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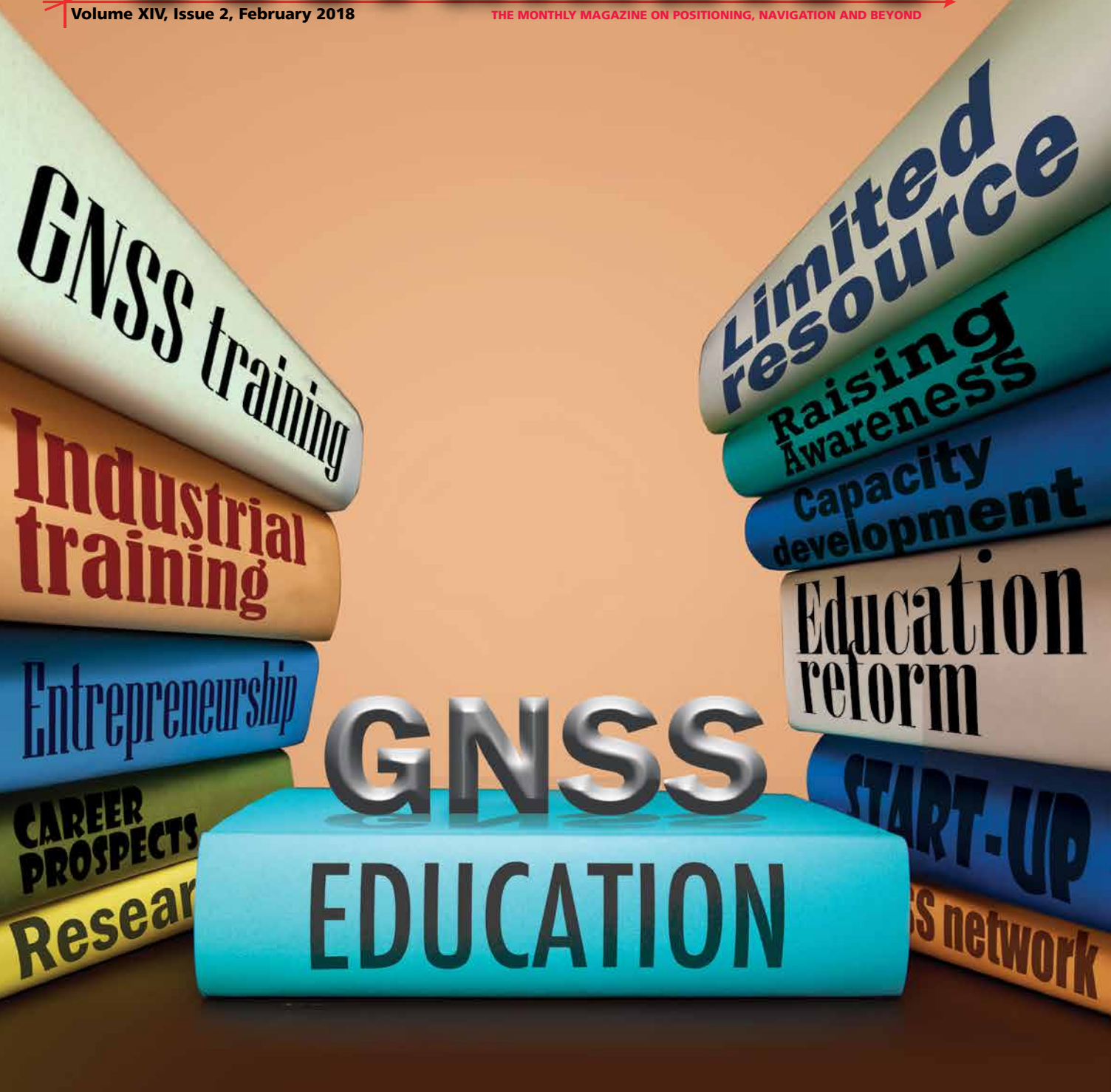

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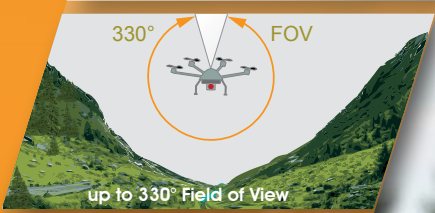

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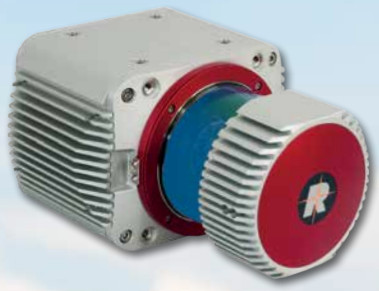

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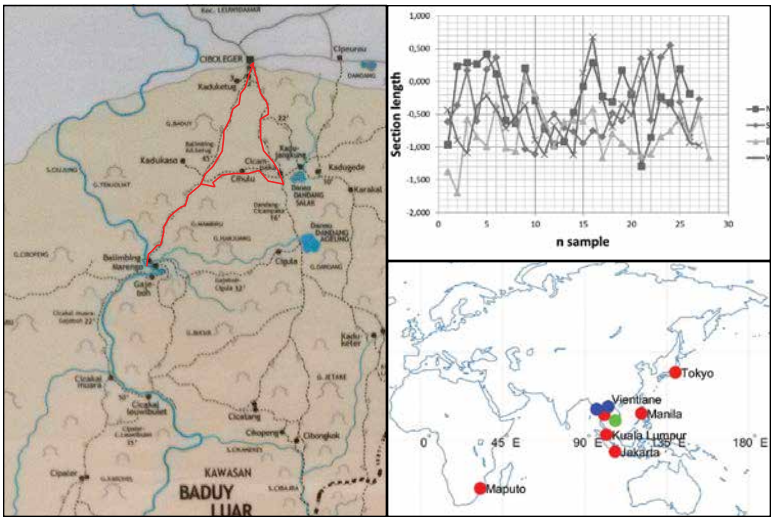

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Articles

Columns

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

Car to caravan

Another feat of mankind.

Falcon Heavy by Sapce X symbolizes

The dreams and the dreamers.

Imagination, inventiveness and ingenuity.

A journey from surrealism to reality.

It was not Falcon Heavy alone,

Along with it was Tesla Roadster.

A craft, along with a car.

Will it eventually be followed by a caravan?

Who knows!

Bal Krishna, Editor
bal@mycoordinates.org

ADVISORS Naser El-Sheimy PEng, CRC Professor, Department of Geomatics Engineering, The University of Calgary Canada, George Cho Professor in GIS and the Law, University of Canberra, Australia, Professor Abbas Rajabifard Director, Centre for SDI and Land Administration, University of Melbourne, Australia, Luiz Paulo Souto Fortes PhD Associate Professor, University of State of Rio Janeiro (UERJ), Brazil, John Hannah Professor, School of Surveying, University of Otago, New Zealand

7-satellite constellation is planned to be implemented in around 2023

says Takeyasu SAKAI, Principal Researcher, Navigation Systems Department, Electronic Navigation Research Institute, National Institute of Maritime, Port and Aviation Technology, Japan while sharing the status and prospects of QZSS and MSAS programmes

Please update us with the status of QZSS.

Following QZS-1 launched in 2010, additional three satellites has been launched in 2017 to complete the initial constellation of QZSS. QZS-2, -3, and -4 satellites were launched in June, August, and October, respectively, from Tanegashima Space Center by Japanese H-IIA launcher. Among these, QZS-3 is put into geostationary orbit at 127E while other three are IGSO (inclined geosynchronous orbit) with inclination angle of around 43 degrees. The operator of QZSS is determined as QZSS System Service Inc. (QSS), a private company, and the operation of QZS-1 was transferred from JAXA (Japan Aerospace Exploration Agency) to them. They are now working for final preparation to begin the service in April 2018.

What are the key features of QZSS?

First of all, QZSS has two missions: Positioning Service and Messaging Service. For Positioning Service, it provides ranging service and augmentation service both on L-band signals. For Messaging Service, QZSS provides mobile communication services for disaster and crisis management including (i) Q-ANPI: S-band two-way data communication service for information on status of evacuation shelters, number of evacuees in shelters, and evacuee condition during a disaster; and (ii) DC-Report: Downlink short messages related to disaster warnings such as about earthquakes, tsunamis, volcanic eruptions, floods, and crisis management information on L1 frequency.

As the ranging service, QZSS transmits GPS-like ranging signals on L1, L2, and L5 frequencies to improve signal availability in urban and mountain areas.

QZSS has two missions: Positioning Service and Messaging Service. For Positioning Service, it provides ranging service and augmentation service both on L-band signals. For Messaging Service, QZSS provides mobile communication services for disaster and crisis management

Additionally, QZSS has augmentation service including: (i) Submeter Level Augmentation Service (SLAS) on L1, code-phase differential correction service for mobile users; (ii) Centimeter Level Augmentation Service (CLAS) on L6, carrier-phase differential correction service for precision applications; (iii) PPP Service by RTCM SSR messages on L6; (iv) L1 SBAS service by QZS-3 GEO; and (v) Transmission of test signal for DFMC (dual-frequency multi-constellation) L5 SBAS.

It should be noted that QZSS employs both IGSO and GEO satellites so that it transmits signals from high elevation angle to the intended users. This feature is actually the origin of the word “Quasi-Zenith”. Anytime, at least one or two QZSS satellites serve to you from the zenith.

What kind of applications QZSS is being used for?

Many applications related to positioning are investigated for harmonization with QZSS. For example, ranging service will improve availability of position fix in urban areas for vehicles and pedestrians by signals from the zenith, and the CLAS service will be quite useful in agriculture and construction applications.

Would you like to share any application in disaster management?

Yes. QZSS has DC-Report which is a small-capacity downlink channel using a part of the L1S message stream for disaster and crisis management potentially used by other States in the coverage area.

How QZSS is compatible with other GNSS systems?

QZSS transmits GPS-like signals for ranging service, i.e., L1C/A, L1C, L2C, and L5IQ; It is quite easy to support QZSS ranging service signals in addition to GPS signals. The QZSS system time is maintained to align with GPS time so that users can ignore the time offset between QZSS and GPS.

The L1 SBAS service will be, of course, fully compliant with the international standards for civil aviation.

The detail of each signal is specified by the IS-QZSS document issued by the QSS and available online.

Does QZSS have any advantage over other systems?

It has been confirmed ranging accuracy of QZS-1 reaches the level of 0.4m. The initial constellation will follow this performance and further improvements are expected for QZS-5 and later satellites.

CLAS and PPP service might be also advantage of QZSS; These precise positioning services will be provided from the space for free of charge without any other radio links.

How can other countries of the region can take benefit of QZSS?

QZSS signals are available for any users in the service area. Simply receive and use them for free of charge. In other words, choose QZSS-supported receivers.

How to address the issues like interference, jamming and spoofing?

QZSS transmits GPS-like signals so the ability against the issues is the same level with GPS in terms of signal interface. The location of QZSS ground facilities are chosen with careful survey for RFI and continuously monitored.

There is some early discussion to implement signal authentication by L1 SLAS signal or L5S Q-channel but it has not been decided yet. It also takes some time for standardization of such an idea.

What are the future plans for QZSS?

Following the initial constellation with four satellites already on the orbit, 7-satellite constellation is planned to be implemented in around 2023. Ranging performance will be improved with additional satellites and it will be enabled to have position fixes independent from GPS.

Please share the status and future plans of MSAS?

The current MSAS, MSAS V1, has been operational since September 2007. Currently it is transmitting SBAS signals with PRN 129 and 137, generated based on measurements at 6 monitor stations, via the MTSAT-2 geostationary satellite. MSAS serves for horizontal navigation only, i.e., currently vertical guidance is not available.

In 2020, the MSAS mission will be taken over by MSAS V2 with QZS-3 GEO satellite. At the same time, MSAS ground facilities will be fully replaced with modernized MCS facility and 13 monitor stations. After that, the update to MSAS V3 which provides vertical guidance service is planned to be done in 2023, along with the launch of the second GEO for QZSS.

Currently, the DFMC L5 SBAS is being discussed for finalization of the international standards. QZS-2 and following satellites have L5S augmentation signal for testing L5 SBAS; Actually we have been transmitting L5 SBAS test signal with QZS-2 since August 2017. It is expected to realize MSAS V4 as an implementation of the DFMC L5 SBAS.

What are key sectors where MSAS being used? Could you highlight its role in aviation sector?

In Japan, there are a lot of small remote islands. Some regional airlines flying to airports equipped with less navaids are using, or planning to use, MSAS to improve their availability. Emergency response aircraft including helicopters are also using, or expecting, MSAS services.

Using MSAS, airlines do not need to conduct RAIM prediction before taking off. For this reason, some major airline has decided to take the SBAS option for their brand-new airplanes. Implementing vertical guidance service will further push them to use MSAS.

In 2020, the MSAS mission will be taken over by MSAS V2 with QZS-3 GEO satellite. At the same time, MSAS ground facilities will be fully replaced with modernized MCS facility and 13 monitor stations

What is the relationship between QZSS and MSAS?

They are separate programs. In 2020, decommission of MTSAT-2 will occur, and MSAS program will continue SBAS service with QZS-3 GEO of QZSS.

2018 Technology trends

From GPS to multi-constellation GNSS

Guy Buesnel
CPhys, FRIN
PNT Security Technologist, Spirent

2018 is definitely going to be the year of Beidou as it becomes a global GNSS system. China plans a further 13 launches of Beidou satellites during 2018 which is an ambitious launch schedule for any nation – but the rewards from having a global satellite navigation constellation that can compete with GPS, GLONASS and Galileo mean that the effort being put into achieving the aggressive launch schedule will prove to be a sound investment. The Chinese government may be likely to mandate the use of Beidou in China for critical applications or segments but for the rest of us it will be yet another available constellation on our connected devices such as smart phones.

Moving to the multi-constellation world from a GPS world is bringing huge benefits to the user – more accurate GPS positioning data might seem one of the more obvious benefits but performance in areas where even recently it was difficult to obtain a navigation fix has improved hugely – the days of standing on a pavement looking up at huge office blocks towering above you whilst vainly trying to obtain a GPS fix, are now something of the past. It is more likely that you will emerge from a subway station into the streets of the metropolis and have a very accurate position fix within seconds. This is because the chipsets in most smartphones have multi-constellation capability enabled and already use GLONASS and Galileo in addition to GPS signals. Many smartphones' GNSS receiver chipsets are also ready to utilise Beidou signals too. With the huge rise in the number of GNSS enabled devices making maximum use of the new multi-constellation GNSS landscape – some market predictions suggest almost 8 billion GNSS devices being used by 2020 – there has also been an astonishing increase in the the amount of location and timing data that is being generated by these devices and where it is ending up. Location data from GNSS devices can be used from everything from locating a friend (or a device) to crowd-sourced data - some of the car navigation applications on the market already use crowd sourced data to give users warning of traffic snags or good diversion routings.

Moving to the multi-constellation world from a GPS world is bringing huge benefits to the user – more accurate GPS positioning data might seem one of the more obvious benefits but performance in areas where even recently it was difficult to obtain a navigation fix has improved hugely

One of the areas where this is occurring is in the rise of GNSS enabled fitness-related devices which can track a user's movements very accurately, and the web applications that collect this data so that individual users are able to compete with friends and other users to win awards or just to compare progress.

The recent release of Strava Labs' heatmap based on over 1 billion fitness activities uploaded to their website show what is possible – the heatmap contains a mass of useful and sometimes unusual information that could be used in many ways by politicians, planners or even malicious actors. The wealth of information here shows that GNSS big data has arrived – imagine what might be possible utilising and perhaps blending other sources of GNSS positioning data. This will lead to a revolution in itself as users, integrators and developers identify novel ways in which crowd sourced GNSS-based location data could be used.

There may be privacy concerns over the use of personal location/timing data – and they will quite rightly need to be debated as criminals have used GPS tracking technology to commit serious crimes.

Academic drift and surveying education

There must be a deliberate strategy to guard against academic drift in surveying/geomatics education while not diminishing the great value of engendering the development of generic critical thinking and problem-solving skills and scientific enquiry among the privileged individuals who are able to access higher education

Dr Garfield Young
Associate Professor and Dean, Faculty of the Built Environment
University of Technology, Jamaica

As universities strive to find a balance between theory and practice; and between generic and specialist knowledge and competencies, a real concern is that there may be a disproportionate shift towards a greater academic approach and a concomitant shifting from the more practical elements. A study of fifteen Surveying/Geomatics programmes in several countries provided empirical evidence that academic drift is a real matter of concern in this discipline (Young et. al., 2012). Associated with this trend, is the risk of profession-oriented courses gradually losing their usefulness for professional preparation. A deeper examination of the concept of 'academic drift' explains this concern.

Academic drift

Academic drift describes the gradual reduction in vocational focus and reciprocal increase in the emphasis on academic and more general education. The term was originally used by Burgess (1972), and described by Harwood (2010) as:

> a term sometimes used to describe the process whereby knowledge which is intended to be useful, gradually loses close ties to practice, while becoming more tightly integrated with one or other body of scientific knowledge (p. 413).

The literature speaks of this phenomenon in higher education, in which vocational courses, and profession-oriented courses such as Land Surveying with highly practical orientations, gradually experience a shifting in vocational and professional focus towards more theoretical orientation with enhanced academic values, attributes and attitudes. This is often seen as occurring at the expense of those vocational and profession-based competencies that are more valued by professions.

Jónasson (2006) explains that both students and academic staff contribute to this shifting of values:

> Thus students (... the primary consumers of education), along with their aspirations for educational credentials, are interpreted as a substantial driving force behind educational expansion. The academic faculty, on the other hand, having a similar aspiration for status, affect the internal structures of institutions and of the system, partly as a response to institutional growth and partly as a method to gain status, which leads to the academic drift that we witness. (Jonasson, 2006 p. 4)

Jonasson sees academic drift as starting

The gap in industry results from an unwillingness of individuals with higher qualifications (degrees) to work in low-status 'vocational' positions with commensurate lower remunerations. Also, the nature of industry in many professions is such that more individuals are required for skilled (vocational or technical) positions than for high profile professional positions

with students' demands for 'educational credentials of the highest prestige to enhance their opportunities in the labour market and their social standing in society' (p. 292). This view is in contrast to the notion that students are more concerned that educational systems are aligned to professional practice. What is perhaps true, is that both issues of academic credentials and professional relevance, concern university students. However, as Bourdieu (1984) indicated, there exists a power struggle between these competing elements, and the more dominant force will determine "the capitals of the field".

Furthermore, it was said that the aspirations of academic staff also influence academic drift (Kyvik's, 2007). As related to professional engineering practice, Christensen et al., (2011) refer to this specific influence as 'staff drift':

> As an academic orientation differs from the practice-based and industrial and utilitarian orientation for professionally educated engineers in terms of reflectivity, critical orientation, regard for theory and orientation towards research, staff members characterised by an academic orientation will tend to push their institutions towards academic values, practices and attitudes' (p. 292)

Systematic changes have also been cited as contributing to academic drift. Christensen & Erno-Kjolhede, (2011) cite the upgrading of college-based engineering programmes in Denmark and the upgrading of the England and Wales Higher National Certificates and Diplomas (HNCs & HNDs) to degree courses after the passing of the ***Further and Higher Education Act (1992)***, as examples of processes that contribute to academic drift. Similar changes in the Higher Education Sector have been observed in smaller countries such as Jamaica (Sangster, 2011), and large countries with emerging higher education sectors such as India (Pednekar, 2011). However, the change from certificates and diplomas levels vocational courses to university-based degree courses is widely perceived to be a progressive step. This is echoed by Pednekar (2011):

> There is good news in store for the nearly five lakhs (500,000) students studying in vocational institutes in the state. The state government has decided to upgrade vocational education to create more opportunities for these students by setting up an independent vocational university, adding mainstream degree courses and post graduate options in vocational subjects…to bridge gaps between vocational students and their counterparts in mainstream courses... (Pednekar, 2011)

Without discounting the benefits of the educational opportunities that the upgrading of vocational or technical courses will provide for students, it should also be noted, that changes such as these may have negative repercussions. It has been shown that wide scale changes of vocational courses to degree courses, with increased academic and reduced vocational emphases, can create a gap in industry. Evans (2010) in his criticism of changes in UK vocational higher education system argued that:

> Foundation Degrees have undermined Higher National Certificates and Diplomas which have long been greatly valued by many employers (another example of academic drift is to attach degree to the title and think it is more important!). These forerunner awards were very much vocationally focussed. (p.1)

The gap in industry results from an unwillingness of individuals with higher qualifications (degrees) to work in low-status 'vocational' positions with commensurate lower remunerations. Also, the nature of industry in many professions is such that more individuals are required for skilled (vocational or technical) positions than for high profile professional positions. For this reason, changes in the higher education sector require careful considerations of labour-market planning (Grossman & McDonald, 2008). This is important because industries need a flow of qualified individuals for different levels of work and appropriate education and training to enhance productivity. This should not be solely based on current trends, but also with a futuristic view, that predicts changes in profession or even sets the pace for change within professions (Hudson et al., 2005).

This shifting of vocational and academic focus has links to the classification of higher education universities in the UK. Sanders (2002) refers to the distinction between polytechnics and universities as the binary divide. She highlights John Marenbon's comment on the issue, which explains, that in the UK context, politics has played a critical role in this labour-market and higher education issue:

> Conservative politicians, as much as Labour ones, believed in the nonsense about making vocational education of equal esteem to academic education. I think the government should have been concerned to see that there existed high-quality academic education for a very small elite, and that there was good vocational training for those who wanted, closely linked to the workplace (Marenbon as quoted by Sanders, 2002, p.1).

This view, suggests that the higher education sector should have distinct pathways. The view also implies the elevation of the more academic approach over more practical, work-specific learning. Marenbon's argument essentially identifies what he perceives to be a tension in the labour market created by the attempt to unify the higher education sector in the UK. This tension impacts several industries as it relates to producing graduates who are

The issue of academic drift underlies failings in the management of professional education. The upgrading of work-based courses should not be done in isolation of labour market planning and consultation with related professions

able to function effectively in professional work soon after graduation. The issue of academic drift underlies failings in the management of professional education. The upgrading of work-based courses should not be done in isolation of labour market planning and consultation with related professions. The literature shows that issues are yet unresolved regarding on-going changes to profession-oriented and vocational education and the impact on industries. If the 'upgrading' of vocational qualifications to more academic qualifications lead to a devaluation in the capital (economic, cultural and symbolic) (Bourdieu, 1997), then there may be need to rethink division of labour within industry along with new ways of managing educational programmes geared towards professional preparation.

Personal reflections as a researcher and surveying educator

Having done studies that explored the nature and impact of the educational strategies used in university surveying/geomatics programmes, I have found that the changing of formerly highly technical surveying courses to university-based degree courses is believed to be the catalyst to an increasing academisation of the professional education programmes within the discipline. Not surprisingly, professional surveyors and surveying academics have conflicting opinions about this issue. To several of the professional surveyors, the increase in theoretical focus and relative decrease in the technical/practical focus, compromise the adequacy of the courses for professional preparation. They perceive that this trend reduces work-relevance, which demonstrates that industry has an expectation that the educational programmes should prepare students for work in a rational way. In this sense employers expect that the substantive knowledge acquired in universities, the technical capabilities and the generic skills should be closely aligned to the demands of professional work.

However, for many surveying academics, an increase in theoretical focus is consistent with a more appropriate emphasis for higher education institutions whose responsibility is for doing far more than preparing individuals for narrow profession-oriented competencies. This philosophical stance considers the development of scientific reasoning and critical thinking along with other generic skills as foundational to professional preparation even within a highly technical field such as surveying. It is believed that these higher level skills are later transferred to specific work-related competencies during professional engagements.

Due to lack of stable forecasts about the nature of future tasks in working life and qualifications as outlined by Barnett (1990), it is difficult to assess the feasibility of professional courses with regard to requirements in working life. It is therefore concluded that the educational preparation for surveying/geomatics work, while conveying the technical and discipline-specific knowledge, should also convey those generic and transferable skills that facilitate life-long learning. This

approach, it is argued, engenders some degree of technical readiness but also promotes a disposition towards learning that facilitates an on-going evaluation and development of relevant competencies.

My research has reinforced the notion that teaching and learning surveying/ geomatics are far more than conveying theoretical and practical knowledge. While these represent important parts of the process, it is evident that an often under-emphasised yet important component is the nature of the relationship between those stakeholders within the university and those within the profession/industry (Young et al, 2012). The implications for pedagogy must be given deliberate consideration in the design and delivery of curricula. Furthermore, pedagogy can, and should be informed by the social arrangements that exist within the profession. This wider understanding of the nature of contemporary surveying/ geomatics education calls for a reorientation of educational philosophy. Thus, surveying pedagogy should have relevance to professional realities and so should include: strategies for engaging students as active partners in the learning and knowledge construction process, and actions to conveying specific and generic knowledge content and an awareness of the social arrangements that exists within the wider field of geomatics. I foresee that this will inform approaches to content delivery, assessment strategies and on-going evaluation of the processes involved. There must be a deliberate strategy to guard against academic drift in surveying/geomatics education while not diminishing the great value of engendering the development of generic critical thinking and problem-solving skills and scientific enquiry among the privileged individuals who are able to access higher education. These are the individuals who will keep the professions vibrant and relevant and innovate practice in ways that enhance professional standards and elevate the role we play in the eyes of those we seek to serve.

"Academisation" of surveying education needs not be viewed as a threat; but rather, an opportunity to strengthen the real and perceived value of the land surveying profession and all the related professions that have emerged in this age of geomatics

This philosophical stance considers the development of scientific reasoning and critical thinking along with other generic skills as foundational to professional preparation even within a highly technical field such as surveying

My challenge to surveying/geomatics academics is that we find a way to work together, engaging all the important players, to build a **signature pedagogy** for our discipline. The objective is to be able to utilize this strategy to teach the content and form with academic rigour - without compromising standards (professional and academic), along with the communicating and modelling the appropriate dispositions that will keep our beloved profession on a path of on-going development in a way that it can attract the best and the brightest coming out of our school systems. Thus, academic drift and the "academisation" of surveying education needs not be viewed as a threat; but rather, an opportunity to strengthen the real and perceived value of the land surveying profession and all the related professions that have emerged in this age of geomatics.

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Assessment of accuracy of basic maneuvers performed by UAV

In the paper a field base for testing the accuracy of positioning unmanned aerial vehicles has been presented, as well as a set of basic tests allowing to define the parameters of accuracy in particular mission scenarios

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The use of UAVs in various works is becoming increasingly popular. They are commonly used in surveying as well as preparation of photographic and video documentation of various objects [5],[7].

The introduction of shipment services, even including transport of blood or human organs, is being discussed more and more frequently. Growing requirements for ensuring high level of safety in aviation operations, as well as legal regulations, will force the certification of UAV equipment. According to the author, one of the stages of certification of this type of equipment should involve tests allowing to define characteristics determining the correct performance of tasks by the UAV. The common definition of the UAV applied for aerial vehicles used for purposes other than recreational or sporting ones, says that it is an aircraft that does not require crew on board in order to fly, nor is it able to pick up passengers, it is piloted remotely or it can conduct autonomous flights. On the other hand, the definition of an industrial robot is that it is an automatically controlled, programmable, multitasking, manipulative device, with multiple degrees of freedom, mobile or stationary, for heavy industrial applications [8]. Considering the above definitions, UAVs can be classified as mobile industrial robots. This paper analyzes tests presented in ISO 9283:2003 [9] for the possibility of their implementation in measurements of UAV positioning accuracy.

The accuracy of an ndustrial robot is determined by its functional characteristics [11], the most mportant of which include the accuracy and repeatability of reaching a position. Guidelines ßor testing the accuracy of robots are described by the PN-EN ISO 9283:2003 standard ([9], [10]). Different measuring methods can be used for examining the ositioning of such devices ([1], [2], [12], [13], [14]).

Table 1 lists all the tests that should be performed when testing an industrial robot.

This paper discusses works allowing to perform the following tests and to define the performance parameters listed below:

- positioning accuracy, understood as the difference between the commanded position and the average pose attained by the robot, when the commanded pose is attained from the same direction,
- positioning repeatability, i.e. the measure of scatter of deviations between positions attained after n repetitions, with the same commanded position attained from the same direction,
- multidirectional positioning accuracy variation, which is the maximum distance between the average of the attained positions, obtained with the same position commanded *n* times

Tab. 1 List of tests to be performed when testing an industrial robot (ISO 9283:2003)

Position characteristics	Path characteristics
• position accuracy • position repeatability • multidirectional pose accuracy variation • distance deviation • distance repeatability • position stabilization time • position overshoot • drift of position accuracy and repeatability • exchangeability	• path deviation and path repeatability • path deviation and reorientation • cornering deviation • path velocity characteristics
Other characteristics	
• minimum posing time • static compliance • weaving deviation	

from three perpendicular directions,
- distance deviation, which is the difference between the commanded distance and the average distance attained,
- distance repeatability, or measure of scatter of deviations of attained distances, where distances attained correspond to the same distance commanded, repeated *n* times from the same direction.

All the tests were performed so that the center point of the test base was reached from four independent directions related to the directions of the world. The UAV was programmed to perform the mission so as to reach the commanded center pose at least 25 times

Description of performed field tests

The research was carried out based on the test base composed of eight points. Their coordinates in the WGS-84 system were determined using RTN technology with reference to the ASG-EUPOS network. The entire base consisted of two basic components:
- three points which constituted a measuring stand and reference points for measurements using the Leica MS 50 total station, which is a tool allowing to capture large data sets of a moving object in a short time and with high accuracy,
- five points constituting endpoints of the sections tavelled by the UAV, which were positioned on the base in the form of a cross, whose arms were parallel to the directions of the world, each arm was 25.00 m long (from the center of the base).

The placement of individual components of the base ensured optimum operating conditions for the Leica MS50 total station, equipped with the ATR system to track the prism installed on the UAV. The Leica MS 50 was positioned above the UAV start point, on which the mini 360º prism was placed. Figure 1 illustrates the position of measurement base points. Before the commencement of each measurement, a test was performed to observe a fixed target for a minimum of 30 seconds. Thus, it was possible to assess the measurement accuracy of the instrument. Spatial deviations from the average position of the fixed prism did not exceed 15 mm which, at their standard deviation of 10 mm, proves that measurement accuracy of this instrument is satisfactory for testing UAV devices equipped with GNSS navigation receivers.

The test unit was the DJI S900 Spreading Wings Hexacopter equipped with a DJI A2 on-board computer. Thanks to all the on-board systems, the hovering accuracy of the DJI S900 declared by the manufacturer is (in GPS ATTI Mode): ±0.5m (vertical) and ±1.5m (horizontal). Additional parameters of the flight controller are: maximum wind resistance (less than 8 m/s), maximum yaw angular velocity (150°/s), maximum tilt angle (35°) and maximum velocity of ascent/descent (6 m/s) [3], [4].

All the tests were performed so that the center point of the test base was reached from four independent directions related to the directions of the world. The UAV was programmed to perform the mission so as to reach the commanded center pose at least 25 times. The number of tests was determined by the time of flight on one power cell. The test was performed at the height of 30 meters, with a wind speed not exceeding 5 m/s, so that the measurement results were not affected by turbulence associated with trees and other infrastructure around the measurement base.

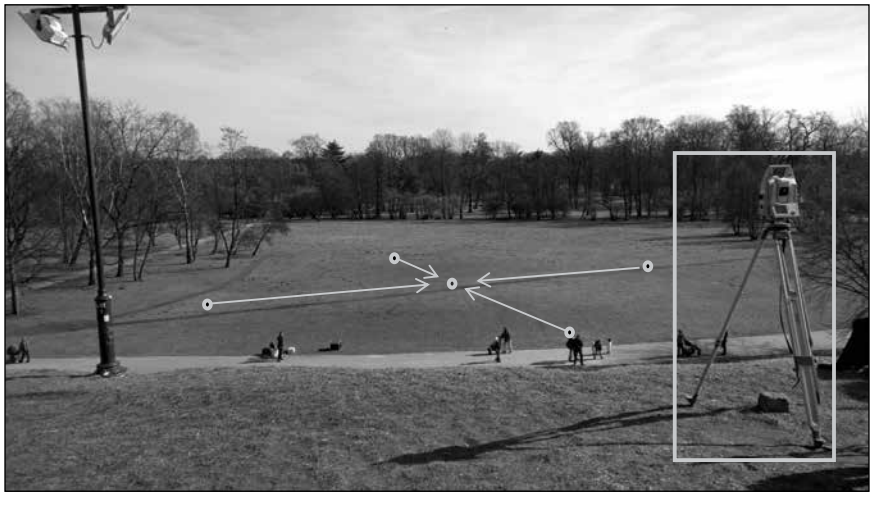

Figure. 1. Test measurement base (own study)

Research results

The measurements resulted in coordinates of the points defining the position of the UAV in space. During the measurements, frequency of recording coordinates of the points was 5.4 Hz, which is less than the value of 20 Hz declared by the manufacturer of the Leica MS 50. It is, however, sufficient for further calculations and analyses. The data were calculated to define the characteristics listed in previous section. The calculations were carried out so that description of the results was related to the direction of approach to the center point, from north (N), south (S), east (E) and west (W), respectively.

Positioning accuracy

Table 2 demonstrates results of the UAV

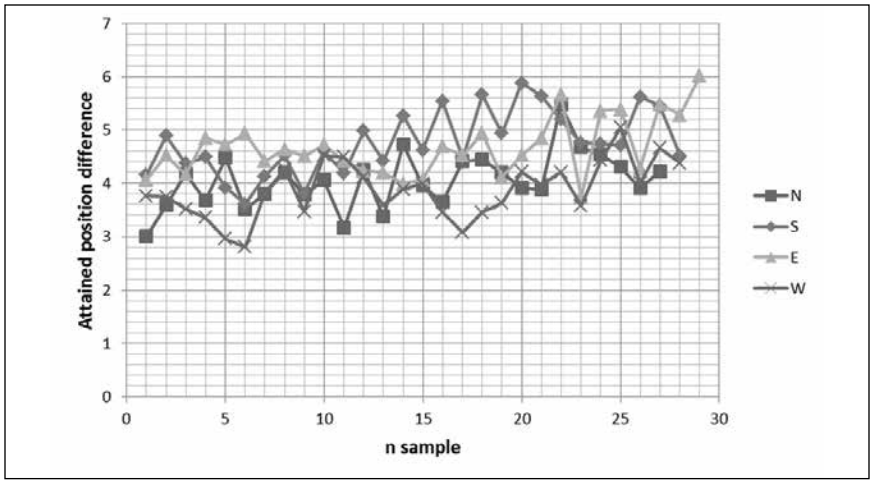

Figure. 2 Values of spatial differences between each center position attained in the test, in relation to the one predetermined for each direction of approach (own study)

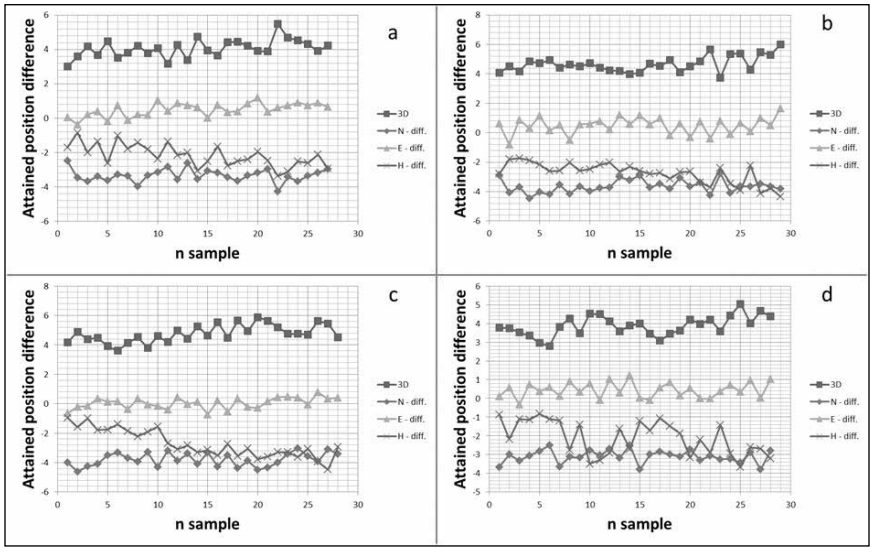

Figure. 3 Values of the differences between each center pose attained during the test relative to the one predetermined for each direction of approach: a – north approach, b – east approach, c – south approach, d – west approach, broken into components of the coordinates (own study)

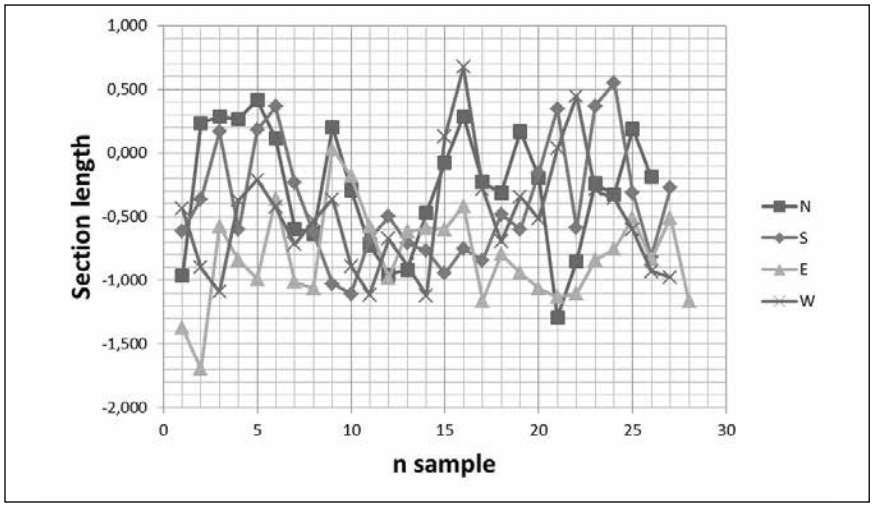

Figure. 4 Differences of all UAV sections depending on the direction of the raid (own study)

positioning accuracy test. The columns contain parameters for the respective axes of the coordinate system: the north and the east ones, as well as for the height. It is important to note that the standard requires only spatial values for the center of gravity of the position attained by the robot from the same direction, which is the fourth column.

Tab. 2 Positioning accuracy of DJI S900 hexacopter with A2 on-board computer (own study)

	Northing [m]	Easting [m]	Hight [m]	3D [m]
N	-3,33	0,50	-2,16	4,05
S	-3,80	0,05	-2,71	4,75
E	-3,65	0,49	-2,75	4,67
W	-3,10	0,44	-2,10	3,87

It should be noted that in all tests, differences in the north direction are much higher compared to the east direction. Considering the accuracy of A2 on-board computers guaranteed by the manufacturer, the results prove that positioning of the device with the commanded accuracy (±1,5m) is not ensured. In addition, it should be emphasized that in the case of height positioning, the difference is significantly higher than values declared by the manufacturer (±0.5m). Figure 2 illustrates values of spatial differences between each of the center pose attained during the tests, in relation to the one predetermined for each direction of approach.

Fig. 3 illustrates a graph of values of the differences between each center pose attained during the test, relative to the one predetermined for each direction of approach, broken into components of the coordinates. The Figure demonstrates that the center point in subsequent measurement tests was attained with the repeatability encumbered with average shift resulting from the GNSS receiver positioning accuracy.

Positioning repeatability and multidirectional positioning accuracy variation

The results of positioning repeatability are summarized in Table 3. It should be

noted that this performance parameter defines accuracy of implementation of a commanded position, having eliminated the systematic factor related to the GNSS receiver solution inaccuracy. Taking its values into consideration, it can be stated that direction of approach to the center point does not affect the positioning repeatability of the device.

Tab. 3 UAV positioning repeatability (own study)			
N [m]	S [m]	E [m]	W [m]
1,70	2,30	2,19	2,03

Multidirectional positioning accuracy variation is represented by one parameter, which in this case is 1.08 m. The value of this parameter defines the maximum difference between the mean values of the pose attained from each direction.

Distance deviation and repeatability

Distance deviation parameters for each direction of approach to the center point are summarized in Table 4. It is worth noting that, in all directions, the length of the section covered was shorter than the predetermined section. In the case of classic industrial robots, this indicates a scale error. Table 5, which summarizes the covered distance repeatability, demonstrates that this parameter exceeds 1 meter. Therefore, it can be assumed that the previously discussed values of distance deviation can be regarded as negligible. In addition, Figure 4 illustrates differences of all UAV-covered sections, depending on the approach direction.

Tab. 4. Distance deviations (own study)			
N [m]	S [m]	E [m]	W [m]
-0,27	-0,41	-0,81	-0,50

Tab. 5 Distance repeatability (own study)			
N [m]	S [m]	E [m]	W [m]
1,40	1,37	1,09	1,33

Discussion of results and summary

The performed tests and calculations allow to draw a number of conclusions. First of all, attention should be paid to practical observations resulting from field research. The use of the Leica MS 50 total station yields satisfactory results. In addition, it is important to note that wind has a significant effect on the trajectory of an implemented mission. Therefore, it is best to test flying equipment in at least two scenarios: in windless weather and in conditions which are close to boundary ones for a specific on-board computer. It is worth emphasizing that the proposed set of tests can be considered as the first element in testing performance of on-board computers.

It is best to test flying equipment in at least two scenarios: in windless weather and in conditions which are close to boundary ones for a specific on-board computer. It is worth emphasizing that the proposed set of tests can be considered as the first element in testing performance of on-board computers

According to the author, research should be conducted, which would be aimed at building a set of tests allowing for a full, independent assessment of the UAV's performance in terms of accomplishment of missions in space. Considering dynamic development of numerical image analysis methods, it is possible to attempt to determine the UAV's position during a flight, based on terrestrial imagery [6]. The UAV positioning using GNSS PPK technologies may also prove helpful. Moving on to analysis of the results, it is necessary to start with positioning accuracy. The parameter provided in specification of the DJI A2 on-board computer is unclear in interpretation. Comparing it with positioning accuracy seems to be the best reasoning.

The measurement results and obtained characteristics are not consistent with the data provided by the manufacturer. Positioning repeatability and multidirectional positioning accuracy variation reach values smaller than those declared by the manufacturer.

This result is most likely related to the systematic shift of the UAV coordinates determined using GNSS technology. When calculating these parameters, such systematic errors are eliminated. This thesis is confirmed by the results for distance deviation and repeatability. To conclude, it should be stated that creating a suitable and secure field base, as well as a set of tests to define the UAV's behavior during a flight, will allow to determine boundary conditions for applicability of this type of equipment in variety of mission scenarios.

Acknowledgments

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Innovations & new standards for mapping of villages in Indonesia

The research was conducted by survey and focus group discussion with the participants of village development activists.

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Rural development is one of the priority programs in Indonesia today. Upto two billion Rupiah villages fund will be granted for each village. Rural development requires comprehensive planning. This requires a village map and village information system [1].

The Geospatial Information Agency of Indonesia is the only responsible institution in making topographic base map national wide. Village map is seen as a kind of topographic map which is cropped by the village border and made in large scale. Recently, village map products in Indonesia is more similar to the standard topographic map "peta Rupa Bumi Indonesia" or RBI in scale 1:5000 [2].

The map has 8 main layers as prescribed in the Geospatial Law, i.e. coastline, hypsography (contour), hydro-network (rivers), utilities and transportation network (roads), landmarking buildings, landcover (vegetation), administrative boundary, and geographic names (toponyms). The main data sources are aerial photos or high resolution satellite imageries and additional field completing work especially to identify public building, administrative boundaries and geographic names. These all are high cost. During past 3 years, only small part of villages in Java, Bali and Nusa Tenggara has mapped newly. Large part has enlarging map from RBI 1:25.000 completed with ortho-images from hires satellite imageries Pleiades and Worldview-2 (resolution better than 0.5 m).

There is an idea to accelerate the village map production, but with the principle of alignment, empowerment and acceleration. The alignment principle said the maps must be made with the emphaty to the villages conditions. There are several type of villages, which should be not seen as homogeneous. There are suburban villages, agricultural villages, villages in forested region and villages in national parks. There are village on mountainous region, and villages in coastal area and small islands. There are villages near state boundary area and isolated traditional villages. The empowerment principle said villages mapping should

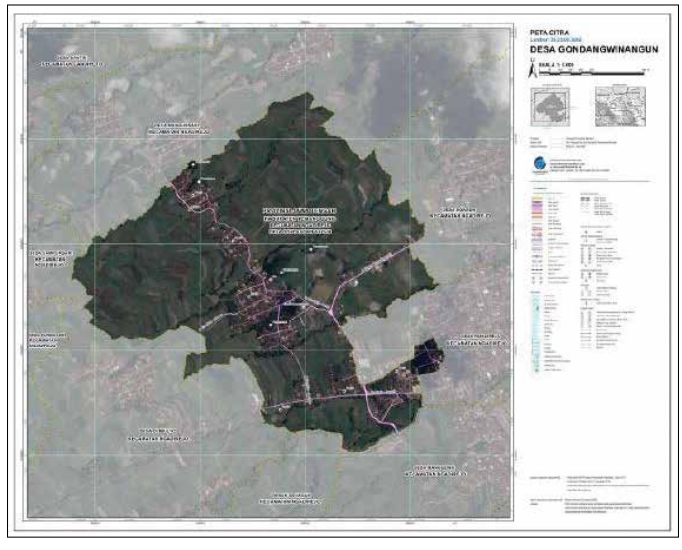

Figure 1. Typical village map in rural area [3]

involve the villages' people. The villages people should later do the optimal use, maintenance and update the data for their own need, not necessary the engineer or surveyor from the Geospatial Information Agency. It means that village mapping should be easy, and only minimal training should be enough already. The acceleration principle said that villages mapping should be done as soon as possible. The president of Republic Indonesia hope that all villages' maps of Indonesia should be finished by the terminus of his presidency, and it is October 2019 [3].

The map is produced according the Indonesian National Standard SNI 8202:2015 about accuracy of topographic base maps [4]. The accuracy of villages map 1:5000 according this standard should be 1 m both in horizontal and vertical if we use the class-1 accuracy, or just 2.5 m in class-3 accuracy.

This standard, especially class-1 accuracy is quite hard. Indonesia consisted of more than 190 million hectare lands. According the Statistical Agency, there are more than 75700 villages in the whole country and they are heterogenous. The area of the largest village is about 458,000 hectare, while the national averages is 2,900 hectare. An obligation of map scale 1:5,000 for all villages will be still in dream [5].

An innovation with the consideration of three principle - alignment, empowerment and acceleration – together, would be very difficult without leave the standards and specification. Therefore the objectives of the research are: (1) to evaluate the existing standards and specification for villages mapping; and (2) to find innovations in villages mapping with several condiions.

Materials and methods

The research was conducted on 4 types of villages in Indonesia, which some of them could represent also another type.

1) Gondangwinangun in Temanggung Central-Java province (see fig.1) is a typical agricultural village in Indonesia. Some similarities also found in Babakanpari in Bogor, West-Java which is mapped participatory by village development activist.
2) Lembang is selected as sub-urban village. It is a village with agricultural area but also with hotel and manufacturing industry.
3) Kanekes is isolated traditional villages in Banten which refuse to has any technology included electricity and road for motor vehicles. Large part of Kanekes is covered by protected forest. Mapping in Kanekes can use only hi-res satellite imagery completed with on-foot survey with distance estimation by step counting. no modern survey instrument could be applied. Some villages in Kutai Barat (East Kalimantan Province) and Mimika (Papua province) has similar condition, despite they don't refuse technology. Some village people and leader themselves don't know the boundary of their teritory. So we believe that the traditional boundary is the about 2 days on foot in hunting wild animals.
4) Temajuk in Sambas West Kalimantan is village in states border mapped participatory by field practising students [6]. Temajuk is also village in coastal area.

The research was conducted by desain various kind of village maps, experimenting a survey idea, and focus group discussion with the participants of village bureaucrats, academician and development activists form civil societies.

Results and discussion

In Gondangwinangun (see Fig. 1), the use of hi-res ortho imagery seem sufficient, although it is in hilly terrain, and terasering

Table-1. The accuracy of topographic base maps according SNI 8202:2015

No	Skala	Interval kontur (m)	Ketelitian Peta RBI					
			Kelas 1		Kelas 2		Kelas 3	
			Horizontal (CE90 dalam m)	Vertikal (LE90 dalam m)	Horizontal (CE90 dalam m)	Vertikal (LE90 dalam m)	Horizontal (CE90 dalam m)	Vertikal (LE90 dalam m)
1	1:1.000.000	400	200	200	300	300,00	500	500,00
2	1:500.000	200	100	100	150	150,00	250	250,00
3	1:250.000	100	50	50	75	75,00	125	125,00
4	1:100.000	40	20	20	30	30,00	50	50,00
5	1:50.000	20	10	10	15	15,00	25	25,00
6	1:25.000	10	5	5	7,5	7,50	12,5	12,50
7	1:10.000	4	2	2	3	3,00	5	5,00
8	1:5.000	2	1	1	1,5	1,50	2,5	2,50
9	1:2.500	1	0,5	0,5	0,75	0,75	1,25	1,25
10	1:1000	0,4	0,2	0,2	0,3	0,30	0,5	0,50

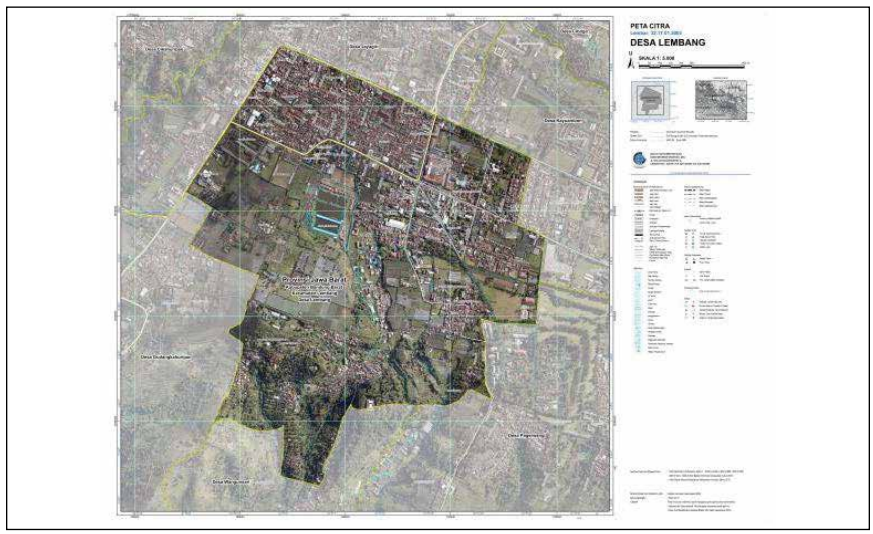

Figure 2. Village map in sub urban area [1]

farm is clearly visible [7]. In agriculture area, dense settlement is rare so that ortho-image with spatial resolution 0.5 m and Digital Elevation Model from RBI 1:25.000 seems sufficient for village map of 1:5000. But in Lembang (Fig. 2), where denser settlement is exist, higher accuracy map will be necessary.

In Babakanpari Bogor, participatory mapping (Fig. 3b) has produced sketch (not yet "map" in geospatial law definition) but useful enough for the work of development activist (Fig 3a).

Although some participatory mapping organization has used satellite imageries, handheld GPS and also drone with camera, but many of them has little competence in produced technical map, but sketch – but their sketch is in many tasks very useful already.

In Kanekes, the research team conducted a survey of several villages in Outer Badui (Baduy Luar) to directly know the access and physical condition of some of Kanekes Village directly. Search starts from Kanekes Village Office then follow the path to Kampung Gajeboh then to Kampung Cihulu, Kampung Cicampaka, Kampung Kaduketug and back to Kanekes Village Office. The search was conducted with the help of Kanekes village map in the village office to find out the route between villages. The existing Kanekes map is made by on foot survey with distance estimation by step counting (Fig. 4a). In Outer-Badui, where the technology restriction is not so stinct like in Inner-Badui (Badui Dalam), we "calibrated" the step method with GPS tracking. The result in is Fig 4b. We surprised with the accuracy of "on foot steps mapping" [8].

In Temajuk, some students made Tourism Map, although there is seldom tourist to this very isolated village at the border to Serawak-Malaysia. Some data sources is taken from Google-map and SRTM data (Fig. 5). The map will be created using GIS software, so larger maps scale is possible. This map has shown also that isolated village could have also nice map.

Village empowerment and development programs have long been implemented in Indonesia, although - initially - the name may not be village empowerment or development. Since the beginning of independence, especially since the New Order era, the development of agriculture is done almost in all parts of Indonesia as one way of doing rural and village development. Agricultural development will not be separated from rural development, so that agricultural development is inherent in rural development - agricultural and rural development.

Although it has been a long time ago, this kind of development pattern is still needed in Indonesia, because most of our people are still active in agriculture in rural areas. However, since activities in the village do not merely include agricultural activities, but also other activities, the scope of activities needs to be expanded, not only to include on farm activities, but also on the processing of agricultural products and other natural resources (off farm), as well as other non-farm activities (non farm), such as craft industry, tourism, trading.

This pattern of rural development is known as integrated agricultural and rural development - integrated agricultural and rural development. This pattern of development is not only the physical development of agriculture, but also has accommodated all aspects (dimensions) of human life in rural areas: physical, social, economic, environmental and others.

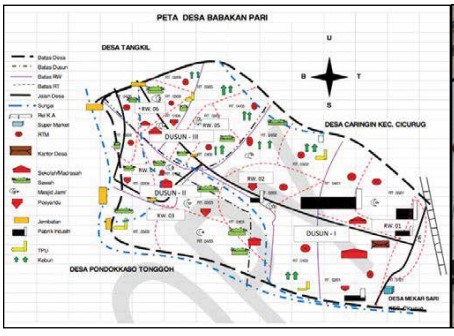

Fig 3a. Result of Participatory Mapping (sketch)

Fig. 3b. Workshop of participatory mapping

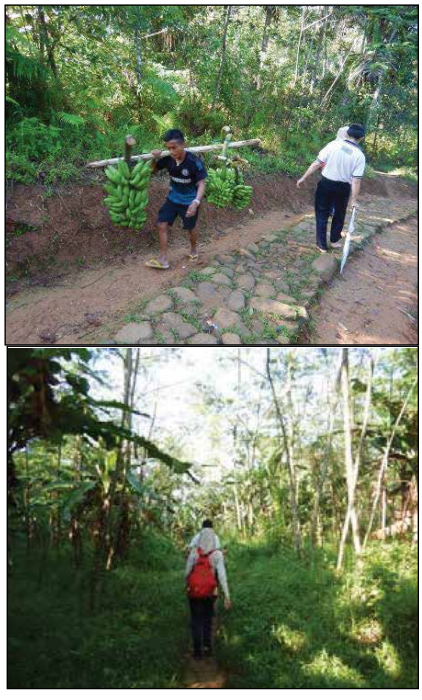

Figure 4a. Typical "road" in Kanekes village

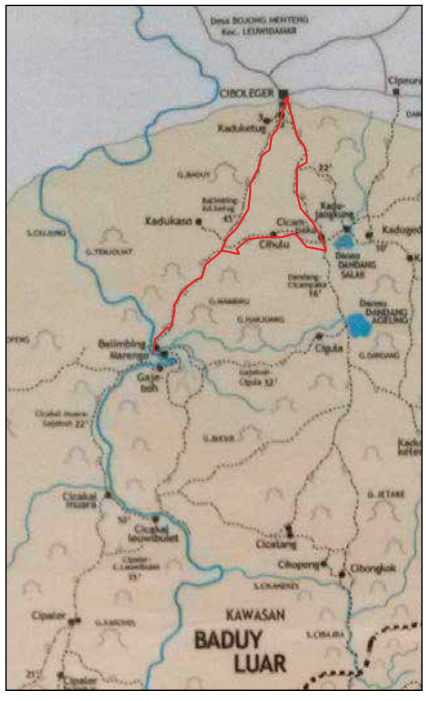

Figure 4b. Callibrating Step-counting map with GPS tracking

Currently, village development programs have involved various programs. But essentially, the development of the village utilizes all available resources in the village, both human and natural resources, and covers all aspects of community life.

As rural development encompasses all of the above activities, the "village map" we are discussing should also represent a map of all dimensions of development in the village.

Village planning and development activities require the availability of geospatial information, especially village maps. The village map not only includes the determination and affirmation of village boundaries but also identifies and inventories the various village potentials, infrastructure conditions, demographics, socioeconomics, and so on. Through the Village Map, should also be known things that can be an obstacle in the effort to empower the potential, so that can be done step completion comprehensively.

The making of village map has various interests, among others [5]:

- knowing the position of the village against the surrounding area,
- identifying village potentials,
- inventory of village assets,
- assist village infrastructure development planning,
- help to overcome the problem of boundary disputes,
- as the basis of information for the spatial integration of regional development
- as a basis for making village development policies

The shape of village maps in Indonesia is still very diverse, both in terms of scale and method of manufacture - ranging from maps that are still manual to the already modern (digital). In relatively undeveloped villages (which account for more than half the number of villages in Indonesia), often the village map has not specified the boundaries of the territory, so the accuracy of the village map is still relatively low. The village map is also generally relatively simple, so it is not very interesting and informative. Manual maps, both contour maps, land use maps, village infrastructure maps are generally made on paper without color, making it very unattractive and less communicative. Therefore, the village map needs to be standardized, including a standard procedure and a prototype of the village map, as a basis for making a national village map.

The limited knowledge of the village and community apparatus on the importance of the Village Map is also often a constraint in the utilization of village maps that have been made though. Therefore, various types of village maps with their territorial boundaries need to be socialized to village officials and village community representatives (village heads, heads of RW) in a forum for socializing the making and utilization of the Village Map, so that the village map can be optimized for use in the planning process and development of a village.

Ideally, the Village Map should be regularly revised, as the village condition changes dynamically over time. This occurs because: a definitive region boundary change (e.g. due to the division of the village), also due to changes in the map component. However, these village map changes can be constrained by the availability of funds.

Map is a tool in conveying spatial information. Based on the function then a map should be equipped with various components and completed to facilitate the user in reading / using the map. Elements of map completeness generally include: Title, Legend, Scale, Wind direction, as well as date (map creation date).

Functionally, the necessary Village Map may include the following information maps:

1) Potential landscapes, natural resources and land cover: mountains, hills, rivers, land use for agriculture / plantation / livestock / fishery / forestry, mining, and the products produced
2) Land use maps: housing, non-housing, yards, cemeteries, and others
3) Map of the product processing industry in the village
4) Road network and utilities network maps: electricity, telecommunication, drinking water, irrigation water services
5) The presence of village social and economic facilities, including: education services (schools / madrasah / pesantren), health services (hospitals / puskesmas), houses of worship, economic facilities (markets, shops, cooperatives / cooperatives village units, rural credit / baitul maal), houses of worship, and others

Figure 5. Tourism Map in Temajuk Village

The components number 1, 2 and 5 is standard and already exist in RBI 1:25,000. Number 3 is optional when industry exist in village. This feature is not yet standard in RBI. Number 4 is standard except drinking water which could be very simple in the villages, which could be not mapped in RBI.

Poverty is one of the major problems in Indonesia. To support the goal of poverty alleviation, which is the main target of national development, it is necessary to create an additional map, the Village "Poverty Map", which gives an idea of how many people in a village are poor (break down to hamlet level, RW and RT). The map of this condition needs to be overlaid with a map of conditions and the utilization of its natural resources, so it can be seen how the appropriate approach (program) in order to overcome the problem of poverty.

With the enactment of Law no. 6 year 2014 about the village, the village serves as the subject of development, no longer as the object of development. The current village development approach is more to the bottom-up or participatory than the top-down ones. The village has the authority to govern itself, as a self-governing community.

Therefore, the role of village officials is becoming increasingly important in planning and implementing development in their villages. Without being followed by their knowledge, capacity and skills (knowledge, capacity and skills) efforts, village development can not be done optimally.

The existence of a comprehensive Village Map is a necessary condition for the planning and implementation of village development. However, the existence of village maps will not benefit, if the map has not been able to be utilized by the apparatus (pamong) village optimally. Also, given that a village changes from time to time due to the development process it does, the village map must be constantly updated (updated) following the rapid development of the village.

To overcome this problem, village map design should be participatory by involving the village apparatus from the very beginning in the process of making it, although the implementation can be done by a certain technical team (consultant).

With the participation of the village apparatus in the preparation of the village map, they will understand and master the detailed information presented on a village map; so that will facilitate them in doing village development planning. Then, on a regular basis, their capabilities continue to be upgraded through training programs at the regional (provincial or district / city) level. Although the village map should be accurate, but in these Focus Group Discussions it appears that the public is not really interested in a very accurate map, but a pretty useful map, they understand enough and can update themselves. Only when they work for cadastral, or for building permission, then an incidental surveying could be done.

Conclusion

The result of this study is that village development requires large-scale maps of up to 1: 5,000 but does not require the geometric quality prevalent on topographic map of 1: 5,000.

In some villages with huge area of forest or unpopulated part, smaller mapscale is enough.

This inaccuracy affects the accuracy of the village area and on the amount of village funds, but all are within the limits of tolerance..

Acknowledgment

This research was supported and fully funded by Center for Research, Promotion and Cooperation, Geospatial Information Agency of Indonesia. The author will thanks to Mr. Dadan Ramdani, M.T. and Mr. Agung Syetiawan for the fruitful discussion and to Dr. Ibnu Sofian, Head of the Research Division, for the permanent encouragement.

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SPOOFERS REVEALED

We show those satellites that are:

Tracked
Used
Spoofed
Blocked/Jammed
Faked
Replaced

See details inside

Spoofers are not only of the Black Sea type, as reported in the press, kids are going that direction too. It is time to take spoofers seriously.

Spoofers are completely different from jammers that block GNSS signals. Spoofers create GNSS-like signals that fool receivers to provide false location solutions.

We combat spoofers in two ways:

1. Detect and alarm that spoofer exist. Then distinguish the spoofer signal, ignore it, and use valid satellite signals.
2. Help find the direction that spoofed signals are coming from.

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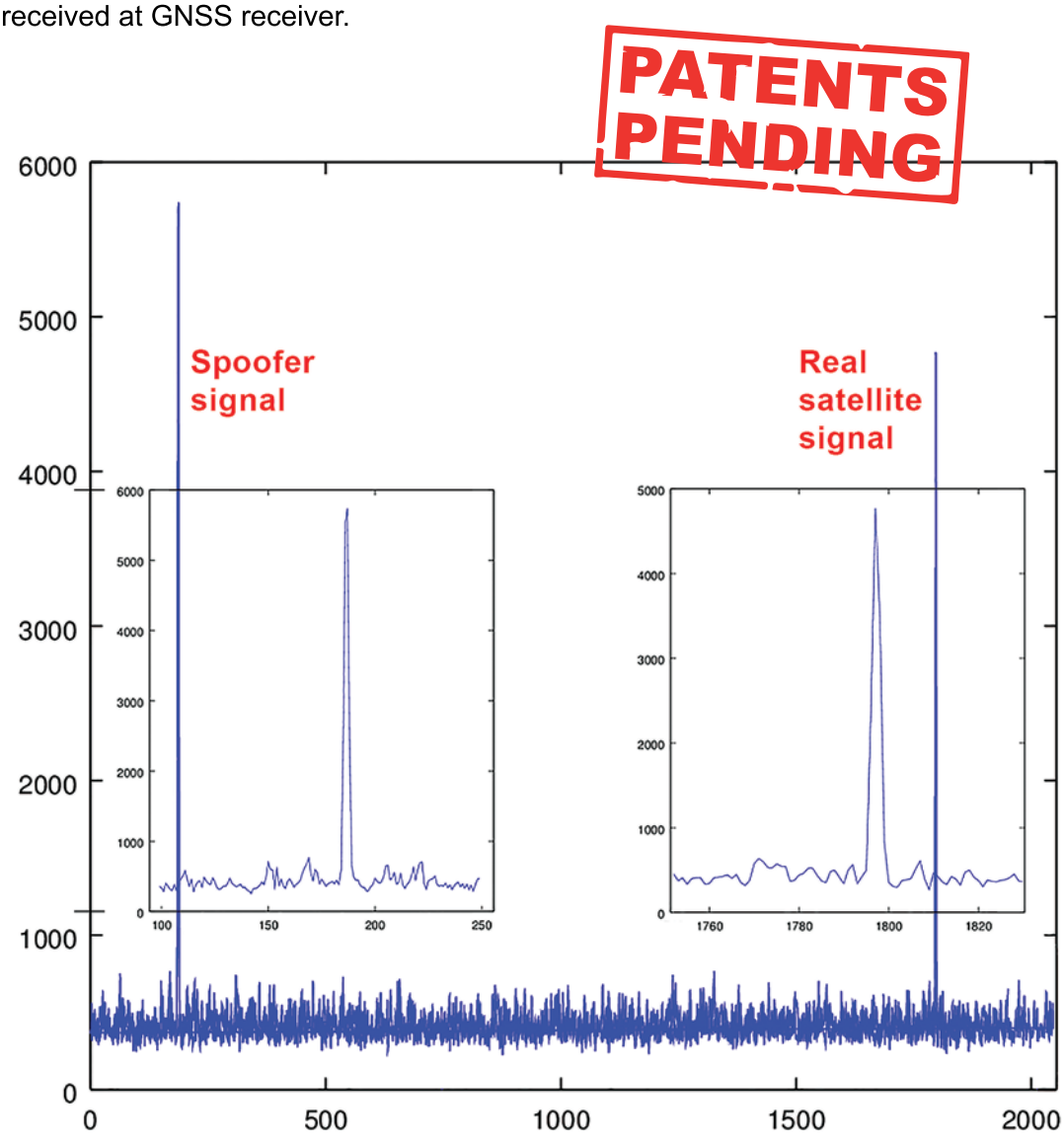
Spoofer Detection

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

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

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

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



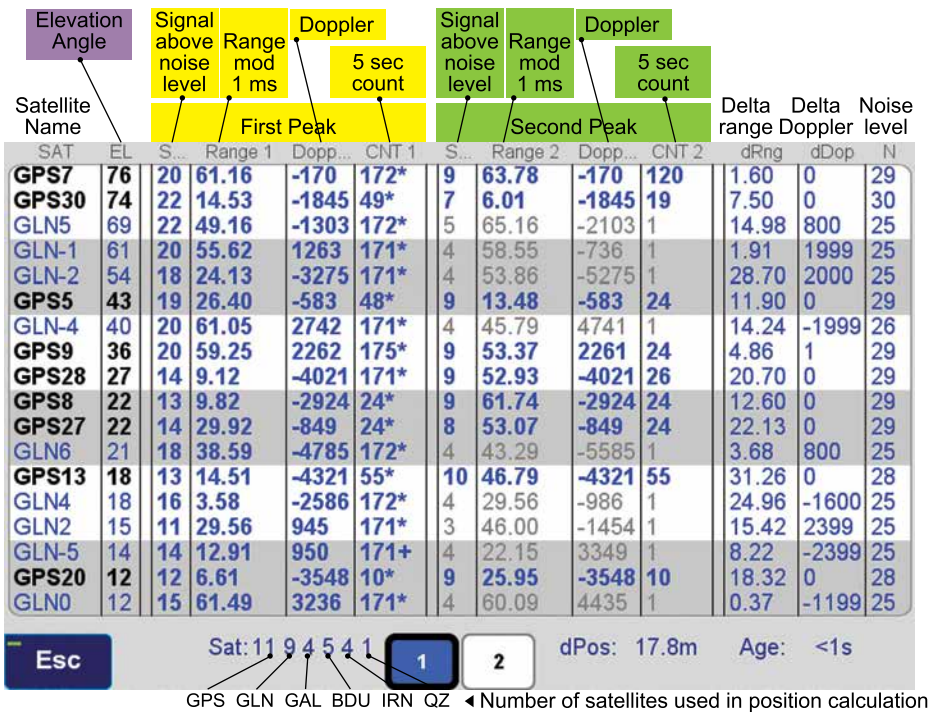
Satellite and Spoofer Peaks

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

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

Esc Sat: 10 7 6 4 4 0 dPos: 19.0m Age: <1s

No spoofer. Only one reasonable peak for each satellite.



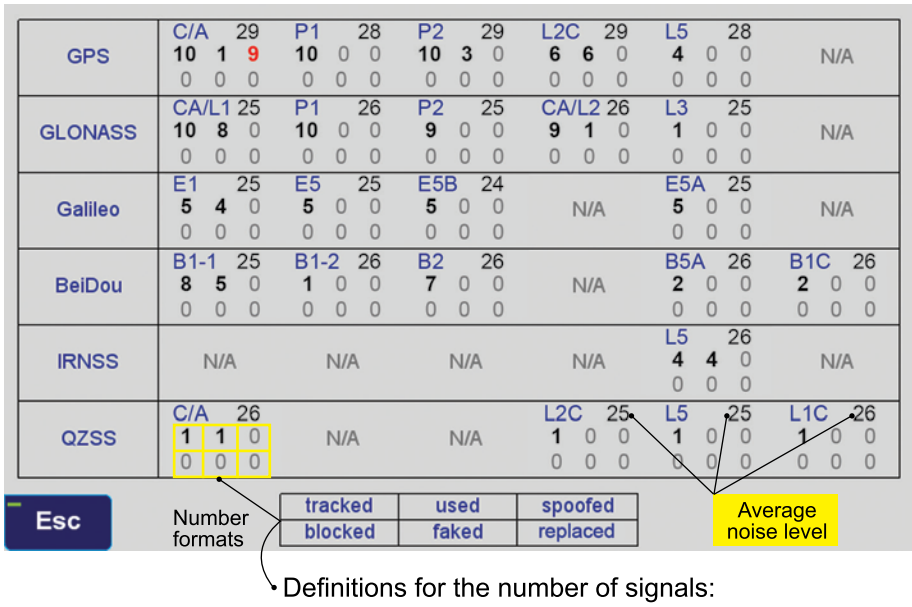
SAT	EL	S...	Range 1	Dopp...	CNT 1	S...	Range 2	Dopp...	CNT 2	dRng	dDop	N
GPS7	76	20	61.16	-170	172*	9	63.78	-170	120	1.60	0	29
GPS30	74	22	14.53	-1845	49*	7	6.01	-1845	19	7.50	0	30
GLN5	69	22	49.16	-1303	172*	5	65.16	-2103	1	14.98	800	25
GLN-1	61	20	55.62	1263	171*	4	58.55	-736	1	1.91	1999	25
GLN-2	54	18	24.13	-3275	171*	4	53.86	-5275	1	28.70	2000	25
GPS5	43	19	26.40	-583	48*	9	13.48	-583	24	11.90	0	29
GLN-4	40	20	61.05	2742	171*	4	45.79	4741	1	14.24	-1999	26
GPS9	36	20	59.25	2262	175*	9	53.37	2261	24	4.86	1	29
GPS28	27	14	9.12	-4021	171*	9	52.93	-4021	26	20.70	0	29
GPS8	22	13	9.82	-2924	24*	9	61.74	-2924	24	12.60	0	29
GPS27	22	14	29.92	-849	24*	8	53.07	-849	24	22.13	0	29
GLN6	21	18	38.59	-4785	172*	4	43.29	-5585	1	3.68	800	25
GPS13	18	13	14.51	-4321	55*	10	46.79	-4321	55	31.26	0	28
GLN4	18	16	3.58	-2586	172*	4	29.56	-986	1	24.96	-1600	25
GLN2	15	11	29.56	945	171*	3	46.00	-1454	1	15.42	2399	25
GLN-5	14	14	12.91	950	171+	4	22.15	3349	1	8.22	-2399	25
GPS20	12	12	6.61	-3548	10*	9	25.95	-3548	10	18.32	0	28
GLN0	12	15	61.49	3236	171*	4	60.09	4435	1	0.37	-1199	25

Esc Sat: 11 9 4 5 4 1 1 2 dPos: 17.8m Age: <1s

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

GNSS Overall View

The screenshot below shows the status of all GNSS signals.
The format and the signal definitions are explained below.



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

Definitions for the number of signals:

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

Used: Used in position calculation.

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

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

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

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

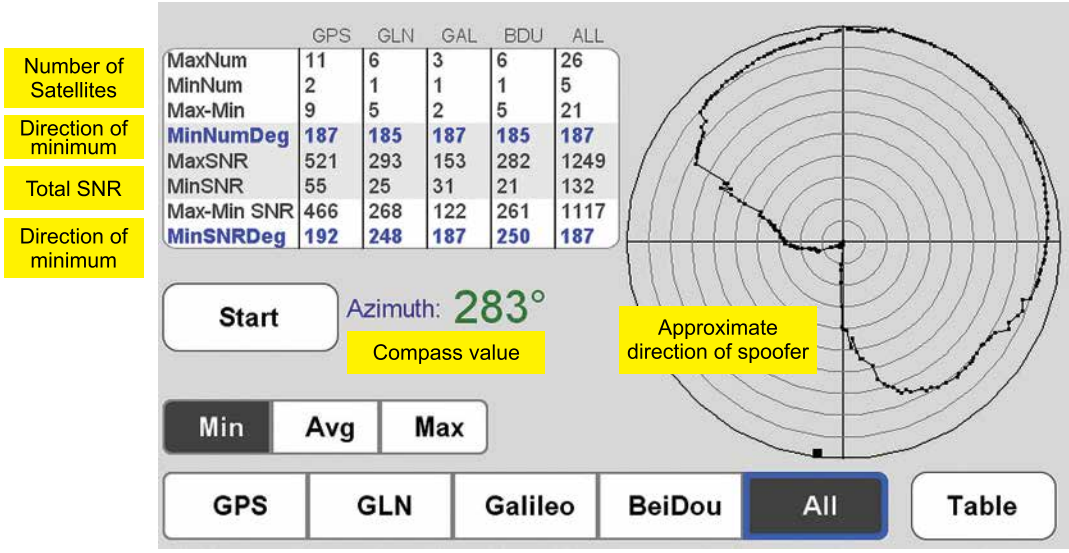
Spoofer detection available in all of our OEM boards too.

See details in GPS World expert opinions section “What is the biggest challenge facing designers of multi-constellation GNSS receivers today?” with Javad Ashjaee and at www.javad.com

Spoofer Orientation

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

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

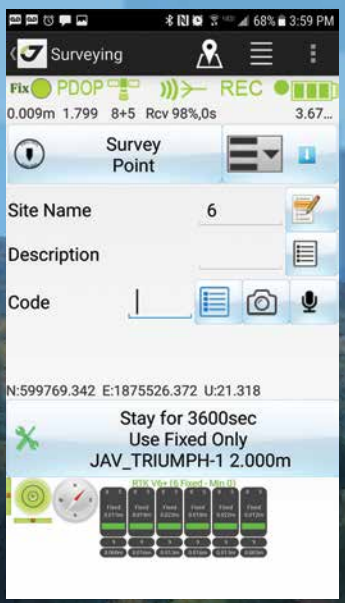


This screenshot is from the experiment within an anechoic chamber. That is why the picture is clean and smooth.

www.javad.com

Javad Mobile Tools (JMT)

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



Javad Mobile Tools (JMT) is an RTK & static control software app which allows you to connect JAVAD GNSS receivers to Android or iOS devices. JMT includes a full set of RTK and static survey routines including, data collection (RTK and static), RTK stakeout, CoGo, localization and more.

“I surveyed 20 acres today and never used the total station.”

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

“Using licensed professionals for development has been a brilliant idea. Tip of the hat to the programmers and designers that put the original box together it appears to me that they knew where they were going with this years ago.”

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J-Field Software Features

864 Channels
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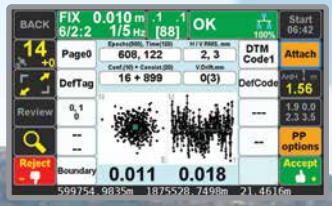
Only from JAVAD GNSS



Verification & Validation Automatic

Only from JAVAD GNSS

Customer favorite feature #1

Hybrid RTK
Another check on the work
PPK Solution

Only from JAVAD GNSS

Customer favorite feature #2

RTK Rovers - On a Budget

TRIUMPH-2
Complete RTK
Network Rover

$5,680
with Budget Smartphone & JMT

$8,255
with Rugged Victor-LS & J-Field

TRIUMPH-2
Complete RTK
UHF Rover

$6,930
with Budget Smartphone & JMT

$8,265
with Rugged Victor-LS & J-Field

GNSS education: prospects and challenges

Academicians share their views and experiences on the prospects and challenges of GNSS education and suggest the way forward

GNSS education reform is needed

Mia Filić
Research Assistant at Faculty of Engineering, University of Rijeka, Croatia

Renato Filjar
Professor of Electronics Engineering, University of Rijeka, Croatia

Satellite navigation has become a component of national infrastructure and therefore one of the pillars of the modern civilisation. This inevitably requires knowledgeable, skilled and competent professionals who will be able to advance, modernise develop, and operate satellite navigation systems and their applications and services. Capacity development in the GNSS segment and attracting talented people to the field of satellite navigation has already been recognised as an important subject. However, education in the satellite navigation discipline still suffers from a number of both inherited and emerging challenges, rendering it not completely suitable for the task.

First of all, satellite navigation is still considered a mixture of the other (mostly applied) scientific disciplines, that shaped the satellite navigation through the period of its development. This leads to curricula biased towards disciplines, that claims inheritance and foster particular education approach common to them. Satellite navigation community comprises professionals with various academic education backgrounds, spanning from mathematics, computer science and electronics engineering to geodesy, geography and transport and traffic sciences. While diversity should be considered and advantage rather than the opposite, significant problems arise from the fact that those specialists are still firmly anchored in the way of thinking and operation characteristic for their fundamental scientific discipline.

Establishing satellite navigation as a separate applied science discipline with its own philosophy based on the foundations of fundamental scientific disciplines (mathematics and statistics, in particular), and new common-interest disciplines (such as computer science) will facilitate recognition of satellite navigation and allows for identification of common capacity requirements regardless of satellite navigation sub-specialisation.

Satellite navigation has significantly and rather quickly changed the scope of its application. Considered a technology merger that will foster and advanced navigation, satellite navigation now encounters the fact that majority of GNSS applications belong to the non-navigation category. Generation of massive positioning data sets that are further processed using statistical and machine learning methods to reveal the hidden patterns and knowledge, time-stamping of financial transactions, taming vulnerabilities and shortcomings to create robust and resilient PNT services, synchronisation of large spatially distributed networks (internet, mobile communication networks, public broadcast networks, power networks, intelligent transport systems etc.) and artificial intelligence and robotics together overtake massively the traditional navigation-related GNSS applications. Making advancements and developments in such a variety of new scenarios of usage requires new and advanced capacity in methods and techniques for statistical/machine learning, modelling, management of spatial data and computing in general.

Challenges of the kind are scientifically and intellectually attractive for talented people across the scientific disciplines. GNSS core and application development, and resilient GNSS development already face a shortage of professionals with the appropriate knowledge and skills, competing with

All the institutions providing GNSS-related academic education are not balanced in their scope and intentions, and education materials are still scarce and provided on individual basis

numerous similar fields. However, the structured offer for academic education in satellite navigation is still sparse.

Organisations such as Stanford University in the US, Imperial College and University of Nottingham in the UK, and Ecole Nationale de'l Aviation Civile (France) and Politecnico di Torino (Italy) in the EU offer systematic way for academic study of satellite navigation. Numerous other universities offer partial GNSS-related education through courses related to particular discipline, depending largely on the enthusiasm and scientific results of individual scientists and educators.

> GNSS core and application development, and resilient GNSS development already face a shortage of professionals with the appropriate knowledge and skills, competing with numerous similar fields

An important move forward was made by the United Nation's Office of Outer Space Afairs (UN OOSA), that worked out an international MSc study curriculum, now used in the UN regional education centres in India, Morocco, Nigeria, Jordan, Mexico, Brazil and China (Beijing). The curriculum would need some modifications, considering the new market share of non-navigation GNSS applications and requirements for additional capacity. All the institutions providing GNSS-related academic education are not balanced in their scope and intentions, and education materials are still scarce and provided on individual basis. Finally, mobility of students and educators passed its infancy phase, but still remains at the levels that struggle to provide contribution to advancement of GNSS education at the needed scale.

We can share our experience in advancing GNSS education through a pragmatic, generalised and problem-oriented education approach in our satellite navigation academic education activities that span from the GNSS-related MSc courses in computer engineering at Faculty of Engineering, University of Rijeka, Croatia to GNSS applications MSc course at the UN Regional Centre, Beihang University, Beijing, China. Founded in mathematics, statistics and computer science, we presented materials in a structured way, and promote research activities and practical problem-solving approach based on utilisation of the open-source statistical computing R platform, GNSS Software-Defined Radio (SDR) for methods and techniques for signal and information processing in base-band and navigation (application) domains, and open-access material that passes our scrutiny.

Addressing the GNSS-related problems emerging from different GNSS application disciplines using experimental data, and bespoke or open-source (SDR and R-based) software render students capable of fast capacity end experience development on real problem solving.

Students are also encouraged to present their research results and accomplishments during major international conferences, where they can discuss subjects with the other colleagues and prominent international GNSS experts. Those activities can be supported by programmes and projects led by the UN OOSA and its International Committee on GNSS (IGS).

A proper GNSS academic education and professional advancement is essential for sustainable development of satellite navigation. Resolving issues related to GNSS deployment in steadily growing number of GNSS-based applications and services requires highly-capable GNSS professionals with broad knowledge and skills. Consequently, the GNSS academic education and professional advancement need a re-structuring reform that will assure the competent GNSS scientific and development community for the decades to come.

Good prospects of GNSS education in Indonesia

Kosasih Prijatna
Geodesy Research Group, Faculty of Earth Sciences and Technology, Institut Teknologi Bandung, Indonesia

Dudy D Wijaya
Geodesy Research Group, Faculty of Earth Sciences and Technology, Institut Teknologi Bandung, Indonesia

The development of higher education in geodesy in Indonesia has been started since the Dutch colonial era, particularly when they established *Technische Hoogeschool te Bandoeng* (Technical High School in Bandung) or TH Bandoeng in 1920. This school was primarily established to fulfil the need for professional engineers to be employed in various sectors. In early curriculum of TH Bandoeng, geodesy related subjects were only minor courses that were taught to civil engineering students. After three decades, in 1950, the curricula completely changed and most importantly geodesy became a department (Department of Geodesy). It was a milestone of the development of higher education in geodesy where geodetic science and its practical aspects were about to evolve into the current shape (Currently the department offers the programs for under/post-graduate students).

It is also important to mention that, in 1950, TH Bandoeng merged with the University of Indonesia and changed its name into Bandung Faculty of

Engineering. Furthermore, Bandung Faculty of Engineering was officially declared became an independent university and (again) changed its name into Institut Teknologi Bandung or ITB. Therefore, it can be said that, in Indonesia, the development of higher education in geodesy started from ITB and it was then spread over the whole country.

Since 1950, higher education in geodesy focused to serve the Indonesian government that requires graduates with high competency in survey and mapping. As a large-scale geospatial information for supporting national development has urgently been required, in 2003, the Department of Geodesy transformed itself into the Department of Geodesy and Geomatics Engineering. This transformation significantly improved the curricula by considering the recent growing of geodetic science and technology. Furthermore, the department moved from Faculty of Civil Engineering to Faculty of Earth Sciences and Technology. This puts geodesy into a much broader perspective: earth sciences.

Recent challenges and adaptation of the curriculum

The archipelagic country of Indonesia is located in an equatorial region (6°N - 11°08'S and 95°E - 141°45›E) and lying above three different active tectonic plates. These geographical and tectonical situations have made many limitations for the national development. As an example of such limitations is that establishment of the nationwide vertical and horizontal reference frames becomes difficult since one should consider the Earth's dynamics over the Indonesian region.

Furthermore, establishment of the vertical reference (geoid) becomes problematic since marine and land geoids should be determined using different techniques and technologies. Unification of the vertical frames is another problematic issue. In addition, acquisition of geospatial data over the Indonesian region should thoroughly be accomplished and the use of state-of-the art positioning technologies, such as Global Navigation Satellite System (GNSS), becomes mandatory to get fast, accurate and reliable results.

The use of GNSS should probably be treated differently since environmental effects over the equatorial region of Indonesia are typically different from those at the other regions. Some modifications in GNSS data processing might be required, in especially for low cost GNSS receivers, to optimally handle tropospheric and ionospheric effects that vary highly during night and day. On another side, a tremendous increasing of public needs for GNSS-based location service requires innovative and creative thoughts in order to build valuable geospatial industries.

In general, geodesy related works in Indonesia obviously requires considerable efforts in both scientific and practical aspects of geodesy. The cost for accomplishing such works becomes expensive. However, these problems and limitations should positively be viewed as challenges to enhance the quality of higher education in geodesy. Here, new approaches and innovations in geodetic observations and the data processing are necessary to get fast, accurate and reliable results with relatively low cost. Close collaboration with geospatial industries and government institutions are also important.

In order to face the recent challenges, higher education in geodesy in Indonesia should be able to produce graduates who are not only competence in doing practical surveying using the state-of-the art technologies such as GNSS, but also having comprehensive fundamental concepts and communication skills. In 2013, the undergraduate curriculum of the Department of Geodesy and Geomatics Engineering at ITB has been revised to fully accommodate recent challenges and developments. It is important to emphasize that several subjects related to geodetic positioning and GNSS plays crucial roles in the revised curriculum. GNSS technology plays crucial roles in many geodesy and geomatics activities, such as accurate positioning and establishment of a global/national reference frame, as well as earth sciences studies. Several mandatory courses (basic physics, calculus, linear algebra, statistics, positioning and least-squares adjustment, geometrical geodesy, satellite geodesy, geodynamics, and geodetic reference system and frame) are given as the basics materials to GNSS technology. Finally, promoting GNSS technology and its career prospects to students is one of our main concerns.

One Map Policy and recent prospects

Some years ago, the Indonesian government officially stated the One Map Policy, by which the government wants to have comprehensive geospatial informations over the whole region of Indonesian. The geospatial data shall be used to optimally manage the national development plans such as urban planning, land managemnent and natural resources. In order to guarantee the policy goes successful, the government declared the law no 4 of 2011 on Geospatial Information, by which acquisition of geospatial data is ruled and protected by law. One of the main points in such a law is that the Indonesian reference frame should be able to serve any kind of geospatial activities around the country. Furthermore, the reference frame should also consider the Earth dynamics.

This point implicitly recommends to use GNSS as a primary tool since it can be used for geodetic positioning and geodynamic studies. Immediate implication of this law was that the Indonesian government allocated huge budgets to establish a dense network of GNSS receiver for surveying and mapping as well as for Earth sciences studies. Currently, there are more than 150 GNSS receivers operate continuously over the country. It is worth to emphasize that the establishment of GNSS network does not only provide unique opportunities for the growing of geodesy and earth sciences, but also affect geospatial industries. This is obviously good prospects of GNSS in Indonesia, where universities can improve the quality of their education in GNSS, geospatial industries may significantly growth, and the government would get benefit from the university and industrial products, and finally the graduates may find jobs easily.

Difficult to find up-to-date resources

Ashley Brooks
Imperial College, London

GNSS is an all-encompassing field, covering a vast array of subject areas. Yet it is rarely taught on the curriculum in many top leading universities (in the UK, at least). There may be a few masters courses out there, but they are few and far between; when it comes to undergraduate courses, it may be touched upon in topics such as Surveying and Transportation within Civil Engineering, but usually very loose explanations are given without any technical depth or rigour. On the other hand, everybody, student and non-student alike, has heard of GPS and knows that it's useful to get around somehow! With this in mind, perhaps the subject could be better promoted and marketed to attract potential newcomers into the field. Apart from Google Maps, the topic doesn't gain much exposure in the academy, hence, other academic streams may be more obvious and appealing to pursue than GNSS, unfortunately.

As for myself, I studied an undergraduate degree in Maths, covering many applied maths topics, but never had an option to study positioning and navigation systems. I did, however, unknowingly develop useful mathematical tools to allow the study of GNSS in the future. The other part of my (master's) studies that would become useful for the field of GNSS was engineering and sustainability. Here, I studied concepts such as risk and resilience of infrastructure, systems thinking and systems engineering, and transportation systems; all have been useful in my current research as a PhD student, new to the field of GNSS.

As a new student of GNSS it hasn't been easy to navigate through the extensive literature. It can be difficult to find up-to-date resources, with concepts clearly explained and targeted at beginners. It is always a challenge to find subject material pitched at the right level, and at the right depth – but there is some great material out there. One of the biggest challenges faced is knowing where to focus your learning as the field is so vast and is changing at a rapid pace!

One great help is supportive supervisors (with available funding) who encourage participation in external training and conferences. I think it is recognised that PhD students (and young professionals in industry) do often have limited exposure to, and education in, GNSS topics; so the European ESA and e-KnoT have run a number of educational training events, seminars and the infamous ESA/JRC International Summer School. These are very useful for learning the fundamentals of GNSS and for networking with peers, as well as experts in the field. Again, they also highlight the wide-ranging nature of positioning and navigation. The UK's Royal Institute of Navigation also put on useful conferences such as their Next Gen Conference for new research students to present their work and ideas, and their annual International Navigation Conference for all navigation enthusiasts highlighting current research trends, far and wide.

An advantageous attribute to working in the field of GNSS is the many opportunities for collaboration at the industry interface. There are a plethora of companies working on various aspects of GNSS development and applications across the globe. This is mostly a good thing for research and development, but can be problematic at times as private companies often want to protect their methods and IP – in contrast with the open, sharing approach in academia. In addition, GNSS research in academia undergoes careful scrutiny and peer review, whereas research in industry is generally less transparent and less rigorous, with more of a commercial focus. This usually makes it difficult to find and trust research methods and performance claims from industry. In this regard, I would certainly like to encourage increased transparency and rigour from industry, to aid research in academia.

Overall, I think there are excellent career prospects for young professionals, especially in light of new GNSS-related systems/applications in many regions, in particular, Europe (with Galileo). The various opportunities and future career paths, both within academia and industry, was certainly something that attracted me into the field. With so many recent developments and interesting world-wide applications in GNSS (and more generally, positioning and navigation systems) it is an exciting area of research to be in. I hope we can 'spread the word' and make this well known to future generations of aspiring scientists and researchers.

As a new student of GNSS it hasn't been easy to navigate through the extensive literature. It can be difficult to find up-to-date resources, with concepts clearly explained and targeted at beginners. It is always a challenge to find subject material pitched at the right level, and at the right depth – but there is some great material out there. One of the biggest challenges faced is knowing where to focus your learning as the field is so vast and is changing at a rapid pace!

Specialization education on GNSS in Morocco, An important step to socio-economic development

Mourad BOUZIANI
Director
School of Geomatic Sciences and Surveying Engineering, Rabat, Morocco

GNSS potential

The field of GNSS in Africa is gaining more importance especially in recent years because of the growing number of applications based on it in agriculture, aviation, geodesy and surveying, internet of things, land management, mapping, natural resources management, space weather and vehicle tracking. They generated important economic opportunities and contributed to human development and the improvement of social conditions.

GNSS has already shown its enormous potential in various fields. In addition, several recently developed geospatial data acquisition technologies are based on satellite positioning. LIDAR, Drones (UAV) and mobile mapping systems (MMS) are some examples. These technologies make technically and economically accessible sites that were not previously. Their use provides valuable help to decision makers for better management of the territory.

The field of GNSS is more than promising. This dynamic technological environment will require constant innovation on the supply side and services that go beyond the simple acquisition of localization but must meet the needs of analysis and management.

The majority of this growth will be generated by significant demand in regions outside Europe and North America. Indeed, the Asian and African continents will be in the next decade the engine of this growth because of the potentialities they offer. In this context, the training of technical experts in GNSS, scientific research and academic partnership with the public and private sector should be encouraged. These are three essential assets for any sustainable development.

GNSS education in Morocco

In Morocco and many other African countries, a pioneering role was taken by professors and engineers of surveying and geodesy in the awareness of the importance of GNSS and in the development of many relevant applications. They were precursor of the first education opportunities of this important technology.

In this context, the School of Geomatic Sciences and Surveying Engineering (IAV Hassan 2, Morocco) integrated GNSS education into its training curriculum of surveying and geomatics engineering graduate program, since the early 1990s. It also contributed in various development and research projects related to this field with public administrations and private companies in Africa.

Aware of the needs in GNSS specialists to meet the requirements of the labor market and the expectations of decision-makers and manufacturers, the School of Geomatic Sciences and Surveying Engineering (IAV Hassan 2, Morocco) established in 2016 a specialized master course on GNSS. This master is fully integrated in the School in partnership with the African Regional Centre for Space Science and Technology Education (CRASTE-LF) affiliated to the United Nations. This education program is the first specialized master on GNSS in Africa.

GNSS has basically an interdisciplinary nature. It comprises many key technology areas. Cooperation with other Schools and partners is required. In this context, several professors and experts from African and European institutions representing academia, research and industry contribute to this master course degree. Other experts from China, Russia and the United States of America participate through seminars and workshops in GNSS technology and applications.

To ensure the success and sustainability of this training, the master on GNSS is accredited by the Moroccan Ministry of Higher Education, Scientific Research and Executive Training and benefits from the support of the United Nations Office of the Outer Space Affairs (UNOOSA) whose contribution is vital.

For the development of education program on GNSS, many issues must be taken into account: Effective implication of the providers to support education programs, Funding support for need-oriented research, Support for international professors and experts, Access to digital documentation and search results and the valorization of students projects to make them more attractive for the industry

Students motivation

Based on my experience at the university level, there is an increasing demand for training in GNSS in general. There is a large interest by students and professionals in getting trained in this field. Related to the specialized master on GNSS, three different categories can be identified:

- professionals seeking improvement and diversification of their activities and areas of application.

- recent graduates seeking to distinguish themselves from conventional training curricula and to position themselves with innovative and high value-added projects in the labor market.

- candidates interested in navigation satellite systems research who want to continue into a PhD program after graduation.

Candidates of the specialized master on GNSS come from a variety of background disciplines: mathematics, electronics, geomatics, surveying and computer science. The selection of candidates to take the master course should be based on three criteria: motivation, the background and the previous academic results.

Indeed, motivation is a powerful energy that can lead to success. In this sense, candidates are encouraged to identify their future plans. Training on GNSS must enable them to achieve their goals. So they have to know what they want to do with their studies. Once integrated into the master course, the students are attracted by several aspects that increase their enthusiasm : the quality of instructors, the relevance and richness of course materials and the importance of the practice and the professionalization of the trainings : positioning algorithms, handling receivers, creating added value through the implementation of applications.

Reputation of institutions involved in the master course and partnership agreements concluded with other organizations are also important to drive motivation. They are the guarantee of the availability of internship opportunities, development projects and job offers. In this environment of education, students remain diligent in all classes and show a sense of progress. At the level of education, we insist, on the one hand, on the basic skills needed to understand the different technological aspects of GNSS and, on the other hand, on the practical tasks and projects that are assigned to students to stimulate their curiosity and their interest in this technology. This way, students can innovate through the development of new software, propose new applications of GNSS and are encouraged to the integration of many technologies and several sensors.

More effort and support are needed

To exploit the full potentials of GNSS, more efforts in education are needed. One of the main challenges is the ability to adapt the education programs to the recent and upcoming needs. In addition to the consolidation of the basics, the training must be in line with the technological and research evolution to meet the current and future needs of the market. Coordination between training, research and industry is very important to ensure the quality of GNSS graduates.

For the development of education program on GNSS, many issues must be taken into account : Effective implication of the providers to support education programs, Funding support for need-oriented research, Support for international professors and experts (Funding air tickets and living expenses), Access to digital documentation and search results and the valorization of students projects to make them more attractive for the industry.

If we look at the enormous socio-economic opportunities offered by GNSS, and the increasing number of candidates seeking GNSS education, we remain surprised to note that the commitment of governments and the industrial world to specialized GNSS education is still insufficient. A lot of work and awareness-raising efforts must be invested to highlight the importance and relevance of this type of training.

Need to develop human resource capable of using GNSS

Dinesh Manandhar
Shibasaki Lab, CSIS,The University of Tokyo, Japan

Today we see more than 30 navigation satellites in the sky over Asia. They include satellites from USA (GPS), Russia (GLONASS), Europe (GALILEO), China (BDU), Japan (QZSS) and India (IRNSS). Theoretically, we need only four satellites to compute a position in 3-D. However, to guarantee accuracy, availability and reliability in different environments, terrain, location and dynamics, four satellites are not enough to provide 3-D PVT (Position, Velocity and Time) solutions. Today, receivers have changed from GPS only or GLONASS only to GNSS receivers that are capable of receiving signals from multiple satellite systems.

GNSS receiver designs are changing from single-system, single-signal and single-frequency to multi-system, multi-signal and multi-frequency. Even a low-cost single frequency GNSS receiver has 66 channels or more with capabilities to process L1C/A, L1S and SBAS signals from all satellite systems. All these show that there are numerous opportunities to use GNSS for machine control, transportation, navigation, aviation, railway, finance, banking etc. besides mapping and surveying applications.

Although, GNSS technology has developed rapidly in the past decade, the capacity development and human resource development could not occur at

the same pace. One of the reasons is due to lack of GNSS training and education institutes in the Asian region (except India, China, Japan, Taiwan, Singapore and few other countries). There are very limited training and education centers that provide education in GNSS technology. Due to this, there is a serious lack of knowledge and information on how this new technology can be applied in various applications to provide better and efficient services besides surveying and mapping applications. For example, how can GNSS be used in agriculture to increase production? How can GNSS be used to broadcast SMS during natural disasters and emergencies? How can GNSS make our daily activities more secured and safer? How can GNSS be used in medical services? How can we avoid car accidents? Can we avoid aircraft crashes due to sudden change in weather by monitoring GNSS signal characteristics? How can GNSS help to predict Space Weather? Which signals shall we use for a specific application? These are some of the questions that we come across when we discuss to find novel applications.

Relatively newer technology

GNSS technology is relatively newer compared to other technologies like remote sensing and GIS. GPS and GLONASS began services in 1980's, however, other systems like GALILEO, QZSS, BEIDOU and IRNSS began their services more than two to three decades later. Until 2000, GPS and GLONASS are like "Black Box" for most of the users. Very little information were available during those days. However, after the availability of software defined radios (SDR) in early 2000, GPS signal processing have become much simpler to understand. It has become possible to develop one's own software defined GPS receiver to process GPS signal as required. This led to emergence of many new applications beyond PNT.

Challenges in GNSS education

There are very few universities in Asia where GNSS is taught as the major subject. For example, there are universities that provides Master's degree in Remote Sensing & GIS but not in GNSS. The RS&GIS course at AIT (Asian Institute of Technology), Thailand offers one credit GNSS course in it's curriculum. This course at least covers the basics of GNSS and signal processing skills for high-accuracy survey.

In Europe, Politecnico Di Torino, Italy offers Master course in Navigation and Related Applications (https://didattica.polito.it/master/navigation/2018/introduction) where the students are taught all about GNSS. Though there are many universities and institutes in the USA and Europe that teach GNSS both at academic and non-academic levels, Asian students can't afford them due to high tuition fees, living expenses and visa issues etc.

In Asia, we need to develop human resource who are capable of using GNSS as an end-user solution in various applications. This requires that one needs to know how GNSS works, what type of GNSS signals shall be used for a specific application, how GNSS surveys shall be conducted, how to remove or adjust errors, how to integrate GNSS with other systems and devices and so on. Thus, education and training in Asia shall be more focused on end-user solution and system integration rather than the development of GNSS receiver itself. Another challenge to provide GNSS education and training in Asia currently is limited number of resource persons. It is also necessary to have a pool of resource persons who can provide their time to conduct lectures and training.

Our approach

In order to help the countries in Asia to learn about GNSS and capacity development, we have been conducting seminars, workshops, trainings and joint research in various countries. We have installed survey-grade GNSS base-stations in some of the universities in Asia. We call it Asian Base-Station Network (ABN). These base-stations provide data for research purpose as well as for local use of high-accuracy RTK survey. The list of the base-stations are shown in Figure 1 and Table 1.

One of the stations of ABN installed at Chulalongkorn University, Thailand is also connected to IGS network. The data can be downloaded from http://www.igs.org/igsnetwork/network_by_site.php?site=cuut. We welcome the readers interested in our ABN data to contact the author of this article for further details. We have already conducted trainings at some of the universities listed above. We have plan to conduct regular training courses in future as well.

GNSS training

GNSS training is one of the effective approaches to develop required human resources in Asia. Trainings at various levels for various applications shall be conducted. In this regard, we have conducted a GNSS training at GIC (Geoinformatics Center), AIT (Asian Institute of Technology), Thailand in January 2018. This training program was jointly organized by GIC/AIT, UNOOSA/ICG (United Nations Office for Outer Space Affairs / International Committee on GNSS) and S4D/CSIS/UT (Space for Development / Center for Spatial Information Science / The University of Tokyo). The objectives of the training programs are:

- Introduction to GNSS
- General overview of GNSS signal processing
- Introduction to PPP and RTK
- Field Survey using Low-Cost receiver for High-Accuracy positioning

There were 67 participants in the training program. 11 international participants were funded by ICG, 14 international participants were self-funded. The participants are from Afghanistan, Bangladesh, Bhutan, Cambodia, India, Indonesia, Japan, Maldives, Mongolia, Nepal, The Philippines, Sri Lanka, Tajikistan, Thailand and Vietnam.

This type of training is very effective to teach practical methods on how to process GNSS data for high-accuracy. Many participants have feeling that high-accuracy GPS receivers are very expensive so they don't think about using GPS in other applications beyond surveying and mapping. Some participants thought that GPS was only for surveying, mapping and navigation. So they never thought about using it in agriculture, traffic analysis, timing applications etc.

The training materials can be downloaded from http://www.unoosa.org/oosa/en/ourwork/icg/activities/2018/ait-gnss.html.

Training for policy and decision making level

GNSS being newer technology, it is also necessary to teach GNSS at policy and decision making level. In many Asian countries, use of GNSS is new application and its implementation requires decisions to be made at higher levels. Sometimes, these decisions are not made on time due to lack of technological information about GNSS. Thus, it is necessary to train and teach at policy and decision making level as well.

Education materials and tools

In order to provide practical exercise on use of GNSS, it is necessary to provide GNSS receivers to each student or trainee. However, a good GNSS receiver that can be used for high-accuracy (RTK) costs from a few thousand dollars to tens of thousands of dollar. It is not possible for an education or training institute in Asia to own multiple number of this type of GNSS receivers. Of course, it is necessary to have one or two units of high-end devices to analyze GNSS data. A low-cost GNSS receiver that is capable to provide high-accuracy (for RTK) is required for effective practical education.

In order to solve this problem of receivers, we are developing low-cost high-accuracy GNSS receiver systems that are capable

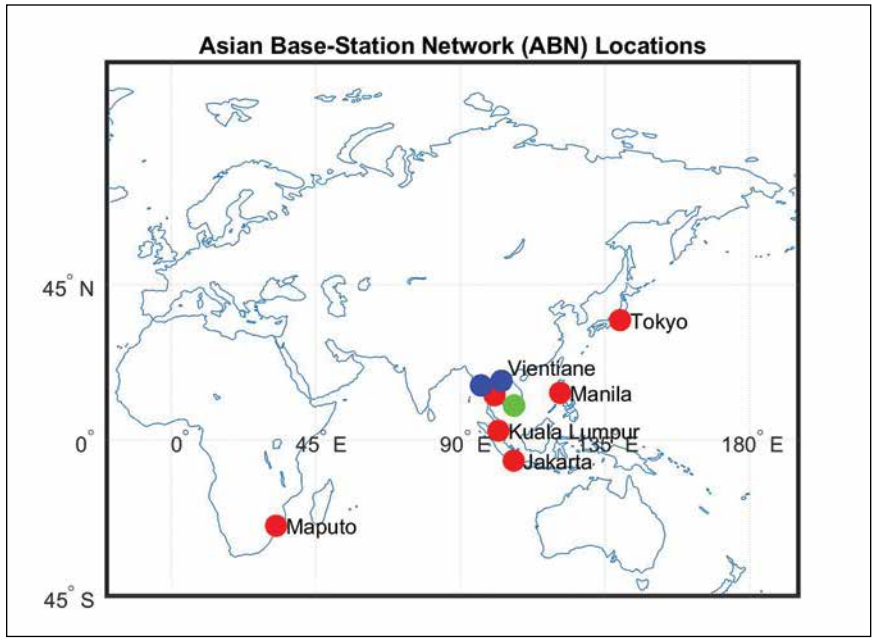


Figure 1

Country	Place	University
Indonesia	Jakarta	University of Indonesia
Japan	Tokyo-A	The University of Tokyo
Japan	Tokyo-B	Tokyo University of Marine Science & Technology
Japan	Tokyo-C	KEIO University
Laos	Vientiane	National University of Laos
Malaysia	Kuala Lumpur	Malaysia Japan International Institute of Technology
Myanmar	Yangon	Yangon Technological University
Thailand	Bangkok	Chulalongkorn University
The Philippines	Manila	University of the Philippines
Vietnam	Ho Chi Minh City	International University Vietnam National University
Mozambique*	Maputo	Universidade Eduardo Mondlane

Table 1

Figure 2: Participant of GNSS Training at GIC/AIT, Thailand

to provide raw data for RTK processing either in real-time or post-processing mode. Currently, this type of device can be made from GNSS module or receiver that can output raw data (pseudorange, carrier phase, SNR etc) by integrating with a board computer (RaspberryPi) instead of a computer. A prototype of this device is shown in Figure 3. The total cost of this device is below US $200- including GNSS receiver, antenna and RaspberryPi board computer. The receiver is capable of receiving signals from all GNSS systems in L1 band.

An Android APP is also developed to control the receiver and software in the board computer. RTKLIB software is installed in RaspberryPi to process GNSS signal for high-accuracy. All necessary signal processing and computations are done in RaspberryPi and the results are send to Android device via Bluetooth link for monitoring purpose.

> In Asia, we need to develop human resource who are capable of using GNSS as an end-user solution in various applications

The device can access NTRIP servers to get real-time RTCM data for RTK.

If the receiver only need to log GNSS data for high-accuracy position in post-processing mode, a system based on RaspberryPi Zero as shown in Figure 6 can be used for lower cost and lower power consumption. This is a sort of plug-and-ply type of device. The device starts logging GNSS raw data necessary for RTK processing once power supply is provided to the board computer (RaspberryPi Zero with WiFi & BT.

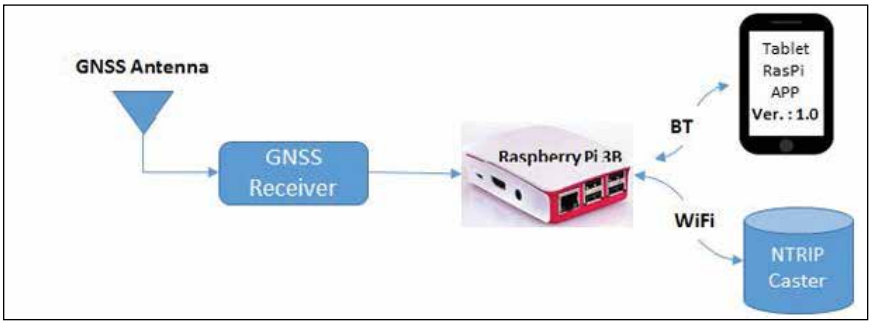


Figure 3: Low-Cost High-Accuracy Positioning System (L-CHAPS) Device

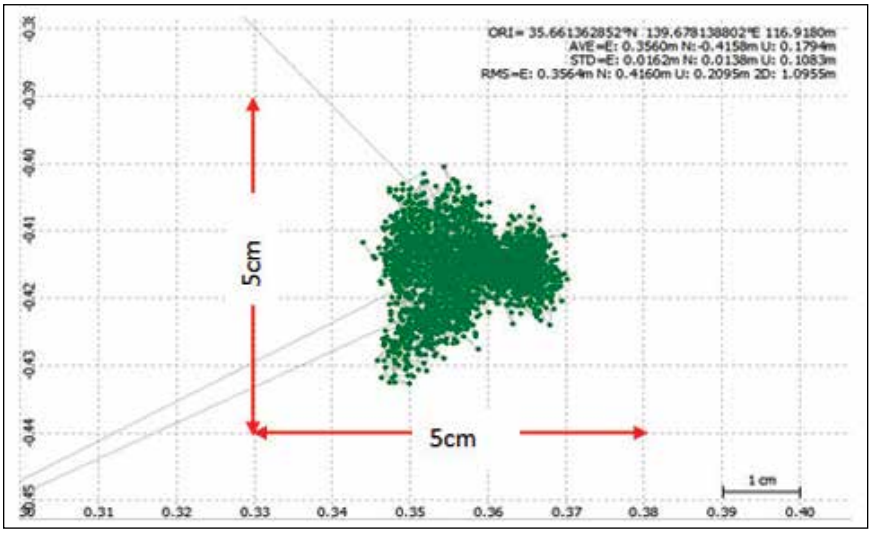


Figure 4: Position Accuracy from L-CHAPS Device shown in Figure 3

Role of ICG

ICG (International Committee on GNSS) is playing a key role in capacity development in the field of GNSS. ICG has a working group "Information Dissemination and Capacity Building" to promote capacity development globally.

Please check the website at http://www.unoosa.org/oosa/en/ourwork/icg/working-groups/c.html to see the activities of service provider members from USA, Russia, Europe, China and Japan to promote capacity development. ICG also conducts many workshops around the globe to promote GNSS technology and capacity development. Please check their website at http://www.unoosa.org/oosa/en/ourwork/icg/activities.html

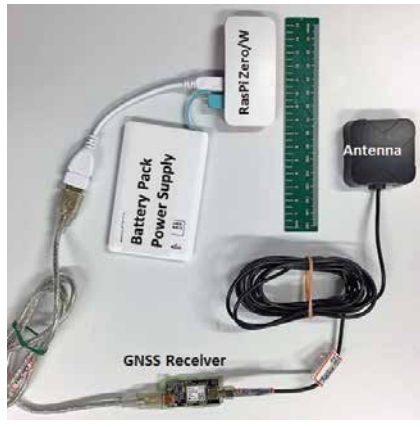


Figure 5: A plug-and-play type of L-CHAPS to log GNSS data for post-processing RTK

Summary

In order to promote GNSS education and training in Asia, it is necessary to conduct regular trainings, workshops and seminars targeting various levels of users. This type of programs may be purely technical, non-technical or business oriented. It is also necessary to have a pool of resource persons who can teach and conduct trainings. In order to enable these activities, it is necessary to have good networking among the GNSS resource persons, users, system developers and integrators, various organizations involved in GNSS or related fields and funding agencies.

Galileo update

Space policy: Galileo Security Monitoring Centre back-up site moves to Spain

The Galileo Security Monitoring Centre (GSMC) is a technical infrastructure, which plays a key role in ensuring the security of the Galileo, including its Public Regulated Service (PRS). The GSMC has its main and operational location in France and its back-up site in the United Kingdom (Swanwick). As a consequence of the United Kingdom's withdrawal from the EU, the GSMC's back-up site needs to be relocated from the United Kingdom to one of the 27 EU Member States.

Commissioner for the Internal Market, Industry, Entrepreneurship and SMEs Elżbieta Bieńkowska said: "Europe's satellite navigation system Galileo has already been delivering high quality services for over a year now. With today's decision the Commission is taking the necessary operational steps to ensure business continuity and preserve the security of the Galileo system."

On 1 August 2017, the Commission launched an open and transparent call for expressions of interest to host the back-up site of the GSMC. Six Member States (Belgium, Italy, Portugal, Romania, Slovenia and Spain) submitted proposals, which the Commission assessed according to objective technical, security, financial and programmatic criteria on the basis of the rules foreseen in the Galileo Regulation. On 18 January 2018, representatives of 27 Member States in the European Global Navigation Satellite Systems (GNSS) Programmes Committee voted in favour of the Commission proposal to relocate the back-up site to Spain. With today's formal decision, the Commission is launching the process for the transfer of the back-up site from the UK to Spain.

The new site will become operational in the coming months, subject to its prior accreditation by the Security Accreditation Board for European GNSS Systems. The hosting Member State will bear the costs for hosting the back-up site, while the EU will bear the costs of staffing and Galileo equipment. The GNSS Agency in Prague (GSA) will decide on the number of staff to operate the back-up centre.

Galileo is a key component of the Commission's Space Strategy, which focuses on fostering new services, creating business opportunities, promoting Europe's leadership in space and maintaining Europe's strategic autonomy.

The Galileo Public Regulated Service (PRS) is an encrypted navigation service for government-authorised users, such as civil protection services, customs officers and the police. This system is particularly robust and fully encrypted to provide service continuity for government users during emergencies or crisis situations.

A growing number of companies and innovative start-ups are using Galileo data and enabling their devices, including the newest versions of smartphones. *http://europa.eu/rapid/press-release_IP-18-389_en.htm*

Iridium announces date for fifth Iridium® NEXT Launch

Iridium Communications Inc. announced that the fifth Iridium NEXT launch has been targeted by SpaceX for March 18, 2018. The first of four launches planned for 2018, Iridium-5 will deliver 10 more Iridium NEXT satellites to orbit, bringing the total number of new satellites deployed to 50.

Iridium NEXT is the company's $3 billion, next-generation, mobile, global satellite network scheduled for completion in 2018. The constellation features 66 active satellites, plus nine on-orbit spares. In total, 81 new satellites are being built, with the six remaining satellites serving as ground spares. Iridium NEXT will replace the company's existing global constellation in one of the largest technology upgrades ever completed in space. It represents the evolution of critical communications infrastructure that governments and organizations worldwide rely on to drive business, enable connectivity, empower disaster relief efforts and more. *www.IridiumNEXT.com*

China launches remote sensing satellites

Recently, China launched a series of Yaogan-30 remote sensing satellites from Xichang Satellite Launch Center in southwest China's Sichuan Province.

A micro-nano 1A satellite was also sent into space along. The satellites have successfully entered their preset orbit. *www.xinhuanet.com*

NorSat-3 maritime tracking microsatellite

The Space Flight Laboratory (SFL) at the University of Toronto Institute for Aerospace Studies (UTIAS) has announced that NorSat-3, a 15-kilogram microsatellite, has been ordered by the Norwegian Space Centre, and that construction is well underway. NorSat-3 follows from the highly successful NorSat-1 and NorSat-2 satellites also built by SFL.

NorSat-3 will carry an experimental navigation radar detector to augment ship detection capabilities from its Automatic Identification System (AIS) receiver. NorSat-3 will add another satellite to Norway's assets in space – four in total so far, all producing data related to maritime traffic monitoring. Combining a navigation radar detector and AIS receiver will potentially provide much better maritime awareness for the Norwegian Coastal Administration, Armed Forces and other maritime authorities. *www.utias-sfl.net*

Remote sensing captures ancient silk road cities

Using remote sensing, Chinese archaeologists believe they have located a city of the Protectorate of the Western Regions, a major city on the Silk Road, in Koyuk Shahri of Luntai County in Xinjiang Uygur Autonomous Region.

The city was established in 60 B.C.to supervise domestic and foreign affairs around Tarim Basin, protecting the Silk Road from military assaults. Last year, archaeologists from the Institute of Remote Sensing and Digital Earth (RADI) under the Chinese Academy of Sciences (CAS) exploited remote sensing technology to find an "abnormal" ring around the Koyuk Shahri, which was later proved to be a moat. They also found the ancient city site in Koyuk Shahri was constructed with the rectangular facade and the round interior.*www.ecns.cn*

Israel launches world's first flight of nano-satellites

A group of three nano-satellites developed by scientists from Haifa's Technion-Israel Institute of Technology will be the first autonomous spacecraft in the world to be flown in formation.

The project, developed with the support of the Adelis-Samson Foundation and the Israeli Space Agency (ISA) in the Science and Technology Ministry, will be launched on the Indian launcher PSLV at the end of 2018 by the Dutch company Innovative Solutions In Space, which specializes in launching nano-satellites.

The satellites will be used to receive signals from Earth and calculate the location of the source of the broadcast for rescue, detection, remote sensing and environmental monitoring. Each of the satellites is 10 cm. x 20 cm. x 30 cm. – about the size of a shoebox – and weighs about eight kg. They will be equipped with measuring devices, antennas, computer and control systems and navigation devices. The software and algorithms that will control the flight were developed in a laboratory for distributed space systems at the Technion. *www.jpost.com*

NITI Aayog, India initiates the first course on Sustainable Urban Planning

The First Global Initiative on Academic Network (GIAN) course on Sustainable Urban planning using remote sensing and GIS has been launched at Indian Institute of Technology Kanpurs outreach center in Noida. Principal Adviser, NITI Aayog, Ratan P. Watal, inaugurated the course at a function in Noida on 15th January,2018.

This course aims to give participants state-of-the-art remote sensing and GIS skills which will allow them to rise to the challenge of managing the rapidly changing urban environment of Indian cities. Focus will be on issues such as water resource management, water pollution and strategic emplacements for water treatment facilities. *www.business-standard.com*

ISRO launches 31 satellites, puts remote sensing Cartosat-2 into orbit

India has deployed a remote sensing Cartosat and 30 other satellites, including 28 from six nations into the earth's orbit. The 44.4-metre tall Polar Satellite Launch Vehicle (PSLV-C40) roared into a clear sky after a perfect lift-off.

Of the 31 satellites, three are Indian and the rest are from Canada, Finland, France, South Korea, UK and the US. The Indian satellites include the 710 kg Cartosat-2 series for Earth observation as the primary satellite of the mission, along with co-passenger payloads, including 100 kg micro satellite and a 10 kg nano satellite.

Cartosat-2 series was the first to be separated from the rocket and injected into the sun synchronous orbit at 505km above the earth, followed by the 10 kg nano satellite and the 100 kg micro-sat in different orbits. The Cartosat-2 series would orbit around the Earth for five years. The micro satellite would be India's 100th satellite in space around the earth's orbit.

The first space mission in 2018 came four months after a similar rocket failed to deliver the country's eighth navigation satellite in the earth's lower orbit on August 31, 2017. *www.thestatesman.com*

K Sivan takes charge as new ISRO chairman

K Sivan took charge as the new Secretary, Department of Space, Chairman of the Indian Space Research Organisation and the Space Commission on January 15. On this occasion, Dr. Sivan said that he took charge from the former ISRO chairman A.S. Kiran Kumar.

A Ph.D in aeronautical engineering, Dr. Sivan is the ninth head of the space establishment.

Astrata launches VanLinc

After more than 25 years developing high-end telematics software for the HGV industry globally, Astrata is now bringing its expertise to benefit the European LCV market with the launch of VanLinc™.

This fleet management solution provides real-time insights on drivers, vehicles and other assets, helping businesses drive productivity and increase capacity for work. The VanLinc solution also effortlessly integrates with refrigeration systems to maintain constant temperature control during transport. *www.astrata.eu/vanlinc*

Location detection when GPS doesn't work

Professor of aeronautics and astronautics Moe Win has spent the last decade investigating the theory and practice of using wireless signals to gauge location.

Recently, Win and two colleagues — Wenhan Dai, an MIT graduate student in aeronautics and astronautics, and Yuan Shen, an associate professor of electronic engineering at Tsinghua University, who did his graduate work at MIT — expand on those results.

First, they show how changing a wireless localization system's parameters — such as the power, bandwidth, and duration of its transmissions — alters the fundamental limits on its accuracy. This, in turn, allows them to determine the system configuration that yields the most accurate location inferences. They also provide practical localization algorithms that can approach those limits in real-world scenarios.

The researchers' theoretical approach assumes that the localization network consists of nodes with known positions, referred to as "anchors," and nodes with unknown positions, referred to as "agents." Wi-Fi access points distributed through an office building, for instance, could serve as anchors. Smartphones trying to determine their positions relative to the anchors would count as agents.

Within the theoretical framework, the goal is something the researchers call "node prioritization" — that is, determining which of the available anchors should transmit, at what power and with what range of frequencies and signal durations, in order to achieve a balance between localization accuracy and consumption of system resources. A solution that produced very accurate measurements by allowing an anchor to blast so loud and long that no other communication over the network was possible, for instance, would not be considered optimal.

The researchers' theoretical analysis shows that the ability to adjust system parameters can consistently reduce localization error by 30 to 50 percent. The key to the new paper is a geometric interpretation of the problem of choosing and configuring anchors. The metric that the researchers use to assess the accuracy of location inferences depends on three different characteristics of the location information extracted from wireless signals. As such, it defines a three-dimensional mathematical space, which turns out to be bullet-shaped. *http://news.mit.edu*

Real-time connected vehicle safety services from Here for BMW drivers

Here Technologies has launched a cloud-based system which aggregates real-time data generated by cars of different brands to provide live road safety information.

The company then delivers this to drivers and passengers through the car's head unit display, or to its advanced driver assistance systems (ADAS) to support automated safety functions. BMW will be the first automaker to offer Here Safety Services in production vehicles from mid-2018. The services will first become available to drivers and passengers across Western Europe and North America. *www.fleetnews.co.uk*

Acuity Brands, Inc. Phunware adds Atrius IoT Indoor Positioning Solution

Acuity Brands, Inc. has announced that Phunware, an enterprise mobile software company, has joined the Atrius(TM) Internet of Things (IoT) partner ecosystem. Phunware will be adding the Atrius Navigator software development kit (SDK) to its indoor positioning technology offerings, providing customers an innovative, energy-efficient option to support Phunware's hardware-agnostic location capabilities. Phunware currently provides an indoor wayfinding solution, available on both Apple® iOS and Android(TM) operating systems, which can be embedded within a fully configurable Phunware-managed native app or within a customer's existing app via its Mapping and Location SDKs. *www.acuitybrands.com/atrius*

Smart city cloud platform by Ford and autonomic

Ford and Silicon Valley-based Autonomic will work together to build a new open platform upon which cities can build out infrastructure communications, including connected traffic lights and parking spots, called the "Transportation Mobility Cloud", according to Ford CEO Jim Hackett.

The platform is designed to help connect smart transportation services, as well as adjacent connected offerings, uniting them with one common language to help coordinate all this efforts in real-time. That means tying together personal cars with vehicle-to-everything communications built in, incorporating things like bike sharing networks, public and private transportation services, including buses, trains, ride hailing and beyond. The Transportation Mobility Cloud will support location-based services, determining routes, sending out alerts about things like service disruptions, handing identity management and payment processing, as well as dealing with data gather and analytics. *https://techcrunch.com*

Intel unveils first autonomous vehicle

In the opening keynote for CES 2018, Intel CEO Brian Krzanich highlighted how data is transforming the world around us and driving the next great wave of technology innovation, from autonomous driving to artificial intelligence (AI) to virtual reality (VR) and other forms of immersive media.

In autonomous driving, he unveiled Intel's first autonomous vehicle in its 100-car test fleet; disclosed that BMW, Nissan, and Volkswagen are moving their Mobileye-based mapping design wins to actual deployments; and announced new collaborations with SAIC Motor and NavInfo to extend crowdsourced map building to China. Focused on the future of AI, Krzanich announceda partnership with Ferrari North America to use Intel's AI technologies to apply data from the racetrack to enhance the experience for fans and drivers.

OS shapes up the UK's driverless infrastructure

Business Secretary, Greg Clark, has appointed Ordnance Survey (OS) to shape the UK's national infrastructure to be capable of supporting driverless car networks.

OS will help the country effectively shape and deploy a national infrastructure that has the capability to support the national network of Connected and Autonomous Vehicles (CAVs) in the digital age.

Named E-CAVE, the project is firmly at the heart of the government's modern industrial strategy and helps to continue the UK's status as a world-leading location in tech and CAVs. The project will be run over a four year period, focusing on the challenges there are to creating an effective connected car environments. OS will use digital data expertise to find effective solutions to deploy the infrastructure. *www.cbrgovernment.com*

PCI Geomatics Releases GXL 2017, Service Pack 1

PCI Geomatics, recently released Service Pack 1 for GXL 2017. It is used by large organizations that must meet time critical deadlines on a regular basis and work with a variety of satellite and aerial images. Most recently, PCI customers have requested improved support for fast processing of imagery collected by ADS push broom cameras, which are increasingly being used for large area mapping and are well suited for corridor mapping.

Apple to expand its fleet of self-driving cars

To test the on-road safety of its self-driving car technologies, tech giant Apple is planning to expand its fleet of self-driving cars from 3 to 27. Approved in April last year, Apple started the self-driving technology project, dubbed as "Project Titan."

The project will use the fleet of Lexus SUVs just like it was used for its last 3 vehicles. Equipped with Velodyne's LiDAR imaging sensor, the cars were registered to test on public roads in California.

Apple's vehicles are also outfitted with radar sensors and a computing stack on the outside that are designed to help support the LiDAR sensors in visualizing the world around the vehicle.

Belgocontrol to assist drone users

Belgocontrol and the Belgian Civil Aviation Authority (BCAA), together with the company Unifly, are developing two digital platforms to assist both recreational and professional drone users in their activities. All applications will be operational by the end of this year.

A first application will result in a website for the general public where a map will play a key role. This map indicates all areas that are prohibited for drones (temporary or permanent). The website also provides general information and useful links, and should already go live this spring. Besides the map functionality, a mobile app will offer a number of practical features. For example, recreational drone users will be able to prepare and validate their flight – in view of the applicable restrictions - and indicate when they will start and stop their flight. *www.belgocontrol.be*

South African national drone association announces action plan for 2018

The Commercial Unmanned Aircraft Association of Southern Africa (CUAASA), an affiliate of the Commercial Aviation Association of Southern Africa (CAASA), hosted its Annual General Meeting on Saturday 27 January 2018 and set out a plan of action for 2018.

In his opening remarks, Dean Polley, President of CUAASA, emphasised the continuous struggles that the South African RPAS industry faces with regards to obtaining a Remotely Piloted Aircraft Systems Operating Certificate (ROC), a requirement, as per the Civil Aviation Regulations Part 101, that is needed to operate any RPAS in a commercial capacity in South African airspace. To date, only 20 ROC's have been issued by the Regulator since the new laws came into effect in July 2015. There are currently around 340 ROC applications pending with the SACAA. The delays and excessive backlog have been attributed to two major factors:

1) The SACAA does not have the required capacity to effectively implement the regulations. "The current system and processes are failing the industry", said Polley. Current ROC holders are also affected by delays with millions of rands in economic losses being suffered, directly attributable to application processing delays.
2) The second major factor is that every new applicant requires an Air Service License (ASL), which unnecessarily adds to the complexity of applications and the increased timelines for processing.

During 2017, CUAASA, together with CAASA, submitted proposed amendments to the Air Service Licensing Act, which will see the waiver of an Air Service License for RPAS below a weight of 25 kg.

"The economic impact has been significant, and according to leading Economist, Dr Roelof Botha, at the beginning of 2017, it was estimated that the cumulative loss in business that the RPAS industry in South Africa has suffered since the enactment of Part 101 amounts to approximately R2 billion. This has been borne out in the dossier prepared by CUAASA representing the losses incurred by legal ROC holders. The estimated contribution to national unemployment was approximately 25,000+ lost jobs", said Polley. *www.cuaasa.orgDrones*

Atlas Dynamics & Luxriot partnership

Atlas Dynamics, a next-generation aerospace company providing autonomous UAV solutions, has announced its partnership with Luxriot, developer of top-quality, high-performance Luxriot Evo Video Management Software, to develop drone-based solutions for the defense, security and first response markets.

Major software upgrade by Dedrone

Dedrone has announced their next generation software upgrade, DroneTracker 3. It is the industry's first airspace security solution that includes automated summary reporting for instant diagnosis of drone airspace activity. Dedrone's software is a machine learning network using information from a proprietary database, DroneDNA. DroneTracker gathers intelligence from various sensors, including radio frequency and Wi-Fi scanners, microphones, and cameras, DroneTracker 3 can detect drones over a mile away from a protected site and determines the communications protocol of the drone, its flight path and the location of the pilot. *www.dedrone.com*

Indian Railways to deploy drones to monitor projects

Drones will now monitor railway projects, aid in crowd management and oversee maintenance work across its zones, railway officials said. Cameras (UAV/ NETRA) will be used for various railway activities especially project monitoring and maintenance of tracks and other railway infrastructure, the national transporter said in a statement. It shall also be used to assess preparedness of non- interlocking (NI) works, crowd management during fairs, to identify scrap and also for aerial survey of station yards. It is going to be instrumental in providing real time inputs related to safety and maintenance of tracks and other railway infrastructure. *http://indianexpress.com*

DARPA working on collaborative autonomy for UAVs and Drones

DARPA's Collaborative Operations in Denied Environment (CODE) program conducted successful Phase 2 flight tests with teams led by Lockheed Martin Corporation (Orlando, Fla.) and the Raytheon Company (Tucson, Ariz.). The Agency has also awarded Phase 3 of the program to Raytheon to further develop CODE capabilities and validate them through a series of planned flight tests.

DARPA's CODE program aims to extend the capability of the U.S. military's existing unmanned aircraft systems (UASs) to conduct dynamic, long-distance engagements of highly mobile ground and maritime targets in contested or denied battlespaces. Multiple CODE-equipped unmanned aircraft would navigate to their destinations and find, track, identify, and engage targets under established rules of engagement-all under the supervision of a single human mission commander. *www.spacewar.com*

Large-scale solar parks in Madhya Pradesh, India

Indian Renewable Energy Development Agency Limited (IREDA) and Rewa Ultra Mega Solar Limited (RUMSL) signed an agreement for financing the shared infrastructure of two large Solar Parks in Madhya Pradesh on 31st January 2018. Ministry of New & Renewable Energy (MNRE), World Bank & IREDA have been able to work out a proposal to channelize US$ 100 Million for creating common infrastructure for ultra-mega solar parks in India to achieve the 100 GW solar capacity addition target by 2022.

New noise maps created for the German Federal Railway

Commissioned by the German Federal Railway Authority, and under the direction of Disy Informationssysteme GmbH, the consortium of firms Disy, Pöyry and SoundPLAN have completed the EU environmental noise mapping of the main German railway lines. In addition to the actual noise calculations, this large-scale project includes a very complex data management system to check, clean, and homogenize huge data sets as a basis for the noise propagation calculations. The results of this nationwide noise mapping are the basis for noise action planning and are available to the public as of now. *www.eba.bund.de*

Water utilities capitalize on hydraulic modeling to minimize TOTEX

Manila Water is a water utility concessionaire in the Philippines that provides water and wastewater services for 24 cities and municipalities and operates more than 100 facilities serving 6 million customers both in water distribution and wastewater treatment. The Philippines sits on the Pacific Ring of Fire where earthquakes and volcanic eruptions frequently occur. Metro Manila falls victim to this circumstance, being geographically transected by several fault systems, including the dangerous West Valley Fault System. To address the great level of risk, Manila Water conducted a Resiliency and Business Interruption (RBI) study to determine the systems and facilities that are most vulnerable in the event of such natural disasters. The study indicated that significant damages amounting to approximately USD 520 million in water infrastructure is inevitable. Consequently, the Natural Calamity Risk Resiliency and Mitigation Master Plan was developed in collaboration with National Disaster Risk Reduction and Management Council (NDRRMC) and Local Government Units (LGU). The NDRRMC and LGU provided the emergency response plan as well as locations of evacuation sites that will be used in the event of a catastrophe.

Manila Water must ensure that these identified sites will have a secure and reliable supply of water in case of emergency. WaterGEMS was used to identify and prioritize critical assets requiring resiliency and contingency measures by simulating the effect of losing one or several components of the water system and seeing how interconnected systems would react.

Geovation programme in UK seeks new GeoTech and PropTech disruptors

The Geovation Programme is now accepting applications from start-ups using location and/or land and property data in their products and services. If selected to join the Programme, the start-ups will each receive up to £20,000 in funding and a range of resources and services to help develop their businesses. This includes access to experienced software developers, geospatial expertise from Ordnance Survey, property expertise from HMLR, and mentoring to assist with business proposals and investor relationships. *https://geovation.uk*

Tel Aviv-Yafo Municipality Launched DigiTel Resident Card in India

The Tel Aviv-Yafo Municipality recently announced the new "DigiThane" digital engagement platform that was launched in the city of Thane, India.

DigiTel is an innovative platform that strengthens the connection between residents and city officials, allowing residents to receive a variety of personalized services and information via email, SMS or the DigiTel webpage. Information is tailored to suit the needs of the individual and is based on many factors including place of residence, interests and personal status. The system offers live updates on current events in a specific neighborhood and around the city, along with discounts to events, cultural institutions and leisure activities. Tel Aviv-Yafo was given the "Smart City Award" at the 2014 Smart City Expo in Barcelona

First research centre for 3D digital mapping at UNSW Sydney

In January, University of New South Wales (UNSW) Sydney set up its first Geospatial Information Centre under the Faculty of Built Environment to focus on 3D digital mapping of buildings and infrastructure. The objective of the new research centre is to advance the data of buildings in Sydney to the third dimension, in order to improve accessibility, safety and emergency response procedures of urban structures in Sydney. *www.opengovasia.com*

Ghana to develop a home-grown digital mapping system

Mr Kwesi Boateng Adjei, a Deputy Minister of Local Government and Rural Development (MLG&RD) of Ghana has said government would develop a Home-grown Digital Mapping of property to promote the National Digital Property Addressing System (NDPAS) and Street Naming system. He said the vision of the initiative is to achieve a nationwide use of spatial database information for good governance and socio-economic development through the development, management and dissemination of property addressing linked with postal codes and to ensure total access to high-quality geographic information and services for individuals and organisations. *www.ghanaweb.com*

VolkerWessels and Trimble partnership

Trimble and VolkerWessels, announced a strategic relationship to standardize VolkerWessels' projects on a key set

of Trimble construction technologies. The collaboration is designed to leverage each company's core capabilities to advance innovations in Building Information Management (BIM) technology and improve the management and predictability of building construction and real estate projects.

Fugro starts surveying Hail and Ghasha fields in UAE

Netherlands-based company Fugro has started conducting geophysical and geotechnical surveys for Artelia, as a part of Abu Dhabi National Oil Company's (ADNOC) Hail and Ghasha gas development. Situated off the Arabian Gulf, the Hail and Ghasha gas development form an important part to ensure sustainable and economic gas supply to the United Arab Emirates (UAE). The survey activities include the delivery of bathymetric, multibeam echo sounder, tide gauges, ultra-high-resolution seismic sub-bottom profiling, magnetometer and side scan sonar. *www.offshore-technology.com*

LeddarTech, OPTIS announce LiDAR simulation partnership

Virtual prototyping company OPTIS and LeddarTech have announced a partnership that will enable the industrial simulation of advanced LiDAR solutions. This collaboration allows transportation companies to virtually test and integrate their next generation of LiDAR developed around the LeddarCore integrated circuit (IC).

INCOIS to create 3D maps of areas at risk of tsunami

Indian National Centre for Ocean Information Services (INCOIS)has commissioned Hyderabad-based RSI Softech India to compile data from the ground to create, with GIS and GPS data, maps for authorities at all levels to use to plan the emergency evacuation of low-lying areas. INCOIS will use the data to prepare detailed maps with data on individual buildings, the number of occupants, the time they spend in the structures and their profiles.

China teams up with U.S. firms to build aviation navigation database

China's top aviation regulator partnered with U.S. companies to develop the country's aviation navigation database.

The air traffic management bureau with the Civil Aviation Administration of China inked a cooperation agreement with U.S. aviation solutions provider Jeppesen and industrial giant Honeywell to make a sound database for aviation navigation.

China is home to 235 civil airports, but only 66 of them can have their data coded into the aviation navigation database, posing risks to flight safety, according to Che Jinjun, head of the air traffic management bureau.

Navigation for aircrafts is more demanding than other transport vehicles in terms of data precision and timeliness. China has been addressing an incomplete aviation navigation database for several years and the partnership will help offer new solutions, according to Che.

Over 5.1 million flight were made last year, up 9.48 percent year-on-year, while flight punctuality rate fell by 5.09 percent year-on-year to 71.67 percent in 2017, official data showed. *www.xinhuanet.com*

Significant improvement over current spatial navigation tests

A powerful new tool for the study of spatial memory described in Nature as a significant improvement over the current gold standard, the Morris Water Maze. The novel Honeycomb Maze design allows for systematic analysis of the decisions an animal makes during navigation.

Spatial navigation tasks are used to study the way animals identify their location and navigate towards favourable, and away from unfavourable, locations in response to changes in the environment.

Professor John O'Keefe of the Sainsbury Wellcome Centre at UCL, and 2014 Nobel laureate for the discovery of place cells, a class of neurons important for spatial sense, commented on the achievement:

The Honeycomb Maze was intentionally designed to overcome the drawbacks of other tests for spatial navigation and memory such as the T- or Y-maze, Olton radial arm maze, Barnes maze and Morris Water Maze. Professor O'Keefe describes the novel spatial navigation task:

"The Honeycomb Maze consists of 37 individually-movable platforms, which enables the confinement of an animal to a localised space anywhere in the maze and forces it to choose between two alternative paths to the goal. By choosing the path with the lesser deviation from the goal-heading direction, the animal shows that it knows where the goal is and the best route to get there." *www.nature.com*

Clemson researchers aim to stop cyber criminals from GPS hacking

Researchers at Clemson University are working on a project that could someday keep key infrastructure we depend on safe from a certain type of cyber attack. It has to do with vulnerabilities in GPS and digital time-keeping.

"If we cannot provide accurate time then the consequences would be catastrophic," said Dr. Yongqiang Wang.

He is leading research at Clemson on how to prevent hackers from manipulating time on our digital networks and devices. Graduate student Mauz Ahmad explains right now that type of cyber attack is possible with a device like this $300 dollar software defined radio.

Why is that alarming?

For one, it can roll back time to gain digital access through old login information.

Two, an attack like that could mess with your GPS, making your phone think you're in one spot when really you're miles away.

GPS, after all, is based on satellite signals that are all linked to, you guessed it, time.

And think of the consequences for ships at sea… Or trains in cities that depend on accurate location coordination.

Wang is quick to point out the U.S. military has its own secret code to verify GPS signals. His research is aimed at helping private industry, like our electric grid.

"They are pretty vulnerable," he said. "So we wanted to come up with some solutions to make sure that the time you get is reliable."

The research only just began, but by the end of the three-year project, the team hopes to be well on its way to providing a service that anyone can use to verify that GPS signals are accurate. *http://counton2.com*

NASA tests X-ray-based "Space-GPS" navigation system

A NASA team has demonstrated the viability of the idea with an experiment showing that a spacecraft can constantly and automatically calculate its position by tracking the perfectly-predictable X-ray signals from an array of pulsars.

When stars die, they collapse in on themselves, often becoming black holes. But not all stars follow the same fate. Those with a mass between 10 and 29 times that of our Sun tend to turn into a small, dense objects known as neutron stars. With very strong magnetic fields and very fast rotations, some neutron stars blast beams of electromagnetic radiation from their poles, and if Earth is in the path of those beams we can detect the signals as regular "pulses" – hence the name pulsars.

Since pulsars spin at a constant rate, their signals can be predicted with astonishing accuracy, and for the most precise examples –known as millisecond pulsars – they can be predicted years into the future, down to a scale of microseconds. That extreme regularity makes them perfect navigation tools, on the same level as the atomic clocks used to keep GPS satellites on track.

The idea of navigating by these natural beacons has been kicking around since at least 2012, and in 2016 the European Space Agency released a detailed feasibility study that outlined just how pulsar navigation might work. Now, NASA has put it to the test in the real world in an experiment it calls the Station Explorer for X-ray Timing and Navigation Technology (SEXTANT).

The agency used an observatory known as Neutron-star Interior Composition Explorer (NICER), which is currently studying neutron stars and pulsars from its perch on the outside of the International Space Station. The observatory is equipped with 52 X-ray telescopes, allowing it to easily identify neutron stars across the universe by their X-ray emissions.

Running over two days in November 2017, the experiment homed in on four specific millisecond pulsars, and took 78 timing measurements. An onboard algorithm then stitched these together to pinpoint NICER's location in space, and compared the results to the satellite's GPS data gathered over the same time.

China sends twin BeiDou-3 navigation satellites into space

China has sent twin satellites into space on a single carrier rocket, as part of efforts to enable its BeiDou system to provide navigation and positioning services to countries along the Belt and Road by the end of 2018. *www.xinhuanet.com*

NAVIC to guide fishing boats

Deep sea fishing vessels putting out to sea from the Kerala coast very soon will be equipped with satellite-based navigational equipment.

The government is planning to promote large-scale manufacture of satellite navigational equipment to be supplied to fishermen as part of a project to ensure their safety in sea. The collaborative project with ISRO involves the use of NAVIC, India's own regional satellite navigation system, to warn fishermen about weather events.

ISRO has agreed to supply 500 NAVIC positioning- cum- communication sets to be fitted on fishing boats for the trial run.

A master control room to be established in Thiruvananthapuram will be at the heart of the early warning system. The facility would be equipped to gather information from orbiting satellites of ISRO as well as data generated by INCOIS and the IMD.

A data network will link the master control room with six regional control rooms located in the coastal areas that would disseminate information to fishermen in Malayalam through the NAVIC sets upto a distance of 1,500 km from the coast. *www.thehindu.com*

ComNav Technology releases new T300 Plus GNSS receiver

ComNav Technology has introduced its powerful T300 Plus GNSS receiver. Featuring full-constellation tracking capability, tilt compensation, 4G/WiFi connection, 8 gigabyte internal memory and easy survey workflow with Android-based Survey Master Software, it is designed for demanding surveying tasks. Users can collect accurate data easier and faster no matter for beginners or professional surveyors, according to the company.

With two hot swap batteries, the receiver helps to extend working hours and ensures fluent workflow in the field.

DJI announces Mavic Air drone

Drone maker DJI has unveiled the "Mavic Air" stating that the new drone combines the "best features" of the Mavic series into an ultra-portable and foldable drone.

Mavic Air includes a 4K camera, QuickShot and SmartCapture modes for simpler photo and video capturing, and FlightAutonomy 2.0 with Advanced Pilot Assistance Systems to ensure safer flights. Mavic Air has a weight of 430 grams, and it can fold its arms and propellers to sit flush against its frame. *www.macrumors.com*

2G ULS-500 PRO System delivered to Kongsberg

2G Robotics has announced the first of four ULS-500 PRO laser scanning systems has been shipped to Kongsberg Maritime for integration into the Norwegian Defence Materiel Agency's (NDMA) newly purchased HUGIN AUV's. The acquisition signifies the Royal Norwegian Navy's transition to autonomous systems for mine countermeasures. During operations, Hugin AUVs will be used to complete surveys of subsea environments focused specifically on locating and identifying mines.

Independently certified eCall test solution by Rohde & Schwarz

The market-leading eCall test solution from Rohde & Schwarz is the first of its kind to be certified by an independent test body. CETECOM has examined the implementation of the eCall test public safety answering point (PSAP) in the Rohde & Schwarz solution for the pan-European emergency call system and certified it as compliant with the CEN EN 16454:2015 standard. This is a prerequisite for tests compliant with Commission Delegated Regulation (EU) 2017/79. CETECOM has been officially designated as a technical service for eCall by the German Federal Motor Transport Authority. After March 31, 2018, manufacturers must equip new vehicles for sale in the EU with an eCall module. The R&S CMW-KA094 test solution is the first independently certified test PSAP system based on a wireless communications test platform. *www.rohde-schwarz.com*

Tersus GNSS RTK board launched for OEMs, system integrators

Tersus GNSS Inc. has launched the BX306Z GNSS RTK board. As a new member of the BX-series GNSS OEM boards is a cost-efficient GNSS real-time kinematic (RTK) board for positioning and raw measurement output. The board is a compact, multi-GNSS (GPS L1/L2, GLONASS G1/G2, BeiDou B1/B2) RTK module with centimeter-level accurate positioning capability.

L1/L2 + G1/G2 antennas by Tallysman

Tallysman, is offering a new light-weight compact GPS L1/L2 + GLONASS G1/G2 antenna, available either as an OEM (TW1829) antenna or in a housed version (TW8829). The antenna is designed for unmanned aerial vehicle use because of its low aerodynamic profile and very light weight.

Sierra Wireless integrates GNSS, SIM, security into multi-mode LPWA modules

Sierra Wireless has introduced multi-mode, low-power wide-area (LPWA) cellular modules. The modules are targeted at rapidly growing markets in asset tracking and connected industrial equipment, smart cities, healthcare, agriculture and wearables. AirPrime HL78 modules, featuring Altair Semiconductor's integrated ALT1250 chipset, deliver power performance that extends the life of battery-operated devices by 5-10X compared to older LTE-M/NB-IoT modules.

BeiDou Phase 3 Signals added to Spirent's GNSS RF Constellation Simulators

Spirent Communications plc, a provider in BeiDou, GPS and other GNSS testing solutions, announced that BeiDou Phase 3 signals have been added to its GNSS RF constellation simulators. The addition of these new signals to the GSS7000 and GSS9000 simulators follows the launch of the first two Beidou-3 satellites in November 2017.

The new signals will use the same carrier frequencies as the GPS and Galileo systems, so chipset manufacturers and device developers will need to test integrated designs to avoid problems caused by confusing data from different GNSS.

iXblue to provide navigation systems for French Navy frigates

Naval Group, formerly DCNS, has awarded a contract to maritime navigation and positioning specialist iXblue to install navigation systems on five of the French Navy's new 4,000t frigates. The deal will see the integration of iXblue's Marins inertial navigation systems and Netans data distribution and processing units on-board the vessels. *www.naval-technology.com*

SuperSurv 10.1's Support for RTCM 3.1

The latest SuperSurv 10.1 is equipped with 3 major new features, including snapping, coordinate system customization, Layerset, and was released in November 2017. Also, Google Maps and TIFF are supported in this version to facilitate the efficiency of field works. Recently, its product team starts to enhance SuperSurv's NTRIP solution, aiming to adopt more RTCM versions and provide a better GNSS positioning service. NTRIP (Networked Transport of RTCM via Internet Protocol) is a protocol to send GNSS related data through the internet, which enables users of differential GPS or network RTK to get correction parameters after connecting to the internet. The correction parameters can be used to calculate a more accurate GNSS location. *www.supergeotek.com*

Mouser GNSS antennas

Mouser are now offering the Antenova Robusta Low-Profile GNSS Antennas. The devices, for metal surfaces, cover the 1559MHz-1609MHz frequency range. Developed using the company's REFLECTOR technology, the Robusta GNSS Antennas radiate in positions where a normal antenna won't function. The patented two-layer technology electrically isolates one layer to offer RF shielding to the second layer. This enables the antenna to radiate effectively in the direction facing away from the base material. *www.electropages.com*

Airbus selected by ESA for EGNOS V3 program

Airbus has been selected by the European Space Agency (ESA) as the prime contractor to develop EGNOS V3, the next generation of the European Satellite Based

Augmentation System (SBAS) planned to provide the aviation community with advanced Safety of Life services and new services to Maritime and Land users.

Developed by ESA on behalf of the European Commission and the European GNSS Agency (GSA), EGNOS V3 (European Geostationary Navigation Overlay Service) will provide augmented operational Safety of Life services over Europe that improve the accuracy and availability of user positioning services from existing Global Navigation Satellite Systems (Galileo and GPS) and provides crucial integrity messages to EGNOS users with alerts within a few seconds in case of system degradation, consolidating EGNOS' position as one of the leading edge GNSS Systems in the future.

EGNOS V3 will thus offer improved Safety of Life (SoL) services performances (where people's lives are potentially at stake) over Europe to Civil Aviation community and new applications for Maritime or Land users, and will improve robustness against increasing security risks, in particular cyber-security risks.

Applanix Introduces its Autonomy Development for Autonomous Vehicles

Applanix, a Trimble Company recently introduced its Autonomy Development Platform to provide automakers, truck makers, and Tier 1 vehicle suppliers the hardware, software, engineering, and integration services they need to accelerate their development programs for on-road and off-road autonomous vehicles.By combining customized integration and engineering services along with Applanix' proven GNSS-inertial positioning technologies, the Autonomy Development Platform advances driverless vehicle development projects at every stage of development and commercialization.

"With the introduction of our Autonomy Development Platform, Applanix now offers on-road and off-road vehicle manufacturers the tools and engineering expertise necessary to support and augment their driverless vehicle development programs," said Louis Nastro, Director of Land Products at Applanix.

Trimble Expands Mixed-Reality Portfolio

Trimble recently announced Trimble Connect™ for HoloLens and a new hard hat solution for Microsoft HoloLens that improves the utility of mixed reality for practical field applications. The mixed-reality solution improves coordination by combining models from multiple stakeholders such as structural, mechanical and electrical trade partners. The solution provides for precise alignment of holographic data on a 1:1 scale on the job site, to review models in the context of the physical environment. Predefined views from Trimble Connect further simplify in-field use with quick and easy access to immersive visualizations of 3D data.

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March 2018

Munich Satellite Navigation Summit
5 - 7 March
Munich Germany
www.munich-satellite-navigation-summit.org

EUROGEO 2018
15 - 17 March
Cologne, Germany
www.eurogeography.eu

Gi4DM 2018
18 - 21 March
Istanbul Technical University, Turkey
gi4dm2018.org

United Nations/Argentina Workshop on the applications of GNSS
19 - 23 March
Falda Del Carmen, Argentina
www.unoosa.org

April 2018

The 7th Digital Earth Summit 2018
17-19 April
El Jadida, Morocco
http://www.desummit2018.org/

9th IGRSM International Conference and Exhibition on Geospatial & Remote Sensing (IGRSM 2018
24-25 April 2018
Kuala Lumpur, Malaysia
https://igrsmconf18.wixsite.com/igrsm2018

International Navigation Forum Navitech 2018
24-27 April
Moscow, Russia
www.glonass-forum.ru

May 2018

Geoscience-2018
2-4 May
Rome, Italy
http://geoscience.madridge.com/index.php

12th Annual Baška GNSS Conference
6 - 9 May
Baška, Croatia
www.rin.org.uk

FIG Congress 2018
6 - 11 May
Istanbul, Turkey
www.fig.net/fig2018/

The European Navigation Conference 2018
14 - 17 May
Gothenburg, Sweden
www.enc2018.eu

GEO Business 2018
22 - 23 May
London, UK
http://geobusinessshow.com

June 2018

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

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

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

July 2018

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

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

September 2018

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

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

October 2018

Joint Geo Delft Conference

The 6th International FIG 3D Cadastre Workshop

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

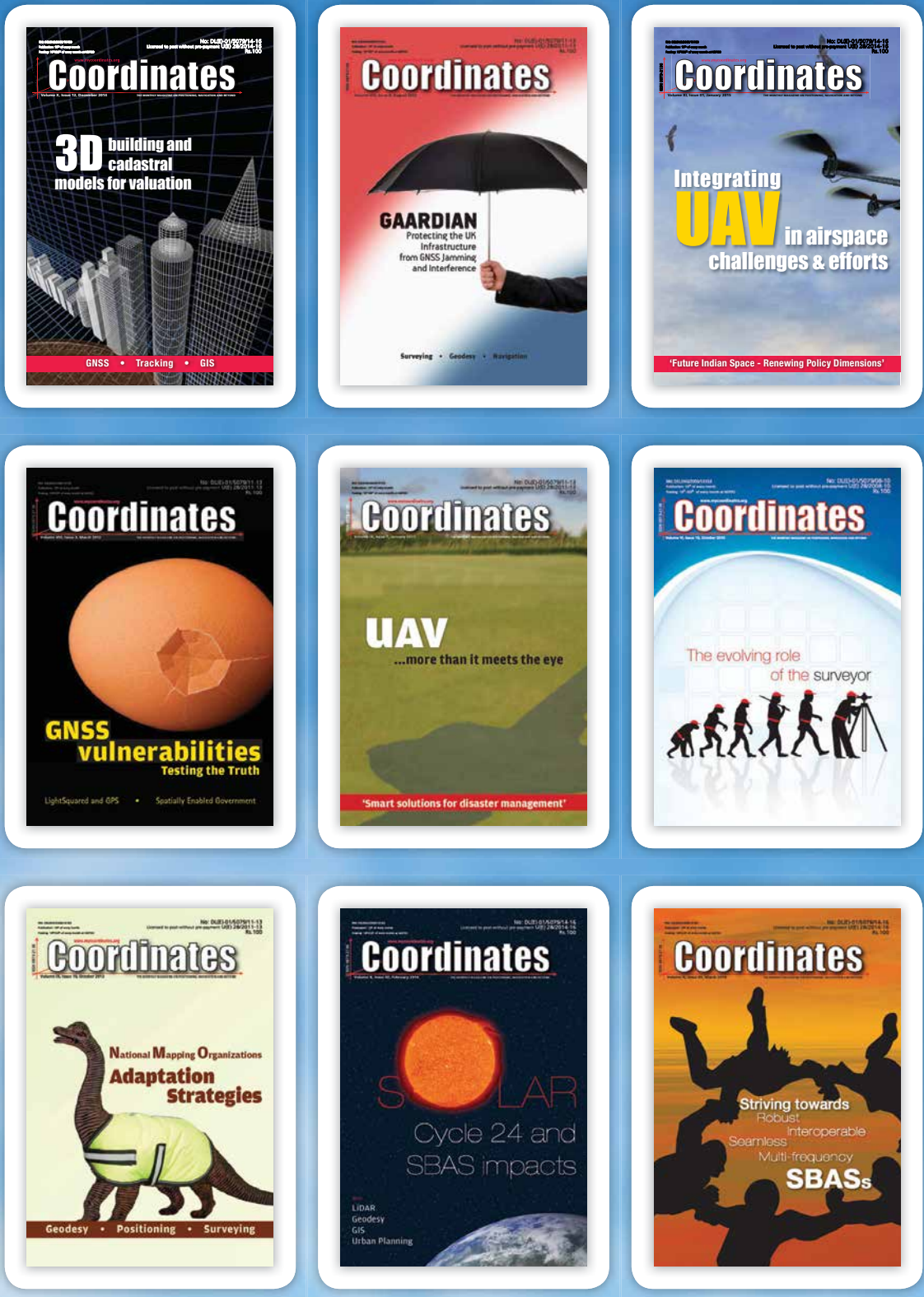
Intergeo 2018
17 - 18 October
Frankfurt, Germany
www.intergeo.de

November 2018

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

December 2018

The 16th IAIN World Congress 2018
28 November - 1 December
Chiba, Japan
https://iain2018.org



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- SBAS: WAAS, EGNOS , GAGAN, MSAS, SDCM
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