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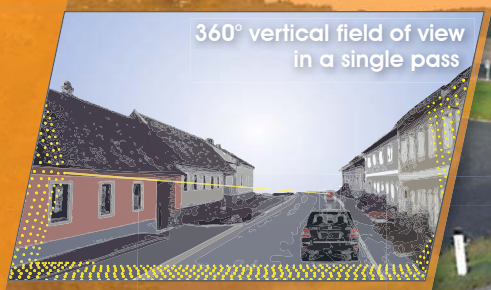

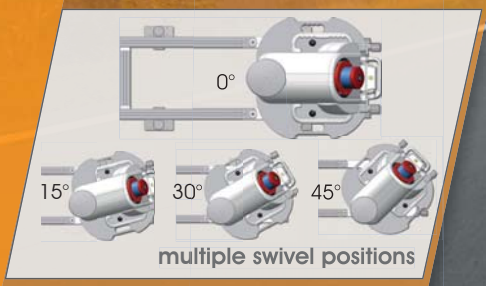

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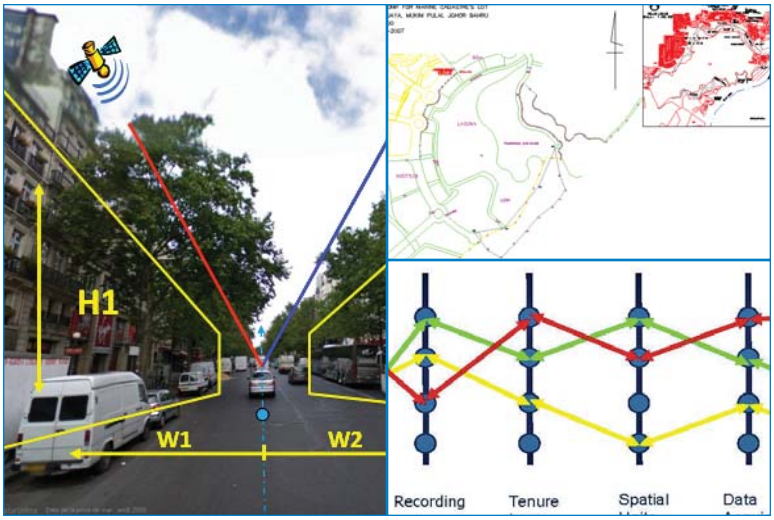

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The profession of surveying is fundamental, important and essential.

However, the temperament of professionals is changing.

The technology ecosystem is evolving fast

With the increasing space for LIDAR, UAVS, GIS, LBS, navigation, …

This opens up new opportunities on one hand,

On the other, it reduces 'entry barriers'

For the 'non-surveyors' in the domain.

There is an increasing demand,

Especially in construction engineering industry,

And there is less interest among youngsters

To join the profession,

Given the temptations for other domains.

Is the shine waning?

Experts differ.

Bal Krishna, Editor
bal@mycoordinates.org


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NavCom products perform equally well when compared to top-tier receivers, but at a much more competitive price point

Says Steve Ault,* Product *Manager, NavCom Technology, Inc., in an interview with Coordinates

What are the features of NavCom's StarFire™ Network?

In the broadest sense, we have two types of users of StarFire™ signals: those who take full advantage of all the NavCom developed navigation feature sets, and those who develop their own navigation feature sets and take advantage of the highly accurate, global availability, and inherently redundant reference and delivery system. The latter group of customers tend to be integrators or government contractors, though that is not entirely the case as we have commercial accounts as well. For those in the first group, NavCom's continuous development in this space has brought improvements in accuracy, convergence time, augmentation to RTK with RTK-Extend (RTK-X) to aid in temporary loss of RTK signaling, Quick Start which virtually eliminates convergence time, and Rapid Recovery which significantly improves performance after navigation signal loss. The fact that we own and operate all of the reference sites, hub equipment, and satellite modulators, allows us to easily modernize the system with thoughtful and purposeful consideration. We can look at our down-stream technology plans and build the network to accommodate those in time of need without reliance on other companies to complete and deploy current or newer technologies. The infrastructure and supporting software is complex, state-of-the-art, and continues to deliver new capabilities.

How does the LAND-PAK system offer the best of both the worlds, i.e., RTK and StarFire™ capabilities?

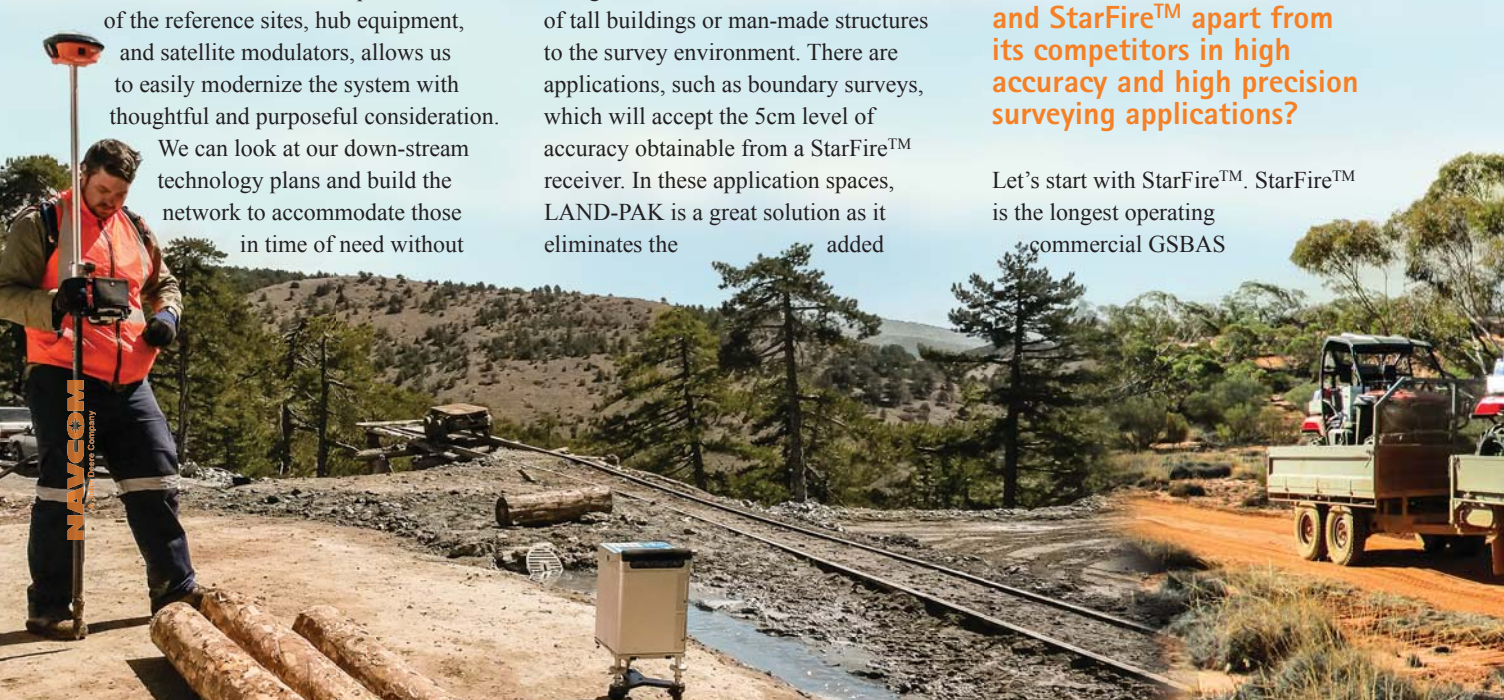
LAND-PAK is marketed as an RTK survey turn-key solution. All surveyors know that there are inherent challenges maintaining an RTK fix, particularly over long baselines. When StarFire™ signals are applied to the survey environment, RTK service gaps can be extended for a workable time to get those last few data points before needing to relocate the base receiver. This improves productivity by extending the fringe areas of the RTK communications link which might be radio signal obstructed due to a small change in the terrain, the introduction of tall buildings or man-made structures to the survey environment. There are applications, such as boundary surveys, which will accept the 5cm level of accuracy obtainable from a StarFire™ receiver. In these application spaces, LAND-PAK is a great solution as it eliminates the added infrastructure needs of a traditional RTK base and rover setup; the communication is automatic, passive, and only requires the rover GNSS receiver and data collector.

What makes LAND-PAK a complete turn-key land survey solution?

Our tightly coupled relationships with the makers of FieldGenius and SurvCE data collection software ensure end-users can take full advantage of the high-performing SF-3040 GNSS receiver. The developers of these programs perform their own acceptance testing before handing the software off to NavCom, where we perform our own extended set of testing. It doesn't stop there… adding desktop CAD software to manage their collected data provides end-users a great package to conduct land surveys.

What sets LAND-PAK and StarFire™ apart from its competitors in high accuracy and high precision surveying applications?

Let's start with StarFire™. StarFire™ is the longest operating commercial GSBAS



available with demonstrated exceptional reliability and performance. This level of performance and continuous improvement is demanded by our adjacent markets and it has its appropriate place in the survey market as well. Where adjacent markets pay a premium for this added capability, it is included in LAND-PAK with no recurring fees. This has proven to be a key market differentiator in lesser developed countries which will accept near-RTK level performance for their survey needs. Customers in developed countries take advantage of the RTK extended features which rely on StarFire as the underlying technology that bridges the gap between continuing work in fringe areas of radio coverage and not being able to work until the base station is moved. Developed countries also have the advantage of using industry standard correctional sources delivered over cell modem (such as NTrip), thereby significantly reducing their infrastructure and operational costs. LAND-PAK is available in a variety of configurations to best meet the end user's needs and budget. NavCom products perform equally well with top-tier competitive receivers as a result of the performance demands in our adjacent markets, but at a much more competitive price point as compared to those top-tier manufacturers.

"Despite the tough, remote conditions we work in, the NavCom receivers have found to be rugged, reliable and dependable"

Atlas Geophysics is a specialist company that carries out high precision, high accuracy gravity, magnetic and seismic surveys in Australia and abroad. Our core work mainly comes from gravity and geodetic survey. Gravity surveys are used with great success to determine subsurface density contrasts and are used widely for mineral and petroleum exploration where direct ore body targeting is required. They are also useful for broader spaced regional geological mapping and often complement other techniques such as magnetic and electromagnetic surveys. On a micro-scale, gravity surveys can also detect small caves, karst structures and even old grave sites.

The gravity field is very sensitive to changes in elevation and in fact changes in elevation can swamp the density effect of rocks and ore-bodies below the observation point, so it is imperative that the position and elevation of the observation point be known accurately so that a necessary correction can be made. Elevations to better than 5cm are generally required and to achieve this, Atlas Geophysics deploys receivers from the NavCom family such as the SF-3040 and SF-3050.

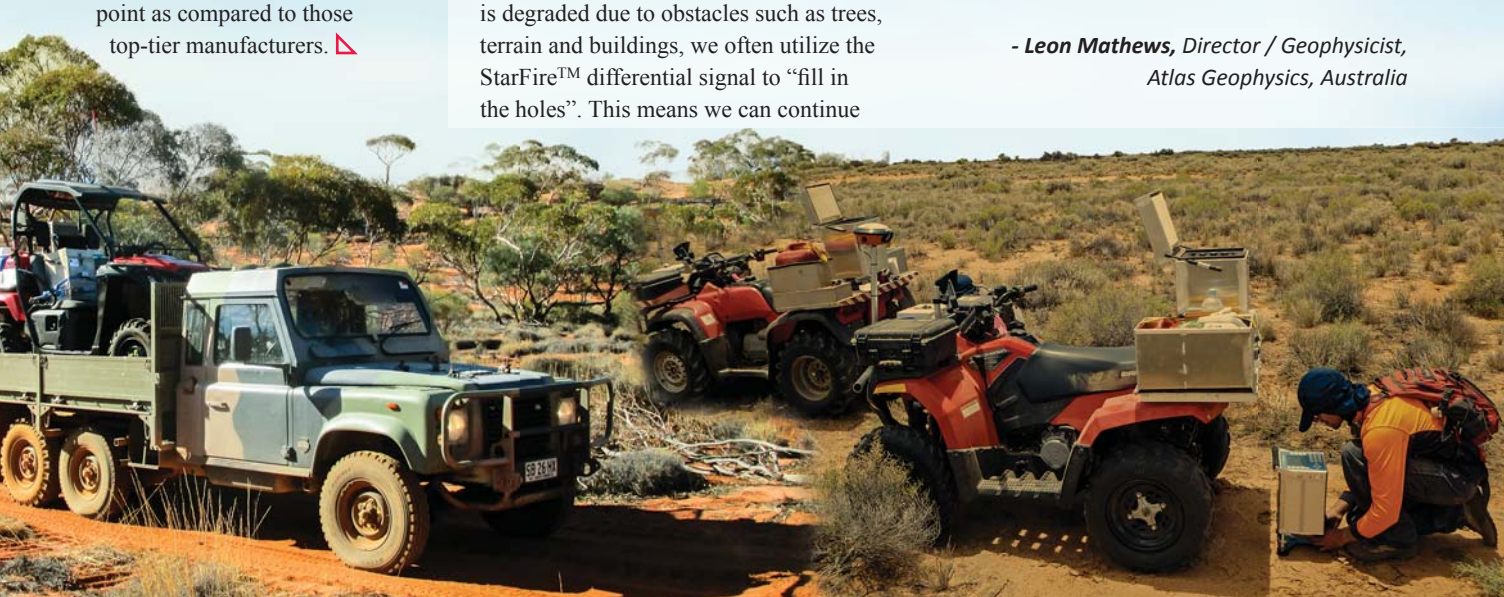
For detailed surveys that need to be walked on foot, we utilize the SF 3040 LAND-PAK receiver as this a great, lightweight all on the pole solution where reliable RTK can be achieved over distances exceeding 30km. Where our high powered UHF link is degraded due to obstacles such as trees, terrain and buildings, we often utilize the StarFire™ differential signal to "fill in the holes". This means we can continue working without having to move our base station or setup radio repeaters, resulting in very little downtime. The great thing about StarFire™ is that we still get high accuracy!

Where stations are spaced too far apart to walk, we generally employ helicopters and custom UTV survey vehicles to carry out acquisition. Radio range is also a factor on these projects, so typically Post Processed Kinematic data are recorded using SF 3050 receivers. We have tried and tested receivers from many stables and have found the SF 3050's performance under helicopter blades to be unmatched. Even at long baselines, we consistently see little to no loss of lock under the blades and can easily return accuracies of 2-3cm using post processing.

Despite the tough, remote conditions we work in, the NavCom receivers have found to be rugged, reliable and dependable. Being thousands of kilometres away from anywhere means we need things to work well, without malfunction and we have found NavCom to deliver.

The equipment is a critical factor but also the expert support we receive from the factory trained reseller allows us to go anywhere in the world with confidence. There are other good systems in the market, but the value and unique features of the NavCom offering is extremely compelling for any survey type business.

***- Leon Mathews,** Director / Geophysicist, Atlas Geophysics, Australia*



StarFire™ provides great savings for remote regional surveys

Says Peter Terrett, Owner RapidMap Global, in an interview with Coordinates

How does NavCom offer solutions for unique customer applications like mining?

The NavCom GNSS receivers provide unique advantages over normal RTK GNSS equipment. The integration of RTK with NavCom's StarFire™ service enables the user to continue to work at RTK accuracies for up to 15 minutes where RTK correction signals can be easily lost. RTK-Extend means you can concentrate on your project and not on your equipment.

By removing dependency on base stations, how does StarFire™ benefit its customers, especially in the field of very remote area gravity and geodetic surveys?

In Australia, 5 cm does not constitute good geodetic accuracy so StarFire™ does not generally apply for geodetic surveys. In regards to gravity surveys it provides great savings for remote regional surveys. In remote areas it can take a couple of hours to travel a couple of kilometers. So setting up a base station, then travelling from and back to it can be time consuming. This is made worse when there may be issues with wildlife, radio propagation, batteries or other factors affecting the performance of the base station. With StarFire™ fully converged, you can simply travel to the points of interest and take your readings. Of interest, we have found that the NavCom will work under a helicopter rotor whereas some other manufacturers simply will not.

"Users have been able to readily and easily complete useful surveys using StarFire"

Sibelco purchased a LAND-PAK package from Peter Terrett at 4Dglobal (RapidMap Group) in July 2012. This package was split-up for two very different uses. One SF-3040 head-unit was mounted on a dredge at a sand-mining site in Victoria and the other SF3040 head unit plus pole and data-collector have been used as a travelling DGPS (StarFire™ corrected) rover for informal survey, mapping and set-out at sites around the country. Both units have performed reliably and demonstrated sub-decimetre accuracy and repeatability.

The DGPS (StarFire™) rover has proven to be relatively easy to use. Users ranging from surveyors to non-technical personnel have been able to readily complete useful surveys. Tasks completed with this unit include topographic surveys, geological mapping, grade control set-out/pick-up, exploration/resource drilling set-out, blast pattern set-out and pick-up and set-out/validation of earthworks and pit designs.

The dredge-mounted unit has been in service almost continually for three years. It is mounted to a mast and powered from a UPS based on a deep-cycle marine battery. This allows the unit to continuously stay in high-precision StarFire™ mode. NMEA data is sent over a custom-built COM cable to real-time navigation and mapping software which assists the operators in mining to plan. The dredge software also logs cutter position and averaged water-level (tide) derived from the NavCom GPS. This logged data (approximately 13.5 million points to date) is used to monitor dredge position, record changing pond levels and model the as-mined underwater surface.

***- Geoff Tonkin,** Sibelco, Australia*

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Surveying as a profession: Is the shine waning?

Experts share views on issues and prospects of surveying profession

Profession is not popular amongst school leavers

John Trinder
Emeritus Professor, School of Civil and Environmental Engineering, The University of NSW, Australia

The 1960s to early 1970s were boom times for enrolments in surveying and geomatics programs in the state of NSW in Australia and I suspect other states as well. At the University of NSW (UNSW) at that time there were up to 100 students per year entering the program. The large enrolments unfortunately led to some graduates in the 1970s having problems obtaining a permanent job and some graduates never entered the profession, but obtained jobs in other areas. The official statements about job opportunities for surveying graduates for the next 15 years or so were that there was an over-supply of graduates, thus turning prospective students away from studying surveying at tertiary institutions. This image of over-supply took some time to overcome, but by the late 1980s, enrolments had recovered to a reasonable level. However from then on, there has been a reduction in enrolments that has been difficult to overcome, leading to a shortage of graduates in a number of states in Australia. Indeed, a 2013 study by consulting company BIS Shrapnel entitled 'Determining the Future Demand, Supply and Skills Gap for Surveying and Geospatial Professionals' commissioned by Consulting Surveyors National painted a bleak future for the supply of surveying and geospatial professionals with the impact that $30.4 billion in construction work and 14,570 private house commencements will be put at risk from surveyor skills shortages. This shortage has not been reduced and the prospects are for a continued shortage of graduates for the next decade. This has led to surveying companies recruiting professionals from New Zealand and other countries under special visa arrangements introduced by the Australian government to allow skilled migrants to enter Australia.

In Australia, the shine probably went off the profession of surveying and geomatics in the 1970s and it has been difficult to attract students into education programs since then

In 2009 I wrote in an article in GIM magazine stating that the total number of new students entering the eight geomatics programs each year in Australia is fairly consistent at between 250-300, while typical output is around 200. The optimum number of graduates required to satisfy local demand is difficult to estimate since it depends on such factors as growth in the economy and current age profile of the profession, but it clearly would be significantly larger than the present number. The number of graduates entering the profession should preferably be approaching twice the current number, at least until the shortage of professionals has been alleviated.

Recent newspapers articles have highlighted the good job prospects for graduates in surveying and geomatics professions, but it seems that in today's employment conditions the profession is not well known or popular amongst school leavers. Therefore the professional bodies in Australia, including the Surveying and Spatial Sciences Institute (SSSI) have developed strong marketing programs to encourage school leavers to enter the profession. Their programs have had a positive effect on the number of school leavers entering the profession in some states. However, it takes time for the shortage to be overcome because of the time required for education and training. The majority of graduates can find a job almost immediately, enjoy their professional life and find their occupation rewarding.

To summarise, in Australia, the shine probably went off the profession of surveying and geomatics in the 1970s and it has been difficult to attract students into education programs since then. There is a need for more graduates in most states of Australia, but surveying and geomatics programs at education institutions are competing with many programs that seem more attractive, certainly as far as income on graduation is concerned. Marketing the courses and the profession is essential to attract more students. This is a task for all sectors of the profession and has to involve significant investment of funds and time from current surveying and spatial professionals.

Young generation still possesses the enthusiasm and keen interest in surveying

Virgo Eresta Jaya
President, Ikatan Surveyor Indonesia (ISI), Indonesia

A higher education in Indonesia for surveying was commenced 65 years ago in 1950. Initially, the academic education was intended to create surveyors to work in army, cadastre and construction industry mainly. In 1960s, the Government of Indonesia established two agencies dealing with agrarian affairs and mapping respectively. It marked the boom of surveying industry, and further built with the rise of oil industry. As the number of mapping projects developed by the government increases in 1970-1990, surveying companies began to flourish.

However, despite of the glory of the industry, the regeneration seemed to have been overlooked. Until now, the majority of surveying company owners are from 70's generation. Only a few are from the 80's, and even less for the 90's.

The young surveyors are forced to enter another niche market that is being abandoned by the seniors, one of them being the GIS industry. As a computer literate generation, young surveyors gained competitive advantage to dominate this field. Moreover, this stream of fresh blood began to specialize in the new technology LIDAR while the established surveyors adhered to traditional photogrametric and terrestrial fields. The youngsters wanting a faster track to earn money usually work for marine and offshore surveying industries. This surveying is mostly to support the oil and gas exploration. They either work for the foreign companies in Indonesia or work overseas.

It all shows that the young generation still possesses the enthusiasm and keen interest in surveying. However, instead of fiercely competing with the seniors in the same specialization, they create their own field. There is no denying that such disparities exist, nor a smooth hand over between generations. Similar phenomenon can be observed in the Surveying Professional Association. First established by a group of enthusiast, aspiring young surveyors in 1972, the association had witnessed the fading new blood, with the last five 3-years terms of presidency held by surveyors of the late 60's and early 70's. Nonetheless, measures are yet to be taken to bridge the gap between the two sides. This remains the concern of the Association.

Recently In May 2015, the Association invited all of the Geodesy- Geomatics student unions from the 11 universities in Indonesia. It was discovered that the students were apprehensive about the future, but highly enthusiastic about the possibility of expanding horizons in the field.

With an extensive network among local universities' unions, these students successfully held a national forum of 65th years Geodesy higher education recently and publish a student-run magazine on a regular basis.

These students are indeed resourceful, although uninformed by understanding, training, or knowledge of the industry, once again proving the fact that there is no existing channel of communication between the student and the surveying industry.

Following this meeting, Indonesian Surveyors Association established the Young Surveyors Compartment which consists of surveyors under 35 years of age and the students. The compartment serves as a medium for students and young surveyors to exercise their network skill and to diminish the barrier among the stakeholders in the organization.

Other initiatives currently undertaken by the association include the provision of more accessible surveying certification. The certification preparation and registration process is now done in each Campus prior to graduation. The objective is to allow an easy, almost automatic access for all graduates to enter the industry. The first batch will commence in coming September graduation in Institut Teknologi Sepuluh November Surabaya.

Once the graduates hold the certification, the participants are subject to an effective oversight by the Association for the first two years while completing their internship and CPD programs. The association will connect them to the survey related companies which allow them to embark upon a career in surveying. The arrangement creates a mutually beneficial relationship between the individuals and the industry. The student experiences a real work environment whilst giving the company opportunities for regeneration and unveiling the big potential in young surveyors.

The CPD was initiated by the association last year. It runs monthly event on introduction of new technology and provides sharing of the successful project of the members. Covering on news regarding the current needs and trends in the industry, the members including young surveyors are ensured to stay on track.

Another factor that influence enthusiasm is also work opportunities. Despite of the current downfall of oil industry, only 20% of total parcels are completed in cadastre. Whereas for topographic mapping, base map of 1:25.000 scale are only provided in Java, Nusa Tenggara, Sulawesi and few other areas. The BIM are not being applied in building construction. Manufacture and other services barely utilizes GIS/GPS for efficient distribution. This is where opportunity arises, young surveyors are expected to complete the spatial data and boost the operating efficiency of other industries.

This generation of young surveyors are energetic, promising and leading a new era of innovation. While young surveyors hold the future of the surveying industry, the responsibility lies on the Association to unleash their full potential.

This is an exciting profession

Eva-Maria Unger
Chair, International Federation of Surveyors Young Surveyors Network (FIG YSN)

No the shine is not waning - it's right there and shining bright. Seriously could somebody ask for a more exciting profession! There are Young Surveyors climbing the highest mountains, diving into the deep sea, flying up into space, establishing their own company, scanning unknown caves and all that is a part of our profession - surveying. The enthusiasm about it is unbroken especially in times like these when the global agenda is referring to us as key players to create a better world for all. It is our profession, which serve towards the betterment of society, environment and economy, as stated in the Sustainable Development goals, and needs to attend the emerging issues and trends. We are the Surveyors of Tomorrow and it is **us** who gonna make a difference in the world! With an estimated 70% of undocumented land worldwide, increasing effects of climate change, increasing population growth and increasing conflicts over the limited resource of land we are facing several challenges - but, and this is the exciting part of it, we have the tools, we have the technology and we have the knowledge.

We were growing up in the era of digital developments which leads to changes in the methods of data acquisition and processing. The growing use of UAVs, affordable and manageable use of laser scanning, the improvements and global all time availability of GNSS, satellite and aerial imagery for spatial units identification and the increasing accuracy in a second step, data collection gets faster, cheaper and more easy applicable. Important developments such as crowdsourced data and its use in platforms as e.g. GoogleMaps, OpenStreetMap, MissingMaps as well as 3D representations in maps and cadaster are key in being addressed by us. Being open minded, revolutionary, innovative and strong believers in do-acracy is one way to describe the surveyor of tomorrow. As restless wanderer we are keeping an eye on other domains which gives us the flexibility to adjust to current developments. Bitcoins/Blockchain is just one example where the Young Surveyors Network was on the forefront in linking it with land administration and there will be more new things coming - for sure.

I am convinced that Young Surveyors who are passionate and excited are the best advocates for promoting our profession. From my experience as a chair of the International Federation of Surveyors Young Surveyors Network (FIG YSN) I can say that there is an overwhelming enthusiasm within our worldwide Network. We are now reaching out to more than 9000 active Young Surveyors and the number is increasing each day. The way we are communicating changed a lot and now being reachable all over the world 24hours changed also the time we are informed about each other. Therefor we can reach out to so many in such a short time in promoting and sharing our success stories. During recent events an increase of the number of surveying students has been reported but of course this increase varies a lot within the regions but that shows that the enthusiasm is there - so generally speaking we are on the right track. The Young Surveyors Network started back in 2006 and probably this is already an effect but this is not proved - yet. Nevertheless supporting and getting engaged with the young ones definitely pays off in many different ways. So summing up the shine is not waning at all - I am sure that there will be more young professionals joining if we are keeping up our good work and show the relevance of our profession in the world we want.

There has never been a better time to enter the surveying profession

Rory M Stanbridge MRICS, FCInstCES, FRSPSoc
Secretary General – The Survey Association, UK

I have been asked to write an article on this topic at a time when I personally believe that the surveying profession offers more excitement and variety than at any other time in my experience.

To put that into perspective, I have been involved in the survey industry now for just over fifty years. I ran a photogrammetric survey company for more than thirty years and for the last nine years have been employed as Secretary General of The Survey Association in the UK. TSA as it is better known is the trade body representing the survey profession in the UK with over 160 member companies in membership. I am therefore, I believe, ideally placed to offer an opinion on the current status.

The importance of surveying in the construction industry should never be underestimated or undersold. No major construction project can commence at the design or build stage without a survey being undertaken so members of the profession can rightly claim to be at the start of almost all that mankind builds. That alone makes it a fascinating choice of career.

Since I joined the profession, technology has moved on at a sometimes alarming pace and the sectors in which surveying is now adopted has also developed. Who would have imagined in the 1960's that surveying or the data collected from it would be used on film sets. Laser Scanning data was used on the last two Bond films and is now becoming an accepted method of producing models for film sets. The recent developments in SUAs or UAVs, whichever is your personal choice of

The importance of surveying in the construction industry should never be underestimated or undersold. No major construction project can commence at the design or build stage without a survey being undertaken so members of the profession can rightly claim to be at the start of almost all that mankind builds

acronym, has brought aerial photography into the public perception. Personally, I hate the term DRONE which I feel is really a tool of war and surveillance.

Google Earth and various street mappers have introduced the public to a whole new area of survey data collection without even realising it. So, with all this wonderful technology and market penetration, does the industry have any problems at all? The answer to this is a resounding YES, but it is not one of a star waning, more a problem of introducing people to the technology and encouraging young people, in particular, to enter the profession.

The recession in 2009 hit the members of The Survey Association (TSA) very hard and a serious number of redundancies were imposed. Many of the people that were both well trained and versed in surveying that were made redundant subsequently left the industry and have never returned. The UK industry has now returned to pre-recession levels and despite major advances in technology, many requiring less manpower than previously, there is still a serious shortage of both qualified and trainee surveyors.

TSA has over the last few years introduced a number of initiatives to address this lack of surveyors. The first of these was to develop a website aimed primarily at schoolchildren and people looking for a change of career. The Become A Surveyor website was launched a number of years ago and was completely revamped in 2014. It can be found at: www.becomeasurveyor.com Visitors to the site can view and understand what the day to day life and work of a surveyor entails and can also see and be guided through the various routes into the profession. To date, the main views have been from people that wish to change their careers but we do need to push the schools to look at it much closer.

With all this amazing technology and the excitement of potential travel whilst being at the start of something major, I firmly believe that there has never been a better time to enter the surveying profession. If I had my chance again, I would most certainly follow the same career path that I chose all those years ago.

People join our profession because it satisfies them intellectually

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Is the shine waning on the surveying profession? A simple and interesting question but one for which there is no easy answer. I'm not an academic, so I've no contact with young people joining the profession, or no knowledge of what motivates them, or what expectations they might have. I'm not sure if most young people starting out on a course of study have a clear picture of the career path they ultimately wish to follow, or even if they do, that they could coherently express it in words. It is said that in our current world we are likely to change career three times in the course of a lifetime and this rate of change may accelerate in the future. Taking up surveying as a lifelong profession in the way that we know it now, may be a thing of the past. Equally in the professional body of which I'm a member, there is hardly anyone in the geomatics area under 30 years of age and the great majority of members are in their fifties and sixties. When you ask if the shine is waning, this presupposes that there was a shine at some stage. Was there a golden age of surveying? I'm not sure that there ever was. Surveyors, and particularly geomatics surveyors take up the profession because they are fascinated by surveying and perhaps a little bit obsessed by the subject. In many fashionable or high-earning professions, students are often attracted because there is the possibility of very high earnings providing a comfortable lifestyle or the professional activity has high social status, allowing its practitioners to cut a dash in society. It's not unknown for people who have no real interest in the law, medicine or accountancy, for instance, to take up study of these subjects in the expectation of high earning despite their lack of interest or intellectual suitability. This rarely happens in surveying. I know very few, if any, wealthy surveyors. People join our profession because it's what drives them and satisfies them intellectually, not because of the financial rewards.

In part the profession has deskilled, with new press-button technologies allowing untrained, non-surveyors to carry out the mechanics of the surveying process, sometimes with poor outcomes, because of lack of understanding of the theoretical science that lies behind what the machines do and what their limitations are. On the other hand, there is perhaps an increasing understanding that a surveyor's worth lies not in operating technology, i.e. acting as a technician, but in the depth of judgement, experience and professional skills which he can bring to the task.

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In certain European countries the surveyor is a liberal professional who operates in the area of property registration, in a quasi-judicial role, with responsibilities both towards his client and towards the state. As long as the legislative base on which this process in founded, remains in place the status and income of the surveyor operating in this area is guaranteed. In the area of construction and civil engineering, the surveyor, in many cases, operates in the role of a sub-contractor, rather than a professional member of the design team. There are indications that this perspective is beginning to change and the professional institutions are working hard to persuade the construction world of the benefits of utilising the professional skills of the surveyor as an integrated part of the design process from the beginning, rather than sub-contracting specified services at a more advanced part of this process.

In the brave now world of the internet mapping, LIDAR, UAVs, BIM, GIS, location services, navigation systems, etc. the surveyor must fight his corner based on his expertise and skills. Surveyors have no accepted or tradition rights in these areas. Certainly not in the way that there is a perceived domain of professional expertise reserved for them in property and construction. There are demands and needs for the surveyor's unique skills in all of these emerging and developing areas, but there are a whole range of other professionals, non-professionals, entrepreneurs and sometimes downright charlatans out there hustling for position and searching out niche markets. Surveyors, if they want to become active in these new areas must fight their corner in the open market and in many cases they may be hampered by their own strict codes of professional behaviour and ethics, given that the competing non-professionals will happily cut corners and produce slipshod work, with the market being the only mechanism for sifting out the good from the bad.

The future is neither dark nor bright. It is what we make of it. Surveyors have a unique and valuable set of skills coupled with a powerful ethical and professional outlook. They must go out there and sell themselves to the mutual benefit of the surveying profession and the world at large.

We have to gear ourselves for the 'new frontiers' that will continue to unfold

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40 years ago, the programmable calculator was a great technological leap forward for land surveyors. Since then, computers and electronic surveying instruments have replaced the theodolite, the chain and the drawing board. Today, rapid data acquisition and analysis are reshaping the professional practices.

With technological advances, we measure faster and more accurately. We process the data and produce the final results in very much shorter time. In some areas, we even have the results in near real time, and with acquired field data being transmitted wirelessly and directly to servers in the office. The productivity improvement also led to fewer manpower requirement; i.e. we actually need less surveyors than before, particularly for traditional area of practices.

Another downside of technological advances is the simplification of works that led to lower dependence on land surveyors. Contractors may execute simple setting out themselves and leaving only the more complex or salient tasks to the land surveyors.

Essentially, the market forces determine the demand and supply of land surveyors. Unfortunately, the professional fees had not increased proportionately with the productivity gains. However it does mean the profession is on the decline.

New opportunities are opening up for land surveyors in emerging areas such as GIS, remote imaging and sensing, development of land administration systems, earth science researches, etc. I once asked a survey-trained director of a centre for remote imaging and sensing why there he has no surveyors among his 40 professional staff. He wished he had but he was not able to find any suitable candidates. Surveyors do have a role to play in emerging fields, and unless we grasp these opportunities, they will become domains of other professions.

Land surveyors are trained in a spectrum of geospatial sciences. In fact the combination of these training with quasi-related subjects put us in an advantageous position for certain new opportunities from new frontiers. These new frontiers not the uncharted jungles and seas but the new arena created by the advances and convergence of technologies. If these opportunities slip us by, we have only ourselves to blame.

We chronically lament about our professional status, or rather the lack of it. The public perception of our profession is very much our own doing. To change that, we have to relook at the surveyor's role in the society because the values we give will determine our worth.

Traditional fields of surveying are not shrinking - just that technology advancement has led to the need for fewer but better trained surveyors. On the other hand, new 'frontiers' where we can be involved in are continually emerging. So there is a shift in paradigm. We need to break out of our cocoons to cover the new grounds. Rather than leaving it to the younger surveyors to find their footing in these new 'frontiers', the experienced ones should pave the way and evolve the roles for surveyors. We should be creating careers for the 21st century surveyors.

Common attributes of a 21st century surveyor are technology savvy, trained in a broader scope of survey sciences, at ease with hi-tech instruments and being well versed in Information technology. A more significant change is that many will be working in offices rather than in the field. Apart from new office-based roles for surveyors, conventional field measurements are increasingly being automated and require less surveyor's physical presence in the field.

The traditional perception of a surveyor is one in the field with an instrument under the hot sun and dressed in sweat-drenched clothes. This does not conjure the right image as surveyors are now spread over in a wide spectrum of roles; i.e. if we do not want to live in the past. We need to update both our mind-set and the projected image of our profession.

The shine in our profession is certainly not waning. In traditional fields we need less surveyors as we became more productive – a victim of our own success! Technology has not replaced the surveyor but will require additional training in new skills. We have to evolve our mode of operation to keep with the times and remain relevant to society. And more importantly, we have to gear ourselves for the 'new frontiers' that will continue to unfold.

In traditional fields we need less surveyors as we became more productive – a victim of our own success! Technology has not replaced the surveyor but will require additional training in new skills. We have to evolve our mode of operation to keep with the times and remain relevant to society

The future of maritime surveying

Capt Bertrand Apperry
President, International Institute of Marine Surveying (IIMS)

The growth of marine surveying business is always linked to the growth of transport by sea when claims and damages were the main operations of a marine surveyor keeping him in business. Today, new skills have become necessary for the operators of the biggest means of transport in this world.

Safety of marine transport

The frequency of maritime accidents is decreasing today compared to the growth of maritime transport itself. This proves that our actions are particularly efficient since the last 20 years.

This industry has made a lot of progress thanks to stricter rules and regulations not only for construction of ships but mainly for the management of human resources which are, as everybody knows, at the origin of more than 80% of accidents. But all improvement introduced by IMO were invariably after the accidents took place. Today, step by step, the result of feedback analysis is no longer considered as the devil's invention towards shipowners!

We have made a lot of progress in the prevention of human errors via training and the implementation of management systems. The question is - will these new concepts reduce the workload of marine surveyors?

At the International Institute of Marine Surveying, we have been thinking about this question for quite some time now and more importantly, how are we going to survive in this industry with decreasing number of accident claims?

New opportunities for marine surveyors

No panic, we will continue to survey damages and claims even if they are decreasing dramatically. However, the sectors of safety and security management in the shipping companies and on board ships is going to require more of specialised new surveyors in a sector where the good specialists are few and far between!

I started out early in France in with the specific job profile as an ISM surveyor and consultant. I must say, I was very much on my own! And with the introduction of the ISM code and particularly due to my need for perfection, I always apply the standard guideline in my job as passenger ship's master.

When you have an income revenue that enables you to live reasonably well, it is easier to start a completely new job without any reference apart from a personal desire to improve.

The only competitors were the classification societies who are always attracted by a new money making sector, but also interested in replacing the decreasing flag inspections sector in their role as a certification body. However, if you are involved in that job, you cannot manage the company at the same time: judge and jury simultaneously! All the big classification societies have done this, forcing even the IMO to voice their concerns. And their answer was incredible - 'the job is carried out by sister companies or even by different inspectors' - can you believe it!

> We have made a lot of progress in the prevention of human errors via training and the implementation of management systems

Finally, even if the classification societies are doing more and more work of the flag administrations, we still have our place in the sector of preparation for certification. We are still in the market.

Look at what the ISPS code has provoked - specialists coming from different armies have invaded the sector, but 10 years later, we are still in operation and moreover, we are working together! In fact, many governments have demanded at least one merchant marine officer in the RSO teams in charge of security assessment and plans for ships and ports!

Conclusion

At present, surveyors and IIMS are thinking about new opportunities such as:

ISM consultant and internal auditor (companies and ships); ISPS consultant and internal auditor (ships, port facilities and ports), and of course, the corresponding training including those already included in STCW.

With officers being involved with the ISM code for more than 20 years and with the ISPS code for more than 10 years, we can propose safety and security management systems for ships and companies which are individually tailored for them without falling into the trap of ready-made systems on the shelf like ISO for example!

In addition, recently the sector of ships under 500 GT and/or ships carrying not more than 12 passengers nor requiring ISM certification, are looking for modern management systems without certification, but only for the dip in their accident rate index! This is fantastic as the ISM code has been created for just this purpose!

So, to conclude, the marine surveying industry will keep its head up by consultancy and training and with the recent birth of e-learning, authorized by STCW 2010 and where we have already great skills at IIMS.

3D-city-model-aided GNSS accurate positioning with integrity provision

Recent research investigations carried out in the GEOLOC laboratory of the Ifsttar (the French institute of science and Technology for transport, development and network) with the SCM (Société de Calcul Mathématique) have shown that a simplified 3D modelling of buildings at both sides of streets, named "urban trench" for that reason, can benefit in the process of satellite visibility check and GNSS positioning

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GNSS positioning in the urban environment remains challenging, because of the occurrence of many satellite signal reflection and diffraction, also called multipath, that, in the best case, combine with the direct signal, but – in the worst case when the direct signal is obscured – make signal tracking drift unboundedly.

Recent research investigations carried out in the GEOLOC laboratory of the Ifsttar (the French institute of science and Technology for transport, development and network) with the SCM (Société de Calcul Mathématique) have shown that a simplified 3D modelling of buildings at both sides of streets, named "urban trench" for that reason, can benefit in the process of satellite visibility check and GNSS positioning.

These urban trenches can be computed from 3D-city-model using road and buildings layers. Initially, the rover is assumed to occupy the arc segment that represents the street. That way, only left and right distance and height attributes depict any urban trench section, which has the advantage of being easily compliant with the existing formats of navigable maps.

Using the satellite positions in azimuth and elevation, our algorithm determinates whether their signal is in Line-Of-Sight or Not (NLOS), with respect to the modelled facades all around. In case of NLOS, a correction of the pseudo-range measurement is made.

The geometry of this model being simplified, and the initial position approximated, the first deterministic approach has been modified: a probabilistic approach is proposed. From this second approach, an urban trench protection level can be computed (UTPL), which provides an integrity indicator adapted to the urban environment.

This article is divided into 2 main parts: the first part gives an overview of the deterministic approach, whilst the second part concerns the probabilistic approach. Afterward experimental results are presented, with improvement not only in terms of accuracy, but also in terms of accuracy.

Deterministic approach

First, the main cause of degradation of GNSS signals in urban areas is due to the morphology of the environment and in particular the geometry of the buildings. These not only cause multipath (i.e. interference between direct and reflected signals) which deviates the tracking loops and thus cause positioning errors, but also hide some satellites whose signal is no longer received. The signals received

from satellites that are not in direct line of sight but undergoing one (or several) reflection (s) before being received cause the biggest measurement errors. They are called: NLOS (non-line-of-sight).

There are different solutions investigated to reduce the effects of NLOS multipath:

- depending on the reception signal-to-noise ratio: actually, a reflection attenuates the signal. This method gives interesting results in terms of detection and exclusion;
- filtering measurements based on a predictable dynamics of the receiver. This method assumes velocity, acceleration, turn rate or requires additional sensors: it is also valuable to perform NLOS detection and exclusion;
- using a 3D city model, and determining a trust area where the sky visibility is good [1]. The problem is that this visibility area is obviously dependent on the position (unknown) of the mobile. Some works propose to use a fisheye camera pointing to the zenith [2]. Without this, it is necessary to make one (or more) assumption(s) on an initial position and then refine this position. The main contributions are: [3], [4], [5], and [6] to which the present research investigations consist in a continuation.

The geometry of the buildings we propose is simplified, to such an extent that, between nodes (i.e. intersections), we consider that the width of a street is constant as well as the height of left and right facades. Another approximation we still make is to project to predicted position of the mobile onto the local road arc segment. So, 4 parameters only depict the geometry we set per arc segment: left and right distances between this arc segment and the footprint of both facades (W1 and W2), and the height of the building on both sides (H1 and H2).

Such modelling is easy to extract from usual data base like IGN BD Topo ® in France.

The format, i.e. the fact that the urban trench parameters are attached to the road arc segments, makes it really ease-of-use in any real-time embedded map-matching process for car navigation. The information to store is more than 2 orders of magnitude lower than that of a typical detailed 3D model one sets up in a ray-tracing approach of this problem.

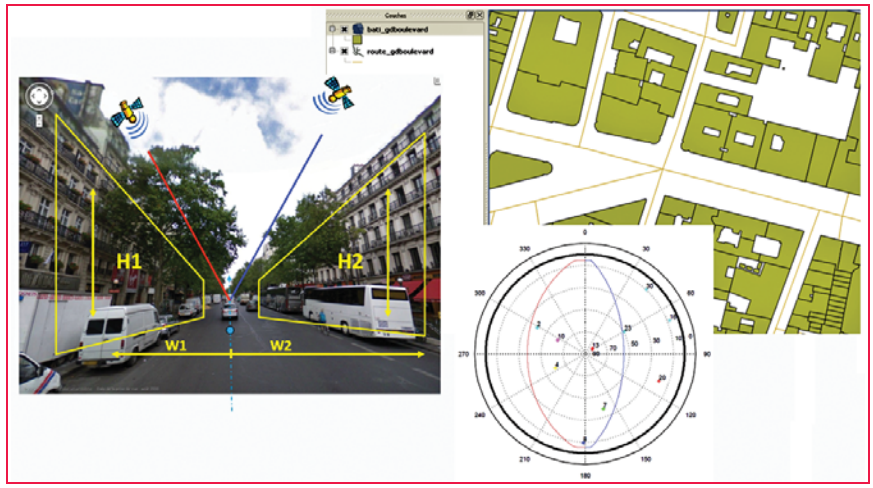

Figure 1: A street view in Paris, with road and building layers of BD Topo® locally, and the parameters of our model: next polar subplot figures out the diagram of visibility resulting from applying the urban trench model

An example of a street view in Paris, Grands Boulevards, and the corresponding BD Topo ® extract is given in Figure 1.

The diagram of visibility, also called mask of visibility, has this rugby ball shape due to the infinite length assumption of the urban trench where one travels. Assuming specular reflection, the LOS/NLOS boundary obeys to (1):

$$el_{los/nlos1} = \arctan\left|\frac{H_1}{W_1}\sin\beta\right| \quad (1)$$

where β measures the angle difference between the satellite azimuth and the street direction.

A similar equation gives the boundary between NLOS with 1 reflection and NLOS with 2 reflections, and it applies in case high enough buildings are facing each other.

A large data set has been collected in Nantes, Paris and Toulouse in 2012, aggregating 10 hours of observation in the usual traffic, with a GPS receiver typically used in car navigation systems: automotive and high-sensitivity GPS Ublox LEA6-T, 5 Hz, mounted on the roof of the vehicle. The ground truth was given in post-processing by a Novatel kinematic receiver coupled with an IXSea Inertial Measurement Unit [7]. We have established that the urban trench modelling, despite its approximation of both the geometry of

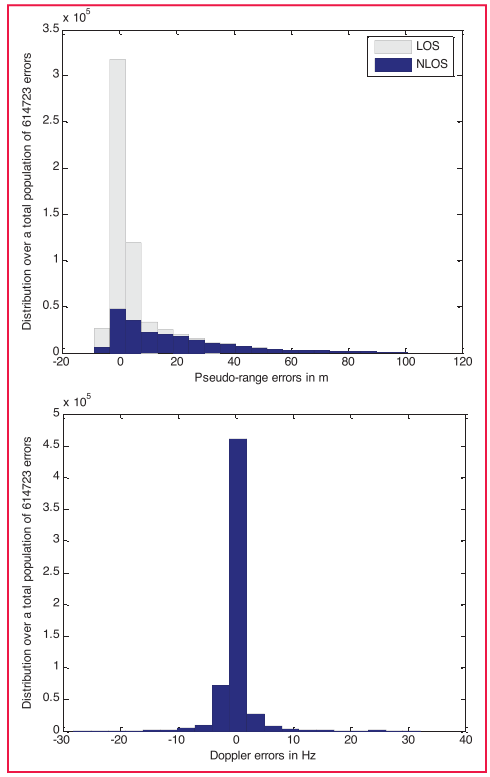

Figure 2: (a) LOS/NLOS pseudo-range errors and (b) Doppler errors

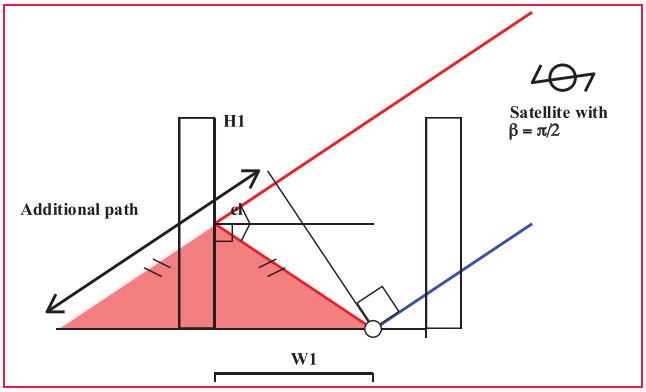

Figure 3: Additional path performed in case of 1 reflection for a satellite azimuth perpendicular to the street

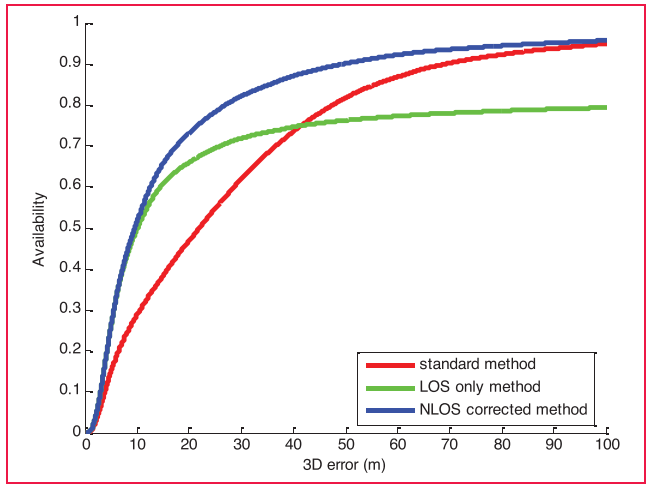

Figure 4: Cumulative distribution function of the absolute error in 3D, for standard and urban trench solutions, for all epochs and all test sites in Nantes, Paris and Toulouse (10 hours of data); note that the asymptote is lower when using LOS only, because solutions are often not computable, which can also be interpreted as an infinite error

buildings and the transversal position in streets, classifies properly LOS and NLOS.

Time series, e.g., have been obtained in Paris, Grands Boulevards, and a histogram of pseudo-range errors is given in Figure 2a. The total number of epochs aggregated is 102335 (approximately 5½ hours at 5 Hz). 7 satellites per epoch are visible in average; note that the highest is used for the receiver clock offset correction, which makes a total population of 614723 errors (5½ hours at 5 Hz for (7-1) satellites).

One notices a positive tail in the distribution of the pseudo-range errors, but a rather normal distribution of the Doppler errors (Figure 2b). On Figure 2a, the proportion of the urban trench model-based NLOS identified satellites have been blued, those responsible of this long positive tail in the error distribution.

Assuming specular reflections in the environment modelled with urban trenches, the pseudo-range errors can be estimated and the additional distance corrected (Figure 3). This supposes that an approximate position of the receiver is first made, and, as concerns the present approach and experimental results, projected onto the nearest road arc segment in a simple map-matching process.
The additional distance obeys to (2):

$$d_{nlos1} = 2\left|W_1 \sin\beta \cos el\right| \qquad (2)$$

where *el* designs the satellite elevation.
In the eventuality of 2 consecutive reflections, a similar equation applies.

Figure 4, from [6], aggregates all epochs and all test sites (i.e. 10 hours of data). The cumulative 3D error distribution is displayed, for the standard estimator (least-mean squares), for the estimator using LOS satellites only, and for the estimator mixing LOS and NLOS satellites, applying the correction given by the modelled urban trenches.

The LOS only method availability is around 80%, while the standard and NLOS corrected methods reach almost 100%. The median error in 3D has been reduced from 21.7 m down to 9.4 m, i.e. 56% improvement globally.

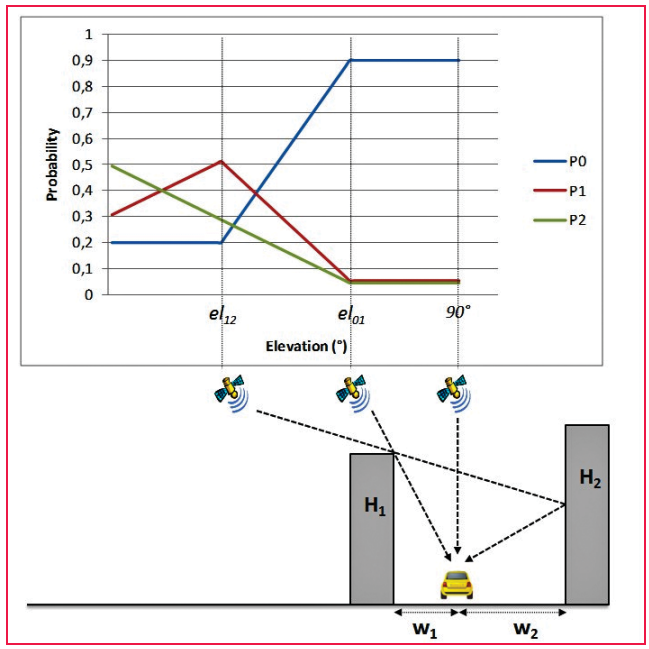

Figure 5: Model of probabilities that a satellite, depending on its elevation relatively to the thresholds el01 (cf. equation 1) and el12, be LOS (P0), NLOS with 1 reflection (P1), NLOS with 2 reflections (P2)

Probabilistic approach

Using a model with simplified geometry (Urban Trench), and approximating the initial position, [6] presented a first deterministic approach, that has been modified into a probabilistic approach [8].

In this approach, are proposed empirical laws modelling the probabilities that signals come LOS or NLOS (with 1 or 2 reflections) depending on the geometry. These laws (Figure 5) depend on deterministic considerations, but they are probabilistic to take into account the random aspects due to difference between the real geometry of the streets and the modelled trenches (gaps between the buildings, differences of heights, etc.).

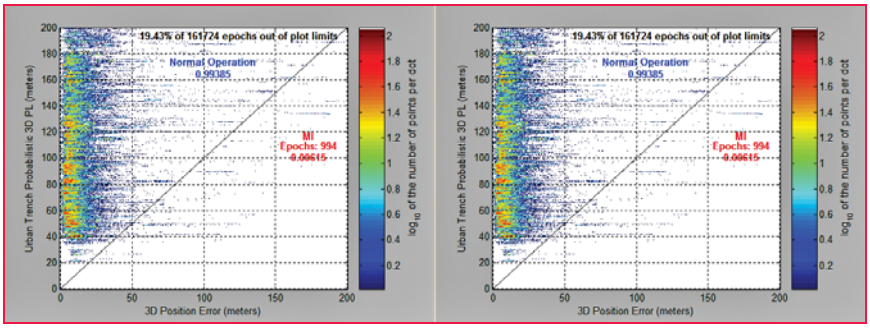

Figure 6: Stanford diagrams with no modelling of multipath and when the Urban Trench model of probabilities is applied

Every combination of the probabilities is considered in the positioning estimation, which averages 3^n solutions, each one being weighted by its own P0*P1*P2 product of probabilities. From this second approach, an urban trench protection level can be computed, which provides an integrity indicator adapted to urban environments. This indicator, computed in 3D, is obtained by multiplying the semi-major axis of the ellipsoid that encompasses the set of 3^n solutions by the usual K factor (6.18) read in the chi² statistic table.

Figure 6 shows that the proposed 3D Urban Trench Protection Level (UTPL) outperforms the standard protection level, which does not consider the local sources of multipath. A total duration of approximately 10 hours of tests have been carried out and processed. Misleading Information (MI) occurred a few percents of time in standard, i.e. without urban modelling, whereas the 3D UTPL occurrence of MI is 10 times less: one thousand over the 161 724 epochs where the computation was applicable (epochs with only 4 satellites were not considered).

Conclusion and perspectives

This communication gives results in urban environments not only in terms of accuracy improvement, but also in terms of integrity. Full scale experiment, in Nantes, Paris and Toulouse, for a total duration of 10 hours, have been carried out, which makes a data set large enough to claim for an integrity risk of the order of magnitude of 10^{-3} with a 10% confidence. The 3D modelling is simple and compatible with today's embedded digital maps. Additional tests and investigations to optimize the Urban Trench probabilistic method are ongoing.

Acknowlegments

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System time synchronization for GNSS interoperability

To make it possible for users to solve navigation problem by signals from SVs of different GNSS constellations it is necessary to provide users with data on the offsets between System Time Scales of these GNSS

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Operational and emerging Global Navigation Satellite Systems (GNSS) GPS, GLONASS, Galileo and others provide high-accuracy determination of position, velocity and time for land, marine, airborne and other kinds of users. To achieve this time scales of all Space Vehicles (SV) are synchronized to System Time and System Time is synchronized to Reference Time. National realizations of coordinated time scale UTC are typically used as Reference Time Scales.

Therefore, to make it possible for users to solve navigation problem by signals from SVs of different GNSS constellations it is necessary to provide users with data on the offsets between System Time Scales of these GNSS.

Users can get the data on the offsets autonomously by processing navigation signals themselves from SVs of different GNSS constellations. However, autonomous calculating data on the offsets between System Time Scales of different GNSS constellations is possible only when signals from no less than four SVs of the same GNSS constellation can be received. As a result, it is impossible to use signals from SVs of different GNSS constellations in challenging environment with three or even less visible SVs. Possible solution is to store the calculated values of GNSS-GNSS Time offset and to use the stored values, however this approach brings additional error because of the growing error of the stored values.

Therefore, to provide interoperability with other GNSS in terms of System Time Scales the following procedures are implemented in each GNSS:

- System Time Scale is synchronized to national realization of UTC;
- corrections for the offset between System Time Scale and national realization of UTC are broadcast;
- corrections for GNSS – GNSS Time Offset (GGTO) are broadcast.

GLONASS Time generation

GLONASS Time is generated as a continuous "paper" time scale on the basis of the Main or Reserved Central Synchronizers (CS) time scale in accordance with the following equation:

$$\Delta T_{GL}(t) = \Delta T_M(t) + \Delta T_M^{ph}(t_i) + \Delta T_M^{fr}(t_j) - \Delta T^c(t) = \\ = \Delta T_R(t) + \Delta T_R^{ph}(t_k) + \Delta T_R^{fr}(t_l) - \Delta T^c(t) - \Delta T_{M-R}(t) \quad (1)$$

where $\Delta T_{GL}(t)$ – GLONASS Time offset relative to Reference Time; $\Delta T_M(t)$, $\Delta T_R(t)$ – Main/Reserved CS time offset relative to Reference Time; $\Delta T_M^{ph}(t_i)$, $\Delta T_R^{ph}(t_k)$ – corrections for Main/Reserved CS phase steering; $\Delta T_M^{fr}(t_i)$, $\Delta T_R^{fr}(t_l)$ – corrections for Main/Reserved CS frequency steering; $\Delta T^c(t)$ – correction for controlling GLONASS Time – Reference Time offset; $\Delta T_{M-R}(t)$ – offset between Main and Reserved CS time scales.

The Central Synchronizer that provides the best accuracy characteristics is used as Master CS, the other operates as secondary.

Central Synchronizers provide the following accuracy characteristics:

– relative frequency error $\Delta f/f$ below $3 \cdot 10^{-14}$;
– daily frequency instability below $2 \cdot 10^{-15}$.

The backbone of CS is Frequency/Time Keeping Facility (FTKF) including four active Hydrogen Frequency Standards (HFS), a system for internal comparisons and a system for steering frequencies and phases of signals from HFS. HFS which provides the best accuracy

characteristics on the results of internal comparisons becomes master standard, the others operate as secondary.

National Time Scale of Russia UTC(SU) generated by State Time/ Frequency Reference (STFR) is used as GLONASS Reference Time.

CS time scale is corrected simultaneously with the correction of coordinated time scale UTC and, as a result, there is no whole second time offset between GLONASS Time and UTC(SU). However, there is a three-hour constant offset between GLONASS Time and UTC due to GLONASS Monitoring and Control Segment operational principles.

Till August 2014 the offset of GLONASS Time relative to UTC(SU) was about 400 ns. It met specified requirements but was not satisfactory for time users. Therefore, to minimize the offset of GLONASS Time relative to UTC(SU) on 18th August, 2014 the procedure for GLONASS Time correction was started. To keep the specified accuracy of SV – GLONASS Time synchronization the value of daily correction change was 3 ns. The results of monitoring proved the efficiency of the correction procedure: GLONASS Time offset relative to UTC(SU) changed from -392.6 ns (19.08.2014) to 29.4 ns (31.12.2014). Now the offset is kept within 35 ns. The offset of GLONASS Time relative to UTC(SU) is presented in Figure 1.

GLONASS Time broadcast to users

To provide users with navigation and timing data GLONASS SVs broadcast in their navigation messages frequency/ time corrections (FTC) for SV time scale offset relative to GLONASS Time.

To calculate FTC for SV time scale offset relative to GLONASS Time it is provided:

- the offset of SV time scale relative to Measuring Systems (MS) time scale is calculated and the results obtained are used to calculate the offset of SV time scale relative to GLONASS Time;
- the values of the offsets obtained for specified observation time interval are processed together to estimate and predict the parameters of SV time scale offset trend for specified time interval;
- FTCs to be uploaded are generated in a specified part of navigation frame.

The offset of SV time scale relative to MS time scale is calculated with using simultaneous one-way range measurements by One-Way Measuring Systems (OMS) and two-way range measurements by Two-Way Measuring Systems (TMS) (one-way/ two-way technique) and by one-way range measurements by OMS and calculated range values (one-way technique).

The values of SV time scale offset relative to MS time scale are converted to the values of SV time scale offset relative to GLONASS Time by consecutive using the parameters of each MS time scale offset relative to Master (connected to Master CS) MS time scale, Master MS time scale offset relative to Master CS time scale and Master CS time scale offset relative to GLONASS Time at session measurement time.

Parameters of SV time scale drift relative to GLONASS Time are estimated with using time scales offset processing algorithm for session results based on linear model and Least Mean Squares (LMS) technique.

Data on FTC is calculated and then uploaded at each SV orbit circle. FTCs are broadcast in SV navigation signals as two linear coefficients of SV – GLONASS Time offset model $\tau_n(t_b)$ and $\gamma_n(t_b)$ for the middle of each 30-minute segment of prediction interval.

GLONASS Time is determined by users in accordance with the following equation:

$$T_{GL} = t + \tau_n(t_b) - \gamma_n(t_b)\cdot(t - t_b) \qquad (2)$$

where t – onboard satellite time.

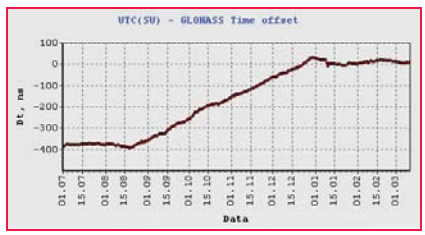


Figure 1: UTC(SU) – GLONASS Time offset

In case all GLONASS facilities are in Full Operational Capability mode the error of FTC calculation and generation is about (3.0 – 6.0) ns (rms).

GLONASS Time corrections

To convert from GLONASS Time to UTC(SU) SVs broadcast correction for GLONASS Time offset relative to UTC(SU) τ_c in navigation signals.

To generate data on GLONASS Time offset relative to UTC(SU) it is provided:

- the offset of CS time scale relative to STFR time scale is calculated and the results obtained are converted to the offset of GLONASS Time relative to UTC(SU);
- the values of the offsets obtained for specified observation time interval are processed together to estimate and predict the parameters of GLONASS Time drift for specified time interval;
- corrections for GLONASS Time offset relative to UTC(SU) are generated for the navigation frame to be uploaded.

The offset of CS time scale relative to STFR time scale is calculated on the base of their mutual comparisons by the signals from SVs of GLONASS and GPS in differential mode with using "all-in-view" method according to the following equation:

$$\Delta T_{STFR-CS}(t_i) = \Delta T_{GL(GPS)-CS}(t_i) - \Delta T_{GL(GPS)-STFR}(t_i) \qquad (3)$$

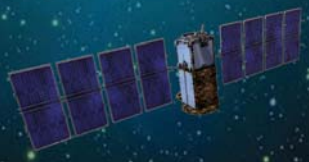
where $\Delta T_{STFR-CS}(t_i)$ – CS time scale offset relative to STFR time scale;
$\Delta T_{GL(GPS)-CS}(t_i)$ – CS time scale offset relative to GLONASS/GPS Time;
$\Delta T_{GL(GPS)-STFR}(t_i)$ – STFR time scale offset relative to GLONASS/GPS Time.

Now the error of calculating Main CS – STFR time scale offset is about 8 ns (rms), Reserve CS – STFR time offset is 13 ns (rms).

Parameters of GLONASS Time drift relative to UTC(SU) are estimated with using special algorithm for processing time scales offset based on linear model and LMS technique.

The corrections for GLONASS Time offset relative to UTC(SU) are calculated

SPIRENT



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and uploaded once per day. They are broadcast to users in navigation messages for the middle of each 30-minute segment of prediction interval.

UTC(SU) time is determined by users in accordance with the following equation:

$$T_{UTC(SU)} = 03 \text{ hrs } 00 \text{ min} + T_{GL} + \tau_c \quad (4)$$

Till 18th August, 2014 the error of broadcast corrections for GLONASS Time - UTC(SU) offset contained a systematic component of approximately 200 ns. Therefore, on 18th August, 2014 the generated corrections to GLONASS Time were also changed. Now the error of broadcast corrections for GLONASS Time - UTC(SU) offset does not exceed 10 ns (rms). UTC(SU) broadcast by GLONASS is presented in Figure 2.

Thus, currently the accuracy of UTC(SU) provided by GLONASS is about 35 ns without using the broadcast corrections to GLONASS Time and about 10 ns with using the corrections.

Corrections for GLONASS – GNSS Time offset

Now GLONASS SVs broadcast GGTO correction only for GLONASS - GPS Time offset τ_{GPS}, which is the fractional part of GPS – GLONASS Time offset (the integer part is determined by users from GPS navigation message).

To generate data to be uploaded on GLONASS – GPS Time offset it is provided:

- the offset of CS time scale relative to GLONASS Time and GPS Time is measured and the results obtained are used to calculate the values of the offset between GLONASS Time and GPS Time;

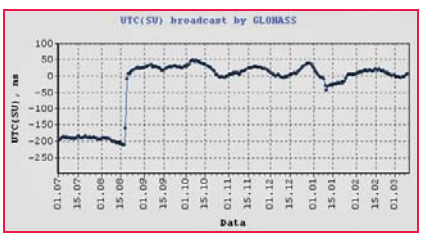


Figure 2: UTC(SU) broadcast by GLONASS

- the offsets obtained for specified observation time interval are processed together to estimate and predict the parameters of GLONASS – GPS Time offset drift for specified time interval;
- corrections for GLONASS – GPS Time offset are generated to be uploaded in the navigation frame.

The offset between GLONASS Time and GPS Time is calculated with using the measurements at CS in accordance with the equation:

$$\Delta T_{GL-GPS}(t_j) = \Delta T_{GL-CS}(t_j) - \Delta T_{GPS-CS}(t_j) \quad (5)$$

where $\Delta T_{GL-GPS}(t_j)$ – GLONASS – GPS Time offset; $\Delta T_{GL-CS}(t_j)$ – CS time offset relative to GLONASS Time; $\Delta T_{GPS-CS}(t_j)$ – CS time offset relative to GPS Time.

The error of calculating GLONASS - GPS Time offset is about 10 ns (rms).

Parameters of GLONASS - GPS Time offset are estimated with using time scale offset processing algorithm based on linear model and LMS technique.

The corrections are calculated and uploaded once per day. They are broadcast to users in navigation messages for the middle of each 30-minute segment of prediction interval.

Now the error of generated corrections for GLONASS – GPS Time offset is below 15 ns (rms).

GPS Time is determined by users in accordance with the following equation:

$$T_{GPS} = T_{GL} + \Delta T + \tau_{GPS} \quad (6)$$

where ΔT - integer part of GPS Time offset relative to GLONASS Time.

Improvement of GLONASS interoperability with other GNSS in terms of System Time

The main approaches to improve GLONASS interoperability with other GNSS in terms of System Time are:

- to increase the accuracy of GLONASS Time synchronization to UTC(SU);
- to increase the accuracy of broadcast corrections for GLONASS Time – UTC(SU) offset;
- to provide users with broadcast GGTO corrections for GLONASS – Galileo Time offset and GLONASS – BeiDou Time offset;
- to increase the accuracy of broadcast GGTO corrections for the offset between GLONASS Time and Time Scales of other GNSS.

These approaches are going to be implemented, first of all, by increasing the accuracy of time scale comparisons between CS time scale and STFR, so it is planned:

- at the 1st stage to install similar calibrated GLONASS/GPS time receivers at STFR and CS. It can provide to determine time scales offset with the error of about 3 ns;
- at the 2nd stage to use time transfer facilities using duplex communication links through satellites in geosynchronous orbit (GEO). It can provide the accuracy of about 1 ns.

Conclusions

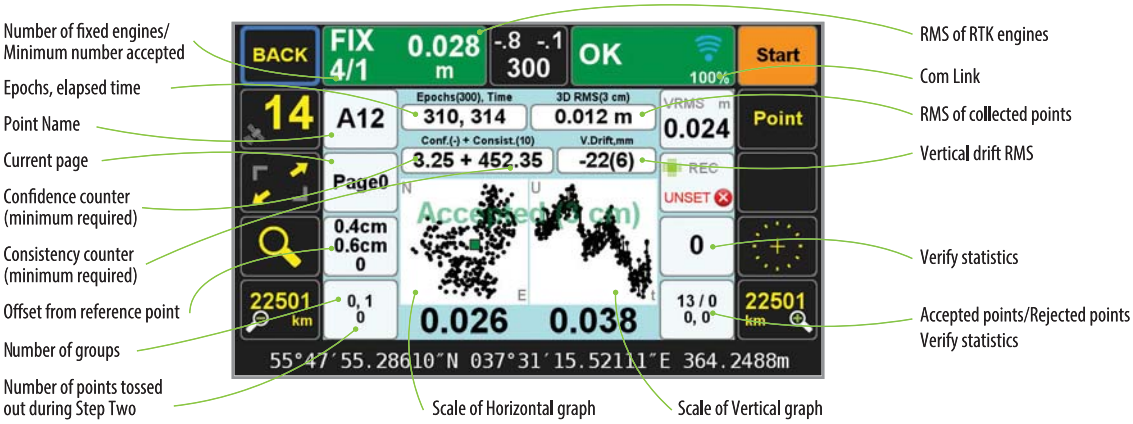
Currently, GLONASS interoperability with other GNSS in terms of System Time is provided by the following:

- GLONASS Time is synchronized to UTC(SU) with the accuracy of 35 ns;
- broadcast corrections to GLONASS Time with the accuracy of 10 ns;
- broadcast GGTO corrections for GLONASS – GPS Time offset with the accuracy of 10 ns.

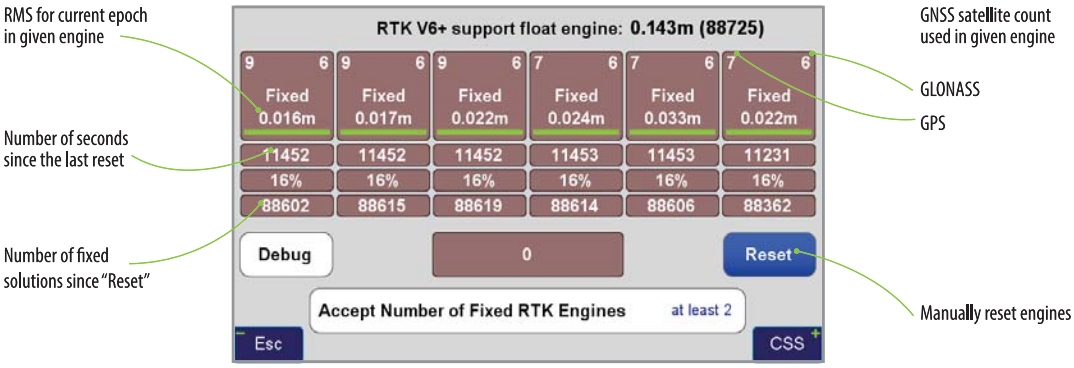
As a result of further GLONASS development the following accuracy characteristics are planned to be achieved:

- GLONASS Time - UTC(SU) offset no more than 20 ns at the 1st stage and 4 ns at the 2nd stage;
- the error of broadcast corrections to GLONASS Time relative to UTC(SU) below 5 ns at the 1st stage and 2 ns at the 2nd stage;
- the error of broadcast corrections for GLONASS – other GNSS Time offset below 3 ns at the 1st stage and 2 ns at the 2nd stage.

RTK V6+ six engines plus one support



Auto Verify... Auto Validate...



This vigorous, automated approach to verifying the fixed ambiguities determined by TRIUMPH-LS gives the user confidence in his results and saves considerable time compared to the methods required to obtain minimal confidence in the fixed ambiguity solutions of other RTK rovers and data collectors on the market today. The methods required by other systems are not nearly so automated, often requiring the user to manually reset the single engine of his rover, storing another point representing the original point and then manually comparing the two by inverse, all to achieve a single check on the accuracy of the fixed ambiguities. Acquiring more confidence requires manually storing and manually evaluating more points. Conversely, J-Field automatically performs this test, resetting the multiple engines, multiple times (as defined by the user), provides an instant graphic display of the test results, and produces one single point upon completion.

Read details inside and compare with other receivers that require Multiple Point survey, Manual Evaluation, Single Engine, and Single Ambiguity Check per Point.

With TRIUMPH-LS you need Single Point survey, Automated Evaluation, Multiple Engines, and Multiple Ambiguity Checks per Point.

Cluster Averaging

Many jurisdictions dictate that surveyors using RTK revisit critical cadastral points several times in order to demonstrate the results of the survey are reliable. These sorts of mandates are meant to trap inevitable errors encountered while pushing GNSS technology to the limits of operability under canopy or nearby obstructions. Producing the same bad coordinate multiple times (such as three observations, separated by several hours) is still possible considering that the base coordinates could be mis-entered, the base receiver could be setup on the wrong point and possible centering and leveling errors at the base and the rover. With Javad's J-Field, VB-RTK using DPOS, and the Base/Rover Setup procedure the risk associated with the base coordinates being mis-entered or the base receiver being setup on the wrong point are substantially reduced, proving that smart technology can help surveyors minimize commonly encountered blunders.

The rigorous verification process found exclusively in J-Field, uses the six RTK engines of the TRIUMPH-LS to quickly fix and then force a loss of fix for a user defined number of times to prove the point being collected was not the result of a bad fix. In as little as a few seconds, J-Field's verification process provides confidence to surveyors that their positions are defensible and reliable. Other systems require numerous manipulations by the user to perform a fraction of what J-Field does automatically. Consider that most RTK users today, desiring to prove RTK results are valid, must collect a point, then manually reset the RTK engine, collect a second point and then compare the first to the second to determine if there is acceptable agreement. This is a tedious and time consuming process that provides one single check on the fixed integer ambiguities.

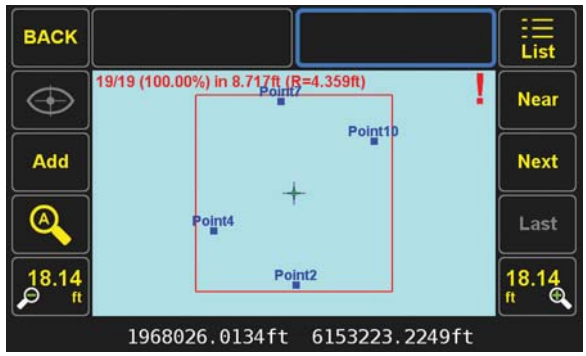
Even with the exhaustive verification procedures in J-Field, the legal obligation in some locales for surveyors to revisit a point hours later remains. J-Field's newest feature, Cluster Averaging makes evaluation of these repeat visits automated and simple. Once a surveyor has collected a point several times, he can initiate Cluster Averaging which searches the points that are visible in the database and finds all occurrences of points that are within a user defined horizontal range of one another. These occurrences are referred to as "Clusters". Next the user is notified of the number of clusters found in the database with the option to create an average point for each cluster. A graphic representation of each cluster is provided, along with the extreme spread of the points in the cluster expressed in North, East and Up. Finally, a rich report is provided with vital statistics of each point used to create the cluster and for the resulting average point. All of this is done automatically, with minimal user involvement, with staggering speed and detail.

It is also possible to manually produce Cluster Averaging, one cluster at a time from the Review Screen. (Home>Collect>Review). First let's look at the one at a time, manual approach in Review:

Here are (pic. 1) four groups of surveyed points (notice the dots are bold squares indicating each dot is composed of more than one point).

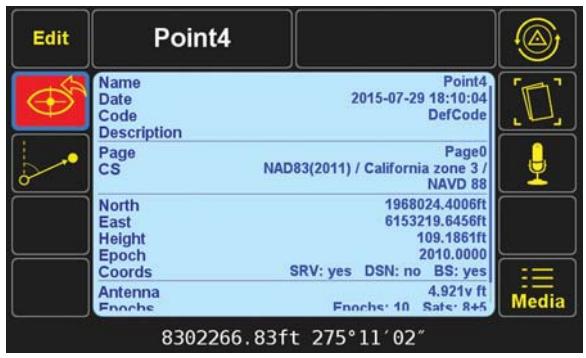
Pressing the selection button (shown in blue here) shows that there are 19 points (pic. 1) within this red square.

Dragging the cursor over one of the Clusters of points

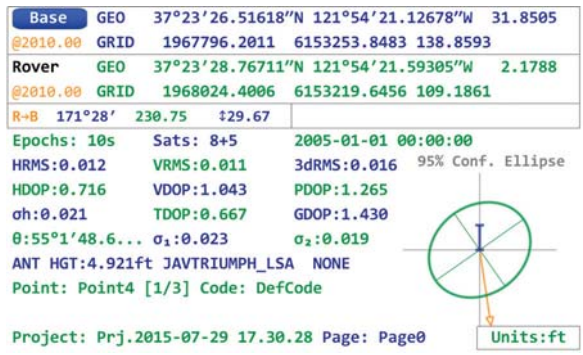


pic. 1 | Four groups of surveyed points

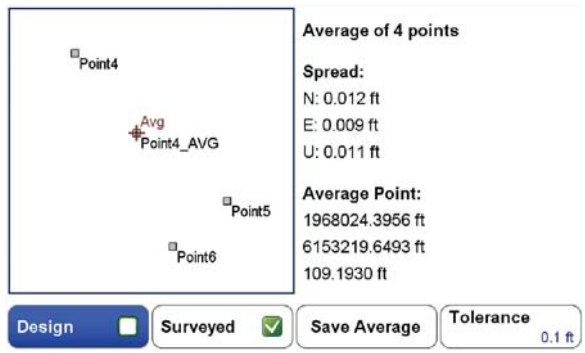
pic. 2 | Points within the Cluster



pic. 3 | Statistics about the selected point



pic. 4 | Base/Rover Statistics screen



pic. 5 | Cluster Average Statistics

Concepts Behind RTK Verification

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

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

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

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

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

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

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

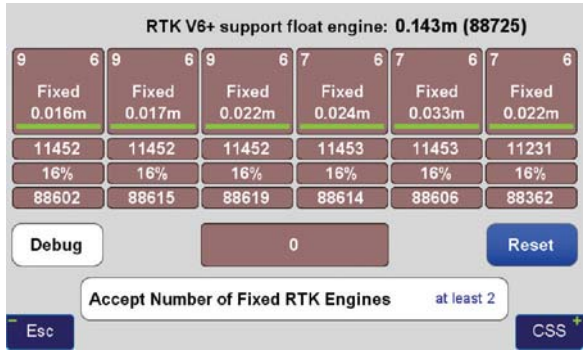


Figure 1 *V6+ six RTK Engines*

User Defined Verification Tools

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

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

Confidence Counter

Figure 2 *Verify Settings*

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

Consistency Counter

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

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

Verify with Automatic RTK Engines Resets

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

• Step One

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

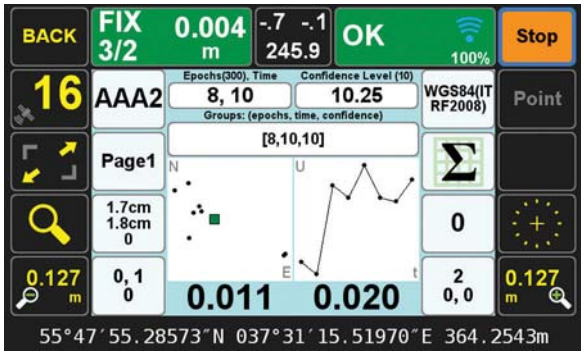


Figure 3 *End of Step one*

• Step Two

In Step Two, engines are not reset and solutions which are inside the CG of the selected group are added to that group for the remaining number of epochs that user has requested (Epoch Number, EN). Solutions that are outside the CG of the selected group, will be ignored but counted and on each such epoch, the RTK engines will reset. If the number of ignored points reaches 30% of EN, the whole process will restart. J-Field has 6 parallel RTK engines. You can specify the minimum number of engines required to be fixed to provide an epoch solution in Step Two. If the number of groups exceeds the Max Group the process restarts at Step One. This is to reduce the possibility of creating too many groups and rare false solutions in difficult environments. (Figure 4)

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

You can manually reset all RTK engines via the V6-RTK engines screen (Figure 1), or assign this reset function to any one of the U1 to U4 hardware

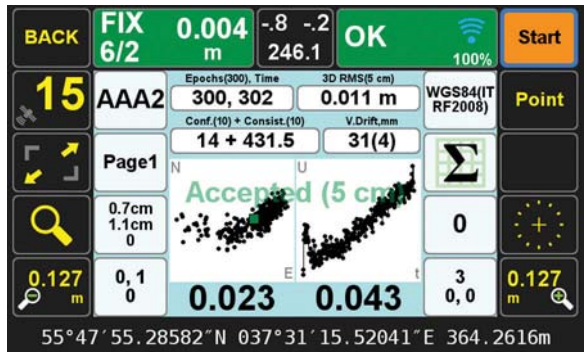


Figure 4 *End of Step 2*

buttons in front of the TRIUMPH-LS for easy access.

Verify without Automatic RTK Engines Resets:

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

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

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

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

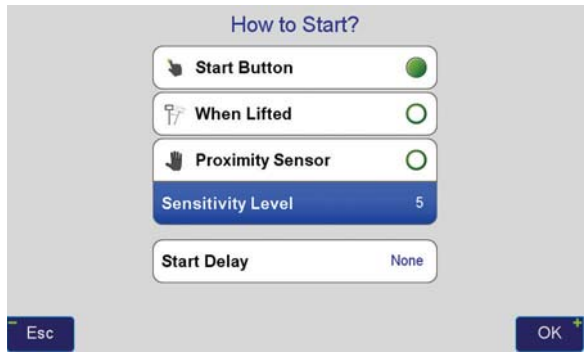


Figure 5 *How to Start*

Figure 6 *How to Stop*

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

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

Screen Shots of Action Screen

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

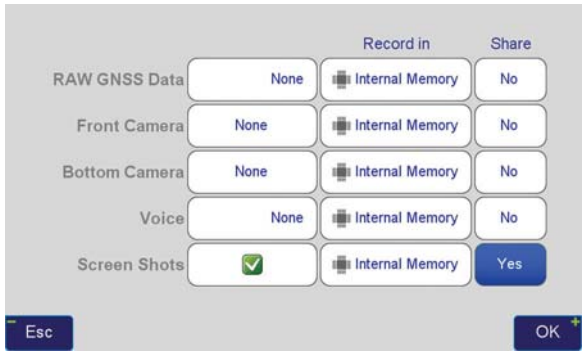


Figure 7 *What to record screen*

Review Screen

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

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

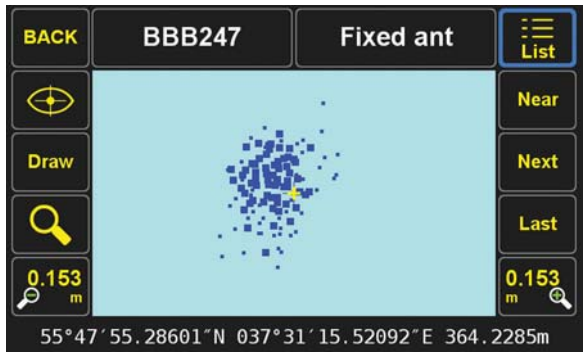


Figure 8 *Review screen shows cluster of 386 points*

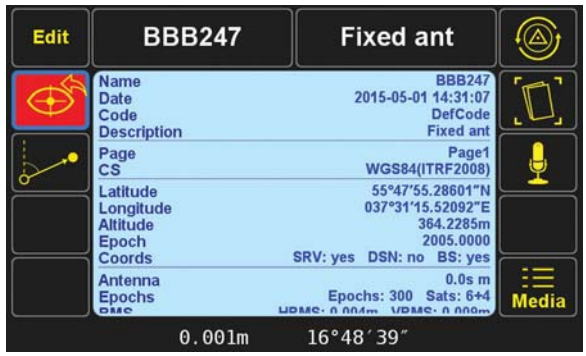


Figure 9 *Detailed information on selected point (scroll to see all information)*

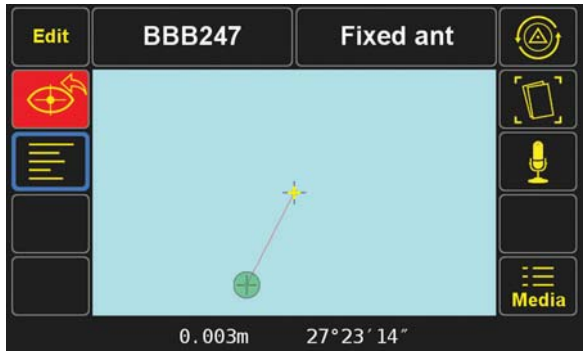


Figure 10 *Distance and direction from the current point to the selected point*

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

website. Point your browser to: *http://www.javad.com/jgnss/javad/news/pr20150219.html*

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

Instantaneous Multipath charts

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

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

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

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

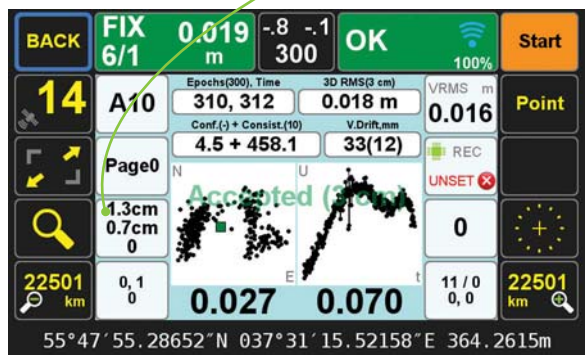
Figure 11 *Code Phase multipath removed (cm)*

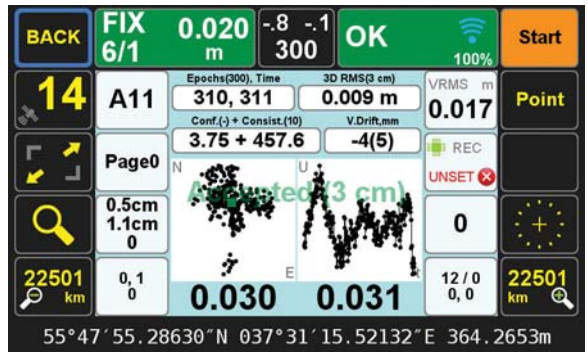
SAT	EL	AZ	L1	P1	P2	L2C	L5	SAT	EL	AZ	L1	P1	P2	L2C	L5
GPS2	29↑	154	7	7	2	--	--	BDU11	75↑	158	-6	--	--	--	-5
GPS6	44↑	98	11	9	2	2	-13	BDU12	36↓	60	-6	--	--	--	-14
GPS12	70↑	282	7	8	-2	-2	--	GPS3	10	26	--	--	--	--	--
GPS14	25˜	302	5	8	-4	--	--	GPS29	3	229	--	--	--	--	--
GPS17	23↓	58	6	9	-6	-2	--	GPS32	3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

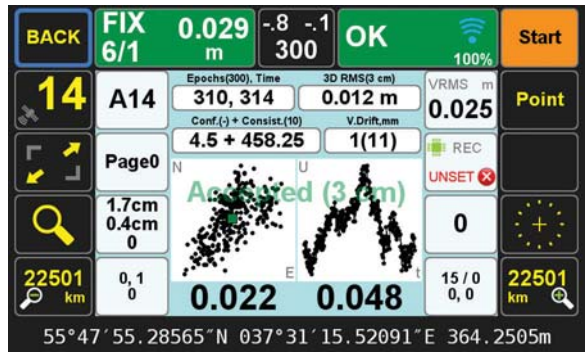
Figure 12 *Carrier Phase multipath remove (mm)*

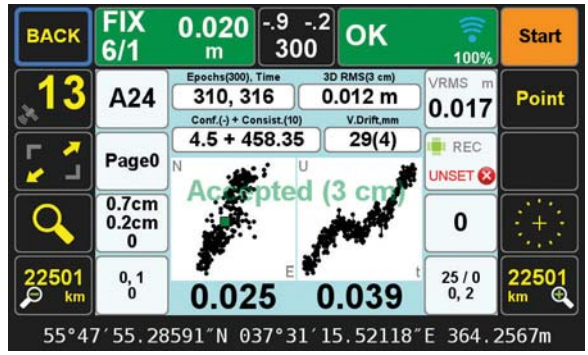
Multipath Showcase

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



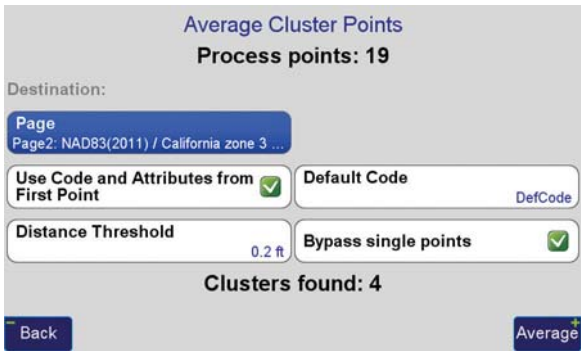




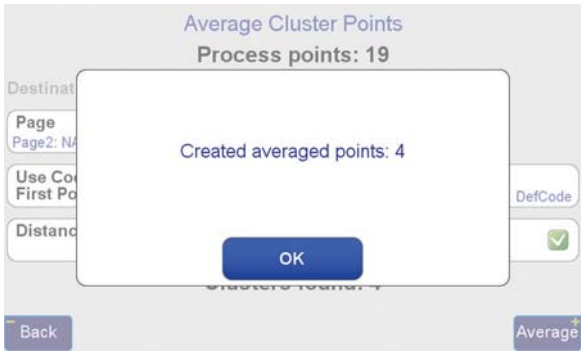


Javad Ashjaee, Ph.D.

pic. 6 | Option for Cluster Average

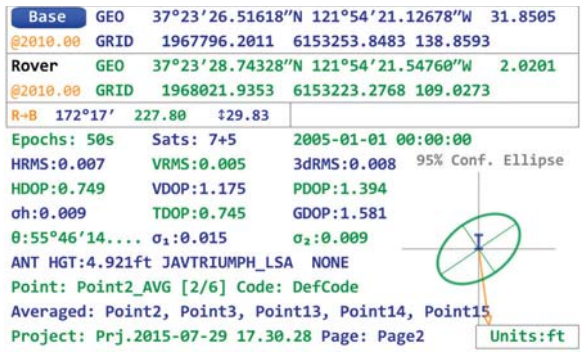


pic. 7 | Cluster options



pic. 8 | Number of Cluster Averaged

pic. 9 | Points lists



pic. 10 | Base/Rover Statistics screen

and pressing the Eye/Crosshair icon presents a options for points within the Cluster radius. In this example (**pic. 2**), Point4, Point5 and Point6 are individually surveyed points. Stake1 is a design point, created from entering coordinates. Point4_AVG is an average point created previously created from Cluster Averaging.

After selecting a point from the cluster, press anywhere on the blue field to see additional statistics about the selected point (pic. 3).

With the Base/Rover Statistics screen (pic. 4) visible, pressing the UP arrow hardware button shows the Cluster Average Statistics screen. Here the user is given the extreme spread of the cluster of points, the average coordinates (weighted by the error estimates in the case of survey points), with the option to include only surveyed points or only design (imported/calculated) points or a combination. The Tolerance value sets the radius used to define what falls within a cluster (pic. 5).

Pressing Save Average displays the Average Tool in COGO for final acceptance of the average.

The process described above creates averages from clusters one at a time as the user selects a point in a cluster and initiates the average command from the review screen. However, J-Field can also create averages from clusters automatically from the Additional Actions button found in the Points Screen. With this command all possible clusters are identified from the points currently visible in the points list (excluding any points that have been filtered from view).

A Pop-Up screen appears (pic. 6) with the option for Cluster Average.

Selecting Cluster Average, J-Field detects all occurrences in the visible database of points within the user defined tolerance (pic. 7-8).

If, Average is selected, the average point of each detected cluster will be created automatically. The name of the point, by default, is [PointName]_AVG, with [PointName] being the name of the first point detected in the cluster. For example the averaged point from a cluster of points named Point4, Point5 and Point6, will be named Point4_AVE (pic. 9).

For efficiency, the Code and Attributes from the first point in the cluster can be assigned to the average point using the appropriate check box.

Once the points have been created from the Cluster Average Utility, they are visible in the Points Screen. If all of the points used in the Cluster are surveyed points, the resulting Average point is also created as a survey point, having the same number of epochs as the combined epochs from the points in the cluster. The error estimates are modified according to the combination of the errors of the individual points, generally resulting in much improved precision in the Average point.

Now there is no longer a need to manually determine how to handle redundant observations of the same point. Store a point as many times as you wish and let the Cluster Averaging simplify your processing time and improve the precision of the your surveys. J-Field's new Cluster Averaging takes only seconds to accomplish and can be done easily while still in the field.

Shawn Billings, PLS

Collecting Points in Difficult Environments

Fundamental in the determination of GNSS solutions is resolving the correct number of full cycles of the carrier signal (so-called fixing ambiguities) in order to determine the distances from the satellites to the receiver. These distances contain errors caused by inaccuracies in the satellite clock and by the ionosphere and troposphere. When a base station is used, these errors and errors in the satellite orbits are nearly identical to both the rover and base station receivers when the baseline distance is short. By removing these common errors through RTK processing, centimeter level accurate vectors can be calculated between the base station and the rover.

Multipath, the reflection of GNSS signals from nearby objects and structures create their own indirect measurements from the satellites to the GNSS receiver and is the most critical source of inaccuracy in precision GNSS applications. The worst case is when the receiver doesn't see the direct signal at all; e.g., the satellite is behind a building, but it's still receiving the signal reflected off of the nearby structure. Such indirect signals are usually strong, unhelpful and misleading.

The other aspect impacting the veracity of a fixed solution is when there are weak GNSS signals. Frequently, weak signals are due to their penetration directly through tree canopy. While the TRIUMPH-LS can't move the obstacles that are creating multipath out of the way, its sophisticated engineering is designed to handle even the weakest signals like no other system with its RTK Verification System (patent pending).

When located in difficult environments and under tree canopy, all GNSS receivers are prone to give bad fixed solutions that may be appear to be acceptable if they are not verified. Existing methods to verify GNSS solutions include "dumping" the receiver, turning it upside down to cause the RTK engines to reset, and re-observing the point at a later time.

The TRIUMPH-LS automates these processes with its built-in software features of Verify and Validate. Verify automatically resets the RTK engines after every fixed epoch is collected in the first step of its process. Epochs are sorted by distance and placed into groups during the first step. Once a group has built up a set level of confidence the RTK engines are allowed to collect the remaining epochs without resetting. If epochs fall too far away from the best selected group from the first step, they are rejected and the RTK engines are reset. Validation is the final step of the process. With this feature enabled the RTK engines will reset one final time at the end of the observation and collect 10 additional epochs. Allowing sufficient time between the first step and the final validation step will guarantee a bad solution is not allowed to be accepted. From extensive testing of these features in the worst of multipath environments, a bad solution has yet to be accepted when the Verify and Validate features are used and 120 epochs are collected.

Matt Johnson, PLS

See Verification Video at **www.javad.com**

JAVAD

Understanding marine cadastre system in Malaysia

Malaysia is currently active in defining the concept and conceptualizing the idea to exercise the procedure of giving right to the marine parcel

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Malaysia is a maritime country with two primary land masses, Peninsular Malaysia and East Malaysia. The country has a total land mass of approximately 330,000 sq km and 4492 km of coastlines. These land masses support a population of 25 million (Chee Hai Teo and Ahmad Fauzi, 2009). Malaysia lies close to the equator between latitudes 1^0 and 7^0 North and Longitudes 100^0 and 119^0 East.

The exploration, exploitation, conservation and management of marine resources within Peninsular Malaysia, Sabah and Sarawak depend on the available maritime jurisdictions which are shared in various ways including by the state government, federal departments and United Nations Convention on the Law of the Sea (UNCLOS).

Table 1: Malaysia Maritime Zone Breadth and Information (Malaysia Maritime Enforcement Agency, 2004)

Boundaries	Area
Internal waters	97,306.83 km sq 37, 571 nm
Territorial waters/sea	63,665.3 km sq 24,581.85 nm
Continental shelf	476,761.87 km sq 184,082.22 nm
Exclusive economic zone	453,186.18 km sq 174,979.43 nm
Coastal area/line	4492 km - 1737 km (Pen. Malaysia) - 2755 km (Sabah/Sarawak
State Jurisdiction - Peninsular Malaysia	17950 km sq
State Jurisdiction - East Malaysia	20250 km sq
Federal Jurisdiction – Peninsular Malaysia	38800 km sq
Federal Jurisdiction – East Malaysia	20300 sq km
Land to Marine	1:2

Although there are no specific legal actions approved related to marine cadastral, but there are a lot of activities related to the right of marine space usage that has been carried out by relevant bodies. General scenario of Malaysian involvement in marine parcel's right, restriction and responsibility are highlighted in this paper.

Malaysian marine zone

In order to fully understand about the marine cadastre, we must look the Malaysian background on maritime legal and its history. The United Nations Convention on the Law of the Sea (UNCLOS) establishes a jurisdictional regime under which Malaysia itself can claim, manage and utilize its maritime territories (United Nations, 1982). Under the legal provision, Malaysia forwards its claim as mentioned in table 1.

There are currently 23 institutions in Malaysia that are involved in the issue of right, responsibility and restriction in the marine area. The full list is given in Appendix A.

Jurisdiction and Authority between Federal and State of Malaysia

As a maritime country, Malaysia has exercised its domestic marine law and adopted international law for the implementation of the nation's maritime policies and boundaries. Malaysia has about 94 domestic laws pertaining to maritime matters and as the solution to cover in diverse matters and maritime issues. As a member of Commonwealth and

United Nations, Malaysia has agreed to the rules and regulations under Law of the Sea (Amy Ai, 2011). Malaysia is engaged in all four Laws of the Sea Convention of 1958 and signatory to the 1982 LOS Convention newly ratified on October 14, 1996. The pertaining laws are listed in Appendix B.

Malaysia's involvement in international negotiations concerning law of the sea - beginning from participation in the First United Nations Conference on the Law of the Sea (UNCLOS I) from February 24 – April 29, 1958; Second United Nations Conference on the Law of the Sea (UNCLOS II) from March 17 – April 26, 1960; Third United Nations Conference on the Law of the Sea (UNCLOS III) from 1973 to 1982, produced several fundamental laws establishing Malaysia's maritime estate of EEZ, extending seawards to 200 nautical miles (Juita Ramli, 1999).

Emergency (Essential Powers) Ordinance, 1969 declares and delimits parts of Malaysia's territorial sea up to 12 nautical miles. However, the marine governance in Malaysia, through the jurisdiction over marine spaces and management responsibilities, are also split between the State and Federal Governments. As a result, the State Jurisdiction covers for Coastal Waters/Area from declaration of baseline until 3nm offshore, whilst the Federal Jurisdiction covers the Territorial Waters from 3 nm to 12nm off shore until EEZ.

This ordinance is an important legal factor as a reference to determination of the power between the State and Federal of Malaysia. This ordinance was promulgated in 1969 by the Yang Dipertuan Agong under Article 150 (2) of the Federal Constitution on May 15, 1969, and under special emergency powers in context with the political development at the time. The reason for declaring a state of emergency was connected with the political instability after the so-called May 13 incident, 3 months prior to the promulgation of Ordinance No. 7. The Malaysian Parliament had been dissolved on March 20, 1969 in anticipation of a general election to be held on May 10, 1969. On May 13, racial riots broke out and 2 days later, the state of emergency was declared under Article 150 of the Malaysian Constitution.

According to the preamble of Ordinance 7, the Yang Dipertuan Agong was satisfied at the time that immediate action was required to promulgate the delimitation of the territorial waters of Malaysia. Urgency was imperative not only for the petroleum sector, but also due to the imminent conclusion of a treaty with Indonesia with regard to delimitation of the continental shelf between both countries. Due to the existence of a grave emergency threatening the security of Malaysia, the Proclamation of Emergency was issued. Whereas the Yang Dipertuan Agong is satisfied that immediate action is required for securing public safety, the defense of Malaysia, the maintenance of public order and of supplies and services essential to community life (Haller-Trost,1996).

Marine cadastre concept in Malaysia

Malaysian land-based legal issue is mainly referred to the National Land Code, 1965 under the title Land Cadastre System. Unfortunately, the execution of this land system is less relevant with maritime environment, particularly to the issues of marine cadastre implementation.

Marine cadastre implementation concept in Malaysia is currently in the development process. Hence, a working group is established with collaboration of local universities particularly with UiTM, UTM and with the Malaysian Directorate of Survey Office. Fundamentally it has been agreed upon that marine space is for universal use and separated into various columns that have a specific reference point, line or polygon. There are spaces which can be allocated for individual, public and for reserve. Sea space is a dynamic platform and the phenomenon is very different from ground. Hence, the concept of giving right, responsibility and restriction to marine space differs from land, although these are common in many aspects.

Hence a definition based on this concept is necessary. Although, there are various definitions on Marine Cadastre as stated for example by Binns et al., 2003 and Ng'ang'a et al., 2003, but Marine Cadastre in Malaysia is currently defined as follows:

A marine cadastre is a 3D marine parcel administration system with respect to the legal and systematic technical arrangement of marine spatial rights, restrictions and responsibilities for marine space activities (Ashraf et al., 2013).

According to Ashraf (2004), there are four major differences of perspective between marine cadastre and ordinary Malaysian cadastre namely:

i) Marine Cadastre is regarding marine spatial information and it leans more towards marine and coastal parcel. Whereas ordinary cadastre is a land registry system in which the land is registered under ownership document and this ownership is tradable. This system is also known as Torrens system and it is being applied and used in Peninsular Malaysia.
ii) Ordinary Cadastre and Marine Cadastre have the most significant difference in marking point of boundary and border. This is odd in the sea environment while is normal to the situation on land. Marine Cadastre uses virtual point based on chart coordinates or its picturesque natural environment.
ii) Marine Cadastre has a different kind of assumption or standard in the application of administration and development of rights, limitations and responsibilities in the sea land area as compared to the land area due to ocean dynamics.
iv) Marine Cadastre ownership right is fundamentally for everyone to share but Ordinary Cadastre gives the ultimate right.

S. Saad and A. H. Omar (2012), in their study on marine cadastre spatial data, have used GIS to develop marine cadastre infrastructure which consists of topographic maps, nautical charts and aerial photographs. The study has provided a methodology and descriptive document on the development of marine data infrastructure which includes physical element, condition,

and the suggested acceptance standard for future development for a sustainable environment.

Marine title/Alienation in practice

Although there is no specific marine title in the marine area but the current practice of marine alienation follows almost the same procedure as applied on land, with a minor difference such as:

- The technical departments in the presence of technical comments involved come from marine institutions such as Marine Department, Drainage and Irrigation Department, Fisheries Department, Maritime Enforcement Agency, Department of Environment, Langkawi Municipal Council (Coastal and Marine Planning Division), Department of Town and Country Planning (Marine Division).
- The applicant must comply with the conditions imposed by the Land Office according to the stated marine space management vision.
- The application is open to the applicant with a proper development plan to the selected marine space, willing to invest in marine activities and the plan will bring benefit to the state.

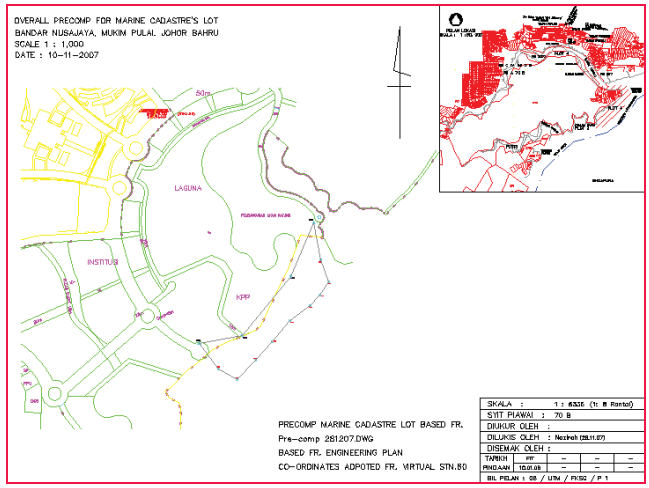

Figure 1: Marine Right Related Activities (Ashraf, 2004)

Until now, the application of marine space right is within the state authority and can be practised within the limit of state boundary's right, endorsed by Malaysian legal documents. Projects of fish cages, cockle areas, ocean recreation areas, ownership of the island and surrounding waters are some common activities applied and granted through Temporary Occupation Licence (TOL), that requires a licence and needs to be renewed annually. However, there are cases of right which were given a Qualified Title to benefit the applicant for a long period as agreed.

Other projects which involve marine navigation right, environment, security, economic and transportation rights are currently handled by federal institutions

Appendix A: Marine Cadastre related Institutions in Malaysia

Institutions /Agencies	Remarks
1. Department of Survey and Mapping Malaysia	As the main institutional in Malaysia given the responsibilities in development of marine cadastre. However, that effort must collaborate with academic institutional to bring out clearly the theory and methodology to apply and also be suitable to implementation and to be consider in marine environment and factor.
2. Maritime Institute of Malaysia (MIMA)	The policy maker and investigator in maritime issue particularly on maritime matters such as boundaries, transportation, port rules and etc.
3. National Ocean of Directorate (NOD), MOSTI	The policy maker on ocean economic and welfare.
4. Langkawi Island Land Office	The main institutional in marine alienation but the implementation just around under state power not involved to federal power.
5. MacGDI	No issue about the marine geospatial data because the agency focus in land data spatial. Later on becoming to establish in marine data spatial infrastructure.
6. Department of Marine	No issue in marine cadastre because involved in operational of shipping and marine transportation only
7. APMM	No issue about marine cadastre but focusing on marine enforcement until 200 nm including the state and federal under act established
8. TLDM	Involved in determination of base point and baseline for Malaysia and only for sovereignty issue not the marine cadastre issues.
9. Marine Police	Focusing on marine criminal enforcement purposes.
10. Department of Fisheries Malaysia	No issue in marine cadastre but done in determination in marine boundary for fisheries for classification and type of fisheries industry. Not in physical but based on radar application in determination marine boundary.
11. Marine Park Department	No issue in marine cadastre because the establishment the marine park is under Sec 41 Fisheries Act 1985 and still follow that regulation including the determination on 2 nautical mile from low water mark in prohibited area and gazette to Marine Park Department. The application used in determination marine boundary and territory was used the GPS.
12. Institute of Ocean and Earth Science, University of Malaya	Related to marine cadastre in subjected unit only and just did in the study for marine science and the characteristic of ocean. Have several unit under this institute especially the marine law unit related to marine cadastre which discussing about the marine spatial elements such as boundary, the marine policy, the data in marine environment.
13. KUSTEM	No issue about marine cadastre only involved and specialized in marine biology and habitat, also the marine ecosystem and marine environment study.
14. UTM	Afford in marine cadastre under Department of Land Information System.
15. UiTM	Afford in marine cadastre, collaborated with UTM in research, seminar, discussion and development of marine cadastre theory and practical.
16. Malaysian Security Counsil	The main party in maritime issue and decision maker to any conflict and disputed area. As the principles in the establishment the Base point and baseline used for Malaysia and as stakeholder in Ordinance No. 7 Emergency Power 1969 in Federal issue in maritime matters.
17. Attorney General Chamber	Involved about the establishment of jurisdiction and related to marine is the 2006 Maritime Baseline Zone Act and the amendment 2006 to Ordinance No. 7 PUA367/69. That requirement is follow the Ministry of Home Affairs, Malaysia.
18. Immigration of Department of Malaysia	No issue in marine cadastre and marine spatial element
19. Royal Malaysian Custom Department	No issue in marine cadastre and marine spatial element
20. Department of Environment	Related to marine cadastre as the stakeholder agency in marine spatial in term of waste dumping issue in marine matters. In this case involved in marine pollution, the impact for marine environment, the testing and maintaining the marine environment ecosystem. Build the procedure and some guideline to control the development in marine and as the evaluator in panel for marine construction.
21. Department of Irrigation and Drainage	Involve in marine cadastre in coastal engineering unit where under this unit the planning and
22. Department of Forest	No issue and idea, that requirement from this agency is about the accurate of area in mangrove for getting the true data and within tolerance.

Institutions /Agencies	Remarks
23. Petronas	Related to marine cadastre in determination of their area in term of agreed by law weather the international or local. That situation is answering the area finding the oil drilled area for beneficial for country. This element about oil and gas industry very important needed in marine cadastre to apply but the existing jurisdiction is also used in it purposes.

Appendix B : Marine Related Laws and Regulation

Category	Laws and Regulations
Port	Penang Port Commission Act1955(Act 140) Port Authorities Act, 1963(Act 488) Port Workers(Regulations of Employment),2000(Act607) Sabah Port Authority(Consequential Provisions)Act 1968(Act25) Declaration of an Area in Bintulu District to be a Federal Port Act 1979(Act217) Bintulu Port Authority Act 1981(Act243) Ports(Privatisation)Act 1990(Act422)
Shipping	1. Carriage of Goods by Sea Act, 1950(Act527) 2. Merchant Shipping Ordinance, 1952 3. Merchant Shipping Ordinance, 1960(Sabah) 4. Merchant shipping Ordinance, 1960(Sarawak) 5. State Boat Rules
Light House	1. Federation Light Dues Act,1953(Act 250)
Non Living Resources	Petroleum Mining Act, 1966(Act95) Petroleum Development Act, 1974(Act144) Petroleum and Electricity(Control of Supplies)Act,1974(Act128) Petroleum (Safety Measures) Act, 1984(Act302) Petroleum (Income Tax)Act, 1974(Act543)
Living Resources/Fisheries	Fisheries Act,1985(Act317) Fisherman Association Act,1971(Act44) LembagaKemajuanIkan Malaysia Act1971(Act49) National Forestry Act, 1984(Act313)
Natural Resources	Continental Shelf Act,1966(Act83) Baseline of Maritime Zone Act, 2006(Act660) Exclusive Economic Zone Act,1984(Act311) Sarawak Natural Resources and Environment(Prescribed Activities) Order, 1994 Sabah Conservation of Environment(Prescribed Activities)Order, 1999 National Land Code 1965
Jurisdiction	Emergency(Essential Powers)Ordinance,1969(Act216) Extra Territorial Offences Act, 1976(Act163) State Land Rule
Enforcement	1. Immigration Act 1959/63(Revised 1975)(Act 155) 2. Internal Security Act, 1960(Act82) 3. Police Act, 1967(Act344) 4. Malaysian Maritime Enforcement Agency Act, 2004(Act633) 5. Military Maneuvers Act, 1983(Act295) 6. Armed Forces Act,1972(Act77) 7. Penal Code(Revised 1977)(Act 140) 8. Custom Act,1967(Revised 1980)(Act 235) 9. Evidence Act, 1950(Revised 1971)(Act56) 10. Poison Act, 1952 (Revised 1989)(Act366)
Tourism	Malaysia Tourism Promotion Board Act, 1992(Act 481) Tourism Industry Act,1992(Act482) Tourist Development Corporation of Malaysia Act,1972(Act481)
Heritage and Antiquity	1. Antiquities Act,1976(Act168) 2. Antiquities and Treasure Ordinance, 1957
Telecommunication	1. Telecommunication Act, 1950(Act588) 2. Telecommunication Services(Successor Company) Act, 19853. Communication and Multimedia Act, 1998(Act588)

Category	Laws and Regulations
Dispute Settlement	1. Convention on the Settlement of Investment Disputes Act, 1966(Act392) 2. Arbritration Act, 1952(Revised 1972)(Act93) 3. Convention on the Recognition and Enforcement of Foreign Arbitral Awards Act, 1985(Act320)
Forestry/Wildlife	1. National Forestry Act, 1984(Act313) 2. Protected Areas and Protected Places Act,1959(Act298) 3. Protection of Wild Life Act, 1972(Act76) 4. Fauna Conservation Ordinance(Sabah), 1963 5. Wildlife and Birds Protection Ordinance, 1955 6. Forest Enactment 1968(Sabah) 7. Forest Enactment 1954(Sarawak) 8. Planted Forest Rules of Sarawak, 1997 9. Land Conservation Act, 1960 10. Malaysian Forestry Research and Development Board Act, 1985 11. National Parks and Nature Reserves Ordinance, 1998

and not seriously taken by the State Authority. This is due to lack of legal support documents to exercise their optimum right in addition to the high cost of management. Currently, there are 14 identified ministries that are responsible for the management of maritime related activities in Malaysia. The responsibility of each ministry sometimes overlaps with the functions and objectives of other ministries (MIMA, 2011). Figure 2.0 highlighted a sample project carried out in the seashore area and were given the appropriate right by local authority.

Conclusion

Marine cadastre is about the right, restriction and responsibilities of stakeholder to any marine parcel. Although the concept of giving right to any parcel is about the same, but there are differences between marine parcel and land parcel's right due to each unique phenomena which contributes to the differences of approach in applying the cadastre concept. Recently the concept and procedure used in Malaysian Land Administrative system of NLC for land system was directly or indirectly used in giving such a right to the marine parcel. Although it was found that the approach was not that appropriate, but the only complete procedure of the cadastre system implementation in Malaysia was given in the NLC. It was found that the existence of various marine legal in the country was irrelevant to the need and their existence was probably designed for empowerment of duty. Malaysia is currently active in defining the concept and conceptualizing the idea to exercise the procedure of giving right to the marine parcel. The approach of implementing the concept has been taken since 2010 and has produced some implementation models. However, it was found that the detail of each component in the model needs further elaboration and improvements. The maritime sector is now recognized as a critical sector which contributes significantly to the Malaysian economy. Being a littoral state, the economic activity of the country is dependent to a large extent on the ability to manage its marine resources. Hence, the need for an amendment of the law and use of great technology are important actions and must be taken to ensure the implementation of a proper marine cadastre concept and make it a reality. Few researchers such as S. Shabudin, (2012), observed that the existing law in practice was weak to govern marine parcel's right, responsibility and restriction enforcement. It was clear that a new marine parcel management law was ultimately necessary with due respect to the concept of power separation in practice between federal and the states.

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Costing and financing of land administration services

CoFLAS is a land tool developed by the GLTN to provide support to national governments and public agencies in identifying and costing optimal methods for land administration service reform

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Public agencies the world over continue to be challenged by citizens to rationalise the cost and quality of public service provision, particularly during repeated cycles of financial crises. The problem is even more pronounced in developing countries, where allocation of public resources must grapple with competing priorities of critical sectors such as health, education, water, infrastructure, etc. The land sector, whilst underlying such sectors, is less visible. It has typically relied on international development resources, a dependency aggravated by the declining availability of such funds for public services. Having observed this trend over the years, GLTN identified Modernizing the Budgetary Approach of Land Agencies as an important area of tool development. This thinking underpins the development of the Costing and Financing of Land Administration Services (CoFLAS) tool.

The objectives of this paper are to:

- Sensitize stakeholders on CoFLAS and the need for urgent solutions that redefine such services in the context of their usefulness to society as custodians of land and property information
- Provide a validation of the tool, based on an Expert Group Meeting in Bangkok, October, 2014

Introduction

CoFLAS – the Costing and Financing of Land Administration Services for Developing Countries Tool – has been developed to address a core need of enabling public agencies to effectively cost the establishment and operation of a land administration service (LAS).

A component of the Global Land Tool Network's (GLTN) Modernizing the Budgetary Approach of Land Agencies tool development, CoFLAS has been developed at a time of decreasing international development budgets and increased competition across critical public sector priorities including health, education, water, infrastructure, disaster mitigation, etc. The core aim of CoFLAS is to assist decision-making in the land sector, by promoting a 'Fit-for-Purpose' approach to ensure that LAS are provided in a cost-effective manner that focuses on service-delivery for all, not just the wealthy.

This paper is extracted from a consultancy report prepared for and financed by the Global Land Tool Network (GLTN). It is part of a longer consultancy report that LEI produced with contributions from GLTN partners, staff and other stakeholders. This paper presents an overview of the CoFLAS tool and follows on from a summary paper presented at the Conference on Land Policy in Africa (CLPA), held from 11th – 14th November 2014 in Addis Ababa. Whilst there is some overlap between these two papers, this paper concentrates on the validation process and potential future implementation of CoFLAS. For further background on the methodology for developing CoFLAS, readers should refer to the CLPA paper and the forthcoming GLTN publication.

Role of CoFLAS

Noting the financial challenges many land agencies face, CoFLAS is a mechanism to provide a business case for funding of LAS through a cost and financing tool. The core contribution of CoFLAS is its role in

supporting decision-makers to identify:

i) The policy context that drives LAS reform (core needs assessment);
ii) Options for implementation that identify decision-impacts (such as immediate and ongoing cost, in particular to acknowledge that 'best is not necessarily optimal');
iii) The costs of LAS reform, based on selected optimal implementation methods; and
iv) Potential revenue from LAS reform implementation.

CoFLAS is implemented by decision-makers in government, using a four-stage approach outlined in Section 3. It may also be implemented by supporting development partners or Ministries to assess a proposal for LAS reform.

What does CoFLAS do?

CoFLAS is essentially a decision-support tool for land administration. It prompts discussion on a country's readiness for land reform, and provides a series of templates to assist public agencies to identify the core needs and necessary investment for land reform processes. The CoFLAS assessment includes:

- A detailed, systemic analysis of context and approach to land governance in-country;
- Preparation of a tenure typology and the legal and institutional frameworks that support this tenure topologies; and
- The essential requirement that LAS services are provided in a cost-effective manner that focusses on service delivery for all sectors in society, particularly the poor and disadvantaged.

This last point is core to the fit-for-purpose approach embodied in CoFLAS. CoFLAS implementation acknowledges that significant effort may be required to improve the geographic coverage and quality of data in developing countries where existing LAS are likely to be incomplete. Making such improvements, will broadly improve the cost-effectiveness, efficiency, sustainability and affordability of land related services, both to government and society in general.

As identified in the previous section, CoFLAS is primarily a tool that supports governments and government staff for the following purposes:

(a) Preparing proposals for LAS reform (land sector staff);
(b) Assessing such proposals and making a case for support within government and from development partners (Policy makers); and
(c) Reviewing LAS reform proposals and ensuring that such proposals provide value for money (Ministry staff and Development partners)

A number of items are out of scope for the CoFLAS tool, and these have been dealt with in detail in the CoFLAS Report, with reference to a number of other authors. In summary, CoFLAS is not intended as a tool to decide on why or how to undertake land administration reform – authors Deininger (2003) and Dale & McLaughlan (1999), among others, provide excellent materials that do this. Similarly, CoFLAS does not identify or quantify the benefits of undertaking LAS reform - Williamson et al. (2009) provide an excellent reference for this task. Finally, CoFLAS does not assist with the troubleshooting of problems to address core land administration issues or prioritisation of LAS implementation steps *(see instead Dale and McLaughlan, 1988; USAID, 2013; Deininger, Selod & Burns, 2012).*

Instead of the above, CoFLAS recognizes the many and varied approaches and circumstances that will impact key decisions surrounding LAS reform, such as approach, legal provisions, survey/mapping methodology and technology. These key decisions will in turn have serious implications on the cost and viability of land administration reform, and CoFLAS seeks to capture these. CoFLAS provides the framework for highlighting the options available at key decision points and the related cost and financing implications of decisions made. In many cases these key decisions are not explicitly set out in proposals for land administration reform and there may be little or no analysis of options or alternative strategies or approaches. The core objective of CoFLAS is thus to highlight the options for key decisions – suggesting a fit-for-purpose approach - and the related cost and financing implications.

How does CoFLAS sit with other GLTN tools?

The GLTN partners have identified 18 key land tools that together are needed to address poverty and land issues at country level, promote innovative land policies and laws and enable land systems to work for the poor, be gender and youth responsive and address issues of customary and informal land. Over the last decade, GLTN has made notable progress in developing and piloting a number of these tools. Some have matured (e.g., the Social Tenure Domain Model, STDM), whilst others are at the piloting stage or under development. STDM provides the technical backdrop to enable affordable and responsive land administration systems, while the Gender Evaluation Criteria (GEC) supports inclusive and equitable land administration. The valuation of unregistered land, another tool under development, is vitally important to unleash pro-poor compensation, land and property transfer as well as taxation in hitherto neglected communities and these are all important variable in the financial equation underpinning the importance of CoFLAS. Though the present version of CoFLAS tends to focus on the formal end of the Continuum of Land Rights (another GLTN tool), subsequent versions will support the understanding of less formal aspects to strengthen linkages with tools that are specifically meant to support less developed systems.

CoFLAS also seeks to promote and is supported by a Fit-for-Purpose approach, drawing on the work of the International Federation of Surveyors (FIG) and the World Bank in their joint publication Fit-for-Purpose Land Administration (FIG/World Bank, 2014). Whilst not a new term, in this context Fit-for-Purpose is newly applied to the building of sustainable land administration systems. It indicates a need for flexibility in the approach used for building land administration systems in less developed countries, including a focus on citizens'

needs, such as providing security of tenure and control of land use, rather than technical solutions or high accuracy. The following elements have been identified as core to the Fit-for-Purpose approach:

- Flexible in the spatial data capture approaches to provide for varying use and occupation.
- Inclusive in scope to cover all tenure and all land.
- Participatory in approach to data capture and use to ensure community support.
- Affordable for the government to establish and operate, and for society to use.
- Reliable in terms of information that is authoritative and up-to-date.
- Attainable in relation to establishing the system within a short timeframe and within available resources.
- Upgradeable with regard to incremental upgrading and improvement over time in response to social and legal needs and emerging economic opportunities. (FIG/World Bank, 2014)

Central to the adoption of a fit-for-purpose approach is the review of a country's legal and institutional framework in order to identify any conflict that should be revised. Such a conflict may, for example, result from unnecessarily strict accuracy requirements for surveys that limit the application of a fit-for-purpose approach. In addition to enshrining the fit-for-purpose approach in law, supporting frameworks and information accessibility should also be reviewed. This element is captured through the first and following stages of CoFLAS.

Steps to implementing CoFLAS

There is great variety in land administration arrangements and systems globally. Even with the qualifications on the scope, CoFLAS must be fairly generic in its formulation in order to be applicable to multiple countries. CoFLAS is thus implemented in a sequential manner through four stages, each of which includes a series of tables that assist implementers to identify the key decisions to be made (across policy and budgetary levels) and the impacts these decisions will have on reform. Due to the inherent flexibility of the tool, these tables are expected to be guiding rather than exhaustive. At the end of the process, the CoFLAS tool should have guided implementers to an understanding of the key existing (and relevant) policies and institutions in place, the key needs and issues in play, the necessary components of reform (fitted to the current status and contextual needs) and an estimate of the costs required for both establishment and ongoing operation. To particularly support the justification of these costs, and the development of an elevator pitch, additional sections on estimating potential revenue, based on decisions made, have been developed. The following sections describe the stages of CoFLAS in detail.

How does CoFLAS work?

There are four stages to the application of CoFLAS. Each stage contains a set of policy and contextual questions that should be addressed – these provide the basis for making decisions on reform and systematic registration methodologies, which in turn impact the estimation of related costs. The four stages are: (1) Readiness Assessment; (2) Commencement Cost Assessment; (3) Operational Cost Assessment; and (4) Likely Revenue Assessment. These are outlined below.

Stage 1: Assessing LAS Reform Readiness

Whilst CoFLAS has not been created to design and implement land administration reform, users of CoFLAS need to understand the existing LAS and supporting framework (policy, legal and institutional) in place to readily understand the key cost implications and possible alternative approaches.

The following information is gathered in Stage 1 of CoFLAS:

1. Key policy issues that impact on establishing a LAS in the country;
2. Information to estimate the number of properties;
3. Analysis of existing records of rights in land
4. Preparation of a tenure typology for the country and an estimate of the properties that could be registered;
5. Preparation of an Institutional Matrix to identify key institutional actors and potential overlaps
6. A review of the major LAS processes with proposals for reengineering
7. Demonstration of knowledge of:
   - the key issues,
   - the status of stakeholder consultation,
   - other government initiatives and existing development partner support.

This section particularly supports the drafting of an 'elevator pitch', in order to generate wider support for reform initiatives.

Stage 2: Establishing broad LAS geographic coverage

CoFLAS has been designed to look not only at the ongoing operational costs of running a LAS but also at the costs of establishing a LAS in the first place, ensuring broad geographic coverage across the country. This is particularly important given that decisions, such as the level of administration providing services to the public, have both establishment and ongoing operational cost implications.

The approach adopted in CoFLAS assesses the following generic costs in establishing an LAS with broad geographic cover:

1. Completing first registration
2. Establishing a spatial framework for land administration
3. Establishing the physical infrastructure to support LAS
4. Implementing ICT to support LAS
5. Capacity development
6. Project management.

These topics generally cover the activities that require a major investment in resources and funds in undertaking LAS reform. The requirements in each country will vary; in some countries there may be complete first registration whilst in others there may be a recent investment in ICT, perhaps as part of a broad eGovernance initiative. The implementation of this stage

of CoFLAS needs to be adapted to the local context, but generic processes and forms are provided as part of the tool.

Stage 3: Cost of Running a LAS

The annual operational costs of LAS will depend upon a number of factors, including:

- the scope of services provided by the LAS;
- the approach adopted in key legal and technical areas;
- the role of the various actors, particularly central government, local government and the private sector; and
- the extent that LAS service delivery is decentralised.

Decisions on many of these factors will have been made explicitly or implicitly as the LAS is established. The cost implications of these decisions in establishing a LAS were reviewed in Stage 2 of CoFLAS. At Stage 3, the cost implications of these decisions in the on-going operations of the LAS are considered.

LAS operational costs were developed in CoFLAS through the review of a number of (developed and developing) country case studies, via a questionnaire developed at an expert group meeting and a number of pilots. Stage 3 concentrates on LAS activities of land registration, cadastral surveying and valuation. Data for land use planning and taxation were deemed to have too great a variety across how these services were implemented to be able to draw useful, generic information, and thus have not been included. The process data gathering and tool validation is ongoing and will be used to refine future versions of the tool – indeed, the Validation workshop discussed at Section 4 noted an opportunity for an online repository of such information that would guide the ongoing review and refinement of CoFLAS.

The framework developed for estimating the annual operating costs of a LAS references the number of properties and the decisions made around the way in which LAS services are managed, rights are measured, and spatial framework is implemented. The annual cost applies to a system where the registration is complete, noting that fewer resources would be required to manage LAS in a jurisdiction where registration is incomplete. The framework includes salary and other recurrent costs, and is applicable globally. The framework, however, excludes major investments that may be required over time, such as CORS maintenance or upgrading, or updated mapping.

Stage 4: Revenue generation resulting from LAS

Governments and decisions makers undertaking CoFLAS implementation and LAS reform will be interested in potential sources of revenue. In the development of CoFLAS, two main potential sources of revenue from LAS were identified:
(a) annual land and property taxes and
(b) the taxes, fees and charges levied on transactions or LAS services.

In most developed countries land-related taxes, fees and charges can be a significant source of government revenue, particularly for local governments. Well-developed LASs enable cost recovery, and revenue generation, from the schedule of fees and charges for the provision of land administration services, such as the first registration of rights, the transfer of registered rights, and the registration of survey plans etc. Revenue above and beyond cost recovery may be allocated to essential infrastructure, including regulatory oversight, development and maintenance of ICT systems, the establishment and maintenance of a geodetic reference frame, etc. Under this arrangement the users of land services or those who benefit from the services, are bearing all or most of cost of the system, rather than having all taxpayers carry the cost of land sector services as they do for many public services such as law enforcement, public health and education.

Even with well-developed LASs there is a tension between the objective of recovering the cost of providing services and the need to ensure that land services are accessible and affordable for all sectors in society. In less well-developed land administration systems, the systems to record rights are often very incomplete in terms of geographic cover and the nature of the information recorded. In many African countries less than 5 percent of properties are registered in the formal LAS. This lack of a complete set of records makes it impossible to consider recovering the cost of land services from user fees and charges in a manner that is not a major barrier for participation in the formal system, particularly for the poor and vulnerable. As a result, development partner support or direct budget allocation may be required in these situations until such time where a more complete LAS is in place.

The potential revenue that might be obtained from an annual property tax will be based on the estimates for the number of properties together with information on the rate for the tax and how it is determined (that is the average characteristic that determines the tax, which might be area or value and the rate at which the tax is assessed). An estimate of the expected annual property turn-over, or the percentage of properties that are sold each year, is also required in order to estimate revenue from transfer and other related services. Forms to assist and guide these estimates are presented in the CoFLAS Report.

Financing LAS Reform

A final component of CoFLAS that sits outside the four stages, is the identification of opportunities, partners and pathways to finance a program of LAS reform. As a public service typically a provided by government, land agencies face a multitude of challenges in implementing strong programs of LAS reform. Arguably, chief among these challenges is the ability to provide affordable, cost effective, efficient and sustainable services to the majority of potential clients.

The service provision challenges that land agencies face are attributed to a number of factors including:

- Out-dated service delivery and reliance on expensive and time consuming processes and systems; and a
- Lack of adequate funding to produce and deliver services, to develop and maintain the fundamental systems necessary to provide services (land records management systems, ICT systems, geodetic reference frames, etc.), and to develop the human resources and capacity to provide services, etc.

Policy decisions related to land related taxes, fees and charges need to particularly consider an best approaches that promote an appropriate mix of annual taxes and/or transaction/service based taxes, fees and charges, that do not inequitably skew access to LAS.

Acknowledging the above, there are a number of strategies that can be adopted to finance LAS over the long term. The options include:

(a) Full funding by government as a public service

(b) Setting fees and charges to fully or partially recover the cost of providing LAS services and therefore transferring the cost of providing LAS services from government to users of LAS services

(c) Transferring core parts of LAS delivery to others such as local government or private sector service providers (lawyers, notaries, private surveyors) that have the ability to recover costs through user charges

(d) Separating the regulatory and service provision LAS functions and outsourcing the service provision function to the private sector under some form of public-private-partnership.

There is a major cost in establishing a LAS and there are limited opportunities to recover this major cost from user fees and charges. The cost of developing an LAS with broad geographic cover should be understood as an investment in public infrastructure. A systematic approach in establishing a LAS that typically involves the mobilisation of teams to the field with extensive community consultation has proved cost-effective and transparent. Charging fees can create barriers to participation in a systematic process and as a result many governments underwrite the cost of establishing LAS under a systematic process, often with development partner support, and seek to recover this initial investment through fees and charges on subsequent dealings and services.

From the above it seems clear that for less well developed systems public funding with possible development partner support is the most likely source of funding for LAS reform. However, LAS data has been shown to have a public good role above and beyond basic provision of LAS services (see de Vries, 2012 and Williamson et al. 2009), and this should be recognised when deciding how LAS reform and services are financed. Such a role enables financing via user access fees and user change/update fees in addition to government funding.

Regardless of the options for financing considered, government needs to ensure that there is little, if any, restriction on the use of LAS data as a fundamental dataset for existing and future needs as part of a National Spatial Data Infrastructure and/or Spatially Enabled Government. This point is particularly critical in the case of private sector suppliers or public-private partnerships.

CoFLAS Validation Process

Having provided an overview of the CoFLAS tool as it has been developed to date, the following section provides an overview of the validation methodology and outcomes. The CoFLAS Validation Workshop was held in Bangkok, Thailand, from 14th – 15th October 2014 and was organized by the International Federation of Surveyors (FIG), with support from the UN-Habitat Global Land Tool Network. The workshop was organized in three sections: Firstly, reflections on and background to the project so far; secondly an overview of the tool, with discussion; and thirdly, breakout sessions to validate the tool through a series of discussion questions.

Key strengths and opportunities of CoFLAS

Key strengths of the CoFLAS tool include its comprehensiveness, the evidence base used to support the costing estimates and its conceptualization of LAS in a manner that supports optimal – rather than 'best' – approaches tailored to specific country contexts. The tool allows for scenario development and priority setting in promotion of fit-for-purpose applications.

This latter point is best demonstrated through the 'equaliser' concept, presented during the workshop by Kadaster International Director, Kees de Zeeuw. He identified the key need for CoFLAS as being the ability for decision-makers to identify costs and necessary financing, and the ability to compare costs across the variety of implementation methods – acknowledging that optimal solutions are fit-for-purpose for the context of the implementation. The 'equaliser' concept depicts the range of simple (low cost) through to complex (high cost) measures, and the need to balance these for a range of criteria and requirements. The tables within each stage of CoFLAS provide guidance on the impact of each decision made, and, taken together, the stages promote a fit-for-purpose approach emulating the equaliser metaphor.

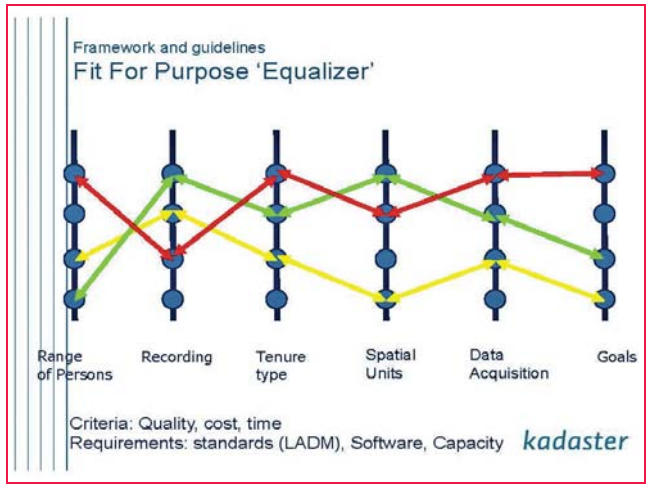

Figure 1: Fit-for-Purpose Equaliser (de Zeeuw, 2014)

General discussion

Whilst the CoFLAS tool was validated as a useful tool and ready for implementation, a number of core issues were raised multiple times throughout the workshop, summarised as follows:

A need to further discuss the role and scope of CoFLAS

Participants, particularly those new to the GLTN and GLTN toolkit, identified a need to know more about how CoFLAS sits within and beside existing and proposed tools, such as the Continuum of Land Rights, the Social Tenure Domain Model, and other tools within the land profession, such as the concept of Fit-For-Purpose. As could also be anticipated, extensive discussions were held on what the scope of CoFLAS should be, and how flexible the tool can be made whilst still remaining specialised enough to assist country governments. The scale at which CoFLAS should be applied was also discussed. CoFLAS can additionally play a role in addressing fragmented governance of land and legacy systems. These points have to some extent been addressed (for example, an earlier section to this paper better describes the GLTN land tools and their relevance to CoFLAS), and to some extent will continue to be addressed through the pilots and further refinement of CoFLAS (for example, addressing the scale at which CoFLAS can be rolled out).

Absoluteness of numbers and management of expectations

In the methodology section of CoFLAS, a number of examples are given for the real-world costs of implementing systematic registration. These costs are dependent on country context, direct funding and expertise received from external development partners, and the approach to systematic registration implemented that will impact not only cost but accuracy, data quality and future costs. Following the workshop, the CoFLAS examples provided were updated to ensure that expectations regarding costs were managed.

The need for an 'elevator pitch' to enable local implementers to garner support from decision-makers

The elevator pitch is enabled by the early policy questions at Stage 1, which explore the existing status, issues, roles and processes relating to LAS in place, including the institutional, policy and legal context. The role of the elevator pitch is also to enable surveyors to challenge the status quo, and will provide a useful tool in driving LAS reform.

Core pilot needs

The core strengths and objectives of the CoFLAS tool saw it validated and approved at the workshop. The discussion additionally provided some key changes to be made to the CoFLAS tool prior to publication by GLTN, and to be particularly reviewed at the pilot stage. An essential change needed was the restructuring of the tool to better guide implementation: the four stages of CoFLAS would be reviewed to provide an implementation manual for the tool, complete with a spreadsheet template to simplify costings.

Piloting of the CoFLAS tool – by both developed and developing countries (and potentially municipalities) – is likely to provide more examples and methodology options to guide future implementation.

However, in spite of the positive benefits of piloting, the structure and implementation of pilots will need to be controlled such that the likelihood of a successful pilot is promoted (success being measured by the potential for the pilot to contribute to the development of the CoFLAS methodology). Successful pilots will therefore require political will, in-country capacity, a broad range of experiences and validation and evaluation of results.

Future Work

The CoFLAS tool has been published by the Global Land Tool Network Secretariat online at www.gltn.net. Many goverments have shown interest in the tool and plans are underway to pilot it. Additional future work may include the further evaluation (following pilots) of the value of the tool and any need for revision, as well as the compilation of country data to further refine the tool and ensure realistic and quality outputs. A key addition to the scope of the CoFLAS tool may be the development of guidelines to estimate potential revenue from the sale and licensing of LAS-generated data to further support and justify reform efforts where needed.

Conclusions

CoFLAS is a land tool developed by the GLTN to provide support to national governments and public agencies in identifying and costing optimal methods for land administration service reform. It addresses the core need of enabling public agencies to effectively cost the establishment and operation of a land administration service (LAS), providing a series of templates in tabular form to guide fit-for-purpose decision-making. It does not compete with existing literature or tools to quantify the benefits of LAS reform or troubleshoot existing LAS issues, but it is supported by and supportive of a range of GLTN land tools that promote pro-poor, inclusive and accessible land policies.

A number of countries have provided data to ground the CoFLAS tool, ensuring its effective application. Further refinement of the tool will occur during the pilot phase, during which time additional case studies may be gathered from both developd and developing countries. Gaps remain for further research, including identifying the application of CoFLAS at different scales, the application of CoFLAS to valuation and planning arenas, and opportunities to capitalise on spatial data generated by reform.

Ultimately, the development of CoFLAS thus far supports the GLTN methodology of utilising intense consultations and multi-stakeholder partnerships to develop innovative and essential land tools that address common land and governance needs.

Acknowledgements

The authors would like to acknowledge the funding provided to GLTN for this project from the Norwegian, Swedish and Dutch governments that enabled the development of this and many other GLTN land tools. Sincere thanks are also provided to Kadaster International, Lantmateriet and the International Federation of Surveyors for their work in developing CoFLAS.

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In Coordinates

10 years before...

mycoordinates.org/vol-1-issue-4-september-05/

SURVEYING

Height of Mount Everest

On 5 May 1999 at 1030 Hours Nepal, for the first time, a survey team placed a GPS receiver on the Mt. Everest peak and was able to collect a good data. Now read on!

MUNEENDRA KUMAR, PH.D.

It is important to note that each new height determination may not necessarily mean that the Everest is going up or down. But, of course, there will always be a scope for accuracy improvement.

POSITIONAL ACCURACY

Positional accuracy and integration of geographic data

Recent Positional Accuracy Improvement initiatives across Europe, North America and elsewhere suggest the need to constantly update and manage the geographic data to reflect ongoing changes in the real world. This article focuses on the consequences of changing reference frameworks for managing geographic data.

CARSTEN RÖNSDORF

Positional Accuracy is an issue of Geometric Interoperability that is becoming more and more relevant in many countries and is largely triggered by the widespread use of GPS as a very accurate surveying and positioning technique. PAI is often seen as a painful exercise. In practice, supported by British Waterways' experience, the preparation and planning can be quite complex but the application is fairly easy and straightforward, even for a bigger organisation with thousands of users.

CADASTRAL DATA

The role cadastral data modelling in e-Land administration

This paper describes the importance of cadastral data modelling in data management as well as coordination among subsystems in an e-LA

KALANTARI M, RAJABIFARD A, WALLACE J AND WILLIAMSON I

GEOID

Malaysia precise geoid (MyGEOID)

The Malaysian geoid project (MyGEOID) is unique where the whole country is covered by with dense airborne gravity with the aim to make the best possible national geoid model

AHMAD FAUZI NORDIN, SAMAD HJ. ABU, CHANG LENG HUA & SOEB NORDIN

The Malaysian gravimetric geoid is apparent accurate to few cm r.m.s, with larger errors closer to the international borders (Forsberg, 2005). The geoid is fitted to GPS-levelling information, and any errors in HLevelling and hGps, will directly affect the high quality of the gravimetric geoid; in other cases it will help control longer wavelength errors. The balance between fit of GPS, and errors in geoid and GPS, is delicate, and undoubtedly there will be many regions in the present geoid where GPS users can expect problems due to fitting of GPS-levelling data with errors.

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G3100-R2
Positioning System
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W-800N
Windows CE Total Station
A highly sophisticated system with auto focus function

Chinese Unicorn team hacks GPS at DefCon

In a session at the DefCon security conference in Las Vegas Aug. 7, Lin Huang and Qing Yang, researchers with Qihoo 360's elite Unicorn Team, revealed how they were able to successfully spoof GPS information.

"Our primary mission is to guarantee that Qihoo 360 [a Chinese Internet security company with more than 450 million users] is not vulnerable to any wireless attack," Yang said about the Unicorn Team. "In other words, Qihoo360 protects its users and we protect Qihoo360."

For civilian usage, GPS c/a (course/acquisition) signals are used, which are typically unencrypted, Huang said. By making use of a Universal Software Defined Radio Platform (USRP), Huang said that a replay attack is possible. In a replay attack, a GPS signal is first recorded and then played back from another device to confirm that the same signal could be used.

Going a step further, Huang said she wanted to see if it was possible to actually create a fake GPS signal, instead of just replaying a signal. It turns out that's also possible, as she showed a video where the location of a GPS device that was actually in Beijing was shown to be Las Vegas. *www.eweek.com*

10th GPS IIF Satellite launched

On July 15, 2015, the U.S. Air Force and its mission partners successfully launched the 10th Boeing-built GPS IIF satellite aboard a United Launch Alliance Atlas V from Cape Canaveral Air Force Stations.

China to deploy Beidou navigation system to track flights

China will use Beidou system to track civilian flights, in an attempt to avoid mysterious disasters. The Civil Aviation Administration of China (CAAC) said the Beidou satellite navigation system (BDS) will be tested on general aviation first before it is used to monitor passenger or cargo flights. *http://articles.economictimes.indiatimes.com*

Updated GLONASS for Russian Defense Ministry by 2016

Russia's GLONASS satellite navigation network, updated in compliance with the Russian Defense Ministry requirements, will be made available for use by the ministry by the end of 2015. The updated version of GLONASS will show significant changes in the system. *http://sputniknews.com*

Nicaragua to host GLONASS Ground Stations

The stations are expected to become operational by July 2016. Initially, the work of the Glonass stations will be handled by Russian specialists and will then be gradually passed on to Nicaraguan workers as they finish their training. The stations will allow to gather satellite information 24 hours a day. *http://sputniknews.com*

New BeiDou GNSS Satellites operational

China's two most recently launched BeiDou navigation spacecraft have begun operating and established inter-satellite links in the nation's GNSS constellation.

The two satellites were launched on July 25 by a Long March III-B rocket from the Xichang Satellite Launch Center in Sichuan Province, southwest China.

Russia May Introduce Glonass-Based Navigation System for Light Aircraft

Russia may introduce a system of automatic dependent surveillance for light aircraft on the basis of Russia's Glonass satellite navigation network. The system be piloted in Moscow and the Moscow region as air traffic is heaviest in there. *http://sputniknews.com*

Myanmar implements its first PBN procedures

Operators using Myanmar's two busiest international airports, Mandalay and Yangon, can finally begin using Performance Based Navigation (PBN) practices after the country's civil aviation authority approved and validated their first ever GPS-based procedures, which were badly needed in the country. Both airports have now unlocked the use of PBN, after flight validations were completed at the end of July through collaboration between experts from Hughes Aerospace and Honeywell. *www.aviationtoday.com*

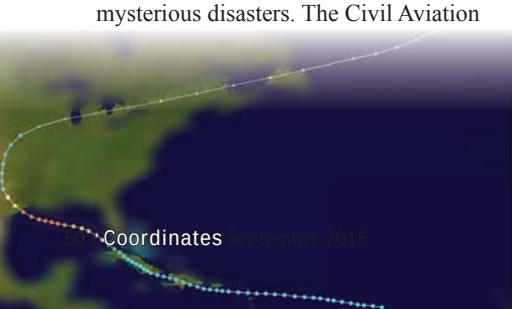
FAA to change navigation codes named after Donald Trump

The Federal Aviation Administration (FAA) said it would rename three navigational waypoints that are currently named after Republican presidential hopeful Donald Trump. FAA spokeswoman Laura Brown said the so-called "fixes" are used by pilots as waypoints to determine their position on a route. The three at issue are located near Palm Beach International Airport in Florida. It is not uncommon in the United States to name flight coordinates after celebrities. *www.unionleader.com*

ESA publishes a document detailing salvage of Galileo 5 and 6

Due to a misfire in the Fregat stage of a Soyuz launch vehicle, Galileo satellite numbers 5 and 6 were left in the wrong orbit and rendering them useless. Much work was done in the days following, communications established, the satellites were turned towards the sun and power from the solar panels restored. This ensured that the satellites were safe but it meant that they could not be used for navigation as intended.

Now the ESA have published a guide, written in layman's terms, detailing their work and the subsequent orbit adjustments that have been made to enable both satellites to be used for navigation, albeit in a limited capacity.



ROI calculator for precision agriculture

The American Farm Bureau Federation, Informa Economics and Measure, a drone as a service company, have released a study that identifies and quantifies the benefits of drone technology in precision agriculture. Version 1.0 of the Return on Investment (ROI) Calculator quantifies the economic benefits of drone as a service for three applications: field crop scouting, 3D terrain mapping and crop insurance. It initially covers corn, wheat and soybeans—three of the largest production crops—which allows growers to quickly and easily determine if drone technology would be worthwhile after getting results from farm data entered into the ROI Calculator.

NMSU to inspect Elephant Butte Dam using drone

New Mexico State University has been selected by the U.S. Bureau of Reclamation to conduct the first dam inspection using an unmanned aircraft system. NMSU will collaborate with the Bureau of Reclamation staff to develop the concept of operations, address safety requirements, select the unmanned aircraft system and appropriate sensors, flight procedures and to perform the inspection. The research project will gather information with unmanned aircraft systems as a tool for infrastructure inspection in the future using light detection, ranging, infrared, photogrammetry and HD video. *www.usbr.gov/research*

FAA Approval for use of Drones in Commercial Ag Ops

Sentera has been approved by the Federal Aviation Administration (FAA) to operate drones for commercial applications. The company's equipment has over 20,000 hours of total flight time. In 2014, Sentera equipment captured 15 million photos, mapped more than 24,000 square miles, logged over 12,000 hours of flight time and managed over 175,000 GB of data.

Drone no-fly zone in California will stifle innovation

California lawmakers have sided with privacy advocates to pass a bill that bans drones from flying lower than 350ft (106m) over private property. If the bill is signed by Governor Jerry Brown it will create a no-fly zone and make it a trespass violation for someone to fly an unmanned aircraft or drone over private property below 350ft without the consent of the owner or tenant. SB 142 passed a third reading in the California State Assembly despite pressure from drone users and manufactures who say the new law will stifle innovation in the growing industry. *www.theguardian.com*

Drone delight: North Dakota test site set to fly high at all hours

Of the six sites in the U.S. where researchers are trying to figure out how to integrate unmanned aircraft into civilian airspace, only North Dakota's can fly high both day and night. The FAA approved a plan recently that allows drones to be flown up to 1,200 feet above the entire state and permits flights at night, a combination that makes North Dakota unique, since other test sites are limited to a 200-foot blanket and daylight hours.

DOT IG To Audit UAS Approvals

DOT's Inspector General (IG) plans to begin an audit this month of FAA's current processes for approving civil unmanned aircraft systems (UAS) operations and overseeing their safe operation, noting "the significant and complex challenges" of safely integrating UAS into the national airspace system.

The IG noted that, "UAS technology is rapidly advancing, with a vast array of potential commercial applications, such as filmmaking, precision agriculture, and package delivery. Some analysts have predicted that as much as $91 billion will be invested in UAS technology worldwide over the next decade. However, until recently, FAA has prohibited commercial UAS operations with very limited exceptions due to the lack of regulations governing their use." *www.aviationnews.net*

Supply of TerraSAR-X data for Copernicus Data Warehouse extended

Airbus Defence and Space, owner of the commercial distribution rights for TerraSAR-X data, and ESA have signed a contract securing the continued supply of TerraSAR-X data for the Copernicus Data Warehouse. The agreement is valid until the end of 2020, thus continuing the successful cooperation between Airbus Defence and Space and ESA for the provision of TerraSAR-X data to public institutions across Europe in place since 2008. TerraSAR-X has been a key data source particularly for activities addressing emergency and security related issues, reliable monitoring needs, and land cover change, both in Europe and beyond.

Satellites Support Crop Yield Estimations in Turkey

Airbus Defence and Space delivers SPOT 6 and SPOT 7 satellite data in support of the TARBIL (Agricultural Monitoring and Information System Project) project in Turkey. TARBIL is a highly technological and comprehensive agricultural monitoring project fusing multi-temporal in-situ data from 44,000 sensors across Turkey with SPOT 6 and SPOT 7 satellite images. Airbus Defence and Space has been supporting the project since 2012, when it signed two agreements with the Istanbul Technical University (ITU) that aimed to develop high-resolution and large-area coverage services in Turkey, particularly for agricultural applications.

Egypt, Germany sign deal to launch satellite by 2017

A new Egyptian Satellite will be launched by 2017 per an agreement signed between the National Authority for Remote Sensing & Space Sciences (NARSS) and Germany. The satellite hardware would be German while the software part would be Egyptian. *www.thecairopost.com*

Galileo update

Galileo satellites are "topped off" for Arianespace's upcoming Soyuz launch

The two European Galileo navigation satellites for Arianespace's next mission from French Guiana have been fueled at the Spaceport, readying them for integration with their Soyuz launcher.

These spacecraft were "topped off" during activity this week at the Spaceport's S3B payload preparation facility, further advancing preparations for the September 10 mission - which is designated Flight VS12 in Arianespace's launcher family numbering system, signifying the 12th liftoff of the medium-lift Soyuz vehicle from French Guiana.

Flight VS12's satellites are the fifth and sixth in Galileo's full operational capability (FOC) phase. *www.spacedaily.com*

Partnership to develop high performance receivers for Galileo satellite systems

Two European companies are partnering up to develop a robust and high performance receiver to take advantage of the new Galileo satellites.

Airbus Defence and Space says it will use Lime Microsystems' Field Programmable RF transceiver technology to develop a timing receiver capable of exploiting signals from the new Galileo satellite navigation constellation. *www.electronicsnews.com.au*

Czech Republic seeking seat of Galileo logistics system

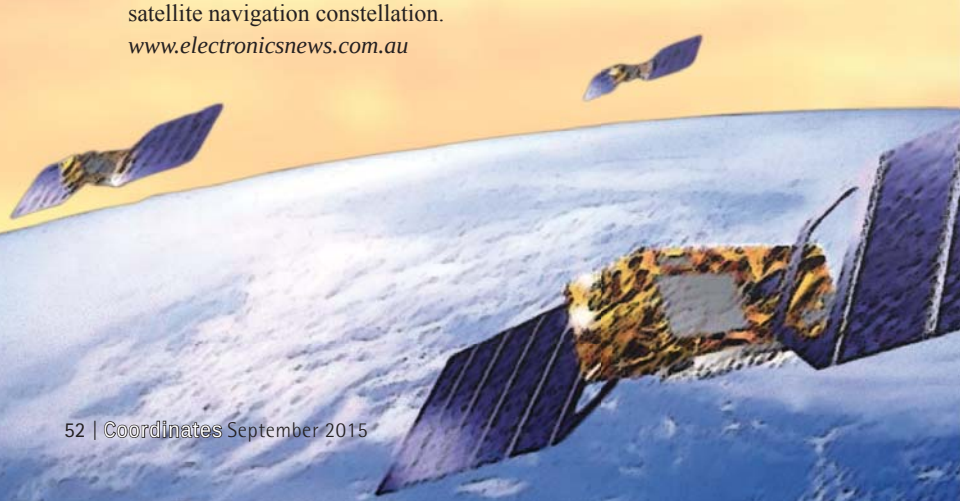
The Czech Republic, along with Belgium, is shortlisted for the seat of the Galileo navigation system's logistics centre, which would be built in the Most-Velebudice complex in the Usti Region, north Bohemia. The Galileo logistics centre will be the only one in Europe to store reserve parts for the Galileo infrastructure, including parts of satellites, ground aerials and other IT components. The centre will also provide basic assembly works. *http://praguemonitor.com*

Next two Galileo satellite reach Europe's spaceport

Europe's ninth and tenth Galileo satellites have crossed the Atlantic, touching down in French Guiana ahead of their joint launch this September.

The delicate navigation satellites made their journey within environmentally controlled containers, having passed a gamut of tests to confirm their readiness for space.

September's launch on a Soyuz rocket will see Europe's own satnav constellation reach double figures. These are Flight Models 5 and 6 of the Full Operational Capability version.



Belarus, Russia sign agreement to develop remote sensing satellite

The Russian corporation VNIIEM and the National Academy of Sciences of Belarus (NASB) signed an agreement on developing and operating a satellite for the high-resolution remote sensing of the Earth. The document was signed by VNIIEM Director General Leonid Makridenko and Piotr Vityaz, NASB Chief of Staff. The new satellite is called BKA 2.

China launches Yaogan-27 remote sensing satellite

China's Yaogan-27 remote sensing satellite was sent into space from Taiyuan launch site in Shanxi Province, north China. It was carried by a Long March-4C rocket, the 207th mission for the Long March rocket family. *http://english.cri.cn*

Russia to develop Earth Remote-Sensing Satellite System for Iran

Two Russian space companies and Iranian Bonyan Danesh Shargh firm signed on Tuesday an agreement on joint development of an Earth remote-sensing satellite system for Iran, Russia's Federal Space Agency Roscosmos said. The pre-contractual arrangement covers the development of an earth remote-sensing system based on an upgraded version of the Kanopus-V1 (Canopus-B) observation satellite, Russia's VNIIEM Corporation CEO Leonid Makridenko specified. *http://sputniknews.com*

EYESMAP: New Architects And Archaeologist 3d Tablet

E-Capture R&D, a Spanish technology-based company, introduces a new 3D accurate measuring tablet: EyesMap. It has an outstanding capacity for modelling 3D scenes both indoors and outdoors, as well as capture in 3D large objects like buildings up to small objects like coins. The "EyesMap" Tablet incorporates two rear cameras, a depth sensor and a GPS system. It is able to measure coordinates, lines and surfaces of all types of objects up to a distance of 30 to 50 m.

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USGS awards $4 Million to Support Earthquake Early Warning System

The U.S. Geological Survey has awarded approximately $4 million this week to four universities – California Institute of Technology, University of California, Berkeley, University of Washington and University of Oregon – to support transitioning the "ShakeAlert" earthquake early warning system toward a production stage. A functioning early warning system can give people a precious few seconds to stop what they are doing and take precautions before the severe shaking waves from an earthquake arrive. The USGS has additionally spent about $1 million to purchase new sensor equipment for the EEW system. These efforts are possible because of a $5 million increase to the USGS Earthquake Hazards Program for EEW approved by Congress earlier this year. *www.usgs.gov/newsroom/*

3D imagery of India's major cities likely in Google Earth

3D imagery of buildings and terrain of India's major cities, including Rashtrapati Bhavan (Presidents House) and Prime Ministers Office, could soon be seen in Google Earth with the government contemplating to give permission for uploading pictures of the country's metropolitan areas. United States, the United Kingdom, China and many countries in the world have already given permission to put 3D imagery of their respective metropolitan areas. *http://articles.economictimes.indiatimes.com/*

3D GIS maps by INCOIS

The Indian National Centre for Ocean Information Services (INCOIS) is working on the creation of 3D GIS maps to ease the evacuation of people from vulnerable areas at risk of tsunami or other natural disaster.

The INCOIS team has been focusing on a multi-hazard vulnerability mapping of the coastal as well as the inland areas of Puducherry town which will bring as result 3D GIS maps of the vulnerable areas. These maps will support the local and disaster management agencies to better plan the evacuation process when a natural disaster warning is issued. *The New Indian Express*

On the right path with OS Maps

Ordnance Survey has produced a new off-road sat-nav style router in its OS Maps application that covers Britain' s 15 National Parks. Using Ordnance Survey' s unrivalled outdoors mapping it allows users to plot routes along public rights of way and footpaths. It is hoped the simple-to-use navigating tool will encourage even more people to explore the parks. *http://os.uk/osmaps*

100 Resilient Cities teams with Trimble for Innovative Global Urban Resilience Initiative

Pioneered by the Rockefeller Foundation (100RC) is partnering with Trimble which will offer a critical resilience building tool to 100RC's network cities. Using Trimble® eCognition® Essentials software, cities can leverage readily available satellite and aerial imagery from manned or unmanned aerial systems (UAS) to produce timely, accurate land use and mapping information that can be used with a GIS. The software enables cities to transform images into quantifiable, actionable information about land use that can be applied to enhance a city's resilience building efforts. 100RC network cities can use Trimble eCognition Essentials to help design and implement the cities' long-term resilience strategy to better plan for and respond to stresses and shocks such as heat island effect, air quality and stormwater runoff, flooding, landslides, fire prevention and recovery and more. *www.trimble.com*

Antenova announces Sinica embedded GNSS antenna

Antenova Ltd. has announced its new, embedded GNSS antenna, named "Sinica." Operating in the 1559 - 1609 MHz L-band range, Sinica is suitable for all GNSS positioning applications on the 1559-1609 MHz bands, including GPS, GLONASS, BeiDou and Galileo, according to the company.

At a Glance

- SuperField Supports Portuguese GPS Provider with GIS Application
- Avineon Unveils Business Intelligence Solution for ArcGIS Geodatabase
- CMC uses Maptek Sentry solution
- Bluesky has produced a prototype map showing where it may be unsafe or even illegal to fly drones
- Global satellite manufacturing market to grow at a CAGR of 5.14% -
- City in Louisiana launches GIS map portal
- Innovyze releases InfoNet Suite Generation V16
- RMSI becomes 'India's best company to work for' across all industries
- Avenza releases Geographic Imager 5.0
- FAA approves Phoenix Arizona's image acquisition drone operation
- ThinkGeo introduces map suite 9.0 with aerial imagery
- Wayne County 911 Communications Center Selects Intergraph®
- Topcon Positioning Group acquires Fort's Digi-Star
- PreTalen wins $15M SBIR contract to support global navigation satellite system
- Esri partners with FlightAware to map aviation data
- China clears acquisition of CSR by Qualcomm

Hexagon introduces smart mapping app

Hexagon Geospatial has announced Smart M.Apps, which can be best described as light-weight applications, designed to combine data, workflows, and analytics. The company has also announced content sharing programmes with Airbus Defence and Space, and BlackSky Global. The business partner network will help to integrate current satellite imagery and earth observation data with Smart M.Apps. The official launch will come later this year.

Detecting depression by analyzing daily usage, GPS data

From texts to maps to social media, we use our smartphones constantly. And while we may think it's just a sign of the times, a new study says it may actually be a sign of depression. According to researchers from Northwestern University, smartphone sensor data can detect depression by tracking the amount of minutes a person uses their phone per day, as well as how often they change their geographical location.

The study involved analyzing the GPS locations and phone usage of 28 people over two weeks. Their locations were tracked every five minutes. The findings showed that the average daily usage for depressed people is 68 minutes, compared to just 17 minutes for non-depressed individuals. The data did not reveal how the participants were using their phones. In addition, the researchers found that those who lack a regular day-to-day schedule are at higher risk for depression, as well as those who spend most of their time at home or spend their time in just a few locations. *http://www.rt.com*

Cell-ID Device Management Platform by GeoTraq

GeoTraq, Inc. has successfully launched the WebTraq Cell-ID Management Platform. The WebTraq platform can manage Cell-ID devices on over 550 cellular carrier networks throughout the world. Manufacturers that design location and tracking products using the GeoTraq G-200 Cell-ID module can offer customers a complement of management features including smart phone applications and cloud connectivity for location data storage. Customers can also integrate Cell-ID device management into their existing systems by downloading and installing the WebTraq API. *www.geotraq.com*

Vietnam to install GPS devices on all radioactive materials

The GPS device installation plan was recently mentioned by Vuong Huu Tan, director of the Vietnam Agency for Radiation and Nuclear Safety, at a meeting with the HCMC Department of Science and Technology. Of the three domestic manufacturers of GPS devices for radioactive materials, devices made by the Integrated Circuits Design Research and Education Center (ICDREC) under Vietnam National University-HCMC had been picked for the plan. *www.vietnambreakingnews.com*

Fast production tests for GNSS solutions with new production tester from Rohde & Schwarz

Rohde & Schwarz now offers a new, speed-optimized production tester - the R&S SMBV100A vector signal generator equipped with the R&S SMBV-P101 package. During production testing of modules and receivers for satellite-based communications, the basic GNSS signal reception and the connection between the antenna and GNSS chipset need to be checked.

The GNSS production tester simulates separate satellites for the GPS, Glonass, BeiDou and Galileo navigation standards in the L1/E1 band specifically for these production tests. The four satellites can be activated individually, each with a high dynamic range of 34 dB. Level changes can be made on the fly without interrupting the signal, enabling users to simultaneously perform independent sensitivity tests for each navigation system. The 1 pps or 10 pps GNSS marker allows exact time synchronization between the tester and the DUT. Pure, level-stable CW signals can also be generated to calibrate the test setup or to simulate interferers. *www.press.rohde-schwarz.com*

New robust GNSS receiver from QinetiQ

QinetiQ has announced a major breakthrough in developing a robust navigation receiver which will utilise the Galileo, and particularly the secured Public Regulated Service (PRS). The prototype receiver is a multi-constellation, multi-frequency, all in view receiver which can receive and process the Galileo PRS as well as Galileo Open Service and GPS Standard Positioning Service. It is also designed to utilise other GNSS signals including GLONASS and Beidou systems as well as space-based augmentation services (SBAS) such as WAAS and EGNOS.

MicroSurvey FieldGenius 8 survey software

FieldGenius 8 is the newest version of the powerful survey data collection software. Developed through close market collaboration and feedback from users, it provides tight control over crucial aspects of field data collection through expanded toolsets and an enhanced user experience. It also includes improvements to road alignments, an onboard basic measurement mode, dynamic screen rotation, and expanded ASCII export options. Additionally, the already long list of supported coordinate systems, geoids, instruments, and data collectors has been expanded in the newest version of FieldGenius, making it easy to integrate into any existing survey operation.

Phase One iXU-R Aerial Camera Series

Phase One Industrial has announced iXU-R aerial camera series. Available in 80 MP, 60 MP and 60 MP achromatic versions, these cameras feature dedicated interchangeable 40 mm, 50 mm and 70 mm Phase One Rodenstock lenses equipped with central leaf shutters that can be quickly changed in the field. They offer unprecedented flexibility in aerial applications. The Phase One iXU-R systems have been designed to address the aerial data acquisition market's needs for a small, lightweight camera with the high resolution of a medium format system, plus high performance optics, flexibility to fit into small places and Phase One's fastest 80 MP platform.

RIEGL becomes LASzip Sponsor for LAS 1.4 Extension

RIEGL Laser Measurement Systems, Austria has become a sponsor of the award-winning LASzip compressor. Their contribution at the Silver level will kick-off the actual development phase of the "native LAS 1.4 extension" that had been discussed with the LiDAR community over the past two years. This "native extension" for LAS 1.4 complements the existing "compatibility mode" for LAS 1.4 that was supported by Gold sponsor NOAA and Bronze sponsors Quantum Spatial and Trimble Geospatial. The original sponsor who initiated and financed the open sourcing of the LASzip compressor was USACE - the US Army Corps of Engineers. *http://laszip.org*

Trimble News

High-Speed Data Communications Link for Industrial Applications

Trimble has introduced the new Trimble® TMR1 data link, an advanced, software-defined industrial, scientific and medical (ISM) radio band, networked transceiver providing license-free wireless communications around the world. The TMR1 data link offers dual-frequency operation with 902-928 and 865-870 MHz, available throughput up to 2.6 Mbps, and range as high as 70 miles. With the seamless integration of serial and Ethernet, coupled with the high throughput, video can easily be streamed across the data links or sensors such as flowmeters or temperature/pressure gauges can be installed for continuous Supervisory Control and Data Acquisition (SCADA) and monitoring applications. *www.trimble.com*

Trimble Launches VRS Now Service in Georgia and New Mexico

Trimble has announced the launch of Trimble® VRS Now™ correction service in Georgia and New Mexico. The commercial subscription service provides surveyors, civil engineers, and geospatial professionals in the region with instant access to Real-time Kinematic (RTK) GNSS corrections without the need for a base station. *www.trimble.com*

Carlson Software Releases Surveyor2

Carlson Software recently released its new Carlson Surveyor2, the newest model in its Carlson Surveyor line of data collectors. It is paired with Carlson's easy-to-use software to provide a powerful, complete solution for surveying, stake out, construction layout, and GIS mapping.

Designed and manufactured by Juniper Systems, the Carlson Surveyor2 is built to withstand the harshest conditions, with an IP68 rating for dust and water and superb durability when dropped or exposed to cold, heat, or other rugged environments.

Bluesky Maps Solar Potential of 100,000 Properties

Working with resource efficiency company Sustain, Bluesky has mapped around 100,000 Housing Association properties across the UK, measuring their potential for energy generation from solar panels. Using a combination of high resolution aerial photography and detailed 3D models, Bluesky can accurately predict the potential for solar energy generation for individual houses based on a number of factors, including roof size and aspect as well as possible interference from neighbouring properties or trees. *www.bluesky-world.com*

NAUTIZ X8 ultra-rugged field computer

Handheld Group has announced new expansion pack features for its NAUTIZ X8 rugged PDA. The new functionalities will make it even more versatile for field workers in a number of market segments, including forestry, surveying, construction, field services, warehouse projects and logistics. It has become immensely popular in the GIS, land surveying, public safety, forestry and military sectors. *www.handheldgroup.com*

SP80 Bests GNSS Competitors in Rainforests of Southern Chile

In the temperate rainforest of the Los Lagos Region of Southern Chile, where rainfall annually exceeds 1,500 mm and two thirds of the days are rainy, the dense forest canopy is a huge challenge for GNSS receivers. One survey firm, Motivazion, headquartered in Puerto Montt, a port city just below the rainforests, makes its living surveying under the densely canopied forest and rugged terrain. In an effort to ensure it was using the best GNSS receivers for the conditions, Motivazion recently conducted field tests to determine just which brand excelled.

Motivazion's owner, Jorge Mesias, said he typically uses a combination of total stations and GNSS receivers for his work. "If understory performance could be improved, efficiency would increase dramatically and reduce the need for using the more time consuming total station," said Mesias. "We had been having generally poor results with our current GNSS receiver, that's why I decided to examine several additional competing brands," he added.

Field tests were conducted in the nearby Lake Rupanco area near a small town of the same name. A light rain fell at all times during the two-day test. The test routine consisted of surveying a total of 21 points in two days. Results were compared to points established by a total station. "The SP80 was the clear winner among the GNSS receivers as it achieved remarkable results compared to the benchmark total station results," said Mesias. *spectraprecision.com*

Airbus, Lime Microsystems partner for GNSS receiver

Lime Microsystems and Airbus Defence and Space, with funding from Innovate UK (formerly the Technology Strategy Board), have begun a joint development of GNSS products. Airbus D&S, using Lime's Field Programmable RF (FPRF) transceiver technology, is developing a robust timing receiver that exploits signals from the new Galileo satellite navigation constellation.

It is envisaged that a highly integrated Field Programmable RF (FPRF) solution based on Lime's technology and an innovative system implementation of the kind provided by Airbus D&S will provide a high performance GNSS product with the potential for integration with other wireless capabilities. *www.onlineamd.com*

Alibaba and Chinese weapon maker invest millions in new satellite positioning company

E-commerce giant Alibaba and government-owned China North Industries Group Corporation--also known as Norinco Group--launched Qianxun Positioning Network, a satellite positioning service provider, in Shanghai on August 18, 2015.

The company will provide precise positioning services to the nation, industries, and the public by combining the technology of cloud computing with the BeiDou Navigation Satellite System. It will also provide data accumulation and data fusion services. *http://www.zdnet.com*

Rockwell Collins introduces ARINC

Rockwell Collins has unveiled ARINC UrgentLink, the first national disaster communications network for public safety that enables first responders, public health, public safety and critical industry officials to communicate with each other when traditional networks are damaged or destroyed. Available as a subscription-based service, the ARINC UrgentLink network uses Federal Communications Commission (FCC) licensed radio frequencies specifically authorized for disasters and Rockwell Collins' proprietary High Frequency (HF) technology. *www.rockwellcollins.com*

OxTS create the world's first Locata+INS system

OxTS have successfully integrated a Locata receiver with their Inertial+ to create the world's first Locata+INS device—capable of achieving centimetre level accuracy where GPS systems fail. The Inertial+ series, first developed in 2008, was designed for users who had an external GNSS receiver already, but still wanted to gain the benefits of an inertial system. They have been able to combine OxTS' Kalman filter and expertise in GNSS/IMU integration with their existing systems, without having to pay again for survey-grade integrated receivers. Inertial+ has expanded from just GNSS receivers and become the first inertial navigation system to integrate a Locata receiver, combining the many benefits of both systems. Locata is an innovative positioning system designed to complement rather than replace GPS, by addressing the issues and shortfalls of a GPS.

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www.isprs-geospatialweek2015.org/

EGNOS workshop
29 - 30 September
Copenhagen, Denmark
www.essp-sas.eu/news

October 2015

Surveying & development regional conference
03-06 October
Sharm El-Sheikh, Egypt
www.sd2015-eg.org/

Commercial UAV Expo
5 - 7 October
Las Vegas, Nevada, USA
www.expouav.com

DIGITAL EARTH 2015
October 5-9
Halifax, Canada
www.digitalearth2015.ca

20th UN Regional Cartographic Conference for Asia and the Pacific
5-9 October
Jeju Island, Republic of Korea
http://unstats.un.org/unsd/geoinfo/RCC/

Intelligent Transportation Systems: 22nd ITS World Congress
5 - 9 October
Bordeaux, France
http://itsworldcongress.com

36th Asian Conference on Remote Sensing
19 - 23 October
Manila, Philippines
www.acrs2015.org

2015 IAIN World Congress
20 – 23 October
Prague, Czech Republic
www.iain2015.org

Joint International Geoinformation Conference
28 - 30 October
Kuala Lumpur, Malaysia
www.geoinfo.utm.my/jointgeoinfo2015/index.html

November 2015

ICA European Symposium on Cartography
10 - 12 November
Vienna, Austria
http://eurocarto.org/

IMIA Asia Pacific Conference
15-17 November
Brisbane, Australia
www.imiaconferences.com/ap

International Technical Symposium on Navigation and Timing
16 - 17 November
Toulouse, France
http://signav.recherche.enac.fr

ISGNSS 2015
16 - 19 November
Kyoto, Japan
http://www.isgnss2015.org/

Drone World Expo/MAPPS Conference
17 - 18 November
San Jose, CA United States
www.droneworldexpo.com

GEOTECH RWANDA
18 - 20 November
Kigali - Rwanda
www.geotechrwanda2015.com/

International Workshop on the Role of Land Professionals and SDI in Disaster Risk Reduction
25-27 November
Kathmandu Nepal
www.workshopnepal2015.com.np

December 2015

Esri India User Conference
2 - 4 December
New Delhi, India
http://www.esri.in/events

7th Multi-GNSS Asia (MGA) Conference
7 - 10 December
Brunei Darussalam
www.multignss.asia/workshop.html

The Geoinformation Technologies for Natural Hazards Management (7th GiT4NDM)
8 - 10 December
UAE University
http://conferences.uaeu.ac.ae/eogc-git4ndm/en/index.shtml

9th International Symposium on Mobile Mapping Technology (MMT 2015)
9 - 11 December
UNSW, Sydney, Australia
www.mmt2015.org

February 2016

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

March 2016

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

April 2016

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

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