this GI scenario in the world. GI is now widely available to citizens and nations. Advanced digital data analysis, data fusion, data mining and data analytics can now crunch volumes of GI in no time and generates new perspectives of society or human activities in geographical domain. On top of this, improved data communication technologies, including the revolution of the internet, have made it very easy to deliver large volumes of GI across any part of our world to users on a near-real-time basis. At same time, large scale hardware implementations (e.g. Cloud Computing; Global Servers) and smartphones with embedded GPS chips have brought the reach of GI to every citizen's hands. Advanced and new capable software process GI and ingest critical geo-spatial information into varieties and varieties of GI applications – millions of applications have sprouted up based on GI. This technology advancement has enabled instant access to GI very easy and has enabled many "mission-critical GI applications" – not just for nations, society but even to individual citizens. GI applications are now on the desk of citizens across the world; desk of any manager in governance; desk of any industry and desk of every policy-maker of the world.

> It will be a travesty of humanity to even attempt to control or curb the use of GI because of the possibility of abuse of GI

There is another scenario to keep in mind – all of these revolutions are being innovated and happening in different nations – these are not anymore restricted to nationalistic connotations and boundaries. Though many governments are actively involved in these GI enterprise, it is corporates that are at vanguard of this new "borderless" GI revolution. This aspect is making the GI a trans-national, commercial and citizen oriented activity – substantially complemented by national and local activities within nations. Thus, the GI regime is global but also national – in a complementary way and this is posing tremendous challenges to nations and societies to adjust and align to. Best practices at international level, at and within national levels and also for local levels of society have yet to emerge for addressing this pan-boundary regime that is already in position.

What will this "GI world" mean and how will this augur for society and its people? While one is already getting a perspective of this "GI world", we are yet to grapple with this vast amount of GI of everything on this Earth (and nations, too) and its impact on humanity (in general), nations (in specific), to communities (in more specificity) and to citizens (by and large). This GI world will bring very new meanings of human behaviour, national development and security and citizen satisfaction – in different levels of intensity and impact.

The first thing that will happen more intensely (it has already started happening) is that all of this GI – which will be computer-amenable, multi-layered and time-stamped will be constantly on-delivery to every citizen's mobile smartphone, every handheld device, every desktop and every advanced computing system of the world. Thus, every citizen will be assured of GI at any time, at any place and this will augur as an "insurance to citizens and society" that they can access GI at any time – so, no worries (Remember: with availability of information on-line, nobody bothers to keep copies/print/photocopy information (unless essential) anymore – we are all assured that we can at anytime go on-line and seek and obtain information - so no hassles!!!). This will become an "insurance" to society and humanity and will be a great differentiator to present-day citizens, their families, their work and life-style; any nation's development, planning and security; bring global peace and harmony (one can easily obtain/have "GI" of any nation/region at any time) – so nothing may have to be required to be hidden or in-accessible (You know about me so do I know about you!!!) and, largely, humanity's tolerance and acceptance of one-another will become universal. Thus, GI will be like a "leveller" in this world (and in every nation) and for every citizen – thereby, in-equity will be questioned by citizens and nations; argued upon at by levels of humanity and urge to an order of harmony and safer society!!!

The second thing that nations GI will impact is in the tremendous societal relevance and demand that GI will place on Governance – every action of governments will be questioned from within and from outside – why the forests burnt away; why water in a flooded area is not "running away"; how schools are located/sanctioned; how watersheds must be developed; how a ring-road around a city must be aligned; how traffic can best be managed; how pollution of industries are dissipating; which are best areas for power plants and so on… Every nation is using GI for inventory/mapping of natural and man-made resources, improved statistics and data of development, improved equity in decision making and managing disasters and in many other national development and global collaboration activities. Every nation is realising and depending more and more upon GI for supporting governance activities, help prepare sustainable development strategies, involve citizens in participatory democracy, enable enterprises to manage business better and bring geographical knowledge to citizens. Thus, GI is and will be the main form of assist to governance, development of society and citizen activities.

Within India, there are new GI ideas that are front-lined. India envisages to implement a National GIS – a seamless, nation-wide, standardised multi-layered GIS platform that will bring efficient GIS Data Services and high performance GIS DSS Applications for governance, citizens and enterprises. India already has a Bhuvan – serving Indian satellite images and thematic maps. Similarly, many states are largely dependant on GI for their local governance – Gujarat is a classic example that has been talked about. Karnataka is establishing a Karnataka-GIS (K-GIS) – based on EO images, positioning satellites and GIS technologies as a major data and applications service capability for decision support to its citizens. So are Maharashtra, Telangana, Rajasthan and many other states. Even Ministries are banking on GI for their services and governance – good examples of Power Ministry, Urban Ministry and many others are well known. India, rightfully so, is planning and developing large-scale national activities based on GI.

The third impact GI is bringing about is "Spatial Analytics" - key domain for "information intelligence" (including citizen-intelligence, society-intelligence, commercial intelligence, governance intelligence, security intelligence and even inter-planetary intelligence) and bringing more "wisdom" to humanity. The "GI intelligence" will certainly serve citizens to reach out to a particular restaurant; make society more equitable to understand that drain-blocks must be removed for flood water to flow away; will make national governments act more responsibly in governance because they would much easier understand "multi-layered disparity" and make democratically-conducive development plans; prepare nations for better internal security; help manage borders of nations/states/local governments etc and bring many other benefits. With vast amount of GI that is available, coupled with demand for GI-based governance, a host of young, entrepreneurial and dedicated communities will emerge that will take up analysis/churning/fusion of the GI world and bring new and innovative information and knowledge to citizens, society, nations and the world, at large. This new Spatial Analytics innovation will trigger a new meaning to our actions (as citizens, society and nations) – thereby, making us being better prepared because of vast amount of "GI intelligence" that one will generate and possess.

There is a security perspective of GI – that is very compelling and cannot be ignored but has to be addressed. While all the civil-good of GI for society has been developing, there is a counter side development too – most weapon systems and military system depends upon GI for their operations and strikes. Thus, all defence equipment use the same GI but for military actions (as against governance or development actions that have been mentioned). This is not a new development, in the sense that even in history one has seen that military and defense activities depended on some form of maps/locations etc (the word GI maybe of this century but the principle has always been there). If one looks in history, every nation (I emphasise "every") had the first control of "GI" for military and security purposes. In fact, all the GI ensemble has originated in military and defense activities. So the principles of GI and science allows one to determine "precise coordinates" of objects and obtain "deeper insights" of regions – both of these without being physically at the objects. Thus, one can easily plan and determine targets to be "attacked" for military purposes – because there is "intelligence" from GI and also the coordinates. These become very important for planning attacks and feeding coordinates to weapon systems… that is where the GI for military has been used always. This military use of GI is still seen as a form of "Public Good" – because it is justified by a larger good of society and based on nationalistic principles.

It is of late that a new scenario has developed with sufficient evidences of GI being used for non-Public Good (or anti-national, cross-border, against humanity etc) activities of destructive nature. There are numerous examples in the world of how disgruntled society have depended upon GI for undertaking their abusive or anti-society and destructive activities. What does this actually mean - if a bad-group wants to "destruct any object" they would also benefit from the GI because it will give them the "coordinates" (and used in their destructive weaponry). It is also clear that by fixing local coordinates of three or more points, one can easily associate geographical coordinates to many feature on a spatial information or map-sketch and convert into "good GI" – which then can be used for destructive purposes. The "bad guys" can also use GI for navigating and locating themselves. Many societies and nations are anxious and concerned about this new character of the abusive use of GI – and are yet to find a way of ensuring that this non-Public Good use of GI can be "regulated" (or maybe, even controlled). It is true that "intelligence" from GI – if it can be used for military purposes (which maybe seen as Public Good) it can also be used for abusive destructive purposes – it is only who is USING that becomes a differentiator. But this possibility, in our troubled world, cannot be ruled out and guaranteed that the case is not so!!!

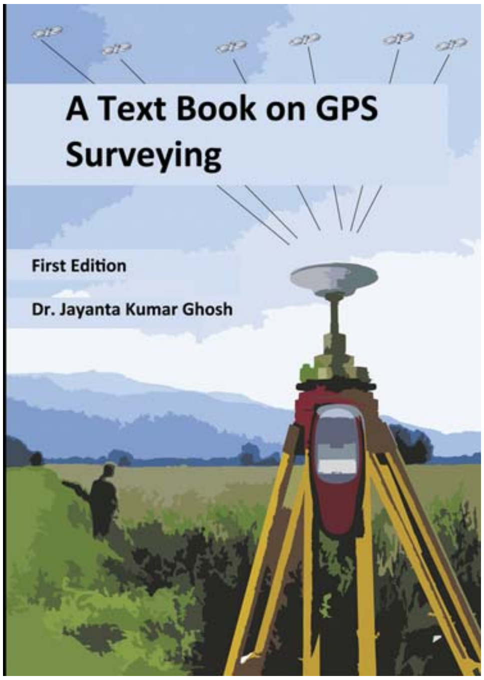
However, the Public Good of GI is so compelling and over-whelming that it is already embedded into the character of every citizen, every nation and large governance activities. It will be a travesty of humanity to even attempt to control or curb the use of GI because of the possibility of abuse of GI. Even to create a scare/fear amongst the legitimate users of GI and for the good of governance and society and its citizens – this itself will be a great dis-service to free and transparent society of democracy.

The GI juggernaut is in motion and "expanding" all over the world (and in India too). The benefit and Public Good of GI is apparent and clear and will become more vivid, visible and all pervading in coming years. The Public Good of GI must not get dismantled or disabled – for the good of society and every citizen, nation and humanity depends upon it.

This large-scale Public Good of GI must only be encouraged, motivated and further enhanced so that the benefit of GI is available and accessible to every citizen, governance activity and all national development activity. India must not get left behind.

At a Glance

- Xinping Guo named Interim President and CEO of Hemisphere GNSS
- Handheld Introduces its First Intrinsically Safe Ultra-Rugged Computer
- SimActive Inc has announced the latest version of Correlator3D™
- Sentinel-1A captures Bangladesh's flood lands
- OGC invites proposals for an Arctic Spatial Data Pilot project
- TerraGo partners with positioning solutions provider PSI
- Airbus, SurveyCopter launch mini-UAVs for military operations
- Kieran Murphy is new Non-Executive Chair of Ordnance Survey
- DARPA invites proposal to develop underwater positioning system
- Topcon announces integration agreement with Volvo CE for 3D-MC excavation
- ESA's Swarm satellites map Earth's magnetic field
- xAd achieves 100% revenue growth in location intelligence
- Intalytics, Cuebiq form mobile data partnership
- ISRO develops TWTA for space borne payloads
- World View raises $15 mn for developing high-altitude balloon
- 5D Robotics acquires UAS service provider Aerial MOB



The book provides a sequence of topics aiming to basic understanding and carrying out land surveying as well as processing for geo-spatial positioning using GPS. The book is meant to serve as an introductory text book on GPS surveying and is expected to be useful for students as well as field surveyors looking for insights into GPS surveying.

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Book Size: 6" x 9" (15.24 x 22.86 cm)
Black & White on White paper (222 pages)

The Geospatial Information Regulation Bill, 2016 (Draft)

Some observations

National development missions would directly suffer setback

Dr Mahavir
Professor of Planning and Editor, SPACE Journal, School of Planning and Architecture, (An Institution of National Importance under an Act of Parliament), New Delhi, India

This is with reference to the draft "The Geospatial Information Regulation Bill, 2016", posted on the link http://mha.nic.in/sites/upload_files/mha/files/GeospatialBill_05052016_eve.pdf (posted on 04th May, 2016).

I wish to offer the following comments/ suggestions:

1. The security, sovereignty and integrity of India is paramount and any measures to ensure the same is a welcome movement. The effort of the Government in bringing this bill to regulate the acquisition, dissemination, publication and distribution of such geospatial information of India which is likely to affect the security concerns of the country deserves applaud.
2. The fact that the proposed bill has (perhaps drafted by and) been put up on the site of the Ministry of Home Affairs and not by the other related ministry like the Ministry of Earth Sciences or ISRO, conveys the seriousness of the bill as far as the security issues of the country are concerned.
3. The draft bill, when enacted, will also ensure the correctness in depiction of National boundaries and its constituents, particularly in the light of some attempts by the international community to omit areas, which are part of the sovereign Indian republic.
4. On a more practical side, the proposed bill raises serious doubts on its utility and that of the use of geospatial information at all, for mundane in house and academic uses.
5. Virtually, all teaching at all levels – be it a primary school where a teacher uses a map to familiarize the students with states of India, or a high school where a teacher might develop a case for relating NaREGA with food production or agriculturally deficit regions, to a technical university where researchers might like to simulate models for the impact of climate change on the future urbanization pattern in India, will come to a halt, as most of these do not require high precision and high quality data but it will still be covered under the geospatial information regulation. Surprisingly, even a tourism picture obtained through a commonly used digital camera and tagged to a location would also fall in the 'geospatial information' and thus subject to the provisions of the bill.
6. On a higher technology side, most National development missions would directly suffer setback. As a part of e-governance initiatives, the interface with the citizen and the planning and implementation agencies is now largely based on geospatial information, though may not be of high accuracy. The people friendly and temper proof interfaces in the form of

Such license RAJ will only promote corruption

N K Agrawal
Former Director. Indian Institute of Surveying and Mapping, Survey of India, Hyderabad.

1. According to Chapter 2, Para 3.1, Any data acquired by any means is illegal without a license. This means that all data acquired even by GPS, total stations, theodolite, chains or tapes is illegal without a license. All mapping and surveying activities and hence development will stop.
2. According to Para 3.2 data acquired previous to this act coming in to force is also illegal without a license meaning all surveys, maps, data acquired or owned by any agency, company or individual will be illegal unless they obtain a license. This is grossly unfair.
3. We are introducing a license permit RAJ even for any individual or company. This is bad and may stop all development as government agencies alone will not be able to do all jobs pertaining to surveying and mapping activities. We are unnecessarily creating hurdles in working of people engaged in these activities. This goes against SABKA SATH SABKA VIKAS.
4. We can understand if this policy is made applicable to only external boundaries of India, say up to 20 t0 50 km from external boundaries. Policy being made applicable to all India is draconian and against individual freedom and development
5. This type of license RAJ will only promote corruption and result in scams including crowding of cases in courts.

Bhoomi (a project of on-line delivery and management of land records) in Karnataka or similar provisions of e-registration of properties would have to take a back seat, being highly dependent on geospatial information.

7. The proposed bill is going to hugely and negatively affect other mega initiatives of the Government, apart from simple day-today web-based or mobile phone based applications. The success of Smart City and the AMRUT missions, for example, are almost fully dependent on the free and wide availability of the geospatial information. Master Plans and related functional plans for infrastructure etc., being highly dependent on accurate geospatial information would almost become impossible to conceive. The dream of smart provisions of utilities and infrastructure at a 24x7 scale is bound to fail with the restrictions proposed. Even the CCTV cameras installed ubiquitously for ensuring the security in urban areas and important installations, would also get covered under the geospatial information, and thus their providers and users liable to be punished.
8. Apart from the 'illegality' of possessing the geospatial data, there is the cost issue. With all persons, companies, firms, trusts, associations of persons or body of individuals and agencies made to seek and obtain 'license' for using geospatial information is bound to increase the costs of providing various services like GPS enabled vehicles, real time monitoring of movement of public transport, guidance on the availability of nearest ATM… The list is huge and so are the losses. The processes of obtaining the 'licenses' could also lead to project delays.
9. One could argue that the 'legal' geospatial information is and would be made available on the Bhuvan portal. Whether or not this information would be for free and freely available is not clear. Whether or not the information would be downloadable is not clear. And with a sudden expected exponential increase in Bhuvan users, the speed of the portal would also pose a challenge. Whether or not all geospatial information users and applications require the geometric accuracy levels of Bhuvan also needs investigation.
10. The provisions for persons (in all of its encompassing meanings) already in possession of geospatial information do not make much sense as the information may have been stored on a Smart phone unintentionally or unknowingly, it may have been stored on cloud, or may be temporarily downloaded from popular sources like google and subsequently deleted. Such geospatial information is freely available, in any case, outside the country.

The proposed draft "The Geospatial Information Regulation Bill, 2016", therefore, may be dropped in its present form and a thorough national debate be convened to thrash out the various that I have listed, besides other issues that others may have raised.

The views/ comments and suggestions presented here are in my personal capacity and not necessarily reflect that of the School of Planning and Architecture, New Delhi.

MHA open to reviewing of draft Geospatial Bill

Three days after the draft Geospatial Information Regulation Bill, 2016 was uploaded on the Home Ministry's website seeking comments from the public, the government on Monday indicated that it was open to review its contents and consider all suggestions that are to come in the next one month. Uttarakhand DGP M.A. Ganapathy who was one of the officials to draft the Bill during his stint in the MHA, told The Hindu, "instead of getting hysterical, people should send valid and sane suggestions to oppose the draft Bill. This is at a draft stage and the idea was to invite comments."

Another official involved in drafting the Bill said, "this Bill has been in the works since 2012. A committee of secretaries (CoS) had submitted a report calling for an regulatory body to monitor the Internet giants like Google and Microsoft. How else do you regulate them, by begging?"

The official added that the investigations in the Pathankot airbase attack revealed that the terrorists who got into the airbase had precise information about its topography. "The Pathankot airbase and other strategic locations are easily available on Google maps and it has become easier for terrorists to plan an attack. When Pathankot happened, we decided that this was the time to revisit the Bill," said the official.

According to the draft Bill, it will be mandatory to take permission from a government authority before acquiring, disseminating, publishing or distributing any geospatial information of India.

"No person shall depict, disseminate, publish or distribute any wrong or false topographic information of India including international boundaries through internet platforms or online services or in any electronic or physical form.

"Whoever acquired any geospatial information of India in contravention of the law shall be punished with a fine ranging from Rs 1 crore to Rs 100 crore and/ or imprisonment for a period upto seven years," according to the draft bill.

The government also proposed to set up a Security Vetting Authority to carry out security vetting of the Geospatial Information of India in a time bound manner and as per the regulations framed by an apex committee.

However, there have been criticism from various quarters saying the provisions of the draft bill are stringent and may violate privacy of individuals.

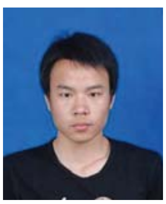
The Home Ministry official discounted the apprehensions saying except authorised agencies, that too after due permission, no one can invade anyone's privacy.

http://www.thehindu.com/news/national/map-issue-govt-ready-for-review-of-geospatial-bill/article8576356.ece

Selection of Suitable Matching Area in Gravity-Aided Inertial Navigation System

This paper utilizes the Principal Component Analysis (PCA) to integrate gravity field's local standard deviation, roughness, slope and correlation coefficients into one singular weighing indicator for the matching suitability of gravity field, which can synthesize different information of different gravity field's characteristic with the original information lost within the allowable range.

DanMei PENG
Master Candidate, Faculty of Geomatics, East China Institute of Technology, Nanchang, China



Cuijun DONG
Master Candidate, School of Geodesy and Geomatics, Wuhan University, Wuhan, China

Gravity-Aided Inertial Navigation System (GAINS), which, as its names implies, is using the priori information of gravity field as the auxiliary information to bind the accumulation of positioning error of Inertial Navigation System(INS) [1-2]. GAINS possesses many a dvantages, such as high precision of positioning, favorable concealment, strong independence, etc. The positioning effects of GAINS is mainly associated with the performance of matching algorithm, the resolution of gravity reference map, the measurement accuracy of gravimeter and the selection of suitable matching area[3-4].

Different areas have different gravity information. Generally speaking, the matching algorithm of GAINS achieves better perform- ance in areas with obvious gravity information and achieves unfavorable performance in areas with indigence of gravity information [5]. Thus the selection of suitable matching area becomes a crucial step for GAINS. It is meant to provide guidance for vehicle route planning based on some kind of criterion like the value of one specific gravity characteristic, or an organic integration of several gravity characteristics [6-7].

This paper aims at provide us with a method on how to select the suitable matching area for GAINS. First, it utilize the Principal Component Analysis (PCA) to integrate gravity field's local standard deviation, roughness, slope and correlation coefficients into one singular weighing indicator, then segment the gravity reference map into suitable matching area and unsuitable matching area by setting a threshold for the weighing indicator. Finally, experiments were carried out by utilizing Terrain Contour Matching (TERCOM) algorithm with performance index of Mean Square Error (MSD) to verify the proposed method. The experimental results validated the reliability and feasibility of the proposed method.

Local Characteristic Parameters of Gravity Field

This paper chose the gravity field's local standard deviation, roughness, slope and correlation coefficients as the input information for PCA, and the calculation results of those parameters at point (i,j) were obtained by moving the local computation window that has the size of m × n m × n (The value of m and n are usually 3 or 5). The formulas are expatiated in this section.

Standard Deviation of Gravity Field

$$\delta = \sqrt{\frac{1}{m(n-1)}\sum_{i=1}^{m}\sum_{j=1}^{n}(G(i,j)-\overline{G})^2} \qquad (1)$$

Roughness of Gravity Field

(1) Roughness of gravity field in the direction of longitude

$$r_\lambda = \frac{1}{m(n-1)}\sum_{i=1}^{m-1}\sum_{j=1}^{n}\left|G(i,j)-G(i+1,j)\right| \qquad (2)$$

(2) Roughness of gravity field in the direction of latitude

$$r_\varphi = \frac{1}{n(m-1)}\sum_{i=1}^{m}\sum_{j=1}^{n-1}\left|G(i,j)-G(i,j+1)\right| \qquad (3)$$

Slope of Gravity Field

(1) Slope of gravity field in the direction of longitude

$$S_\lambda = \frac{1}{6}\big[G(i+1,j+1)+G(i+1,j) + G(i+1,j-1)-G(i-1,j+1) - G(i-1,j)-G(i-1,j-1)\big] \qquad (4)$$

(2) Slope of gravity field in the direction of latitude

$$S_\varphi = \frac{1}{6}\big[G(i-1,j+1)+G(i,j+1) + G(i+1,j+1)-G(i-1,j-1) - G(i,j-1)-G(i+1,j-1)\big] \qquad (5)$$

Correlation Coefficients of Gravity Field

(1) Correlation Coefficients of gravity field in the direction of longitude

$$R_\lambda = \frac{1}{m(n-1)\delta^2}\sum_{i=1}^{m-1}\sum_{j=1}^{n}(G(i,j)-\overline{G}) \bullet (G(i+1,j)-\overline{G}) \qquad (6)$$

(2) Correlation Coefficients of gravity field in the direction of latitude

$$R_\varphi = \frac{1}{(m-1)n\delta^2}\sum_{i=1}^{m}\sum_{j=1}^{n-1}(G(i,j)-\overline{G}) \bullet (G(i,j+1)-\overline{G}) \qquad (7)$$

Utilization of the above formulas can enable us to obtain the value of corresponding characteristic parameters on every gridding point in gravity reference map [8-10].

Fundamentals of PCA

PCA is a simple, non-parametric method of extracting relevant information from confusing data sets. It is often been used to reduce a complex, correlational data set to a group of lower dimensional and independent comprehensive indexes, which in some degree can reveal the hidden, simplified dynamics that often underlie it[11].

Mathematical Model of PCA

Suppose there are a set of original indicators $\{X_1 \cdots X_n\}$, and we are going to express it with a set of mutually independent and comprehensive indicators $\{Y_1 \cdots Y_p\}$ with the original information lost within the allowable range. The mathematical model is shown in the following:

$$\begin{cases} Y_1 = a_{11}SX_1 + a_{21}SX_2 + \cdots + a_{n1}SX_n \\ Y_2 = a_{12}SX_1 + a_{22}SX_2 + \cdots + a_{n2}SX_n \\ \vdots \\ Y_p = a_{1p}SX_1 + a_{2p}SX_2 + \cdots + a_{np}SX_n \end{cases} \qquad (8)$$

Thereunto, a_{ij} (i=1⋯P, j=1⋯n) are the eigenvectors corresponding to the eigenvalues of covariance matrix of $\{X_1 \cdots X_n\}$. $\{SX_1 \cdots SX_n\}$ are the normalized values of $\{X_1 \cdots X_n\}$, this is intended to eliminate the effects caused by the unified dimensionless of original indicators. Generally speaking, $p<n$ and it means the original indicators has been simplified into a lower dimensional and pithy indicators $\{Y_1 \cdots Y_p\}$[12].

Procedures to carry out PCA

(1) Select the original indicators based on the demands of studied problem.

(2) Normalize the original indicators and calculate out the covariance matrix of it.

(3) Calculate out the eigenvalues of covariance matrix and its corresponding eigenvectors.

(4) Determining the expressions of principle components based on the eigenvalues and eigenvectors.

(5) Calculate out the final one comprehensive indicator and utilize it to conduct the research of the problem [13].

Experiments

Experimental data

The gravity background map can be gravity anomaly map or gravity gradient map, in this paper we choose the gravity anomaly map as the reference map because there is no public data of global gravity gradient.

The gravity anomaly data utilized in this paper were downloaded from the website of University of San Diego, it covers the range of 25°~30°N, 130°~135°E and owns the resolution of 1′×1′. The maximum value of the gravity anomaly in this area is 152.5mGal and the minimum one is -169.6mGal.

The data we downloaded are scattered point data, and has been processed into grid data in order to make it convenient for utilizing [14-15]. The gravity anomaly contour map has been shown in Figure 1.

Gravity Field' Characteristic Parameters processing with PCA

This paper chose the gravity field's local standard deviation, roughness, slope and correlation coefficients as the original indicators. And they have to be calculated out before the processing of PCA carry out. The formulas of calculate these Gravity Field' Characteristic Parameters has been given out in Section1. As the calculation of these Characteristic Parameters is not the main purpose of this paper, we give out the calculation results with PCA directly.

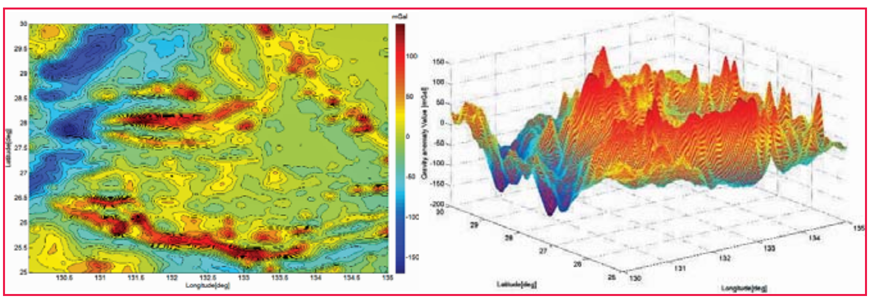


Figure 1: Gravity anomaly map of experimental area

Table 1: Correlation Coefficient Matrix

Original Indicator	δ	S_λ	S_φ	r_λ	r_φ	R_λ	R_φ
δ	1.000	.016	.029	.698	.885	.287	-.094
S_λ	.016	1.000	.050	-.003	.032	.009	-.005
S_φ	.029	.050	1.000	.025	.033	.009	-.009
r_λ	.698	-.003	.025	1.000	.310	-.274	.435
r_φ	.885	.032	.033	.310	1.000	.569	-439
R_λ	.287	.009	.009	-.274	.569	1.000	-.854
R_φ	-.094	-.005	-.009	.435	-439	-.854	1.000

Table 2: Principal Component Extraction Analysis of Variance Decomposition

Component	Initial Eigenvalues			Extraction sums of square and loading		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.608	37.258	37.258	2.608	37.258	37.258
2	2.018	28.835	66.092	2.018	28.835	66.092
3	1.048	14.966	81.059	1.048	14.966	81.059
4	.950	13.574	94.633			
5	.240	3.422	98.055			
6	.127	1.819	99.874			
7	.009	.126	100.00			

Table 3: Initial factor load matrix

Original Indicator	Component		
	1	2	3
δ	.787	.608	-.030
S_λ	.034	.008	.729
S_φ	.046	.036	.717
r_λ	.209	.920	-.027
r_φ	.936	.218	-.011
R_λ	.790	-.530	-.017
R_φ	-.665	.687	.007

Table 1 shows the correlation coefficients among the seven selected characteristic parameters. And larger values means stronger correlations between the corresponding two indicators.

Table 2 shows that there are three eigenvalues larger than 1, it means that the seven original indicators can be reduced into three principal components.

The coefficients to transform the seven original indicators into three principal components can be obtained through divide the three set of data showed in this table by the square root of its corresponding eigenvalues $\sqrt{\lambda_i}, i = 1, 2, 3$, and the transformation formulas are shown as follows:

$$\begin{cases} Y_1 = 0.4873SX_1 + 0.0210SX_2 + 0.0285SX_3 + 0.1294SX_4 + 0.5796SX_5 + 0.4892SX_6 \text{-} 0.4118SX_7 \\ Y_2 = 0.4280SX_1 + 0.0056SX_2 + 0.0253SX_3 + 0.6476SX_4 + 0.1535SX_5 - 0.3731SX_6 + 0.4836SX_7 \\ Y_3 = \text{-}0.0293SX_1 + 0.7121SX_2 + 0.7004SX_3 - 0.0264SX_4 - 0.0107SX_5 - 0.0166SX_6 + 0.0068SX_7 \end{cases} \quad (9)$$

The three principal components can be further simplified into one final comprehensive indicator based on the percentages that their corresponding eigenvalues accounted for the sum of the three eigenvalues. By multiply the coefficients of each corresponding components by $\lambda_i / \sum_{j=1}^{3} \lambda_j$ and added the results together we can get the coefficients to transform the seven original indicators into one comprehensive indicator, and the transformation formulas are shown as follows:

$$F = 0.3708SX_1 + 0.1432SX_2 + 0.1515SX_3 + 0.2849SX_4 0.3190SX_5 0.0891SX_6 \text{-} 0.0161SX_7 \quad (10)$$

F Is the final comprehensive indicator that measure the richness of gravity field information, and concrete status of the comprehensive indicator of the experimental area in this paper are shown in Figure 2.

As is shown in Figure 2, larger values of the final comprehensive indicator means more abundant gravity field information. The maximum value of the final comprehensive indicator in this experimental area is 6.4781 while the minimum one is -1.3580, and the average value goes to 5.8098e-09, almost equals to 0. In order to raise the standards for suitable matching area appropriately, we choose a value that are a bit larger than the average value of the final comprehensive indicator, which goes to 0.5. The decision results are shown in Figure 3.

In Figure 3, areas with red background are the suitable matching areas while the blue parts are the unsuitable matching areas.

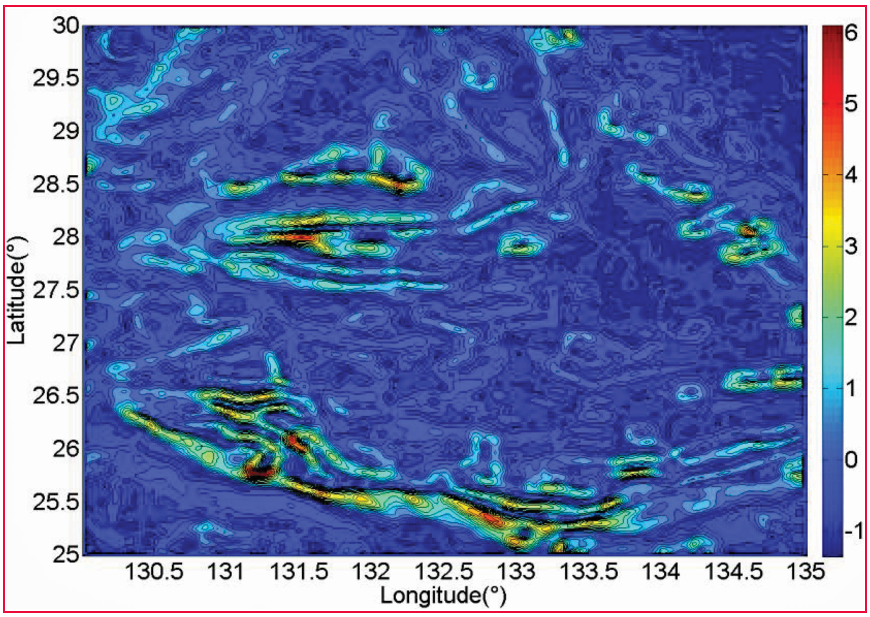


Figure 2: Richness of gravity field information in experimental area

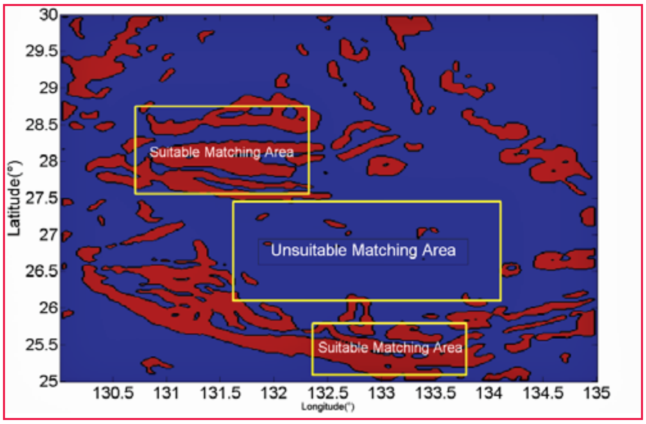


Figure 3. Decision result of experimental area

Experiments with TERCOM algorithm

Principle of TERCOM algorithm with MSD

TERCOM algorithm with performance index of MSD is utilized in this section to verify the reliability and feasibility of this proposed method. And the calculation formula is shown below:

$$J_{MSD}(\Delta e, \Delta n) = \frac{1}{n}\sum_{i=1}^{n}[g_r(i) - g_m(i)]^2 \qquad (11)$$

In formula (11), $g_r(i)$ represent the actual measurements of the gravity anomalies, $g_m(i)$ represent the extracted values of the gravity anomaly map corresponding to the positions which INS assigned, n is the length of point sequence, Δe and Δn are the deviation in the direction of east and north respectively. We can obtain the best matched positions in a certain range of area on the condition that J_{MSD} gets the minimum value [16-18].

Experimental Conditions

We choose four trajectories in suitable matching areas and unsuitable matching areas respectively, each simulated trajectory contains 10 waypoints and owns the sampling interval of 10 minutes. The vehicles sailed along the northwest or northeast directions and the speed is 12 n mile/hr and 10 n mile/hr in the direction of longitude and latitude respectively. The random errors of positions assigned by INS were 0.12 n mile in both directions [19].

The errors of gravity anomaly measurements are 3mGal, which contains the measurement error and the errors in digital making [20].

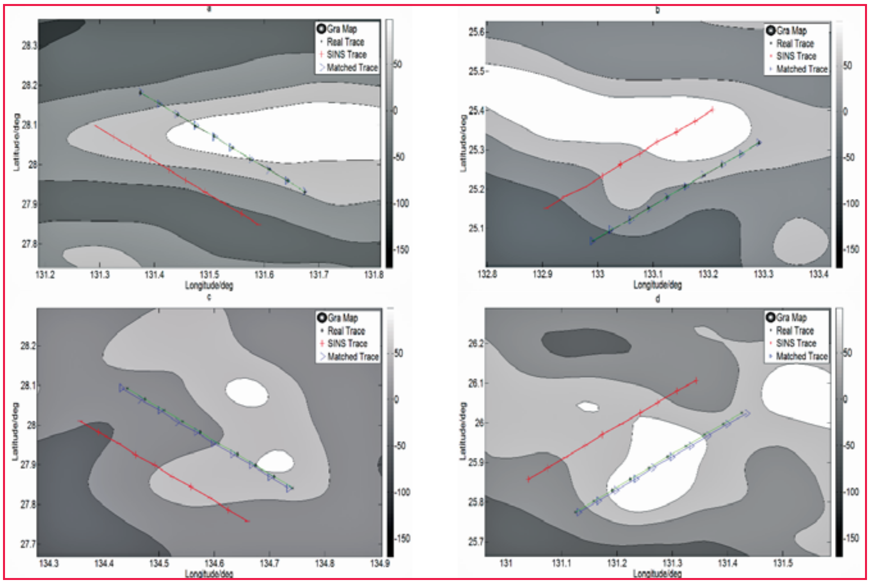


Figure 4: Matching effects in suitable matching areas

Experimental results

The matching effects in suitable and unsuitable matching areas are shown in Figure 4 and Figure 5 respectively.

The comparison of the two figures (Figure 4 and Figure 5) roughly shows that the matching effects of the four trajectories in suitable matching areas is better than that in unsuitable matching areas for the former gets smaller position deviations. More accurate statistical analysis of matching effects are shown in the following Table 4.

Statistics in Table 4 shows that the four matched trajectories in suitable matching areas gets smaller values of Minimum Position Deviation, Maximum Position Deviation, Average Position Deviation and Standard Deviation of Position than that in unsuitable matching areas.

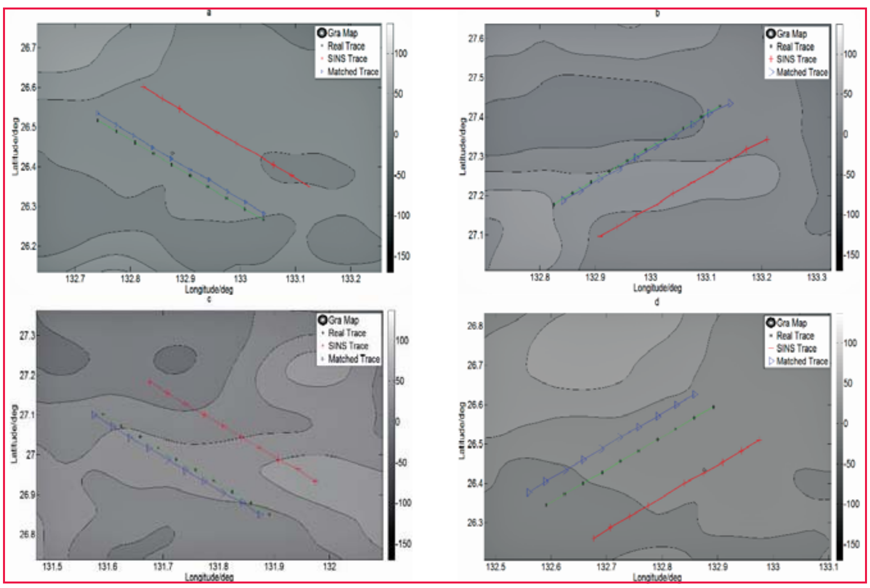


Figure 5: Matching effects in unsuitable matching areas

Table 4: Statistical analysis of matching effects

	Trajectory	Minimum Position Deviation (n mile)	Maximum Position Deviation (n mile)	Average Position Deviation (n mile)	Standard Deviation of Position (n mile)
Suitable Matching Area	a	0.0236	0.1872	0.0894	0.0988
	b	0.0419	0.1697	0.1083	0.1156
	c	0.4286	0.6300	0.5164	0.5209
	d	0.3745	0.6024	0.4868	0.4921
	Average Values	0.2171	0.3973	0.3002	0.3069
Unsuitable Matching Area	a	0.9469	1.2262	1.1179	1.1209
	b	0.8574	1.1335	1.0014	1.0056
	c	0.9111	1.1168	1.0166	1.0190
	d	2.6989	2.8880	2.7873	2.7877
	Average Values	1.3536	1.5911	1.4809	1.4833

And the average Standard Deviation of Position of the four matched trajectories in suitable matching areas is about 1.1-1.2 n mile, which is smaller than that in unsuitable matching areas.

Conclusion

This paper utilizes PCA method to simplify the selected characteristic parameters into one comprehensive indicator, which can synthesize different information of different gravity field's characteristic with the original information lost within the allowable range. Experimental results shows that the average Standard Deviation of Position of matched trajectories in suitable matching areas is 0.3069 n mile, which is smaller than 1.4833 n mile in unsuitable matching areas. The experimental results validated the reliability and feasibility of the proposed method.

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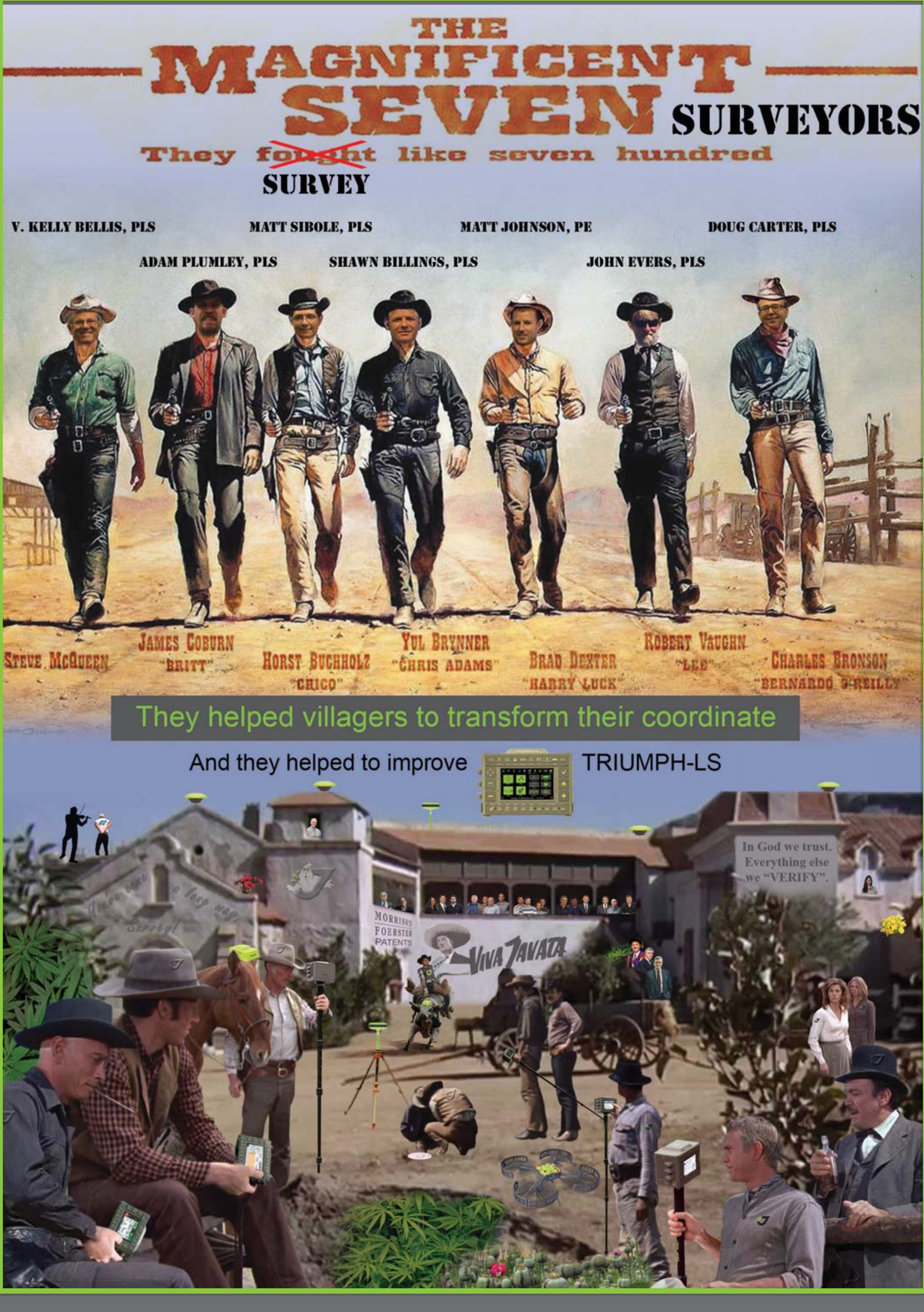
THE MAGNIFICENT SEVEN
SURVEYORS
They ~~fought~~ like seven hundred
SURVEY
V. KELLY BELLIS, PLS
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JAMES COBURN "BRITT"
HORST BUCHHOLZ "CHICO"
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After your field work, sip your favorite drink...

With six RTK engines, auto verify, Confidence and Consistency counters, and validation features of our RTK you are already confident that you have reliable and accurate RTK results. You may have base/rover communication outages in some points and you may want to make sure your base location was correct. You may want to use Autonomous solutions for your base and then find the accurate position. DPOS complements your filed work.

With DPOS we check the accuracy of you Base in two ways. One is to post process the Base raw GNSS data with CORS stations and second is to use the known points during your survey and inverse to base. We record the history in three buckets of the "Base" screen. 1) Original base, 2) CORS processed, and 3) m-Local reverse calculations.

In m-Local reverse calculation of the Base, you can pair as many known points with the points that you have surveyed.

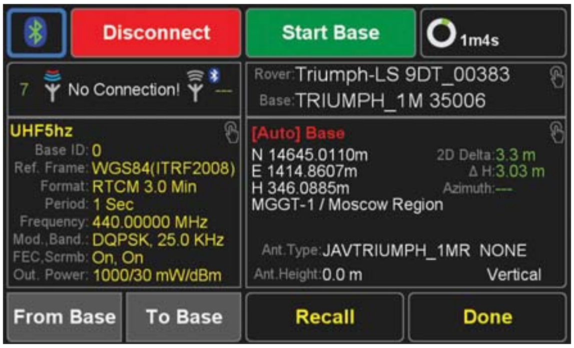
We also check the accuracy of the RTK solutions in two ways: 1) we post process your base and rover data and 2) we process your rover data directly with CORS stations, provided that there is enough data for long baseline processing.

We record all histories in the following ways:

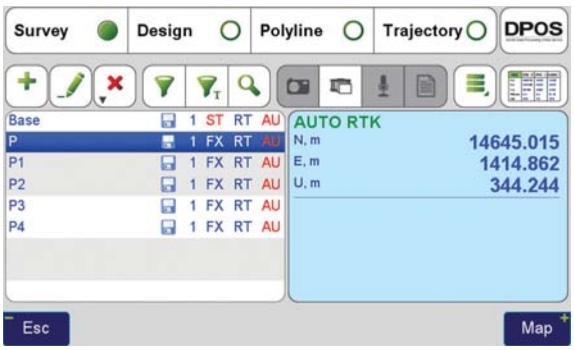
In Base screens there are three buckets for the Original Base, CORS processed Base, and m-Local processed Based. We don't show the coordinates of the CORS stations. They can be viewed in reports.

And this is how it works.

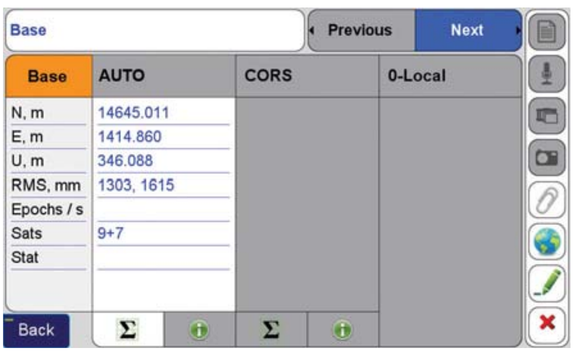
Here we explain the process and details of the six solution buckets (in Auto/ Known and Absolute screens) and three buckets of base in Base screen.



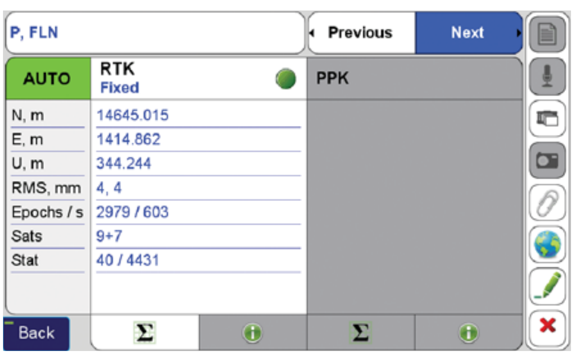
When survey is done, in Base/Rover Setup screen, download the base data in rover and enter a name for Base.



Click "Points" to see the list of points that you have surveyed. The first in the list is your base, followed with all the points that you surveyed relative to that base. Click to see details of base and rover points details.

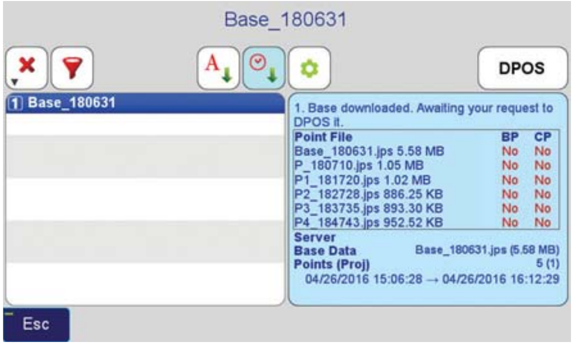


The original Base coordinate is saved in "Auto/Known" bucket of the "Base" screen.

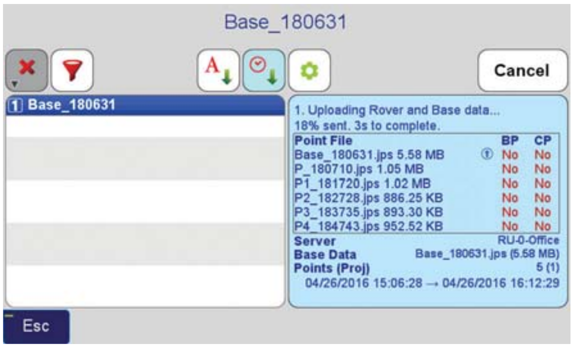


The RTK solution of each point is saved in the "RTK" bucket of that point in the "Auto" screen.

You can long click on the Point name box and select which of point code and description also to be shown in that box.

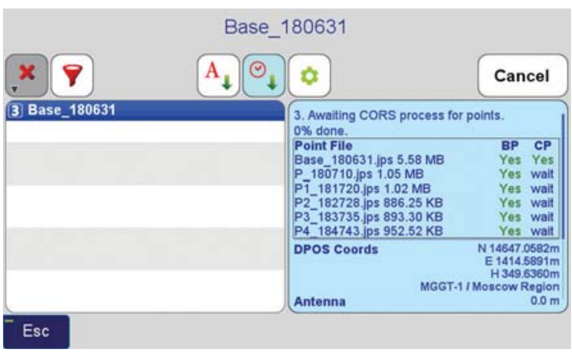


If you want to verify and improve your original solutions click DPOS to send your data to DPOS server and do the following tasks automatically and fill the other 5 buckets.

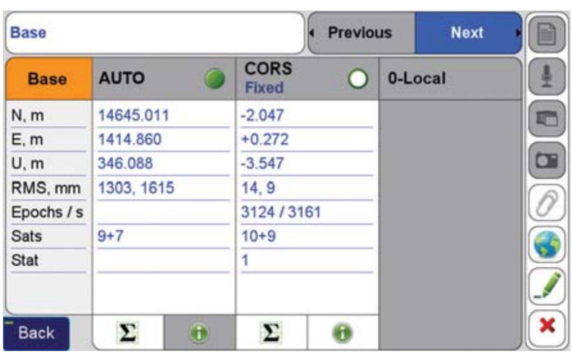


Base and rover data is sent to DPOS.

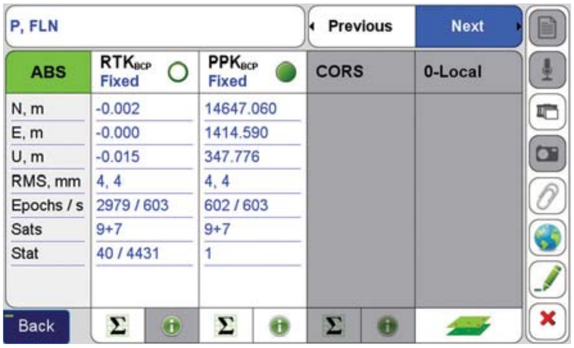
First DPOS will post process the rover data at each point with the Base data and verify that RTK results were correct. The new results are saved in PPK (Post Processed RTK) bucket of each rover point in the "Auto" screen. This will cover any failure at RTK due to communication loss or else.



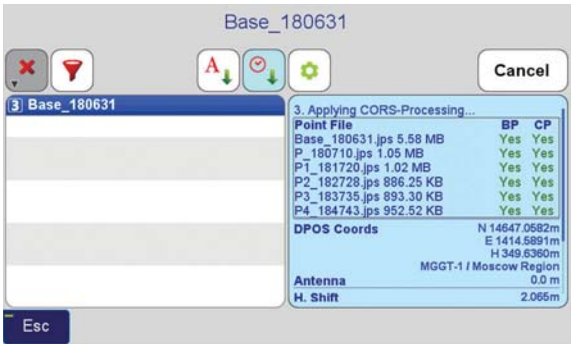
The status and progress of DPOS process is shown in the DPOS screen.



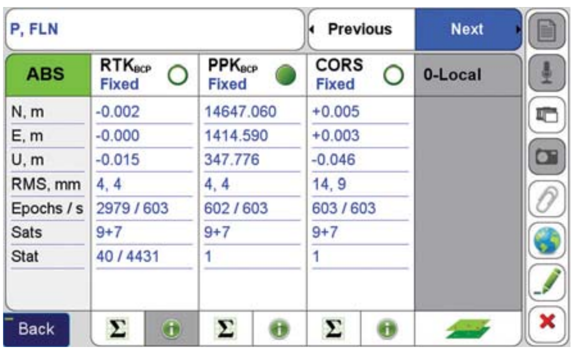
Then DPOS will process the base data with CORS stations and record accurately calculated coordinate of the base in the CORS bucket of the "Base" screen. You could have installed the Base in any location, use Autonomous solution for base and later find its accurate position in DPOS.



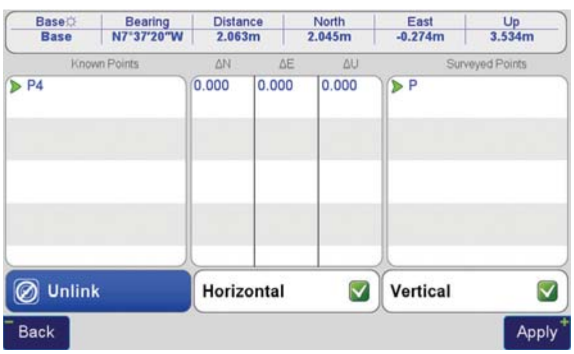
The accurate position of the base calculated with CORS stations is used to adjust the rover RTK solutions and record them in the PPK bucket of each point in the "ABS" (Absolute) screen. As said, you don't need to know the accurate position of your base. You can toggle the top left button.



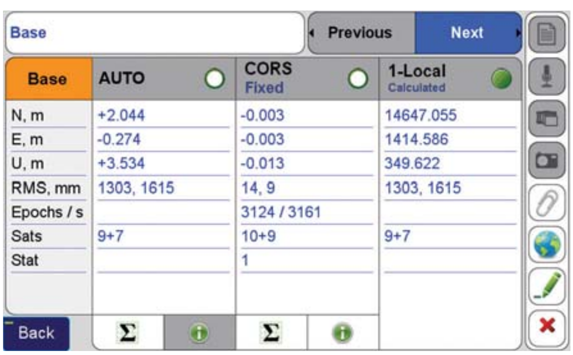
DPOS also processes all rover data directly with CORS stations (if sufficient data) without need for your own Base station. This is another way to check the accuracy of your RTK.



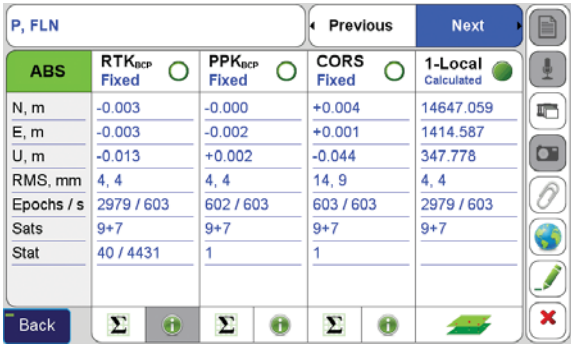
The CORS processed rover points are saved in the CORS bucket of the points in the "ABS" screen.



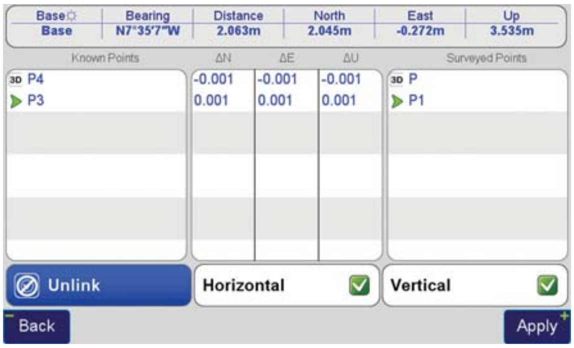
If you know the accurate location of some of the points that you have surveyed, you can use the "m-Local" process to pair them, "reverse calculate" the position of the base. You can do this in the field in real time too.



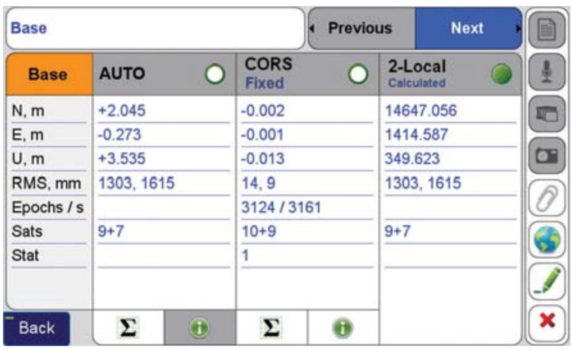
The inversed location of the base is saved in the "m-Local" bucket of the base screen.



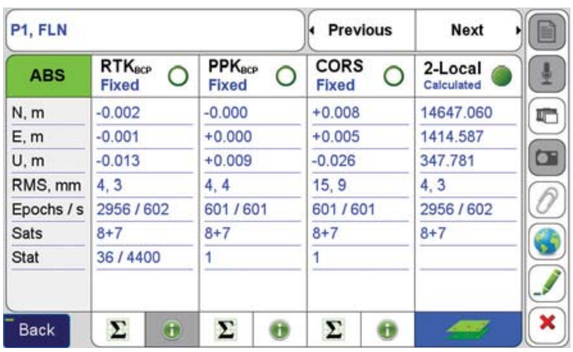
The adjusted points according the "inverse calculate" base are saved in the m-Local buckets of the points in the ABS screen. With this process you don't need to know the accurate location of your base or use this to verify your works.



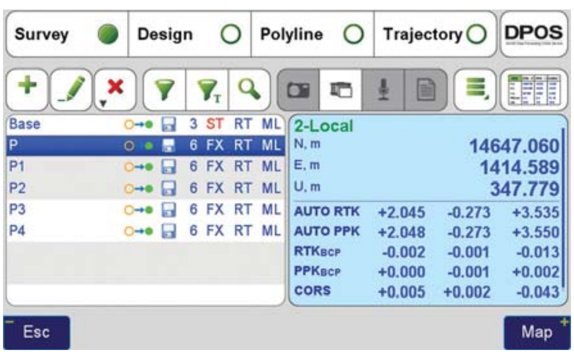
You can continue the "m-Local" process with more than one pair and enhance your base and results.



The result of newly reverse calculated base is recorded in the m-Local bucket of the Base screen.

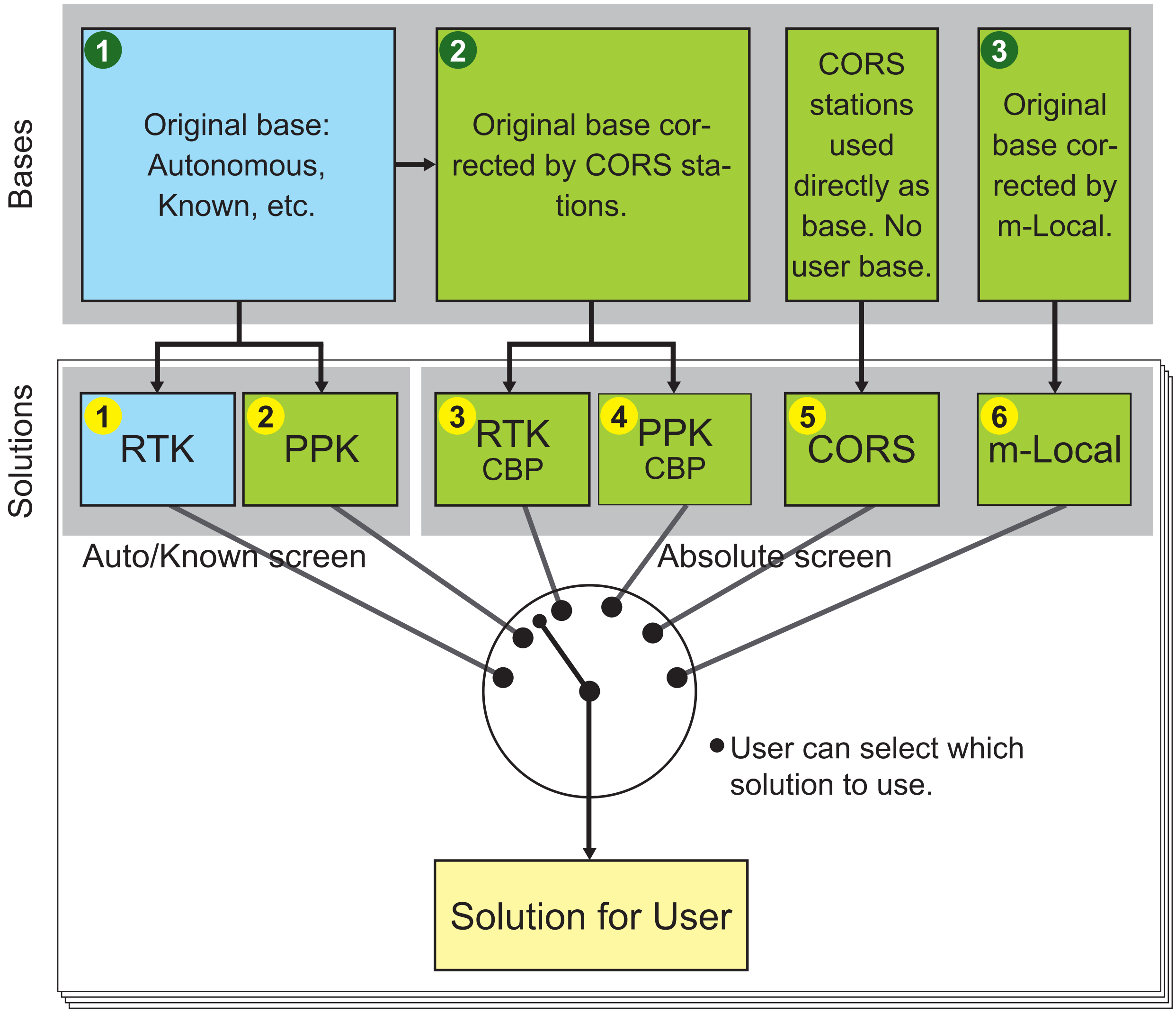


The impact on points are recorded in m-Local bucket in the ABS screen of each point.



The summary of the six buckets and the one that is selected is shown in the points list screen. You can change the selection in the detail point screen. Shift and GNSS raw data symbols, number of solutions, solution type, Process type, and Base type are shown in columns.

... while we fill the other 5 buckets.



For the Original Base there are two buckets in "Auto/Known" screen: one for the RTK solutions in the field and second for the PPK (Post-Processed Kinematic) based on the Original base.

For the CORS processed base, there are two buckets in "Absolute" screen: One for the corrected RTK solutions and one for the PPK based on the corrected base with CORS.

For the rover data processed directly with CORS, there is one bucket in the "Absolute" screen.

Rover solutions that are corrected with "m-Local" are also shown in the m-Local bucket of the "Absolute" screen.

So, the six rover solutions are shown in two screens: two in the "Auto/Known" screen and four in the "Absolute" screen. You can view them by clicking the boxes in the upper left of the "Point Detail" screen.

We will show one solution as default, but you can change to what you want by clicking the radio button of that point bucket. Buckets in the Base screen are only for information.

In the Base screen, the selected coordinate for the base is recorded as the effective position of that base for future use.

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Comparison of orthometric heights determined by GPS and simple geometric levelling: case studies

The paper develops regression models for the variation of these height differences as function of change in altitude and baseline length

Prof El Hassane SEMLALI
Professeur Associé, Sciences Géomatiques et Ingénierie Topographique, IAV Hassan II, Rabat, Morocco

Prof Moulay Mohamed AJERAME
Professor and the Head of the Department, Applied Statistics and Computing Data at the institute of Agronomy and Veterinary sciences, Rabat, Morocco

Hind HAMYA
Surveying engineer, she studied in the School of Geomatic Sciences and Surveying Engineering, Pursuing the engineering cycle ENSG in France

Fouzia EL MARZOUQY
Surveying engineer. She got an Engineer's degree from the School of Geomatic Sciences and Surveying Engineering by the "Institut Agronomique et Vetérinaire Hassan II", Rabat, Morocco

GPS positioning system is designed to determine the position of a point any time and at any place with an accuracy that could reach a few millimeters depending on the type of equipment and the used methodology. In this context, Permanent GPS stations were used to detect displacement of a few mm/year along the Alps (Caporali A. et al., 2000).

The use of GPS technology has evolved rapidly especially in the fields of geodetic sciences and surveying engineering. Nowadays, *space* technology is witnessing a great revolution in terms of positioning. All Geodetic networks are established using GPS technology, as it is a reliable and efficient mean for geodetic network densification.

If GPS has shown its effectiveness in the planimetric determination, the height positioning remains not demonstrated.

Several studies have experimented the use of GPS for height determination. For example, GPS has been used for the assessment of height variations around the Mediterranean and Black Seas (Becker et al., 2002). GPS combined with a gravimetric geoid have also been used for deriving orthometric heights in North Algeria by Ben Ahmed Daho (2003). In addition, there are many other related studies that have discussed the use of GPS for the purpose of height determination. We can mention Dodson (1995); Dursun et al. (2002); Stig-Coran (2002); Battaglia et al. (2003); Lin (2013); Xingsheng (2013); Cakir et al., (2014); and Peter (2014).

Objectives

Morocco knows the development of a large number of construction sites and arts structure, such as bridges, roads and highways. Engineers in Surveying should connect these structures to the *Moroccan General Levelling Network (MGLN)*. Unfortunately, levelling benchmarks of the MGLN are not available everywhere. Sometimes, surveyors do have to cross several kilometers by geometric levelling to achieve these levelling benchmarks. Such work takes long time and needs great efforts.

For that purpose, surveyors want to know how far they could use GPS instead of geometric levelling to determine orthometric heights from levelling benchmarks that are several kilometers far away from their sites.

In order to respond to surveyors' preoccupations, we purpose in this article to compare the orthometric heights determined by GPS dual frequency to those obtained by simple geometric levelling. The comparison is discussed with respect to three factors: baseline length, altitude change, and the topography of terrain.

Accordingly, the objectives of this study concern two aspects:

First aspect: experimental studies

This aspect concerns several experimentations consisting in:

- Use dual frequency receivers to determine the orthometric heights

for a set of known benchmarks of the *MGLN* and a series of new points, taking in consideration the three factors cited above.
- Measure the orthometric heights of the same set of benchmarks and the new points using simple geometric leveling.
- Compare the heights determined by GPS to those obtained by SGL, the later ones will be taken as reference.

Second aspect: statistical analysis and modeling

This second aspect concerns statistical analysis on the experiments, namely
- Statistically analyze the variation of *differences* between the two aforementioned height determinations.
- Develop linear regression models expressing the variation of these *differences* as a function of the baseline length, and the change in altitude, taking into account each type of terrain.

Experimental studies

Basic data

The Department of the National Agency of land registration, Cadastre and Cartography (ANCFCC), has placed coordinates of points as well as data on the *MGLN* at our disposal. Benchmark files contain approximate coordinates, orthometric heights, and synoptic description, in addition to the approximate distances between benchmarks.

Data collection

This phase consists in selecting sites of experimentations and collecting data concerning benchmarks and reference points as well.

Therefore, we choose three different cases of terrain, corresponding to four different sites in Morocco (see annexe). The corresponding leveling sections are :
- The first case of terrain contains the two axes of Rabat to Temara (north-west of Morocco) and Ait Melloul to Tiznit (south of Morocco).
- The second case of terrain is the axis of Meknes to El Hajeb (middle of Morocco).
- The third case of terrain concerns the axis from Fes to Taounate (North of Morocco).

After that, we draw a rough outline that includes the following elements:
- Choosing some benchmarks of the MGNL: these are chosen so that they are easily accessible, stationnables and clear to facilitate observations of geometric leveling,
- Verification of the existence and status of these benchmarks,
- Choosing new points around these benchmarks. These new points are selected so as to have different baseline lengths and various changes in altitudes with respect to benchmarks. These new points are materialized in stable places with iron.
- Planning GPS mission: determining the observation periods, the number of available satellites, the PDOP, the number of sessions of observation per day, the duration of each session, and establishing a program of GPS observations

Observation campaigns

Before starting observations, we made a check of the homogeneity of benchmarks: this check consisted in determining the changes in altitudes between benchmarks and compare them to the known altitudes. So for the three cases of terrain, the homogeneity tests show that differences between the known altitudes and observed altitudes vary between 0.1 cm and 11.9 cm. adopting a tolerance of 15 cm, we can conclude that benchmarks are homogeneous and stable with respect to each others, therefore they can be used as control points in our experiments.

Annexe : The sites of the experimental studies

Note that our GPS Observations are done during several days, for the three cases of terrain. During these experiments, we used only dual frequency receivers of three types. The static mode is used for the control points, (observation time varies from 1 Hour to 4 Hours), while the rapid static mode is used for the new points (minimum of 30 minutes of observations).

Concerning the geometric levelling operations, we used an optical level and a rod graduated in centimeters.

Experiments for the first case study: sites of Rabat-Témara and Sidi Bibi

The first case concerns two sites of flat terrain, the site of Rabat-Temara in north west of Morocco, and the site of Sidi Bibi in the south of Morocco. For these two sites, the lengths of baselines vary from 92 m to 7.6 km.

The first site (Rabat-Temara**) i**s located between the city of Rabat and Temara. On this site, we conducted two sessions of

ACRONYMES: *the related terms used in this paper are defined as follows.*

ANCFCC: Agence Nationale de la Conservation Foncière, du Cadastre et de la Cartographie

MGLN: Moroccan General Levelling Network

SGL: Simple Geometric leveling

H_{SGL}: *orthometric height determined by simple geometric levelling*

H_{GPS}: *orthometric height derived from GPS observations*

Height difference: expresses the difference between orthometric height determined by simple geometric levelling and GPS, represented by $\mathbf{H_{diff} = H_{SGL} - H_{GPS}}$

Altitude change: is the difference of orthometric height between two different points P_1 *and* P_2, *it is noted* $\mathbf{DH = H_{P1} - H_{P2}}$

observation, with three fixed benchmarks and seven new points. For this site the altitudes of points vary between 15 m and 54 m, while changes in altitude range from 41 cm to 32.99 m.

The second site of Sidi Bibi is located 22 km south of the city of Agadir. In this experiment, we choose five control points, and ten new points. In this case, we conducted two sessions of observations.

For this second site, the altitudes of points vary between 50 m and 67 m, while the maximum height difference is 16.9 m.

Experiments for the second case study: site of El Hajeb

The second experiment case study concerns the axis Boufekrane-El Hajeb. It is located 18 km south of the city of Meknes. For this second case, the altitudes of points vary between 708 m and 1107 m, with an average altitude of 842 m. Changes in altitudes vary between 31 cm and 394 meters. Distances between selected control points vary from 3 km to 5 km. The maximum baseline length between benchmarks is 15.8 km. For this experimentation, we planned three sessions of GPS observations.

Experiments for third case study: site of Taounate

This site is located along the main road from *Fès* to Taounate. The average altitude of the levelling points is 407 m, with a minimum altitude of 320 m and a maximum of 465 m.

For this site, we have accomplished a single session of observations with the following data:

- Changes in altitudes vary between 20 cm and 144.99 m, the average is 70 m.
- There are nine new selected points, and three control points.
- Baselines lengths vary between 17 m and 7.6 km.

Presentation of results: summary of height differences (GPS vs levelling) for the three cases

After treating the GPS data, and simple geometric leveling, we calculate differences between the orthometric heights (we will use the term *height differences*) determined by these two technics (GPS and simple geometric leveling). Table 1 summarizes the *differences* obtained for the three cases of terrain, as well as orthometric heights and baseline lengths for each case.

Referring to this table, we can notice that:

- The differences between GPS orthometric heights and levelling vary between 0 and 13.5 for the three cases.
- We can see that differences vary depending on the baseline length and the altitude change for the three cases.
- Through the obtained results for the three types of terrain, we realize that the orthometric height determination by GPS may depend mainly on two factors, the length of baseline and the change in altitude between the observed points.

Table 1: Summary of height differences (H_{diff}) for the three cases

Case	Range of baseline length (km)		Range of change in altitude (m)		Difference $Hs_{GL} - H_{GPS}$ (cm)	
	Max	min	Max	min	Max	min
First case study	7.6	0.092	33.60	0.041	11.5	0.3
Second case study	15.8	0.035	394.67	0.310	12.6	0
Third case study	7.7	0.017	145	0.197	13.5	0

Table 2: Analysis of variance ANOVA: effect of baseline length

	Sum of Squares	df	Mean Square	F	Sig.
Factorial effect	992,020	2	496,010	24,566	,000
Residual effect	2786,399	138	20,191		
Total	**3778,419**	**140**			

- For this purpose, we will carry out a statistical analysis to assess the effect of these two parameters and try to model this variation by considering each type of terrain.

Statistical analysis

In this statistical analysis, we suggest studying the variation of height differences case by case, as follows:

- Effect of baseline length on the determination of *height differences* ($H_{SGL} – H_{GPS}$).
- Effect of change in altitude on the determination of *height differences* ($H_{SGL} – H_{GPS}$).
- Effect of the type of terrain on the determination of *height differences* (H_{SGL}-H_{GPS}).

Analysis of variance

Analysis of variance, or ANOVA, was used by SIR Ficher (Dagnelie, 2011), to analyze data from experiments. This test consists in testing the effect of any parameter; by comparing the value of probability ***Sig*** at a level of significance. This probability is computed based on the sum of the squares of the differences; the degree of freedom (df); the mean square; and the random variable of Fisher (F). The significance levels are as follows:

- *Sig* > 0.05 indicates that the test is not significant.
- *Sig* ≤ 0.05 indicates that the test is significant.
- *Sig* ≤ 0.01 indicates that the test is highly significant.
- Sig ≤ 0.001 indicates that the test is extremely significant

Analysis of the effect of baseline length

In order to perform this analysis, we gather all obtained height differences (H_{diff}) from all the three cases, then, we classify the baselines lengths in 3 classes which are defined for this analysis as follows:

- Class I (short baseline): D < 1 km. For this class, there are 47 cases
- Class II (medium baseline): 1 km ≤ D < 5km. This class contains 46 cases
- Class III (long baseline): 5km ≤ D < 16km. This class includes 48 cases

The result of the analysis of variance for the baseline length effect is shown in table 2.

This test (*Sig* < 0.001) statistically shows that there is a very highly significant effect of baseline length on the orthometric difference ($H_{SGL} - H_{GPS}$). This means that this difference is very highly dependent on the baseline length.

Test of NEWMAN and KEULS

This test procedure compares all pairs of averages at a defined α (5%) level of significance. Thus, it indicates what averages are significantly different from others. We have used this test to compare averages of three classes of baselines. We came up to the following result: The effect of the first class with an average equal to **3.1 is** statistically different from the other two classes. The other two classes are statistically identical.

From this test, we conclude the following:

- For short baselines (less than one km), height differences (H_{diff}) between leveling and GPS gives an average of 3.1 cm.
- For the other two classes, the test shows that the results can be shown as similar. The average height differences (H_{diff}) are 8.1 cm for the 2nd *class (higher or equal to 1 km and less than 5 km), and 9.1 cm for the 3rd class (higher or equal to 5 km*, less than 16 km).

Analysis of the effect of change in altitude

To prepare this analysis, we have grouped all observations, and we have classified the changes in altitudes into 3 classes:

- Class1: Small change in altitude: DH < 10 m. There are 45 cases.
- Class 2: medium change in altitude: 10 m ≤ DH < 100 m. There are 63 cases.
- Class 3: high change in altitude: 100 m ≤ DH < 400 m. There are 33 cases.

The results of the analysis of variances are shown in table 3.

This test (*Sig* < 0.001) shows, that there is a very highly significant effect of change in altitude on the height differences between GPS and leveling.

NEWMAN and KEULS test

Using this test, we compared the averages of the three classes of changes in altitudes, we have achieved the following results.

- The effect of the three classes is statistically different from one class to another
- This difference increases more rapidly with the change in altitude compared to the effect of the baseline length.

For each class of change in altitude, we have obtained the following averages:

- 3.2 cm for the first class (small change in altitude).
- 7.3 cm for the second class.
- 10.7 cm for the third class.

Analysis of the effect of the type of terrain

Looking through the results, we note that the height differences between GPS and levelling for the same baseline length and elevation differs from one type of terrain to another. Therefore, we plan to study the influence of the terrain according to the three cases studied. The analysis of variance gives the results as mentioned in table 4.

The ANOVA test shows that the terrain has a very highly significant effect (*Sig* < 0.001) on the orthometric height differences (H_{diff}).

Concerning the influence of the terrain, we can conclude that:

- For the first case of terrain, the average of the height difference is 5 cm.
- For the second case of terrain, the average of the height difference is 6.7 cm.
- For the third case of terrain, the average of the height difference is 10.8 cm.

Modelling the orthometric height differences (H_{diff}) using linear regression model

Linear regression is an approach for modeling the relationship between a scalar variable Y (dependent variable) and one or more explanatory variables (independent variables) denoted X. The case of one explanatory variable is called simple linear

Table 3: Analysis of variance ANOVA: effect of change in altitude

	Sum of Squares	df	Mean Square	F	Sig.
Factorial effect	1080,955	2	540,478	27,650	,000
Residual effect	2697,463	138	19,547		
Total	**3778,419**	**140**			

Table 4: Analysis of variance ANOVA: effect of the type of terrain

	Sum of Squares	df	Mean Square	F	Sig.
Factorial effect	566,261	2	283,130	12,164	,000
Residual effect	3212,158	138	23,277		
Total	3778,419	140			

Table 5: Analysis of variance ANOVA : effect of change in altitude (First case study)

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	244,409	1	244,409	24,897	,000
Residuals	481,031	49	9,817		
Total	**725,440**	**50**			

Table 6: Analysis of variance ANOVA: effect of change in altitude (Third case study)

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	331,530	1	331,530	14,928	,001
Residuals	510,796	23	22,209		
Total	**842,326**	**24**			

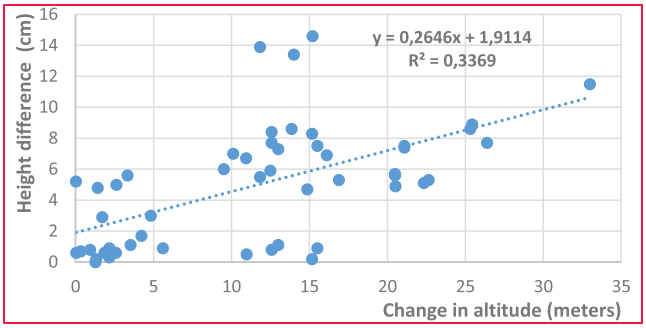

Figure 1: Regression model as function of change in altitude (site of Rabat-Temara and Sidi Bibi)

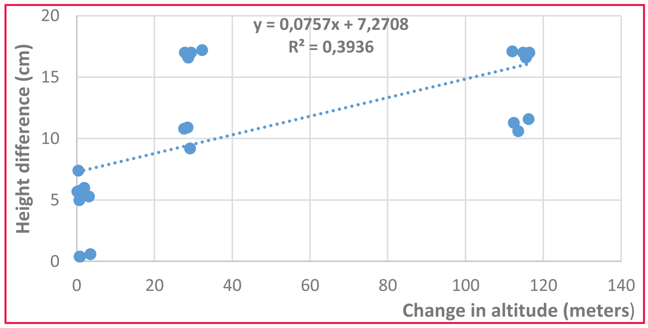

Figure 3: Regession model as function of change in altitude (site of Taounate)

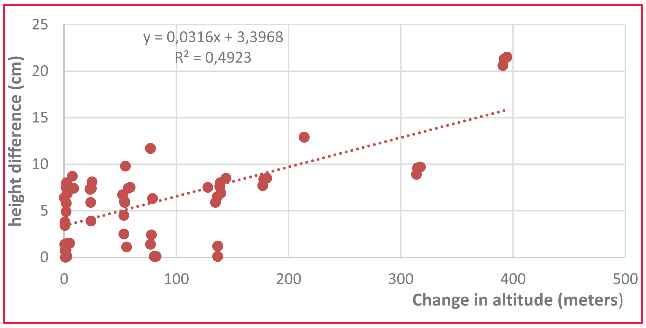

Figure 2: Regression model as function of change in altitude (site of El Hajeb)

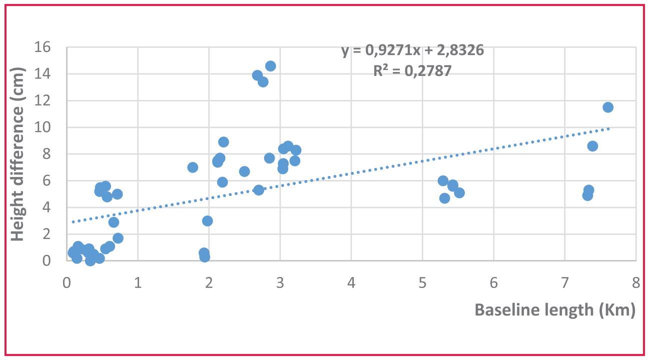

Figure 4: Regression model as function of baseline length (site of Rabat-Temara and Sidi Bibi)

regression. For more than one explanatory variable, the process is called multiple linear regression (Dagnelie, 2011).

In order to study the influence of the change in altitude on the one hand, and the effect of baselines lengths, on the height differences (H_{diff}), on the other hand, we use a linear regression model with a single variable. This model has the following form:

$Y = H_{diff} = a + b X$

In this model, we have:

***H_{diff}**: represents the height difference between levelling and GPS.*

***X** is the random variable, for this study it represents either the change in altitude or the baseline length.*
***a** is a constant term*
***b** is the regression coefficient*

Modelling the orthometric height differences (H_{diff}) as function of change in altitude

By studying each case of terrain, we have used a simple regression model to express the relationship between the height difference (H_{diff}) and the change in altitude.

a) The first case study (Rabat-Temara and Sidi Bibi sites)

After regrouping all the height differences (H_{diff}) for this case of terrain, the linear regression model can be expressed by the following equation:

$H_{diff}\,(cm) = 1.9\,(cm) + 0.265 * altitude\ change\ (m)$

For this model, the height difference will increase by 2.65 cm per 10 m change in altitude, with a constant term of 1.9 cm (figure 1).

The ANOVA test is very highly significant; implying that here is a very highly significant effect of altitude change on height differences (H_{diff}) (table 5).

b) The second case study (site of El Hajeb):

The regression model expressing the height difference for this second case of terrain is given by the following equation:

$H_{diff}\,(cm) = 3.4\,(cm) + 0.032 * altitude\ change\ (m)$

For this second model each altitude change of 100 m, will give a height difference of 3.2 cm, with a constant term of 3.4 cm (figure 2).

c) The third case study (site of Taounate).

Table 6 represents the results of the influence of altitude change on height difference for the third case study.

The ANOVA test is very highly significant, implying that there is a very highly significant effect of altitude change on height differences (H_{diff}). This height difference is represented according to the change in altitude by the following model:

$H_{diff}\,(cm) = 7.3\,cm + 0.076 * altitude\ change\ (m)$

This model displays that the height difference will increase by 7.6 cm for each altitude change of 100 m, with a constant term of 7.3 cm (figure 3).

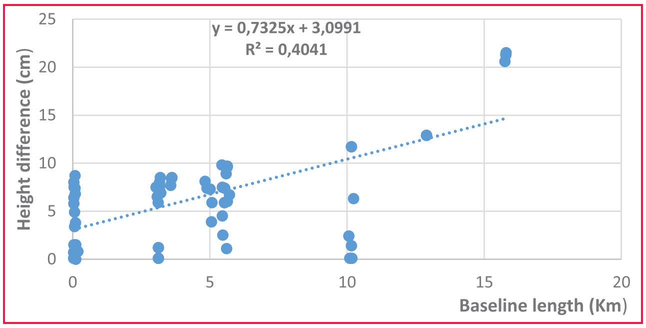

Figure 5: Regression model as function of baseline length (site of El Hajeb)

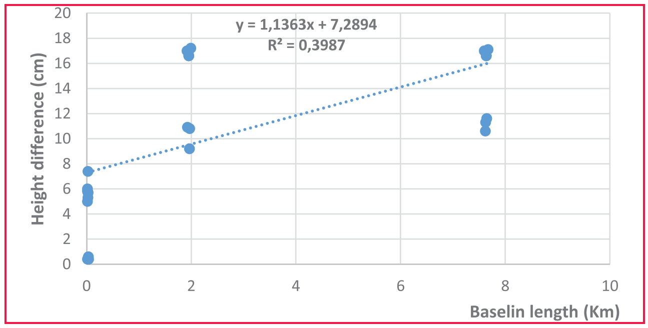

Figure 6: Regression model as function of baseline length (site Taounate)

Table 7: The coefficients of determination (R^2)

Experimental site	Model for change in altitude	Model for baseline
First case study	0.30	0.50
Second case study	0.492	0.404
Third case study	0.394	0.399

Table 8: The RMSE of the models

Experimental site	RMSE for change in altitude model (cm)	RMSE for baseline model (cm)
First case study	3,2	3,1
Second case study	3,9	3,6
Third case study	4,5	4,5

Modelling the orthometric height differences (H_{diff}) as function of the baseline length

By studying the variation of height differences (H_{diff}) as function of baselines lengths, we can use the simple regression model to express the relationships for each study case.

a) The first case study

The coefficients of the regression model for this terrain are represented by the following equation (Figure 4):

H_{diff} *(cm) = 2.8 + 0.927 * baseline length (Km)*

For this case, the height difference, increases by 0.92 cm, for a baseline of 1 km, with a constant term of 2.8 cm.

b) The second case study

The coefficients of the simple regression function for this second site are:

H_{diff} *(cm) = 3.1 cm + 0.732 * length of baseline (km)*

For this type of terrain, the height difference increases by 0.73 cm for a baseline of 1 km, with a constant term of 3.1 cm (figure 5).

c) The third case study

In this case the ANOVA test is very highly significant. Therefore, the height difference as a function of baseline length can be represented by the following regression equation (Figure 6):

H_{diff} *(cm) = 7.3 cm + 1,136 * baseline length (km)*

This equation shows that the height difference increases by 1.14 cm for a baseline of 1 km, with a constant term of 7.3 cm.

Analysing and assessing the models

in this statistical section, we have developed linear mathematical models that express the variation of height differences (H_{diff}) depending on the altitude change on one hand and on the baseline length on the other hand. These Mathematical models show that:

- Regarding to the effect of altitude change, the constant terms of these equations are 1.9 cm, 3.4 and 7.3 cm respectively for the three types of terrains.
- Concerning the baseline length, the constant terms are 2.8 cm, *3.1 cm and 7.3 cm for* each case study respectively.

In order to evaluate the performance of these models, we have used two statistical elements: the coefficient of determination (R^2) and the RMSE.

The coefficient of determination (R^2): For each model, we have obtained a coefficient of determination that expresses the percentage of the response variable variation that is explained by a linear model. Table 7 summarizes these coefficients for each model and for each case.

From this table, we can conclude that:

- For the first case of terrain, 30% of the variation of height difference is explained by the effect of altitude change. The baseline length has an effect of 50% on this variation. For this case of terrain, the baseline length has a greater effect on the variation of height difference compared to change in altitude.
- For the second case of terrain, the change in altitude influences height differences (H_{diff}) by 49.2% and only 40.4% is explained by the baseline length.
- For the third case of terrain, the altitude change has an influence of 39.4% on the variation of height difference, while 39.9% of the variation is explained by the baseline length.

The RMSE: in addition, we have evaluated the RMSE of these models, that is, we applied these models using the observed baselines and changes in altitudes (***DH)***. RMSE are computed using observed values of height difference ($\mathbf{y_{ob}}$), estimated values of height differences ($\mathbf{y_{es}}$) from the models, and the number of observations for each case (**n**), as shown in the following equation:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(y_{ob} - y_{es})^2}{n}}$$

The RMSE of these models are given in table 8. RMSE for models of change in altitude vary from 3.2 cm to 4.5 cm, while RMSE for models of baseline vary between 3.1 cm and 4.5 cm.

Conclusion

This article highlights the effect of altitude change and baseline length on the differences in orthometric heights between simple geometric levelling and GPS. We have used several experimental tests on three cases of different topography.

Comparison of orthometric height differences (H_{diff}) using statistical tools allows us to reach the following conclusions:

- The height difference between leveling and GPS increases very significantly with the length of baseline and depends on the topography of the terrain.
- The height difference between leveling and GPS is very significantly influenced by the altitude change.

Based on these experiments, we used linear regression to express the variation of orthometric height differences (H_{diff}) as function of the baseline length, and on the altitude change for the three types of terrain. RMSE of all experimented models, vary between 3.1 cm and 4.5 cm.

At the end of these experiments, and in response to surveyors' preoccupations, we can conclude that we could use dual frequency GPS for determining the orthometric heights, with an accuracy of a few centimeters (up to 15 cm) with respect to simple geometric levelling.

Acknowledgment

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Operating Civil Unmanned Aircraft System in India

Office of the Director General of Civil Aviation, Government of India has issued draft Guidelines for obtaining Unique Identification Number (UIN) and Operation of Civil Unmanned Aircraft System (UAS). Coordinates invites comments on this

The UAS consists of an Unmanned Aircraft (UA), a Remote Pilot Station (RPS), Command and Control (C2) Link, the maintenance system and the operating personnel. Unmanned aircraft are either pilotless or do not carry pilot(s) on board. Remotely Piloted Aircraft (RPA), Autonomous Aircraft and Model Aircraft are various types of unmanned aircraft.

ICAO Circular 328 highlights various issues and complexities involved with respect to civil UAS such as; regulatory issues, legal matters, operations, certification of aircraft and systems, personnel licensing, etc. ICAO has also issued Doc 10019 AN/507: "Manual on Remotely Piloted Aircraft Systems (RPAS)" which provides guidance to contracting states. ICAO has amended Annex 2 (Rules of the Air) to cover Remotely Piloted Aircraft (RPA), which is an unmanned aircraft piloted from a remote pilot station. However, at present Standard and Recommended Practice (SARPs) in Annex 6 (Operations) and Annex 8 (Airworthiness) on UAS are not available.

Civilian use of UAS includes damage assessment of property and life in areas affected with natural calamities, surveys; critical infrastructure monitoring including power facilities, ports, and pipelines; commercial photography, aerial mapping, etc. They are also increasingly proliferating into recreational field and are likely to be used in many other domains.

2. Definitions

Autonomous aircraft *	An unmanned aircraft that does not allow pilot intervention in the management of the flight.
Command and Control (C2) Link	The data link between the UAV and the remote pilot station for the purposes of managing the flight.
Controlled Airspace #	Airspace of defined dimension within which air traffic controlserviceisprovidedtoflightsinaccordancewith the airspaceclassification.
Model Aircraft	Unmanned Aircraft (UA) without payload used for recreational purposes only.
Payload	All components of equipment on board a UAV thatare not needed for the flight or for its control. Its transport aims exclusively to fulfill a specific mission.
Pre-flight Inspection	Set of manufacturer recommended system and components functional tests to be performed prior to any launch.
Remote Pilot	Apersonchargedbytheoperatorwithdutiesessential to the operation of a remotely piloted aircraft and who manipulates the flight controls, as appropriate, during flighttime.
Remotely Piloted Station (RPS)	The component of the remotely piloted aircraft system containing the equipment used to pilot the remotely piloted aircraft.
Remotely Piloted Aircraft (RPA)	An unmanned aircraft which is piloted from a remote pilot station
Remotely Piloted Aircraft System (RPAS)	A remotely piloted aircraft, its associated remote pilot station(s),therequiredcomm andandcontrollinksand any other components as specified in the typedesign.
RPA observer	A trained and competent person designated by the operator who, by visual observation of the remotely piloted aircraft, assists the remote pilot in the safe conduct of the flight.
Unmanned Aircraft (UA)	Anaircraftwhichisintendedtooperatewithnopiloton board.
Unmanned Aircraft System (UAS)	An unmanned aircraft, its associated remote pilot station(s),therequiredcomm andandcontrollinksand any other components as specified in thedesign.
Visual line-of-sight (VLOS) operation.	AnoperationinwhichtheremotepilotorRPAobserver maintains direct unaided visual contact with theRPA.

* have no official status within ICAO.

Controlled airspace is a generic term which covers ATS airspace Classes A, B, C, D and E as described in Annex 11, 2.6.

UA operations present problems to the regulator in terms of ensuring safety of other users of airspace and persons on the ground. However, in view of technological advancements in UAS over the years and their increased civil applications, it has become necessary to develop guidance material to regulate this activity.

This Circular lays down guidelines for obtaining UIN & operation of civil UAS.All the UAS operators are required to adhere to these guidelines in the interest of flight Safety. DGCA will register all civil Unmanned Aircraft and issue a UA Operator Permit (UAOP) on case to case basis.

3. Category of UA

Civil UA are classified in accordance with weight of UA as indicated below:

i) Micro : Less than twokg.
ii) Mini : Greater than two kg and less than 20kg.
iii) Small : Greater than 20 kg and less than 150kg.
iv) Large : Greater than 150kg.

4. Issue of Unique Identification Number (UIN)

4.1 All unmanned aircraft intended to be operated in India will require an Unique Identification Number (UIN) issued from DGCA. The UIN can be granted onlyto:

a) a citizen of India;or
b) a company or a body corporate providedthat:
    i) it is registered and has its principal place of business withinIndia;
    ii) its chairman and at least two-thirds of its directors are citizens of India; and,
    iii) its substantial ownership and effective control is vested in Indiannationals;

4.2 Following documents are required to be submitted to DGCA for issue ofUIN:

a) Address of Operator along with contact details with valid identity proof. In case of a company/organization, TIN number will beaccepted;
b) Purpose of operation of UA;
c) Specification of UAS (manufacturer name, type, model number, year of manufacture, weight and size, type of propulsion system, flyingcapabilities in terms of maximum endurance, range and height, etc. including detailsof equipment);
d) Verification of character and antecedents of the operator and remote pilots from local sub-divisional police office;
e) Permission for all frequencies used in UAS operations from Department of Telecommunication (Wireless Planning and CoordinationWing);
f) Copy of Unmanned Aircraft Flight Manual(UAFM);
g) Copy of Manufacturer's maintenance guidelines forUAS;

4.3 The identification plate (made of fire proof material) inscribed with UIN and RF ID tag or SIM shall be affixed to the UA, and appropriate makes to identify ownership.

5. UA Operator Permit (UAOP)

5.1 All civil UA operations at or above 200ft AGL in uncontrolled airspace for any purpose whatsoever will require UAOP fromDGCA.

5.2 Operation of civil UA in controlled airspace isrestricted.

5.3 Following entities will not require UAOP fromDGCA

a) Civil UA operations below 200ft AGL in uncontrolled airspace and clear of notified prohibited, restricted and danger areas as well as Temporary Segregated Areas (TSA) and Temporary Reserved Areas (TRA). In addition, the operator shall obtain permission from local administration, the concerned ADC.
b) Model aircraft operating below 200ft AGL in uncontrolled airspace & indoor UA for recreational purposes only. (Aero modelling activities carried out within the premises of educational institutions will be considered as recreational purposes).

6. Procedure for Issuance of UAOP

6.1 The operator having an UIN intended to conduct civil operation of a UA at or above 200ft AGL in uncontrolled airspace shall submit his application for UAOP to DGCA along with followingdocuments:

a) Permission from ANS provider (civil/defense);
b) Permission of the land / property owner (when operated below 200 ft AGL and area used for take-off and landing ofUA);
c) Details of Remote Pilot(s) and training records;
d) Insurance details ifapplicable;
e) Security Clearance of firms/ operator of UA fromBCAS;

6.2 The application shall be submitted at least 90 days prior to actual conduct of UA operations to Director Regulations & Information (DRI), O/o DGCA for issue of UAOP.

6.3 Upon being satisfied on the following issues, DGCA may issue UAOP for UA operations:

a) That the operator has produced and will keep up to date UAFM, specifying procedures to be followed by remote pilots and other relevant persons to ensure the safety of UAoperations;
b) Thattheoperatorhasestabli shedmaintenancesystem,d etailsofwhichwill be kept up to date at alltimes.

6.4 The UAOP shall contain at least the following information:

a) Name and location (main place of business) of theoperator;
b) Date of issue and period ofvalidity;
c) Scope and description of the type of operationsauthorized;
d) Area ofoperation;
e) Type(s) of UA authorized for use;

f) Unique Identification Number (UIN) ofUA;
g) Special limitations, if any (e.g. not over populous areas,etc.);
h) List of approved personnel for operation of UAS (security clearance of personnel will berequired);
i) Insurance validity with respect to allliabilities;

6.5 Validity of UAOP shall be for period of two years from date of issue and is not transferrable. Renewal of NOC shall require security clearance from MHA & BCAS.

6.6 CopyofUAOPshallbeforward edtoMHA,BCAS,IAF,ANSPr ovider(AAI/MoD), and Local Administration/ concerned state's DGP/ Local ASP forinformation.

6.7 Import permission shall be obtained from DGCA based on which DGFT shall provide licence for import ofUAS.

6.8 DGCA may impose additional requirements/ waive off requirements depend upon justification on case to casebasis.

7. Security Aspect

7.1 The UAS (issued with UIN) shall not be sold or disposed of in any way to any person or firm without permission fromDGCA.

7.2 The owner/operator shall be responsible for the safe custody, security and access control of the UAS. In case of loss of UA, the operator shall report immediately to local administration/ police, BCAS andDGCA.

7.3 The operator shall ensure that all security measures are in place before operation of each flight.

7.4 Owner/operator is responsible for notifying any incident/ accident during flying of the UA to Director of Air Safety, DGCA and BCAS within 24hours.

8. Training requirements for remote pilots

8.1 Remote pilot should have attained 18 years of age and have thorough ground training equivalent to that undertaken by aircrew of manned aircraft or a PPL holder (aeroplane/ helicopter) with FRTOL.

8.2 Remote pilots shall undertake thorough practical training in the control of a UA in flight, which may consist of a proportion of simulated flighttraining.

8.3 The training should enable the remote pilot to demonstrate that he/she can control a specific UA throughout its operating conditions, including safe recovery of UA in case of emergencies and system malfunction.

8.4 The above training requirements for remote pilots are not applicable for micro category UA & recreationalflying.

9. UAS Maintenance

9.1 Maintenance and repair of UAS should be carried out in accordance with manufacture's approved procedures.

9.2 Maintenance of the ground control equipment should be in accordance with manufacture's recommended period of inspection and overhaul, asapplicable.

9.3 The remote pilot shall not fly the UA unless before the flight he/she is reasonably satisfied that all the control systems of UA including the radio link are in working condition.

9.4 The UAOP holder shall maintain records of each UA flight and makes such records available to the DGCA ondemand.

10. Requirement for operation of UA

10.1 Irrespective of weight category, the UAS operator shall intimate Local Administration, ATS unit (for operations at or above 200ft AGL in uncontrolled airspace), BCAS, Aerodrome operator (if applicable) before commencement and after termination of operation. In the event of cancellation of UA operations, the operator shall notify the same to all appropriate authorities as soon aspossible.

10.2 The operator shall refer to Aeronautical Information Publication (AIP) and active NOTAM regarding details of notified prohibited, restricted and danger areas (airspace) including TRA and TSA. The operation shall be restricted to areas outside the boundaries (lateral and vertical) of above mentioned areas in the uncontrolled airspace.

10.3 The operator shall carry out safety assessment of the UA operations including the launch/ recovery sites. The UAS operation site (including emergency operation zone and any safety zone for the operations of the UAS) shall be under the operator's full control.

10.4 Privacy and Protection of Personnel/ property/ data shall be given due importance.

10.5 UA shall be operated in accordance with the rules governing the flights of manned aircraft as specified in CAR Section 9, Series C, Part I (Rules of the Air).

10.6 UA should be able to comply with regulations applicable to the class of airspace within which they intend tooperate as specified in CAR Section 9, Series E, Part I (Air Traffic Services).

10.7 For operations at or above 200ft AGL in uncontrolled airspace, the UA operator shall file a flight plan and obtain necessary clearances with concerned ATS unit and ADC.

10.8 The flight plan shall contain the following information, but not limited to the following:
a) Description of the intended operation (to include type of operation or purpose), flight rules, visual line-of-sight operation, date of intended flight(s), point of departure, destination, cruising speed(s), cruising level(s), route to be followed, duration/frequency offlight.
b) Performance characteristics of UA, including operating speed, maximum climb rate, maximum rate of descent,

maximum turn rate, maximum range andendurance.

c) Number and location of remote pilotstations.

d) Fixed Payloadinformation/ description.

e) Proof of adequate insurance/ liabilitycoverage.

f) Contact number of the remote pilot and/or RPS in field 18 of the Flight Plan.

10.9 The UAV shall enter the controlled airspace only with the prior approval of the ANS provider, which will be in the form of an airways clearance. The SOP shall contain take-off/landing procedure, collision avoidance procedure, noise abatement, flight plan filing, local airspace restriction, right-of-way rules, communications requirements, UA emergency procedures, pre co-ordination and procedures necessary to safely recover UA through controlled airspace in case UA system failure precludes the ability to remain outside controlled airspace, etc. AIP Supplement of AAI may be referred for flying outside the controlairspace.

10.10 Prior to the operations of UA, the operating personnel shall be in coordination with the appropriate ATS Authority, and Local police station probably through VHF/ landline/ two mobile phones with independent serviceproviders.

10.11 Remote pilots should prefix RPA call sings with the word UNMANNED during voice communications between ATC and the remote pilotstation.

10.12 The operator shall ensure that the UA is flown within 500m Visual Line of Sight (VLOS) during the entire period of the flight. (Applicable for micro and miniUA)

10.13 International operations of civil UAS (flying across the territory) and/or over water shall be strictly prohibited. The UA shall not be flown over the entire air space over the territory of Delhi (30km radius from Rashtrapati Bhavan) and areas falling within 50 km from the international borders. Also, UA shall not be flown over other sensitive locations viz. nuclear stations, military facilities and strategic locations.

10.14 UA flight shall be conducted as per the manufacture's approved UAFM available with the remote pilot within the Remote Pilot Station (RPS).

10.15 UA shall be operated (as VFR flight only) when the following meteorological conditions exist:

a) During daylight with Visual Meteorological Conditions (VMC) having ground visibility of 5 km.

b) Surface winds of not more than 20 knots (measured using hand held anemometer atsite).

c) Cloud base not lower than the approved altitude of operations.

10.16 The UAS operator shall not launch the UA when rain/ thunderstorm warning is in force.

10.17 The UAS operator shall have adequate means to ensure that the actual altitude flown isaccurate.

10.18 The operator shall be responsible for ensuring that the UAV is operated safely and remains clear of air traffic including other UAs and obstructions except where operation in close proximity of obstacles has been authorized on the operator's UAOP.

10.19 The take-off and landing area should be properly segregated from public access.

10.20 Designated "safe areas" should be established by the UAS operator for emergency UA holding and flight terminations.

10.21 UA shall not discharge or drop substances unless specially cleared and mentioned in UAOP. UA shall not carry any explosives/ dangerous goods, animals/ human payloadetc.

10.22 Operator shall ensure that no Radio Frequency Interference (RFI) is caused to air traffic operations and air navigationequipment.

10.23 The UA shall have following components/equipment:

a) Identification plate and/ or RFID;

b) SIM card slot for an app based tracking (Mandatory for Micro & MiniUA);

c) SSR transponder (Mode 'C' or 'S') or ADS-B option (Mandatory for Small & Large UA);

d) GPS/ INS (with option to GPS tracking and GeoFencing);

e) Detect and avoid capability (if required, operator shall engage an RPA observer)

f) Return Home option (mandatory in the event offailure)

10.24 For operation of large UA, it is recommended that reporting of UA position by the ground control station in ICAO standard ATFM format to ATS/ AD agencies.

11. Legal Obligations

11.1 UAOP issued by DGCA wouldnot:

a) Confer on UAS operator any right against the owner or resident of any land or building on or over which the operations are conducted, or prejudice in any way the rights and remedies which a person may havein respect of any injury to persons or damage to property caused directly or indirectly by the UA.

b) Absolve the operator/ remote pilot from compliance with any other regulatory requirement, which may exist under State or local law.

11.2 Any legal dispute as far as DGCA is concerned shall be settled at Delhi only.

12. Insurance

All civil UAOP holders shall have insurance with the liability that they mightincur for any damage to third parties resulting from theaccident/incident.

13. Enforcement Action

The UAOP issued by DGCA shall be cancelled or suspended at any time if in the opinion of the DGCA, the performance of the Remote Pilot /maintenance of UAS is no longer to an acceptable standard.

(Smt. M. Sathiyavathy)
Director General of Civil Aviation

In Coordinates

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SURVEYING

MyRTKnet: Get set and go!

MyRTK network is an effort to use real-time survey technology for the advancement of many services and dissemination of various geodetic products

Dato' Hamid Ali, Ahmad Fauzi Nordin, Dr Samad Hj Abu, Chang Leng Hua

Objectives

In order to take full advantage of the real-time capabilities of the RTK network, MyRTKnet has been designed with the following objectives:

i. To establish a network of permanently running GPS base stations, at a spacing of 30 to 150 km, feeding GPS data to a processing centre via frame-relay IPVPN communication network.

ii. To establish a central facility that will model the spatial errors which limit GPS accuracy through a network solution and generate corrections for roving receivers positioned anywhere inside the network with an accuracy better than a few centimeters (dense network) to a few decimeters (sparse network) in real time.

iii. To establish a web site that will make available near real time (1 - 3 hours) reference station data to the users for post-processing differential GPS throughout the coverage area.

POLICY

A new move(ment)

India comes out with guidelines for implementing its National Map Policy that was announced last year. We present guidelines and observations by Professor George Cho and Professor JG Krishnayya. We will continue this discussion in the next issue

4. Licensing of Digital Maps:

Digital data will be available in single/ multiple/ commercial licensing for general use, value addition and marketing. All digital maps will be provided with encryptions/mechanisms which may corrupt the data while copying unauthorisedly or while attempting the same. Every such attempt shall attract criminal and civil liability from the user without prejudice to the corruption of data or software/hardware for which the SOI will not be liable. SOI digital data will be licensed based on usage. Following are the categories:

Digital Licence
Publishing Licence
Internet Licence
Media Licence
Value addition Licence

Terms and conditions governing each of the licence is available in SOI web site www.surveyofindia.gov.in.

GNSS

Space-based positioning system with no on-board atomic clocks

An overview of the architecture and its advantages and disadvantages over the classic GPS scheme

Fabrizio Tappero, Andrew Dempster, Toshiaki Iwata

Conclusions

With the opportune shrewdness, the basic idea that lies behind the QZSS-RSS could theoretically be applied to other GNSSs. The two proposed methods, [3] [4], are practical implementations of this remote synchronization concept specifically made for QZSS. Both schemes could theoretically be applicable to a world-wide GNSS, i.e. GPS or GALILEO. For such systems, all time view is not applicable and more ground stations would be necessary to guarantee the necessary synchronization update. Beside being a very interesting research topic, the idea of a GNSS with no on-board atomic clocks would offer several advantages in term of satellite cost, life expectancy and satellite power consumption. This concept could be advantageously applicable to Low Earth Orbit, LEO, positioning systems, [7], where satellite weight is clearly a critical issue.

LiDAR

Going hand in hand

The combination of aerial photography and LiDAR has great potential

Madhav N Kulkarni and D M Satale

Harris Geospatial Solutions to offer Icaros OneButton™

Icaros Inc. has announced that Harris Geospatial Solutions will offer the Icaros OneButton™ family of image processing software as a front-end complement to its ENVI® geospatial analytics solution for users extracting information from manned and unmanned aerial sensor data. Icaros developed the OneButton family for geospatial end users to easily and automatically generate precise, fully orthorectified 2D maps and 3D models from frame-based aerial imaging systems. Originally engineered for manned aircraft sensors, the OneButton software has been modified to accommodate the unique collection conditions of unmanned aerial systems (UAS). *www.icaros.us*

Draganfly UAS now use GPS + GLONASS

Draganfly Innovations has added support for GLONASS satellite navigation, which will provide higher accuracy and function in more locations than GPS alone. Adding GLONASS support allows additional satellites to be detected, which is important in situations where fewer satellites are in line of sight. The Draganflyer Commander, X4-ES, and X4-P unmanned aircraft systems (UAS) now use GNSS receivers that support both GPS and GLONASS.

NASA marks success for most complex drone traffic management test

In the first and largest demonstration of its kind, NASA and operators from the FAA unmanned aircraft systems (UAS) test sites across the country flew 22 drones simultaneously to assess rural operations of NASA's UAS traffic management (UTM) research platform. Operators outside NASA interacted with the UTM research platform, entering flight plans and planned operations from several geographically diverse locations, using various aircraft and software. The UTM research platform checked for conflicts, approved or rejected the flight plans and notified users of constraints. Engineers at NASA's Ames Research Center in Silicon Valley, California, monitored operations and system load and gathered qualitative feedback to identify capability gaps to further refine the UTM research.

A total of 24 drones flew multiple times throughout the three-hour test, with 22 flying simultaneously at one point. The mission was declared successful, given the minimum success criteria of 16 simultaneous operations was achieved. In addition to the live aircraft interacting with UTM, NASA Ames introduced dozens of virtual aircraft into the same airspace to further enhance the test. *www.nasa.gov/*

Europe wants to keep track of migrant route surveillance with UAS

EU border patrol agency Frontex announced recently that it intends to use remotely piloted aircraft for maritime surveillance, adding drones to its existing portfolio of satellite and sensor technologies for monitoring vessel traffic and migrant flows. At present, Frontex is dependent upon individual member states' coast guards, with widely varying assets, capabilities and practices but the agency's operations have progressively expanded over the course of the last two years as an unprecedented migrant crisis has shaken European politics. The European Commission has even proposed folding Frontex into a new European Border and Coast Guard with expanded authority and twice as many personnel, and the measure is making its way through the EU's legislative process. *http://i-hls.com/*

Xiaomi launches drone with 4K recording capabilities

Mi Drone has a 5100 mAh capacity battery that is meant to last for a 27-minute flight on an average. The drone has a modular body which makes it easy to detach and service. The camera module is detachable too. The Mi Drone is navigable with a remote control that comes with it. The drone can also work on autopilot mode which enables automatic take-offs, landings, and returns. The operator can chart the flight path of the drone which has built-in GPS and GLONASS support. In the absence of GPS availability, Mi drone can use a special technology called vision positioning. *www.huffingtonpost.in*

SuperGIS Server 3.3

The new to be released GIS server from Supergeo, SuperGIS Server 3.3, is a product designed to meet the modern technologies in client side applications. One of the major upgrades will focused on the Ultra application, which will support both PC web browsers and mobile web browsers. The default web application built with SuperGIS Server 3.3 will allow users to view and interact with the map both on PC and mobile platforms including iOS and Android. *www.supergeotek.com*

Digitization of land records in final phase in Patna, India

A team of European experts of GIS Consortium India Private Limited reached Patna for the final phase of aerial photography of the land as a part of digitization project of land records in the state. Revenue and land reforms department sources said land records in Bihar were last updated between 1888 and 1915. The project is under the Digital India National Land Record Modernization Programme and its expenses are borne by the central government. Bihar is the first state in the country where aerial photography project for land reforms has been initiated. *http://timesofindia.indiatimes.com/*

GIS mapping, drones to help Railways protect land

The Delhi Division of the Railways is taking the hi-tech route to manage its fixed assets in the National Capital Region. From GIS mapping of its vacant land to aerial survey of its railway station through drones, the Railways is adopting state-of-the-art technology for asset and project management. The Railways has developed a web-based application, Land Management Module, and the pilot project will start in Delhi. The GIS mapping of all Railway land in Delhi will help the authorities in curbing the menace of encroachments.

"Through the use of this state-of-the-art technology, we will get to know where are the encroachments and how they are spreading," according to Arun Arora, Divisional Railway Manager, Delhi.

Galileo update

Galileo PRS signal accessed via the cloud

In a world first, the Public Regulated Service (PRS) of Galileo has been delivered via the 'cloud', paving the way for its automated use by the security and emergency services and critical national infrastructure (CNI) as the secure position and timing service of choice across Europe. Accessing PRS via the cloud overcomes a major problem for some potential PRS users due to the security protocols required when managing the cryptographic keys needed to access the signals.

PRS is Galileo's secure signal, available to government authorized users; usually those integral to a country's operation that require location, navigation or timing information to operate. PRS signals are encrypted and decrypted by cryptographic keys which, until now, are stored on the PRS receiver and managed by the PRS user. However, the system developed by NSL and QinetiQ places these keys in a secure server located in the 'cloud', accessed via the internet, making PRS available as a service for secure, authenticated position and timing information.

On the 18th May 2016, Ordnance Survey in Southampton successfully demonstrated three different "user scenarios" - an Unmanned Aerial Vehicle (UAV), a surveyor with a GNSS receiver attached to a mobile phone and a static reference receiver. In each scenario, a receiver captured signals from both Galileo open access and PRS signals, and also open GPS signals. The three different users were located around the Ordnance Survey site, simulating routine tasks. The signals captured by their receivers were sent, via cellular 3G links, into the 'cloud' to be processed. Position and time was calculated from the open-access signals by servers at the NSL site in Nottingham.

European GNSS Agency announces Prize for Galileo Initial Services

The GSA is accepting applications for its annual ESNC Special Topic Prize. This year, the Agency's 2016 prize will reward the most innovative application idea for Galileo Initial Services.

Submissions must leverage Galileo Initial Services, which should be declared later this year. Submissions should also utilise the power of a multi-constellation environment as a means for providing new and more robust benefits to end users.

All ideas and applications need to demonstrate commercial feasibility, use European GNSS signals as a primary means of positioning, and be able to contribute to Galileo market uptake, among others.

The winner will have the opportunity to develop their idea at an incubation centre of their choice within the EU-28 for six months, with the possibility of a further six months according to progress. Furthermore, the winning idea will have the chance to be showcased at the official Galileo Service Declaration Ceremony in Brussels, when Initial Services are announced to the world.

The main use of GIS mapping, however, will be for project management, Mr. Arora said. He said that apart from GIS mapping, "drone surveys" too will soon start in Delhi to help with big-ticket projects. He said the use of camera-fitted drones will help railway officials get an imagery of the projects at a scale that is not possible manually. Another major use of drones will be for redevelopment of old railway stations like old Delhi and Hazrat Nizamuddin. *http://www.thehindu.com/*

Maharashtra to launch satellite-mapping, digitisation of rural land

Over 150 years after the last comprehensive survey of land across Maharashtra was launched, the state government will undertake satellite mapping of rural land and digitisation of these maps. The survey will initially be launched initially in six districts -- Raigad, Pune, Amravati, Nagpur, Aurangabad and Nashik. It will eventually cover the entire 3.07 lakh square km area of Maharashtra. Of this, 2.85 lakh sq km area comprise the rural areas. The land records reform project will help the transition from the current system, under which only a presumptive title of land is provided, to one where title is clear and ownership is guaranteed to reduce litigation and disputes. *www.dnaindia.com*

GIS-based map protects children's lives in Chiba

To protect primary school students from traffic accidents, the Chiba prefectural police in Japan have distributed commuting route maps among schools, indicating spots where students have been injured or killed in traffic accidents. The initiative is rare, but the maps have been used to raise awareness and have been effective in protecting children from traffic accidents on the way to and from school. The prefectural police have compiled a database of traffic accidents resulting in injury or death since 2001, and have accumulated data on accident locations and weather, as well as who was involved in the accidents. With the GIS, users can check different kinds of data on their computer by pointing their cursor to spots where accidents have happened. *http://the-japan-news.com/*

Earth-i and Telespazio Vega Sign Memorandum

Earth-i UK has signed a MoU with space technology and enabled services specialist, Telespazio VEGA. This MoU will permit each company to provide each other's specialist products and services to their respective customers. In the case of Earth-i, this will permit them to provide new and existing customers with advanced synthetic aperture radar (SAR) data from the COSMO-SkyMed satellite constellation alongside their existing optical data.

China launches YAOGAN- 30

China successfully conducted its fifth orbital launch this year, sending the Yaogan-30 remote sensing satellite into space. The spacecraft lifted off at 10:43 a.m. local time on May 15 atop a Long March 2D rocket from the Jiuquan Satellite Launch Center, located at Jiuquan in northwest China's Gansu Province. Yaogan-30 was launched into a Sun-synchronous orbit (SSO) of 429 by 437 miles (690 by 704 kilometers) with inclination at 98.23 degrees. It now remains in an orbit of 389 by 407 miles (626 by 655 kilometers), inclined 98.07 degrees. *www.spaceflightinsider.com*

Mapping satellite puts China among best in the business

China launched a high-resolution mapping satellite from the Taiyuan Satellite Launch Center in north China's Shanxi Province. Also on board were two NewSat satellites from Uruguay. Ziyuan III 02 will be used in land resource surveys, natural disaster prevention, agricultural development, water resources management and urban planning. *www.shanghaidaily.com*

ISRO signs MoUs for space exploration with 37 countries

Indian Space Research Organisation (ISRO) has signed MoU/ Cooperative agreements for exploration and use of outer space with 37 countries viz. Argentina, Australia, Brazil, Brunei Darussalam, Bulgaria, Canada, Chile, China, Egypt, France, Germany, Hungary, Indonesia, Israel, Italy, Japan, Kazakhstan, Kuwait, Mauritius, Mexico, Mongolia, Myanmar, Norway, Peru, Republic of Korea, Russian Federation, Saudi Arabia, Spain, Sweden, Syria, Thailand, The Netherlands, Ukraine, United Kingdom, United Arab Emirates, United States of America and Venezuela.

The areas of these explorations will include newer research activities in Joint development of advanced scientific instruments to observe earth and universe; joint realization of satellite missions; jointly carrying out calibration and validation experiments; conducting airborne campaign with advanced instruments; deep space navigation and communication support for space science missions; development of advanced technologies for building and launching of spacecrafts for earth observation and space science exploration.

China's Earth observation satellite assists Ecuador quake relief

China has offered a set of hi-resolution imageries of the Ecuador quake zone, captured by satellite Gaofen-2 to aid relief work, according to the China National Space Administration (CNSA).

The earthquake, the strongest in Ecuador for over 35 years, has claimed more than 500 lives, and injured nearly 6,000 others.

The images of the region before and after the quake were provided after a request from the Ecuador's government.

Australia turns to GNSS for primary navigation

The move on 26 May will see the Airservices Navigation Rationalisation Project switch-off 179 navigation aids, including non-directional beacons, VHF omni-directional radio ranges and distance measuring equipment. Withdrawn procedures will be replaced with straight-in area navigation (RNAV) approach procedures that perform the same function. At many airports, RNAV approach procedures will be provided at both ends of the runway, essentially duplicating the navigation service.

Australia's Civil Aviation Safety Authority also required from 4 February that instrument flight rules (IFR) aircraft use GNSS technology as their primary means of navigation. GNSS is a key component of a long-term strategy to address growth in aviation.

Benefits of the switch to satellite navigation include a reduced requirement to use ground-based aids, greater operational flexibility, and reduced track miles, step-down and circling approaches, as well as reduced fuel burn and flight times. Airservices will monitor the remaining 213 navigation aids forming the industry-selected Backup Navigation Network (BNN) which will be available in the unlikely event a pilot is unable to access the satellite service. *www.airservicesaustralia.com/*

Iridium launches timing, location service as GPS back-up

U.S. firm Iridium Communications Inc said its Satellite Time and Location (STL) system was ready for use as an alterative or companion to the GPS satellites.

Iridium developed the new STL system with Satelles, a private firm, to deliver signals using Iridium's 66 low-earth satellites, making it less vulnerable than ground-based terminals used for GPS services. The Virginia-based company said the STL system gives users access to accurate position, navigation and timing technology using inexpensive chips that work anywhere on earth, providing an alternative to GPS and a way to verify GPS signals. *www.reuters.com*

Euro Soyuz orbits two Galileo satellites

A Europeanized Russian Soyuz rocket on May 24 successfully placed two European Galileo PNT satellites into medium-Earth orbit – the 13th and 14th in a series of 26 Galileo spacecraft, with more to come. Launch operator Arianespace confirmed the accurate orbital injection, and European Space Agency officials said both satellites were healthy and sending signals. *http://spacenews.com*

'Father of GPS,' wins prestigious Marconi Prize

Bradford Parkinson, the Edward C. Wells Professor in the School of Engineering, Emeritus, at Stanford, has been awarded the Marconi Prize for his role in guiding the development of GPS from an orphaned project to a technology that is deeply seeded in nearly every aspect of modern life. The $100,000 Marconi Prize, given annually, recognizes major advances in the communications field that benefit humanity. Aero/Astro Professor Emeritus Brad Parkinson has won the 2016 Marconi Prize for his role in guiding the development of GPS from an orphaned military project to a ubiquitous technology. *https://news.stanford.edu*

China to launch 30 Beidou navigation satellites in next 5 yrs

China plans to launch 30 Beidou navigation satellites during the 13th five-year plan period (2016-2020), to build a global navigation system by 2020. The first batch of 18 satellites will be launched before 2018 to cover countries along the routes in "the Belt and Road" (Silk Road) initiative, Ran Chengqi, director of the China Satellite Navigation Office said, addressing the China Satellite Navigation Conference. *http://economictimes.indiatimes.com*

South Korea revives GPS backup project

South Korea has revived a project to build a backup ship navigation system that would be difficult to hack after a recent wave of GPS signal jamming. GPS and other electronic navigation aids are vulnerable to signal loss from solar weather effects, radio and satellite interference and deliberate jamming.

South Korea, which says it has faced repeated attempts by the rival North to interfere with satellite signals, will award a 15 billion won ($13 million) contract to secure technology required to build an alternative land-based radio system called eLoran. *www.yahoo.com*

Russia deploys another GLONASS-M

A Russian Soyuz 2-1B has launched the latest GLONASS-M Global Navigation satellite from the Plesetsk Cosmodrome, recently. The spacecraft was launched with the designation of Glonass n°53, ahead of being renamed Kosmos-2516 once operational in orbit. *www.nasaspaceflight.com*

The InLocation Alliance Partners with the OGC and i-Locate

The InLocation Alliance (ILA) has announced the publication of a comprehensive Use Case White Paper written with the Open Geospatial Consortium and the European Union's i-Locate Project. The white paper is based on the 2016 ILA Use Case Survey promoted by ILA, OGC, i-Locate and the Location Based Marketing Association to members, participants and the general public that resulted in over 150 results. The white paper provides insight to thought leaders of the opportunities afforded by indoor LBS and technical solutions being developed in the ecosystem.

The survey results provide a snapshot of the requirements submitted by different stakeholders (within and beyond the members and participants in ILA, OGC and i-Locate) and an up-to-date overview of the market for indoor positioning. In this new frontier of geospatial information there is ever increasing reliability of determining indoor positions and OGC standards are providing standards for indoor positioning coordinates, identifiers and building and urban models (CityGML and IndoorGML). *www.inlocationalliance.com*

FOCUS 35 Total Station Monitors Dam for Movement

At the Razisse dam on the Dadou River in southwest France, a Spectra Precision FOCUS 35 robotic total station has completed monitoring the structural movements that occurred during recent major repairs and improvements to the dam. The Razisse is an arch and gravity type dam 30 meters high and 300 meters across built in 1955 to impound water for hydroelectricity. The current engineering project to improve dam performance and ensure downstream safety included raising the dam height by 60 cm, reinforcing existing abutments and adding two new piano key spillways.

Raising the height of the dam was expected to cause the abutments to settle. To ensure that the abutments were settling properly and within expectations, the FOCUS 35 was positioned to measure XY movement. Eight survey points were selected. Four prisms were place on the existing parapet of the right abutment and four prisms on the reaction points of the left abutment. The survey points were measured and recorded at different steps in the project: before deconstruction, after deconstruction and before and after post-tensioning tendons. To ensure accuracy each prism was measured four times and averaged to produce a final result. Measurements were taken at each step, then five days and 10 days following each step. *spectraprecison.com*

Future evolution of GPS III satellite design

Designed with evolution in mind, Lockheed Martin's GPS III satellites for the Air Force's next acquisition will be able to offer on-orbit re-programmability so they can be upgraded in space to add new signals or missions, a first for the GPS constellation. The satellite's modular design will also allow for low risk, easy insertion of new, future technology into the production line – guaranteeing GPS III remains the gold standard for positioning, navigation and timing. Lockheed Martin will demonstrate the value of its flexible GPS III design over the next 26 months, as part of the Air Force's GPS III Space Vehicles 11+ Production Readiness Feasibility Assessment. *http://lockheedmartin.com/*

"Future Proof" GNSS RTK Technology

Septentrio has introduced Altus APS3G RTK receiver, which brings technology only previously available in scientific receivers into the field for professional surveyors.

The new multi-constellation APS3G addresses major concerns about compatibility with new satellite constellations, as well as interference and jamming. Built on Septentrio's AsteRx4 engine, the APS3G tracks all-in-view GPS, GLONASS, Beidou, IRNSS, SBAS, Galileo and QZSS, including E6/L6, and all other signals known to be available in the medium term. *septentrio.com*

AFC Mapper App by Trimble

Trimble has released its AFC Mapper App, a free, standalone Web and mobile app that can run on the latest version of the Trimble® Unity software-as-a-service (SaaS) solution for managing critical water utility assets and field operations. It is designed to leverage technologies from Trimble, AMERICAN Flow Control (AFC) 2D barcodes and Esri to automate mapping and asset management of hydrants, valves and related water network assets, using Android- or IOS-based smartphones and tablets or Trimble handhelds. AMERICAN Flow Control, who manufactures the American-Darling and Waterous fire hydrant brands, is one of the largest fire hydrant companies in the utility industry. *www.trimble.com*

Trimble Introduces Compact, Dual Antenna, High-Accuracy GNSS Module for System Integrators

Trimble has introduced the Trimble® MB-Two GNSS module. The MB-Two delivers highly accurate GNSS-based heading plus pitch or roll in an advanced industry standard form-factor for system integrators. The module's embedded Z-Blade™ GNSS technology uses all available dual-frequency GNSS signals equally, without any constellation preference, to deliver fast and stable centimeter-accurate position and heading information. The MB-Two is an ideal solution for a wide variety of applications such as unmanned, agriculture, automotive, marine and military systems.

The MB-Two features an enhanced dual-core GNSS engine with 240 channels capable of tracking L1/L2 frequencies from the GPS, GLONASS, Galileo and BeiDou constellations. The GNSS engine supports Trimble RTX™ correction services, including CenterPoint® RTX and RangePoint® RTX, delivered worldwide via L-Band satellite. *www.trimble.com*

BAE developing new navigation system for submarines

BAE Systems is developing a new undersea navigation system for U.S. Navy submarines and unmanned underwater vessels. The project is part of a program called Positioning System for Deep Ocean Navigation, or POSYDON, and was commissioned by the U.S. Defense Advanced Research Projects Agency.

Current navigational methods that pose a detection risk for undersea vehicles forced to surface periodically to access the space-based GPS which cannot sufficiently penetrate seawater. Under the program, the company will create a positioning, navigation, and timing system -- as well as vessel vehicle instrumentation to capture and process acoustic signals -- that allows vessels to remain underwater when navigating by using multiple, integrated, long-range acoustic sources at fixed locations around the oceans. Working with BAE Systems will be the University of Washington, the Massachusetts Institute of Technology, and the University of Texas at Austin. *www.upi.com/*

IZT Expands its GNSS Support Cooperating with TeleOrbit

To expand its GNSS support, IZT GmbH announced the cooperation with TeleOrbit, the marketing & sales unit of TeleConsult Austria. As a result of this agreement the generation of GNSS signals provided by the GIPSIE® software from TeleOrbit will be integrated into the feature set of the

IZT S1000 signal generator. The S1000 signal generator with its broad frequency range and the Virtual Signal Generator (VSG) channels enables the similar generation of various GNSS standards in one device which can be combined with interferers or broadcast signals. In addition, it supports the combination with recorded signals. *https://teleorbit.eu/en/*

Geode™—A Rugged Sub-Meter GNSS Receiver

Juniper Systems' Geode is a real-time, sub-meter GNSS receiver. Its overall focus is the same: high-quality data collection in rugged environments. It is an all-in-one, sub-meter receiver that provides users with real-time, precision GNSS data at an affordable price. Designed with versatility, the Geode features one-button simplicity and can be used with any Juniper Systems rugged handhelds, and a wide range of Windows®, Windows Mobile, and Android® devices – particularly useful for bring-your-own-device workplaces.

Mayflower receives small GPS user equipment contract

Mayflower Communications Company, Inc., has been awarded a Phase III SGUE (small GPS user equipment) contract with the United States Air Force Research Laboratory (AFRL), sponsored by the Space and Missile Systems Center/GPS Directorate (SMC/GPSD), to develop a small SWaP (size, weight, and power) security certifiable Common GPS Module (CGM) for the Air Force's Modernized GPS User Equipment (MGUE) Program.

Mayflower's SGUE program is aimed at the development of advanced GPS receiver technology to support future military GPS requirements. The goal of the program is to develop a NAVWAR (Navigation Warfare)–compatible CGM form factor that will support SWaP-constrained military users.

CHC launches high-end GNSS receiver for science, surveying

CHC has launched its new N72 GNSS series, a high-end sensor designed for GNSS applications including offshore surveys and machine control, national geodetic networks, crustal deformation monitoring and bathymetry

The N72 GNSS series is designed to offer all necessary technical features, making it one of the most complete and reliable GNSS receivers for scientific and surveying industries professionals.

"To meet the market requirements from geodetic survey and demanding applications such as CORS, on-board machine control and disaster monitoring, CHC research and development has designed one of the most feature-rich GNSS receivers available on the market. The N72 GNSS went through extensive validation and stringent quality process to achieve high performance and reliability," said George Zhao, CEO of CHC.

Eos Positioning teams with SST Software for precision agriculture

SST Software and Eos Positioning Systems have announced a technology partnership to deliver in-field mobility solutions to precision agricultural service providers. The offering is now available to Sirrus for iPad users.

The new pairing allows agronomists and service providers to have reliable geospatial tools when and where they need it. Instead of relying on iOS location updates, Sirrus for iPad users can purchase one of Eos' Arrow series GNSS products to stay connected anytime, anywhere.

CMD gets nod to pair FreeFlight GNSS with TDR-94

CMD Flight Solutions has received an approved model list supplemental type certificate (AML STC) of its ADS-B OUT solution for Part 25 airplanes. The STC covers installation of FreeFlight's 1203C SBAS/GNSS GPS position sensor with Rockwell Collins TDR-94/94D transponders. According to FreeFlight, "The pairing is a cost-effective way to help aircraft owners meet the ADS-B mandate."

In addition to being used for ADS-B OUT compliance—due Jan. 1, 2020 in the U.S.—the 1203C, a 15-channel GPS sensor, is also an approved position source for NextGen applications such as CPDLC, TAWS/FMS, RNP and others. *www.ainonline.com*

Datalink Radio for GNSS Positioning by Harxon

Harxon Corporation has launched the HX-DU1603D, a high-speed, Bluetooth-enabled, wireless data link designed for GNSS/RTK surveying and precise positioning. It is a lightweight, ruggedized UHF receiver designed for digital radio communications between 410 and 470 MHz in the radio frequency spectrum using either 12.5- or 25-kilohertz channels. The HX-DU1603D has a 1.9-inch display screen with which to configure system parameters such as frequency, protocols, power display, serial port baud rate, and air baud rate.

Tallysman adds triple-band GNSS antennas + L-band

Tallysman has added two triple-band GNSS antennas to its multi-band antenna line.

The TW3970 is a pole mount, or through-hole mount antenna, which is also available in an embeddable form as the TW3965. Both employ Tallysman's Accutenna technology and are capable of receiving GPS L1/L2/L5, GLONASS G1/G2/G5, BeiDou B1/B2, Galileo E1/E5a+b plus L-band correction services (1164MHz to 1254MHz + 1525MHz to 1606MHz).

u-blox 8 Module

u-blox has released its 8 module series that addresses user needs for power-sensitive operation. A derivative of the u-blox 8 GPS/GLONASS receiver platform launched in January, the module is related to the u-blox M8 platform that targets applications where navigation performance and high accuracy are paramount.

Autonomous Vehicles of the Future: The Drive to Safety Critical Performance

NovAtel Inc. recently announced the company's ground breaking initiative to develop functionally safe GNSS positioning technology for fully autonomous applications. NovAtel is leveraging its extensive experience developing safety critical systems for the aviation industry to meet the future safety thresholds required for driverless cars and autonomous applications in agriculture, mining, and other government, military and commercial markets. In early 2015, NovAtel took an important step in meeting this goal by forming a specialized Safety Critical Systems Group comprised of highly skilled engineers with backgrounds in functional safety as well as all aspects of GNSS and Inertial Navigation Systems (INS) technology.

Following is an interview with Mr. Jonathan Auld, Director Safety Critical Systems at NovAtel briefly explaining about the companys initiatives in the autonomous applications space.

Please explain briefly about NovAtels initiative to develop functionally safe GNSS positioning technology for fully autonomous applications.

We've seen a trend amongst a number of our target markets over the last few years related to the need for both high precision and functionally safe GNSS. NovAtel is a global leader in providing high precision GNSS to markets such as Precision Agriculture, UAV/UGV, and Rail applications, to name a few. In all of these there is a growing need for, what is termed in the automotive industry, functional safety as they move to more autonomous operations. We have also seen the explosion in the efforts to develop the same autonomous capability for the automobile industry. At present the capability to deliver both high precision and functional safety doesn't exist in the market. The new initiative at NovAtel is to build a team of experts to tackle this challenge and transition NovAtel's core technology into a safety context. We see GNSS as the heart of many autonomous systems and this is a new capability we need to add to our portfolio to continue to lead in these market segments.

How do you foresee the growth of autonomous application?

NovAtel's involvement in autonomous applications from a GNSS perspective has been extensive over the last several years. We see more and more industries finding reasons to exploit autonomous operations and at the heart of many of these is a need to determine the absolute position, velocity and in some cases attitude of the platform. The growth of these applications is expected to be significant over the coming years in several market segments (agriculture, mining, UAV/UGV, Rail, as well as the automotive world) and we need to anticipate the future requirements. As more and more systems go autonomous the need for safety increases.

Please educate our readers about the 'Safety Critical Systems Group' at NovAtel.

The group was assembled initially in early 2015 as a project team to explore the opportunities and conduct business development and technical feasibility studies. In late 2016 the decision was made to form a separate cross functional team, containing Engineering, Product development, and Business Development staff, with the mandate to define the needs and begin development of a new platform to meet those needs. The team is made up of experts from all aspects of NovAtel's core engineering functions as well as members of that contributed to our Aerospace products in the past. These staff have experience with safety critical development already and their experience is key to helping the new team understand what needs to be done.

How is ISO/TS 16949 and ISO 26262 compliance going to benefit NovAtel product development?

ISO/TS16949 is a more rigorous quality management standard based on ISO9001. TS16949 builds in additional requirements for overall defect prevention, more sophisticated supply chain management, continuous improvement and a philosophy of reduction in waste throughout your corporate processes. These concepts are certainly not new to NovAtel as we have been on a successful Lean journey for a number of years already. In this case the TS16949 solidifies the requirements cross-functionally in the organization and aligns to what many automotive OEM's and Tier1 suppliers expect. We expect adopting this standard and getting certification will further increase NovAtel's already exceptional quality and reliability.

ISO26262 is the functional safety standard that supports the development of electronic subsystems for the automobile industry. This standard is "table steaks" for developing products where there is a safety of life aspect to the operation of the system. There are other standards in other industries (like DO-178 and DO-254 for aviation) which are similar in their overall structure of how to conduct product development to mitigate the potential for risk. ISO26262 puts in place the structured process and requirements in all stages of the development, production and service stages of a products life cycle to manage and mitigate risk. The goal being to provide a system that can operate safely and meet the performance expectations of the customer.

NovAtel expects these two standards to help increase our capabilities in all of our markets over the coming years.

Leica releases 'self-learning' GNSS receiver for survey

Leica Geosystems has announced the Leica Viva GS16 survey receiver, along with updated Leica Captivate and SmartWorx Viva software.

The GS16 is a "self-learning GNSS receiver," the company said, able to automatically select the optimal combination of GNSS signals and stay connected with or without reference links.

The addition of self-learning GNSS is accompanied by increased lock-on capability in the multi-station and various upgrades to the immersive Captivate software.

The new receiver is empowered by RTKplus to access all known and current signals, while intelligently distinguishing which ones are the optimal combination to lock onto for accurate positioning adapting to any environmental conditions. The GS16 also has capacity for future signals, such as the full deployment of BeiDou and the expected progress of Galileo and QZSS.

Teledyne Optech introduces low-cost, automated airborne surveying

Teledyne Optechs latest airborne systems is Optech Eclipse. As the world's first autonomous airborne collection system for active and passive data, the Eclipse is a great step forward for low-cost and flexible surveying. The system's highly simplified operation workflow and innovative sensor motion detection system let pilots manage surveys on their own, eliminating the need for an in-aircraft operator and drastically reducing survey costs. To minimize maintenance costs and down time, the Eclipse lidar system uses a rugged polygon scanner, and an integrated camera with a fully electronic shutter. Combined with a relatively low purchase price, these features make the Eclipse an affordable way for many groups to start collecting high-accuracy spatial data and camera imagery remotely for small-area and corridor surveys.

MARK YOUR CALENDAR

June 2016

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

July 2016

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

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

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

September 2016

The Commercial UAV Show Asia
1-2 September
Singapore
www.terrapinn.com/exhibition/commercial-uav-asia/index.stm

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

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

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

October 2016

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

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

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

3rd Commercial UAV Show
19-20 October
ExCel, London, UK
http://www.terrapinn.com/exhibition/the-commercial-uav-show/

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

November 2016

ICG-11: International Committee on GNSS
6 - 11 November
Sochi, Russia
http://www.unoosa.org/oosa/en/ourwork/icg/icg.html

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

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

36th INCA International Congress
9 -11 November
Santiniketan, West Bengal, India
http://incaindia.org

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

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

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

December 2016

ISGNSS 2016
5 - 7 Dec
Tainan, Taiwan
http://isgnss2016.ncku.edu.tw/

United Nations/Nepal Workshop on the Applications of Global Navigation Satellite Systems
5 - 9 December
Kathmandu, Nepal
http://www.unoosa.org/pdf/icg/2016/nepal-workshop/InfoNote.pdf

IGNSS 2016
6 - 8 December
UNSW Australia
ignss2016.unsw.edu.au

Navitec 2016
14 - 16 December
Noordwijk, Netherlands
http://navitec.esa.int

V60

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