RNI: DELENG/2005/15153
Publication: 15th of every month
Posting: 19th/20th of every month at NDPSO

No: DL(E)-01/5079/11-13
Licensed to post without pre-payment U(E) 28/2011-13
Rs.100

ISSN 0973-2136

www.mycoordinates.org

Coordinates

Volume IX, Issue 9, September 2013

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

100th Issue

Positioning, navigation and beyond

issues, priorities and challenges

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This issue has been made possible by the support and good wishes of the following individuals and companies A Grant, Abbas Rajabifard, Akio Yasuda, Anindya Bose, Börje Forssell, C Hargreaves, Chris Rizos, David Last, Debipriya Dutta, Erhu WEI, George Cho, James L Farrell, Jiandong LIU, John Hannah, Mark Sampson, P Williams, Rakesh Malik, Renato Filjar, Saikat Das, Sang Jeong Lee, Sharafat Gadimova, Suresh V Kibe, Yufeng GU and Zakaria Yehia Ahmed and; Ashtech, CHC, Foif, Galileo, GGS, iFEN, Hemisphere GPS, HiTarget, Javad, LabSat, MicroSurvey, Pentax, Navcom, NovAtel, Rohde & Schwarz, Sensonor, Nikon, South, Trimble, and many others.

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Web www.mycoordinates.org

Annual subscription (12 issues) [India] Rs.1,200 [Overseas] US$80

Printed and published by Sanjay Malaviya on behalf of Centre for Geoinformation Technologies at A221 Mangal Apartments, Vasundhara Enclave, Delhi 110096, India.

Editor Bal Krishna

Owner Centre for Geoinformation Technologies

Designed at Spring Design (springdesign@live.com)

Printer Thomson Press India Ltd., B 315, Okhla Phase I, New Delhi - 110020, India

This issue of Coordinates is of 64 pages, including cover.


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*Percentage of all GNSS receiver models available worldwide (source: GSA analysis based on GPS World Survey 2013).

100th Issue

Navigating together

It has been a journey

From apprehensions to aspirations,

Enthusiasm to endurance,

Potential to performance.

It is not about desires

But more of deliverables.

Not about destination but determination.

The journey continues…

To embrace challenges

Raise bars and set benchmarks

Trying to meet increasing expectations…

Add more dimensions to the domain

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Who have been with us all along

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The milestone of 100th issue.

Bal Krishna, Editor
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Positioning, navigation and beyond

Experts share their views on issues, priorities and chanllenges on the occasion of 100th issue of Coordinates

Coordinates 100th Issue – Longitudes and Latitudes

Professor George Cho AM
Chair, Academic Board, Associate Dean Research, Professor of Geoinformatics and the Law, Faculty of Education, Science, Technology & Mathematics, University of Canberra, Australia

Coordinates 100th Issue is indeed a milestone. Just like in cricket or baseball scoring a century or a home run does not come in every innings except for the very gifted and talented. However, in the case of *Coordinates* it is very welcome and heartening to note that the journal is endurable, enduring and is producing a kind of a continuing dialogue that many subscribe to.

It is fascinating to read Dava Sobel's *Longitude* about the clockmaker William Harrison who took nearly forty years to solve the 'longitude' problem – determining east-west location at sea. The scientific problem was how to make a clock that would keep precise time at sea something that no clock has been able to do on land. Now we know this perfect time piece is the chronometer. It is about triumph over astronomy, navigation and clock making. Then when you couple this with Latitude – *voila* we can tell with some precision a precise location on Earth and anywhere else. Today, the GPS and GNSS make it all too simple that we even have it in our cars.

The story of *Coordinates* is precisely about the dissatisfaction with simply GIS and its variants – GI Science, GI Systems, GI Services – because all these are bound up by to omnipresent location of something. Geography is in our everyday lives and we cannot do without it. Web enabled devices ensure that we cannot get lost, are always in contact somewhere and somehow as well as being noticed even without our knowledge with near field communications, RFIDS, 'bumps' with our hand phones. The challenge now is for *Coordinates* adapt and ascend to the skies, as it were, to deal with 'Big Data' and with Cloud Computing and be prepared to deal not only with the 2-dimensional coordinates but also with the 3-dimensional z-coordinate as well as the 4th dimension temporal elements.

A survey of the table of contents of all of the 100 issues of *Coordinates* will chronicle the evolution and development of the field of coordinate geometry in terms of not only where something is taking place but also what, how, and when. There are a myriad applications which could be simply location-based services, surveying, disasters and crises both natural and human induced, border demarcation and disputes, determination of geodetics, technology and all its gadgets but also intangibles like policy and the law. The geospatial industry is inextricably intertwined with all matters that impinge on human activities, the geographical matrix and the interactions between all these in a dynamic world.

There is no doubt that the basic premise and philosophy behind *Coordinates* as a respected journal will endure into the future with its constant re-invention to adapt to the digital a nd natural environment. The challenges could be whether the digital environment has inadvertently determined that the paper copy is being transformed into the paperless copy and that such a business model will prove enduring.

Growing realisation of the limitations of all GNSS

Professor David Last
Consultant Engineer and Expert Witness specialising in Radio Navigation and Communications Systems. Professor Emeritus, University of Bangor, Wales and Past-President of the Royal Institute of Navigation.

During the 100-issue lifetime of Coordinates magazine, new navigation satellite systems have joined GPS and there has been a growing realisation of the limitations of all GNSS. Satellite Navigation has been an outstanding technical development of the last quarter century: it has brought great benefits to mankind without polluting the environment or frightening the horses; everybody loves it! But, as with every innovation, the euphoria eventually gives way to reality and a willingness to recognise and address its limitations. Understandably, the USA has led the way here with its early recognition of the vulnerability of GPS to jamming, interference, solar weather and spoofing. In contrast, many European and Far Eastern nations, caught up in the excitement, effort and high costs of developing new satellite systems, have closed their ears to any talk of their imperfections.

The vulnerability of GNSS is seen most dramatically at sea. Shipping, in marked contrast to aviation, which has retained legacy technologies, has

GNSS has become a truly international resource

Sharafat Gadimova
Programme Officer, Office for Outer Space Affairs, United Nations Office at Vienna

International Committee on Global Navigation Satellite Systems (ICG), for which the United Nations Office for Outer Space Affairs acts as Executive Secretariat, was established in an international meeting at the United Nations Office at Vienna as an informal, voluntary forum where governments and interested non-government entities can discuss all matters regarding global navigation satellite systems (GNSS) on a worldwide basis. ICG promotes international cooperation on issues of mutual interest related to civil satellite-based positioning, navigation, timing, and value-added services. The establishment of ICG recognizes that GNSS has become a truly international resource, and demonstrates the willingness of providers and users to ensure that GNSS services continue to be available in the future for the benefit of humankind. Furthermore ICG represents a milestone achievement in Member States cooperation in the use of outer space for peaceful purposes.

The neutral, negotiation-friendly nature of the United Nations provides the context necessary to enable Member States such as the United States, the Russian Federation, States members of the European Union, China, India and Japan, which have highly-developed GNSS technologies, to come together, and to work out ways and means to use multiple GNSS systems and hence to build a system of space-based navigation and positioning systems.

Once all (global and regional GNSS systems) become fully operational, the user will have access to positioning, navigation, and timing signals from more than 100 satellites. However, to achieve a true system of GNSS systems, a host of questions concerning compatibility and interoperability need to be addressed by system providers. Additionally, GNSS user community inputs regarding interoperability and the provision of improved capabilities should be considered.

For developing countries, GNSS applications offer a cost-effective way of pursuing sustainable economic growth while protecting the environment. Satellite navigation and positioning data are now used in a wide range of areas that include mapping and surveying, monitoring of the environment, precision agriculture and natural resources management, disaster warning and emergency response, aviation, maritime and land transportation, as well as research areas as climate change and space weather.

To date, the vulnerabilities of GNSS are well categorized, and it is understood that space weather is the largest contributor to single-frequency GNSS-errors. Primary space weather effects on GNSS include range errors and loss of signal reception. The GNSS industry faces several scientific and engineering challenges to keep pace with increasingly complex user needs: developing receivers that are resistant to scintillation and improving the prediction of the state of the ionosphere. With GNSS modernization, the use of additional signals is expected to reduce errors caused by ionosphere.

Significant progress continues to be made through ICG, and the results of this work not only promote the capabilities of GNSS to support sustainable development, but also promote new partnerships among members of ICG and institutions of the broader user community, particularly in developing countries. As a member of ICG and serving as the ICG Executive Secretariat, the United Nations Office for Outer Space Affairs will continue to further its contributions to ICG's achievements in the future.

In conclusion, as we move forward in the 21st century, governments and business in developing and industrialized countries are exploring potential growth area for their national economies. Almost without exception, the most promising option seems to be outer space and in particular satellite positioning, navigation and timing, and its potential and future almost universal applications. ◺

come to rely almost entirely on GPS for navigation even in the busiest seaways in the lowest visibility. Multiple GPS receivers drive multiple systems on the ship, often in ways no-one aboard understands. Low-level interference causes not only loss of service, but also false positions and velocities, which appear without warning. Even the ship's radar and gyrocompass - apparently independent of satellite navigation – turn out to be linked to GPS. These are major safety concerns. Not surprisingly, nations are now turning to Enhanced Loran as a source of PNT wholly independent of satellite navigation, yet compatible with it.

Applications of GPS have expanded rapidly into those financial and legal areas in which new technology is rigorously tested in the adversarial processes of the courts. In many countries, GPS evidence in criminal prosecutions must meet the stringent standard of "beyond reasonable doubt"- when challenged by lawyers who are fully briefed on the multiple vulnerabilities of the technology. They will probe the substantial position errors due to multipath propagation in dense urban areas. Disputes over payments in GPS-based road user pricing schemes, claims of theft by delivery drivers, and the behaviour of motorists whose vehicles are fitted with telematics insurance units are all coming into the courts. As Coordinates magazine enters its second hundred issues, these matters will be tested and some of them resolved. I will be paying particular attention to watching the developing use of spoofing: commandeering GNSS receivers by transmitting false signals. Once just a theoretical possibility, spoofing has now been demonstrated and effective equipment is becoming available. This provides mouth-watering opportunities for practitioners in the criminal arts of hijacking and stock-exchange fraud - on all of which Coordinates magazine will no doubt keep us well informed in the next 100 issues. ◺

Multi-GNSS: Now and in the Future

Chris Rizos
Professor, Geodesy & Navigation, Surveying & Geospatial Engineering, School of Civil & Environmental Engineering, The University of New South Wales, NSW Sydney, Australia, President, International Association of Geodesy (IAG)

For years we have been extolling a future in which several constellations of navigation satellites – global and regional systems as well as a small number of geostationary satellites making up SBASs, but all conveniently lumped under the term "GNSS" – beam signals to users at several frequencies on which receivers make multiple measurements from which Positioning, Navigation and Timing (PNT) information is derived. We drool over the new signal structures, simulate the performance benefits, speculate on new applications, and promote greater multi-GNSS interoperability.

The multi-GNSS future epoch when all are expected to be operational is 2020. Yet we make progress and it is useful to take stock of what has been achieved just in the last 3 years since 2010. Consider the pace of space segment development: all four U.S. GPS-IIF satellites were launched (and tests of L2C and CNAV were made), broadcasting the new L5 signal; Russia's GLONASS system became operational (and plans for next generation CDMA signals were announced); China's BeiDou achieved RNSS status with 15 satellites (to reach 35 satellites by the end of the decade); Japan's first QZSS satellite was launched (and plans for 6 more were released); four E.U. Galileo satellites are functioning; and India launched the first of its planned seven satellite Indian RNSS.

There is considerable progress in terms of international initiatives, such as: the launch of the International GNSS Service (IGS) Multi-GNSS Experiment (MGEX); the launch of the IGS's Real-Time Service (supporting Precise Point Positioning techniques); the establishment of several global reference receiver networks by commercial and government entities; standards setting (e.g. RTCM, RINEX, ITRF, etc); UNOOSA International Committee on GNSS (ICG) activities with regard to interoperability and compatibility; growth in interest in non-PNT applications of GNSS; and recognition that society's ever growing reliance on GNSS comes at a cost of increased vulnerability to denial of PNT service by jamming or spoofing.

Furthermore, we have been surprised by the quality of the BeiDou signals. A particularly useful PNT solution, especially for high accuracy carrier phase-based techniques, combines GPS+BeiDou measurements. We are delighted by the innovative QZSS signals, especially the augmentation service provided by the correction data modulated on the LEX signal, and applaud that QZSS is truly 100% interoperable with GPS. The modernisation of GLONASS – to broadcast in future CDMA signals in addition to the current FDMA signals – will lift interest in a GNSS that otherwise could be at a disadvantage in the future multi-GNSS world. We also wait for a significant "push" from Galileo, that has to prove many sceptics wrong, and launch 18 or so satellites in the next few years to reach full operational capability before the end of the decade. (Perhaps the most underwhelming GNSS news this year was Galileo-only solutions, using measurements from the four satellites, for just a few minutes each month!) India's IRNSS is still (unfortunately) a big unknown, and there have been few indications that the IRNSS will even acknowledge the benefits of a multi-GNSS world.

In 2013 there is a lot to be enthused about. The future of multi-GNSS is always but one satellite launch away.

Education, Integrated Navigation and Safety are key issues

Professor Börje Forssell
Secretary General of the Nordic institute of Navigation, Norwegian University of Science and Technology, Dept. of Electronics and Telecommunications, Trondheim, Norway

GPS is well and flourishing, still dominating the satellite navigation user market completely after 20 years of operation. It has even become the synonym of sat.nav. equipment for many people who, when talking about their car navigators, use the words "my GPS". GLONASS is again operational with some 24 satellites, Galileo with now 4 operational satellites will reach 18 in about two years, and Beidou is developing fast with now 16 satellites in partly regionally operational modes. Satellite-based augmentations like WAAS, EGNOS, MSAS, GAGAN and SDCM cover different regions of the world, and together with autonomous regional systems as IRNSS and QZSS they contribute to a multitude of navigational satellites. The question has been asked: Do we need all that? The answer depends on political, economic and technical considerations, but it has been shown that global systems have a kind of break-even at about 70 satellites in total. This means that a bigger number leads to decreased performance because of the raised noise floor.

I will focus on three issues with priorities and challenges: Education, Integrated Navigation and Safety.

Education at all levels is important, not only to tell people that GPS is not that device which they have in their cars.

> It is astonishing that a good terrestrial system as eLORAN gets so little attention

Teaching and research in navigation at several European universities has been considerably reduced during the last decade. Convincing governments and university administrators that these subjects still are important, also at academic levels, is necessary.

Integrated navigation (multisensor, sensor fusion) is important because satellite equipment alone cannot meet all requirements in every situation. Particularly indoor navigation and position determination has turned out to be demanding and economically increasingly important. Lack of standardization contributes to a multitude of incompatible and expensive solutions, many of which are tailor-made for specific tasks. Tracking elderly people, children and handicapped persons has developed into a multi-million business area, and this requires good indoor capabilities. MEMS inertial-based equipment is fast getting better and cheaper, offering viable solutions.

Safety has the highest priority, and at the same time this is a big challenge which has received far too little attention. With GNSS-based equipment being such an important part of everyday life, it is astonishing that politicians and other decision makers have so little knowledge and take so little interest in this matter. This concerns civil use in particular; on the military side people are usually well aware and taking their precautions. Because of the very weak signals received from the satellites, reception is easily interfered with. Experience shows that intentional interference (jamming) is a smaller problem than unintentional, although the Internet offers a wide variety of cheap jammers. Most users can live with the interference threat, but the problem is that those who cannot too often are not prepared and do not know what to do when their GNSS-based equipment does not perform as required. From this point of view it is astonishing that a good terrestrial (back-up) system as eLORAN gets so little attention.

GNSS-related spectrum protection should become the international priority

Dr Renato Filjar, FRIN
Electrical engineer, satellite navigation, space weather and geomatics specialist and analyst; and an Associate Professor of Electronics Engineering and a Research Fellow at Faculty of Maritime Studies and Faculty of Engineering, both University of Rijeka, Croatia

In the modern world not only familiar with, but increasingly reliant on, satellite navigation, the four major challenges emerge to be exploited and resolved in the forthcoming future.

First, the sustainable, inter-operable and continuous core GNSS service should be guaranteed through both technological and financial efforts. Questionable funding of core GNSS operation should be removed by raising the GNSS technology to the level of national infrastructure, essential for uninterrupted provision of position, navigation and timing (PNT) services. GNSS-related spectrum protection should become the international priority. Currently on-going technological modernisation of GNSS system should continue in concert with the market demands and opportunities in more optimal spectrum utilisation.

> The sustainable, inter-operable and continuous core GNSS service should be guaranteed

Then, the considerable enhancement in GNSS signals offering should spark the innovative research and development work on both navigation and non-navigation applications. New and advanced methods for signal processing of satellite signals are to bring landmark developments in GNSS receiver design (including the advanced utilisation of software-defined radio, SDR, and cognitive systems), as well as in creation of entirely new GNSS application segments for remote sensing, meteorology, agriculture, environmental monitoring, and sensing the environment in general.

A growing number of services and applications emerges as the result of the exploitation of mobile objects' identification in space. A part of them, especially in classic navigation tasks, requires position, as description of an object's identification in material (physical) world. However, many applications exploit a complete different approach: description of an object's place in the information landscape (context) and contextual relationship with the other neighbouring objects. This description is frequently referred to as location. Exploitation of location can be considered as contextual navigation, being in heart of the applications in telecommunications (Location-Based Services, or LBS) and transport (Intelligent Transport Systems, or ITS), to name just a few.

Finally, but still far from being insignificant, recent years have brought increased interest in the inherited natural human navigation and orientation knowledge and skills. Exploitation of this inheritance should be considered, with satellite navigation appearing as the assistive rather than the competitive technology. Both the EU and the USA have recently announced kick-offs of large scientific projects, aiming at understanding of human brain. Expectations should be kept that the understanding of inherited natural navigation human skills will be among the projects' targets, providing the framework for a development of a new segment of the so-called cognitive navigation, which is to form a fundamental contribution to system integration with artificial navigation technologies (including GNSS) in the aim to provide another breakthrough in the safely and economically leading the moving objects (including humans) from starting to ending points of their journeys.

Photo: Sindre Lundvold

NORWEGIAN EXTREME ARTIST, ESKIL RONNINGSBAKKEN, DURING A BALANCING ACT AT PULPIT ROCK, 1982 FEET ABOVE THE LYSEFJORD, NORWAY, 2006.

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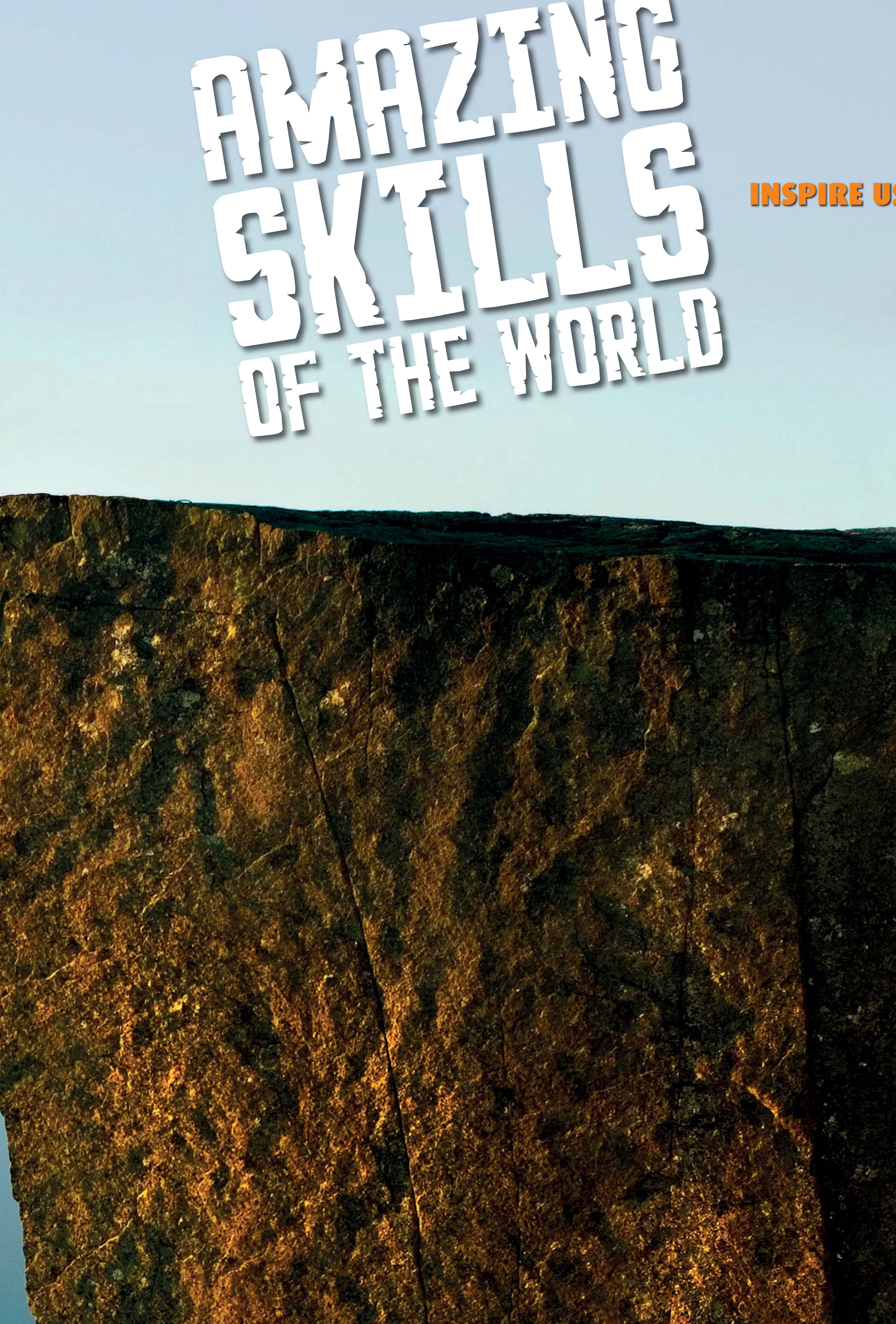

Air traffic safety and earthquake prediction are key applications

James L Farrell
VIGIL Inc., Institute of Navigation Pacific PNT 2013, Honolulu Hawaii, USA

Among the key issues involving navigation, two applications connected to safety (air traffic and earthquake prediction) are discussed here, with most space allocated to the first. Both are heavily affected by crucial choices for data to be acquired and shared. Importance of that, obscured by current custom, is loaded with major opportunities to enhance capability.

It is widely acknowledged that today's air traffic control system

- is an evolutionary product of incremental design
- if configured now with no need for back compatibility, would change radically
- cannot safely be granted the design freedom just identified.

It is becoming less widely recognized that present plans exhibit performance falling short of (not-too-distant) future needs.

I first highlight various methods ***ingrained*** in our industry, and describe how those habits severely limit our industry's capabilities. Today's systems work in terms of coordinates. When generated by GPS, those come from SVs selected by different receivers. Positions, inherently perishable, are mediocre and there are ***meters*** per second of velocity error. During the time (e.g., two minutes before time-to-closest-approach in collision avoidance) while control decisions are taking effect, that produces ***hundreds*** of meters uncertainty. Alternative features ***not*** being used (nor even planned) include

- transmitting measurements, not coordinates
- using carrier phase comparison
- computing ***relative*** separations ***not*** based on "absolute" positions
- single-measurement RAIM instead of always requiring at least 5 SVs with good GDOP

These and others, cited in an expanded discussion at [1], produced vast performance improvement, flight-verified [2]. This was communicated to the European Commission Call for Ideas, and to those involved in collision avoidance for cars [3], noting that decision-makers have a once-in-a-lifetime opportunity to avoid severe limitations inherently imposed by convention.

For the second application considered here, earthquake prediction is widely regarded as an unsolved problem. In addressing it I obtained encouraging results by applying morphometrics adapted from medical imaging. A deformable structure was represented by a point mass located at each observation station landmark near Tohoku. Migrations produced a sequence daily recorded in 2011, used in affine transformation modeling. Five of the affine degrees-of-freedom affect shape; those 3D shape states, and a rotation-minimization procedure preceding their least-squares extraction, provided the following features:

- abnormal departures in the rotational behavior appeared twice pre-quake (16 days and 5 days ahead).
- abnormal residuals (departures from the affine model) offered valuable revelations, in time (premonitions at those 16 and 5 days pre-quake) and spatially -- most corresponding to the landmark closest to epicenter!

No generalization is claimed, but other quakes should be examined for these traits. The full manuscript [4] included detailed steps for verifying rotation behavior just described plus data enabling duplication of that portion of the results. The methods are of course applicable also to data recorded from other quakes, ***provided*** that procedures described in [5] are heeded; without the data from [5], results just described would not exist.

In summary, stunning benefits obtainable in both traffic control and earthquake prediction depend heavily on seemingly mundane but critical decisions for data acquisition and handling. Procedures used here for both applications depart significantly from custom, hence their slow march toward adoption. I'll close by offering a revised adage: necessity is the mother of invention ***and*** of willingness to use what's been invented.

[1] http://jameslfarrell.com/gps-gnss/1223
[2] http://www.ion.org/publications/abstract.cfm?articleID=10234
[3] http://www.insidegnss.com/node/3628
[4] J.L. Farrell, "Earthquake Analysis by 3-D Affine Deformations," ION Pacific PNT 2013.
[5] F. van Graas and R. Kollar, "Processing of GPS Station Data for Prediction Algorithm Analysis of the 2011 Tohoku Earthquake," ION Pacific PNT 2013.

Cloud PNT and the reliable PNT are the most important

Sang Jeong Lee
Professor, Head of National GNSS Research Center, Chungnam National University, South Korea

Thanks to the US government policy of opening GPS signal to publicity, the technology development in GPS applications brought us almost ubiquitous navigation for past 20 years. Moreover, other technologies like MEMS and WiFi positioning technology has been rapidly developed in order to fill the gap between almost ubiquitous and seamless navigation. Recently, with the rise of multi-constellation GNSS it can be expected that more effort will be made for achieving the cloud PNT which try to use every available resources like the cloud computing. Meanwhile, the need of reliable PNT will become stronger than ever as the application of GNSS becomes wider. The reliable PNT is likely to means robust usage of GNSS against interferences and secure usage of GNSS in the aspect of the privacy as well. I personally believe that the cloud PNT and the reliable PNT are the most important issues in GNSS for the coming years.

QZSS has a unique function called augmentation

Akio Yasuda
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8 GPS satellites, 5 GLONASS ones, 10 BeiDou ones, one QZS and 4 SBAS. What does this imply? The number of satellites elevation at higher than 15degrees from Tokyo at noon in the end of July. Good 28 satellites are available in the sky in Tokyo. In 2015, more than 5 satellites may join them if the Galileo satellites are launched following the schedule. The Japanese Government has decided to continue developing the regional satellite navigation system QZSS additional two IGSO satellites and one GEO in September 2011 by 2020. And the new scheme was established in this March and it has been announced that the 4 satellites can be used in early 2018. It is said that 7 satellites' regional system will be deployed after complete the present project with additional 3 satellites. QZSS satellites are said to be supplemented to GPS satellites, because they transmit exactly the same ranging signals for civil use with those by GPS. However, how they will work as additional GPS satellites in the circumstance with so many positioning satellites in the sky where more than 4 times larger number of satellites can be observed than those of GPS only. Of course, some effect is expected such as somewhat improvement of the accuracy with lowering DOP, especially in the urban canyon. The positioning function itself is not much expected from QZSS. Fortunately, QZSS has a unique function called augmentation, which GPS does not have. It has two data transmitting channels, named L1-SAIF (Submeter Augmentation with Integrity Function) and LEX (LEX – L-band EXperimental). They are the key factors for QZSS to be worth existing. After the first launch of QZS-I named "Michibiki" which means "Guiding light" in English, on 11th of September, 2011, the original software to deduce the orbit and clock deviation has been developed successfully by the cooperative research program of Japan Explore Research Agency (JAXA) and Tokyo University of Marine Science and Technology. MADOCA (Multi-gnss Advanced Demonstration tool for Orbit and Clock Analysis) is the fruit of the research program. It is originally developed for the QZS, but it shows the better performance to estimate the orbit and clock errors than those estimated by the traditional ones such as Bernese, GAMIT and GIPSY. Now they are going to develop the PPP algorithm using deduced parameters by MADOCA. Then LEX (L-band experiment) signal, on the same carrier of Galileo E6, which has a broad service area and can be used as a tool to transmit the augmentation data which realize the cm-level real time precise point positioning with neither user's own reference receiver nor data transmission line in its service area. As for L1-SAIF signal, it is transmitted overlaying on L1 C/A signal. It has the equivalent format to that of SBAS. But the originally produced more suitable data for the area than SBAS data. Although data on LEX and L1-SAIF are still under developing to improving the performance, the augmentation data, originally designed, transmission must be the key function such regional satellite system, QZSS and IRNSS, besides the security function, implicitly expected.

Role of the surveyor as a measurement specialist has now become blurred

Emeritus Professor John Hannah
School of Surveying
University of Otago,
New Zealand

Change is an axiom of life and this has been particularly so for the surveying profession over the last 50 years. For those of us who have lived through these times, we have been part of the transition from optical theodolites and steel measurement bands to electronic distance measuring equipment appended to optical theodolites, to total stations, to the GPS and thence on to fully integrated measurement systems whether they be founded upon robotic, inertial or scanning principles. Spatial data collection platforms can now be terrestrially based, drone based, aircraft based or satellite based.

Commensurate with these changes in data collection have been changes in data computation and processing. The move from log books and mechanical calculators to electronic scientific calculators, thence on the mainframe computers, mini computers, and on to PCs has been equally fast. Our smart phones alone now possess computational, data processing, communication, and data capture capabilities formerly never previously imagined. As for data back-up, just look above to the cloud!

Against this backdrop of successful adaptation to change, what can surveyors expect in the future? Without doubt, further technological change! But, perhaps even more importantly, changes in who we are and what we do.

To my mind, the distinctive role of the surveyor as a measurement specialist has now become blurred. While high precision work in specialised areas such as engineering surveying, and underground mining will continue to require specialist training, other measurement tasks are just as likely to be undertaken by specialists from other discipline groups. Geophysicists regularly conduct their own GPS campaigns in assessing earth deformation whilst a number of (non-surveying) discipline groups now use terrestrial or airborne laser scanners and process the resulting data. As a profession, we either move quickly and adapt to these new technologies or we will be left behind, either marginalised to those increasingly fewer specialist tasks that technology has not yet made ubiquitous to the masses, or to those tasks where we have convinced a wider audience that risk mitigation demands the use of our specialist skills.

Fortunately, surveying, in its broadest sense, is far more than measurement - it is also land administration. While technology can assist in the land administration task, the understanding of the basic principles of land administration is much more a matter of social science and land law. The surveyor's intimate knowledge of cadastral systems combined with a fundamental understanding of both reference and measurement systems, gives a strategic professional advantage. Typically, it has been in the definition of cadastral boundaries that surveyors have found their regulatory niche where other professions have been unable intrude. Will this remain the case in the future? We cannot be sure.

Some would argue that the management of spatial data is also the domain of the surveyor – a view with which I would agree. However, it is also an area in which other professionals have an active interest and thus, again, will be subject to competitive professional pressures.

At the broadest level, then, it is my view that the surveying profession needs to decide urgently what it is that defines uniquely the domain of the "surveyor". At a global level, what mix of knowledge, training and skills should form the core component for an enduring professional qualification – one that will stand the test of the next 50 years as robustly as the one in place 50 years ago. This is the crucial question that needs to be answered, in order that the foundations be strengthened so as to allow the profession to move forward with confidence.

GNSS market is fragmented

Dr Suresh V Kibe
Programme Director
SATNAV (Retd.),
Consultant, SATCOM & GNSS, Bangalore, India

The Indian SBAS GAGAN has two Indian satellites at 55 and 82 deg, East longitude and I understand that GAGAN has reached the RNP 0.1 capability. The APV 1.0 target is likely to be achieved in a few months. This performance has been achieved with dedicated efforts of the Indian Department of Space & Indian Space Research Organisation, Ministry of Civil Aviation and Airports Authority of India on the one hand and Raytheon US and MITRE on the other. With L1 and L5 downlinks, GAGAN would be one of the most advanced Air Navigation System in the World. GAGAN can be used for both Civil Aviation and non-CA applications in India. The precise positioning, navigation and time (PNT) service provided by GAGAN will find ready market in Mobile phones, personal mobility,Engineering Surveying, Large Infrastructure projects,Intelligent Transport Systems, LBS, precision farming,green-field airports and a host of other services. Many countries in the Middle East, South East Asia, Korea and Sri Lanka could benefit by collaborating with the Indian Administration in fielding similar systems in their region.

The GNSS market in the world is looking up with 31 GPS, 24 GLONASS, 4 GALILEO and 12 SBAS satellites augmenting the GPS. In India the GNSS market is fragmented and there is a need to bring diverse users under one umbrella to boost sales and educate the service providers of the benefits of Wide area systems and their impact on Engineering applications. The European SBAS EGNOS and GAGAN are similar and cover a large landmass over Europe, Africa, Middle East, India, South East Asia and Sri Lanka. It opens up vast opportunities for collaboration between Indian and European industry to team-up for mutually beneficial projects.

LAS underpins efforts to realising Spatially Enabled Societies

Professor Abbas Rajabifard
Head of the Department of Infrastructure Engineering and Director of the Centre for Spatial Data Infrastructures and Land Administration, University of Melbourne, Australia, Immediate Past-President of Global Spatial Data Infrastructure (GSDI) Association and is an Executive Board member of this Association

Land Administration Systems (LAS) enable the management of land information, which is fundamental for informing decisions about economic, environmental and social issues of priority. In today's modern society, LAS also underpins efforts to realising Spatially Enabled Societies, where location and spatial information are regarded as common goods and made available to citizens and businesses to encourage creativity and product development. Spatial enablement uses the concept of place and location to organise information and processes and is now consistently part of broader government strategies. This promotes innovation, transparency and democracy by enabling citizens and we are therefore, potentially at the start of a spatial information revolution.

Such developments have only been possible due to the increasing ubiquity of spatial data and location information, which is reliant on a variety of technical infrastructure not only for dissemination and use, but for supporting the entire lifecycle of spatial information. Fundamental to the genesis of any type of spatial information is the accuracy and reliability of the positioning network. Many jurisdictions have adopted satellite-based position to improve accuracy and transparency in their LAS and in this context the data is increasingly being captured directly from Global Navigation Satellite Systems (GNSS), but there are still challenges that need to be overcome such as applicability in built environments, and more integrated manner to deliver a better connected government and society. As well, research into different dimension and utilisation of positioning including 3D land and property management and indoor positioning are providing new aspects to LAS, improving its relevancy to modern land administration requirements.

Advances in geodesy and GNSS have vastly improved the accuracy and reliability of spatial information in general and LAS in particular. And yet, ongoing research shows there is still much progress to be made, even as we simultaneously continue to establish new developments in positioning technology. There will be ongoing challenges in communicating these developments to users and helping them to interpret and understand this information to facilitate their purposes.

Record and Replay Signals for the Sporting Market

In recent years there has been an explosion in the sporting world in the use of GPS. You will scarcely see a runner or cyclist on the road without either a smartphone strapped to their arm, or a dedicated GPS device clamped to their handlebars, tracking their every move. The amount of information that the modern sportsperson – from casual amateurs to full time professionals – is logging, analysing, and sharing is phenomenal. There are now dozens of ways of uploading data for the whole world to share and study.

A run through heavily tree lined paths recorded with a LabSat3. The high sensitivity design allows for signal capture in difficult environments.

As more manufacturers come to this market with the hope of capturing a share of it they are faced with the challenge of effectively developing, and then testing their devices. For one thing, new products will have to have capability for local constellations such as BDS and QZSS rather than GPS alone. New market entrants won't have the same budget as the established big players, and constantly travelling to China or Japan in order to try out a new gadget is going to escalate costs to an unsustainable degree.

Then there's the issue of getting out into the kind of environment in which you imagine your new sporting GPS device will be put to use. In many cases this is going to be remote areas, forests, hills and mountains: stepping outside into the office car park is not a realistic test for satellite acquisition and retention. Driving home with it isn't either.

So you need a GPS simulator or replay device, to allow for bench testing. But these are expensive. They might not actually be all that useful, either, if all they play into the GPS engine is a perfectly clean signal that has been generated, or recorded from an ideal environment. You need to know how your new product will operate through a forest, or down an urban canyon.

Soon to launch at the ION exhibition in Nashville, LabSat3 provides a solution to these problems. The third generation to be launched in the LabSat range, the new product from UK based Racelogic is a very cost effective GPS record and replay system available for anyone developing GPS devices, and arguably the most convenient to use. It is a battery-powered, standalone unit that can be taken anywhere and used to record satellite signals for reply back at base. It measures 167mm x 128mm x 43mm and weighs 900g, making it a truly portable record and replay system. And it has the ability to record and replay two constellations in parallel.

Racelogic have designed the new LabSat with great care. Chris Smith, Design Director, who has worked closely on the project, says: "We have deliberately built the unit to have a high degree of sensitivity when operating in difficult circumstances. The user can capture satellite signals in heavily tree-lined areas even using a passive antenna, with the LabSat in their backpack, and still get a recording that is going to be perfectly useable back in the office. It gives the developer huge flexibility for real-world testing without having to spend a fortune. And a one-button press to make these recordings means that anyone can do it, not just a specialist engineer."

LabSat 3 comes with a pre-recorded library of world-wide scenarios to allow engineers to perform immediate bench testing

Mark Sampson
LabSat Product Manager

Resilient PNT – Making way through rough waters

The Accessibility for Shipping, Efficiency Advantages and Sustainability (ACCSEAS) project will be considering several means of obtaining alternative PNT information


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The International Maritime Organisation (IMO) is developing e-Navigation as the future approach to marine navigation in order to enhance maritime safety. As such, the IMO state that positioning systems for e-Navigation "should be resilient …. robust, reliable and dependable. Requirements for redundancy, particularly in relation to position fixing systems should be considered" [1].

GPS has become the primary source of positioning for mariners; but no Global Navigation Satellite System (GNSS) alone can provide resilient Position, Navigation and Timing (PNT). GNSS, including GPS, GLONASS, BeiDou, QZSS and Galileo, is vulnerable to deliberate, accidental or natural radio interference. Despite these weaknesses, GPS has become a crucial element not only of maritime navigation, but also of critical national infrastructure, and is often used without any backup being provided. A complementary system, compatible with GNSS but independent from it, is essential to achieving the resilient PNT required for e-Navigation; it is also essential for supporting a wide range of national and international critical infrastructure systems.

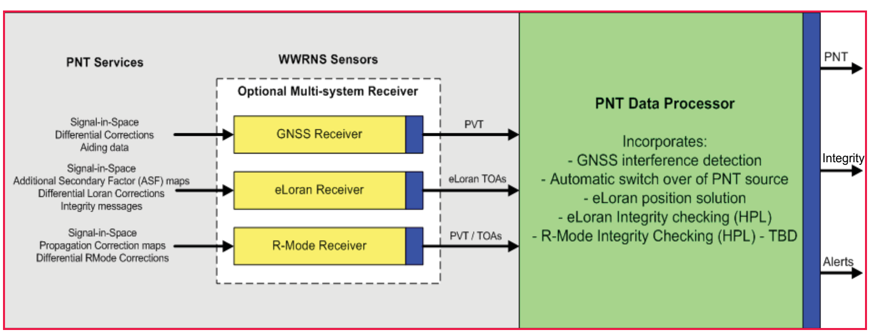

Figure 1: ACCSEAS Resilient PNT architecture

The Accessibility for Shipping, Efficiency Advantages and Sustainability (ACCSEAS) project will consider resilient PNT as part of its overall aim of developing potential e-Navigation services that will enhance maritime safety and efficiency within the North Sea Region (NSR). The project will develop an e-Navigation test bed within the NSR which will be used to demonstrate the potential e-Navigation services, developed by the project. The project is being completed by a collaboration of 11 partners from across the NSR, made up of service providers, industry and academia [2].

The need for resilient PNT

The ACCSEAS project is investigating the future navigation issues which are due to affect shipping in the NSR and has highlighted the fact that shipping density is set to increase with bigger, faster vessels, leading to reduced manoeuvrability. The navigable area of the North Sea will reduce in size due to the growth in offshore installations, such as wind farms and oil and gas platforms. As a result, the risk of an incident or accident occurring will increase, particularly at pinch points such as approaches to major ports and constrictions, such as Rotterdam and Dover, and inland waterways like the Kiel Canal.

Within this environment, the project recognizes that GPS has become the normal method used for maritime PNT, primarily because it is freely available and usually provides excellent performance. As a result, the number of GPS receivers installed on a ship's bridge is increasing and, depending on the nature of the vessel operations, GPS data can be fed to a large number of the bridge systems, including some

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which may be unexpected, for example the vessel's radar, gyrocompass and clocks.

In addition to ordinary positioning and navigation functionality, another key component affected is the Automatic Identification System (AIS). While AIS was developed to provide information from ship-to-ship and ship-to-shore, it is likely to form a vital part of e-Navigation data exchange, in conjunction with broadband Internet. It is also noted that many satellite broadband systems use GPS to align a high gain antenna towards a geostationary satellite.

It is well known that GPS, and GNSS in the broader sense, is vulnerable to system failures as well as intentional and unintentional interference [3]. An example of natural interference was observed in 2006 when a radio burst from the Sun affected GPS reception over the entire sunlit side of the Earth [4]. Such solar events occur with very little advanced warning, if any, and can affect large areas. As such, suitable mitigation is required; mitigation that can be used automatically and seamlessly should GNSS suddenly become unavailable.

Inference can also be caused through the use of GPS signal jammers which can prevent a receiver from maintaining lock on GPS satellites. Jamming does occur and the fear is that it is on the increase, whether due to accidental use, such as the case of a military jamming unit being accidentally left switched on in San Diego harbour in 2007; or through the indirect effects of intentional use, as in the case of GPS jamming observed at Newark airport in 2010 [5]. The latter example highlights the unintentional consequences of using such systems as the user did not intend to affect the airport systems, but reportedly used the jammer to prevent their movements from being tracked.

A more significant intentional act of jamming occurred in 2012, when North Korea jammed GPS over large areas of the Republic of Korea, affecting military and civilian users alike. There are reports of various aircraft and ships altering course in order to maintain safety [6], this would not have been necessary if resilient PNT options were available.

These problems are not limited to GPS; by design, signals broadcast from GNSS satellites are low power and with the use of a common frequency band to aid interoperability, it is easier to affect more than one GNSS with a single jammer. In this case, ease of interoperability also leads to joint vulnerability.

Options for resilient PNT

In order to achieve resilient PNT, other sources of PNT information are required in addition to the primary source, which is recognised as GNSS. Any additional system needs to have dissimilar failure modes to GNSS otherwise it too will be affected by the same vulnerabilities. It is not a case of simply adding more receivers or using different constellations providing signals in the same band of frequencies, as they can all fail together. Similarly, adding more physical Aids-to-Navigation may enable mariners to know their relative location, but it would not be sufficient to maintain the many different systems, and potential e-Navigation services, which require an electronic position.

One of the aims of the ACCSEAS project is to consider the question of which system, or systems, can be used to provide resilient PNT. When considering candidate systems one must keep in mind their availability and failure modes, what level of performance can be provided, how the resulting PNT information can be integrated and, of course, cost.

The General Lighthouse Authorities of the United Kingdom and Ireland (GLA) studied a number of options for resilient PNT; from the use of dissimilar technologies such as inertial systems, the use of alternative radionavigation systems and whether GNSS receivers and systems can be "hardened" to make them less susceptible to vulnerabilities. The study concluded that inertial technology is relatively immature for maritime applications and as such, the costs are prohibitive and also, while GNSS hardening options exist, they are normally reserved for military use. As such, the ACCSEAS project is considering using alternative radionavigation systems; including:

- R-mode
- eLoran
- Absolute radar positioning

R-Mode, or Ranging Mode, is obtained by adding a navigation ranging signal to the signal broadcast by marine radiobeacon DGPS stations and AIS base stations.

Radiobeacon DGPS operates in the Medium Frequency band (around 300kHz), where the signal propagates as a groundwave over the surface of the earth from a transmitter to the mariners' receivers. AIS operates in the VHF band (approximately 160MHz), and propagates along a line of sight path from the transmitter to the receiver. By receiving a ranging signal from three or more stations, an appropriate receiver could then determine the mariner's position independently from GNSS. Each ranging signal requires synchronising to UTC, or other common system time, a suitable signal structure for tracking purposes and propagation effects need to be taken into account. R-mode is not currently available and is being developed as part of the ACCSEAS project.

eLoran is a system of low frequency broadcasts, from terrestrial stations that provide PNT information, independent from and complementary to GNSS. eLoran receivers calculate the distance the signals propagate from the transmitters to the users' receivers via groundwaves propagating over the surface of the earth. This calculation makes an assumption that the world is made entirely of sea water. But there are additional propagation delays due to the signal travelling more slowly over land, these are known as Additional Secondary Factors (ASF). They are measured and published for each service area. ASFs are measured once and for all, published, and then stored within a user's receiver; but the actual values may change slightly due to short term weather, and longer term seasonal effects. A Differential-Loran reference station, installed near to the service area, measures these small changes and sends differential-Loran correction data to the eLoran transmitting station for broadcast to the mariner over the eLoran signal itself; on the Loran Data Channel.

Radar is traditionally a relative positioning system, used to determine where the ship is relative to structures around it. However, it has been demonstrated that it is possible to get ranging information using a coastal network of active radar transponders with New Technology (NT) radar [7]. Such transponders would respond to radar illumination by transmitting their location or ID back to the vessel's radar. By calculating the range from a series of transponders at known locations an absolute position can be calculated. The ACCSEAS project plans to investigate this option further, with a trial planned to take place within the next few months.

System integration

The selected PNT systems will need to be integrated into a resilient PNT system that can monitor the performance of each of the different solutions and provide a resilient PNT output to the bridge systems. The ACCSEAS project is investigating how this can be achieved and has developed a prototype Resilient PNT Data Processor (RPDP). This module monitors the availability of the different PNT sources and selects which system to use based on a number of criteria. The architecture of the RPDP is shown in Figure 1.

The RPDP runs on a lap-top computer and takes input from the different PNT sources, currently GPS is the primary source and eLoran is the secondary source; in the future this may be expanded to include R-mode.

The RPDP works by building a model of the expected signal performance from the GPS satellites in view. Having built this model, any significant changes to the expected performance, taking into account the movement of the ship, will then be flagged. If the performance crosses a particular threshold then the RPDP swaps the output from the primary PNT source (GPS) to the secondary PNT source (eLoran). The RPDP is also able to monitor the performance of eLoran to ensure the data is fit for purpose.

The decision was made not to implement any multi-system integration, but to keep the GPS and eLoran data separate and have a binary decision of which to use as the ship's position data. Deeper, multi-system integration has several benefits, including greater accuracy; improved availability of the solution; the ability to calibrate cross-system biases; and increased coverage or better HDOP by combining signals from several systems. However, for safety-of-life navigation where a high level of integrity is required, any multi-system integration or calibration process risks introducing faults from one system into another. Likewise the use of Kalman Filtering or any other type of multi-epoch smoothing propagates Integrity Risk from one epoch to the next. Both techniques risk 'poisoning the well' if severe integrity hazards, such as jamming occur and go undetected. As a general rule, for high-Integrity applications cross-system calibration and cascaded filtering should be avoided whenever possible to maintain the level of system-separation needed to 'quarantine' the Integrity Risk [8]. Hence the systems are monitored and analyzed separately.

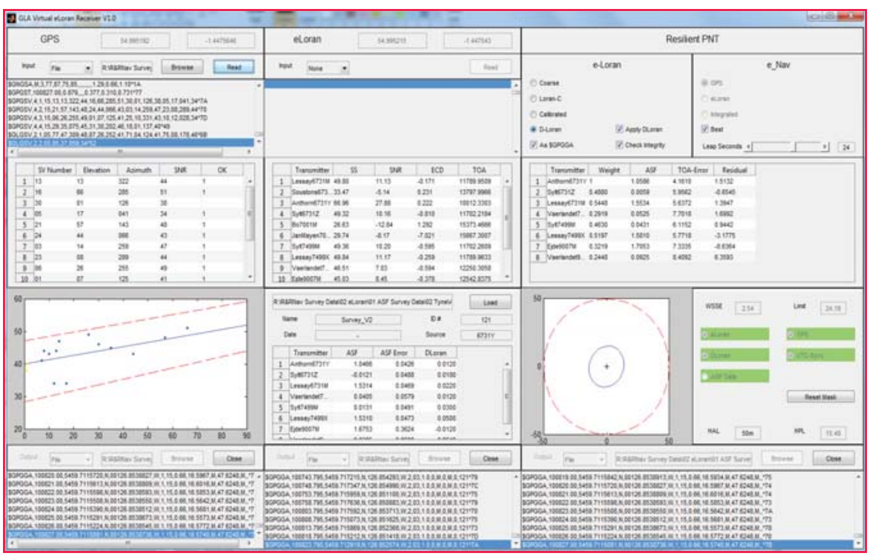

Figure 2: Screen image of the ACCSEAS Prototype PNT Data Processor

Demonstrating the benefit of resilient PNT

The GLA conducted a series of resilient PNT demonstrations in February and March 2013, as part of the ACCSEAS project, with the aim to test the RPDP and to promote the need for resilient PNT. Demonstrations were held on board a GLA buoy tender, THV Galatea, where the RPDP was installed on the bridge.

In order to integrate the prototype into the bridge of the Galatea it was necessary to determine the extent to which the different ship's systems were dependent on GPS and from where that GPS data originated. It was determined that the majority of equipment is fed GPS data from two receivers with NMEA data splitters used to feed this GPS data to the different bridge systems. For the demonstrations, one of the GPS inputs was replaced with the output from the RPDP (Figure 3) So that systems such as the AIS, ECDIS, gyro and radar were subsequently supplied with resilient PNT data.

The UK Ministry of Defence was contracted, by the GLA, to operate an L1 GPS jammer which was installed aboard the THV Galatea. The jamming power was set so that it would only affect the Galatea. The vessel was constrained to operate in an approved experimental area off the coast of Harwich on the east coast of England, where GPS jamming had been licensed for the duration of the trials

The demonstrations followed the scenario that the vessel was unwittingly steaming towards a source of GPS interference, either radiating from another vessel or from a nearby coastal headland. To simulate this, the power of the jammer installed on the vessel was slowly increased until systems failed. In order to demonstrate the benefit of a resilient PNT system the scenario was repeated twice, first without the RPDP active and then with the RPDP


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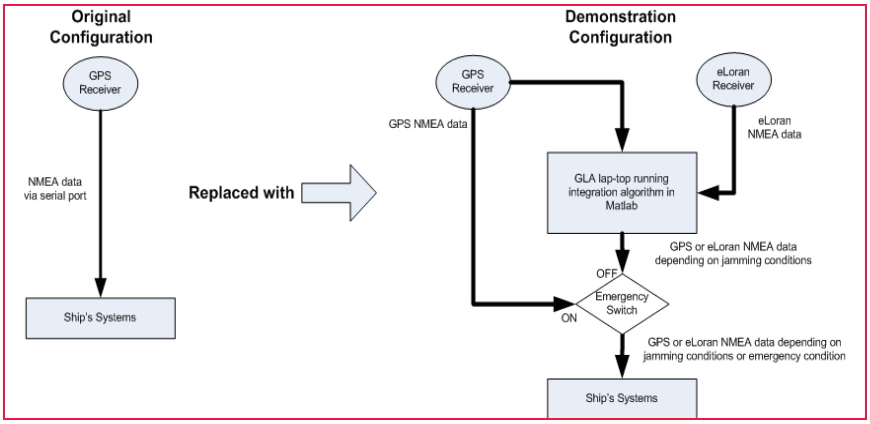

Figure 3: Schematic of the prototype data processor integration with the bridge systems

enabled. During the demonstrations the vessel remained within the jamming area, travelling slowly, and used the radar to maintain situational awareness.

During the first run, with the RPDP disabled, the audience observed the many different bridge systems enter an alarm state, reporting the loss of position or timing information, as demonstrated during previous GLA jamming trials [9]. Alarms sounded from the various systems and their repeaters around the bridge. If not expected, these could have caused confusion to the crew as they attempted to understand the causes of the alarms and silence them. Once the effect on a normal bridge had been established, the jamming signal was stopped and the vessel systems were allowed to recover.

When the systems had returned to their normal operational condition, the RPDP was enabled and the scenario repeated. During this second run the RPDP monitored the performance of GPS and identified the presence of jamming at a level below that which caused the ship's bridge systems to alarm, enabling the PNT source to be swapped to eLoran before the effect of the jamming could raise any alarms on the bridge. This resulted in the quiet, seamless and automatic transfer from one source of PNT to another, all with no fuss. For the first time, bridge systems were operating on a resilient PNT solution; navigating using eLoran position data in place of GPS when GPS was lost. Also, for the first time, the vessel was able to report its position over AIS using eLoran derived PNT information.

Following the demonstrations, data recorded from the various GPS receivers were processed, including the output of the RPDP. Figure 4 shows the GPS position output from one of the demonstrations. The ship entered the jamming zone from the north-west and sailed around the region. The green trace shows the reported GPS position. Where GPS was lost due to jamming, there are gaps, highlighted by the red ovals. The plot also shows examples of how the GPS reported position can wander. This tends to occur when the jamming signal strength is relatively weak and tends to happen at the beginning and end of the various segments, when the jamming power is increased and decreased. This wander is Hazardously Misleading Information (HMI) and the mariner would prefer to have NO GPS at all rather than GPS that gives incorrect positions.

Figure 4: The reported track of the vessel as provided by the GPS receiver during the first day of the demonstrations

Figure 5 shows the RPDP output overlaid in purple on the GPS output. When GPS is available the processor outputs GPS derived positions and the two traces overlap exactly. Where there are gaps in GPS due to jamming, eLoran derived positions are output instead and fill the gaps. However on closer inspection, it's possible to see eLoran taking over before GPS is lost entirely (the red circle). The RPDP has identified that something is wrong with GPS and switches to eLoran before the GPS data is output, thus avoiding the presentation of Hazardously Misleading Information to the mariner. Whilst outputting eLoran data, the RPDP continues to monitor the performance of GPS and once it is deemed usable again, the output is swapped back to GPS.

Conclusions

This work has shown that the ACCSEAS project has not only developed a prototype resilient PNT solution, but that it has been successfully tested and demonstrated under live conditions on a typical ship's bridge.

The benefits of such a system were clearly demonstrated since, when GPS was lost because of jamming and the PNT data processor unit was enabled, the ship's crew were able to seamlessly continue to navigate safely and efficiently and were not distracted by the many different alarms that would otherwise have sounded.

ACCSEAS will be considering several means of obtaining alternative PNT information as the project progresses. For these demonstrations eLoran was used to provide the additional, complementary PNT information, demonstrating that it is available to use today.

The GLA, and the ACCSEAS project, continue to support the use of multiple PNT sources in order to keep the mariner safe and avoid the presentation of Hazardously Misleading Information.

Acknowledgements

The authors acknowledge that this work was conducted as part of the ACCSEAS project, which is part funded by the INTERREG

IVB North Sea Region programme, and would like to thank the project participants along with the crew of THV Galatea for their assistance and professionalism when conducting these trials.

ACCSEAS Project partners

ACCSEAS partners are General Lighthouse Authorities, UK & Ireland; Chalmers University of Technology (Sweden); Danish Maritime Authority; Federal Waterways & Shipping Administration (Germany); Rijkwaterstaat, Minesterie Infrastructuur en Millieu (The Netherlands); Swedish Maritime Administration; Norwegian Coastal Administration; SSPA Sweden AB; Flensburg University of Applied Science (Germany); NHL Hogeschool, Leeuwarden, Maritiem Instituut Willem Barentsz (The Netherlands) and World Maritime University (Sweden)

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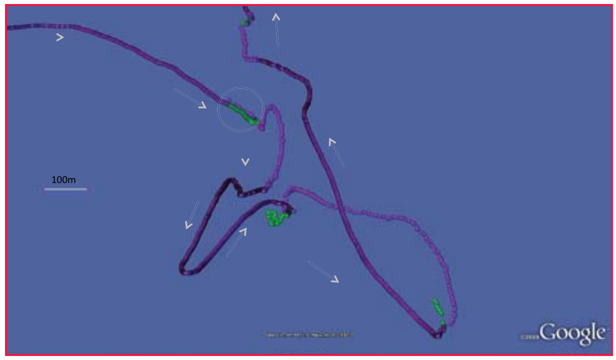

Figure 5 – The Resilient PNT output is overlaid with the GPS position alone

This paper was presented at the RIN GNSS Vulnerabilities conference at Baska, Croatia during 18 - 20 April, 2013.

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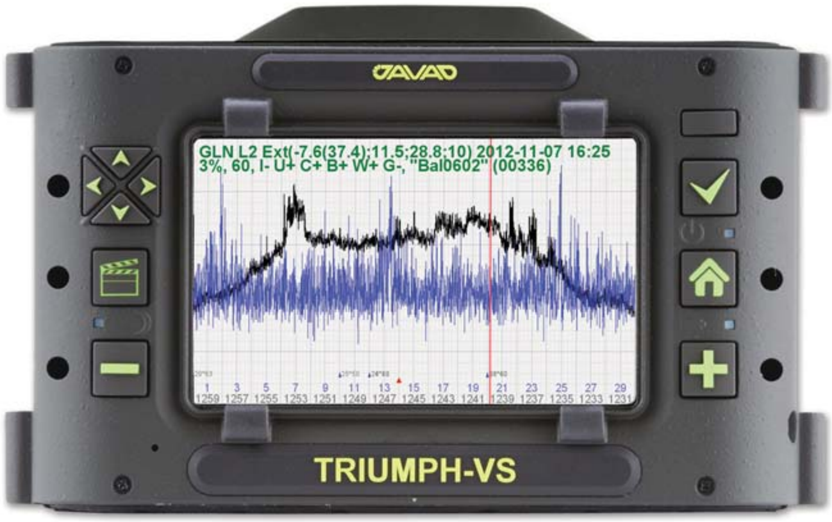

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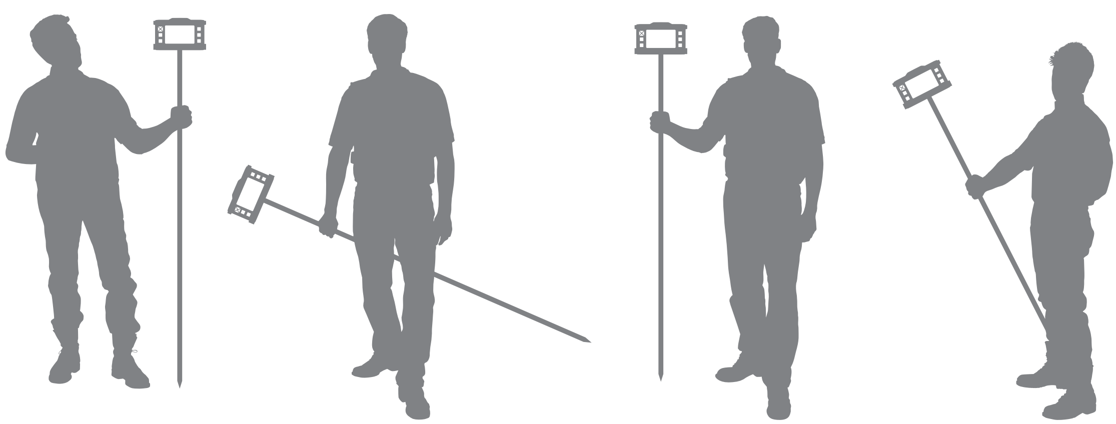

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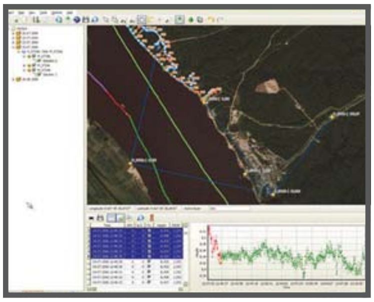

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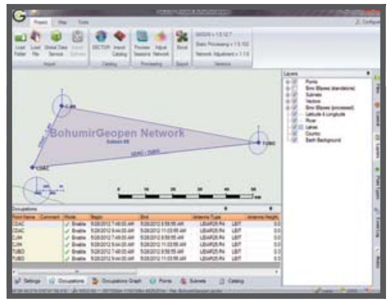

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GALILEO-only Position Fix from India: First Experience

This paper reports the first successful Galileo-only 3-dimensional position solution obtained from Burdwan, India on 03 July, 2013. The paper also presents the initial observations of solutions obtained using one or more Galileo satellites with GPS and/ or GLONASS

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Galileo is Europe's contribution to the multi-GNSS to provide a highly accurate, guaranteed global positioning service under civilian control. Offering dual frequencies as standard, Galileo is expected to deliver extremely good real-time positioning accuracy. From users' point of view, availability of Galileo's signal would help in achieving a multi-GNSS environment for redundancy and system independence. Since its deployment Galileo has generated interest among research groups worldwide. Reports from several groups tracking Galileo signals and obtaining Galileo-only position solution have been obtained. This paper presents a brief description on Galileo deployment and reports from groups situated in different parts of the globe on Galileo tracking; the paper finally describes the first report of Galileo-only solution from India and the preliminary results obtained.

GALILEO development – a brief history

The first Galileo In-Orbit Validation Element GIOVE-A, was successfully launched on 28 December 2005 by the European Space Agency and was retired in June 2012. GIOVE-B, with advanced payload over GIOVE-A was successfully launched on 27 April 2008 and retired in July 2012. In the next phase, In-Orbit Validation (IOV) satellites, which are closer to the final Galileo satellite design, were launched. Presently there are 4 IOV satellites in orbit designated by the PRN #E11, #E12, #E19 and #E20 as described in Table 1. More details can be found in [1, 2].

GALILEO signal tracking and GALILEO-only 3-dimensional solution reports

With four operational Galileo IOV satellites, efforts have been seen over the globe for tracking and observing 3-dimensional (3-D) position solution using Galileo-only or Galileo with other GNSS constellations. Reports from several research groups are briefly described here. On 12 December 2011, one of the two GALIEO IOV satellites launched on 21 October 2011 started transmitting its payload signal on E1 band over Europe and on the same day was successfully acquired and tracked by the researchers of the Navigation, Signal Analysis and Simulation (NavSAS) group of Istituto Superiore Mario Boella, Politecnico di Torino, Italy. Two days later, on 14 December, the E5 signal was also available [3]. On 01 December 2012, the E1 signal

Table 1: Galileo IOV satellite details

Satellite	Launch Date	PRN	Slot No	Current Status
IOV PFM (GSAT0101)	2011-10-21	E11	B5	Operational
IOV FM2 (GSAT0102)	2011-10-21	E12	B6	Operational
IOV FM3 (GSAT0103)	2012-10-12	E19	C4	Operational
IOV FM4 (GSAT0104)	2012-10-12	E20	C5	Operational

of the Galileo Flight Model 3 satellite (FM3 or GSAT0103 launched on 12 October, 2012) was tracked by the same group for the first time and reported on GPS+Galileo PVT Experiment done on 21 December 2012 [5]. On 12 March 2013 ESA announced about the 3-D position fixing using Galileo. This first position fix of longitude, latitude and altitude took place at the Navigation Laboratory at ESA's technical heart ESTEC, in Noordwijk, the Netherlands on the morning of 12 March 2013 with an accuracy between 10 and 15 metres [6] and the positioning capability was confirmed by the NavSAS group [7]. Within a day of activation over Europe, Galileo satellites were visible over North America. The Position, Location and Navigation (PLAN) Group, University of Calgary, Canada captured and processed signals from Galileo IOV satellites. Researchers from PLAN group simultaneously tracked GPS L1 and GLONASS L1 for combined solutions in real time on 13 March, 2013 [8]. The next report can be obtained from the researchers of the NAVIS Centre in the Hanoi University of Science and Technology, Hanoi, Vietnam. On 27 March 2012, four Galileo-IOV satellites were visible at the same time from Hanoi, Vietnam. The researchers of the NAVIS Centre could, for the first time, receive the signals of all the four satellites and track them [9]. The report of Galileo-only solution can also be obtained from M/S Javad GNSS Inc. On the basis of the data collected from the Moscow region, Russia report on position fixes using Galileo-only and GPS+GLONASS+Galileo constellations can be found 29 April, 2013 [10].

Efforts from India

GNSS Activity Group, The University of Burdwan, India, is engaged in exploring the use of multi-GNSS signal for the benefit of the Indian user community. The group therefore, tried to track Galileo signal and to obtain Galileo-only position solution. As a part of the available infrastructure, a Javad DELTA G3T receiver with Galileo tracking capability was used for the purpose.

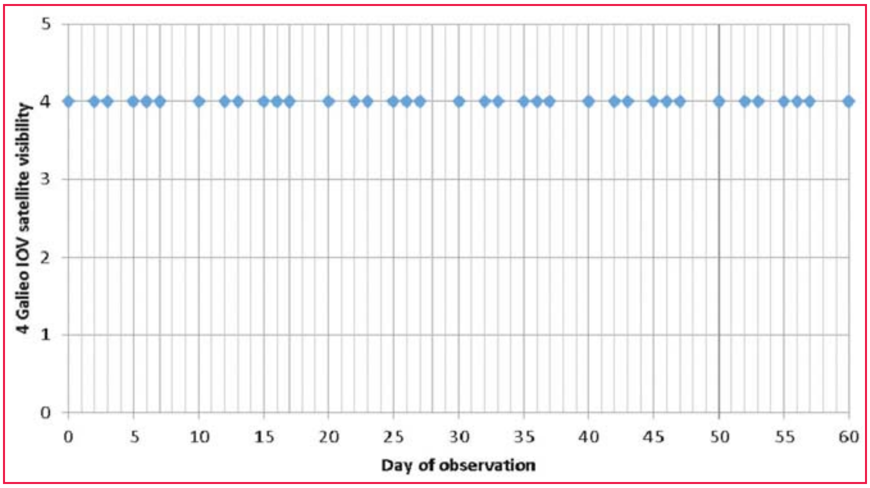

Figure 1: Galileo IOV 4-satellite repetability pattern from Burdwan, India (Day 0:31/05/13)

After some initial system problems and unhealthy Galileo FM-4 status, first Galileo-only 3-D position solution was obtained on 03 July 2013 from Burdwan, India (Lat 23.2545^0 N, Lon 87.8468^0 E) using E1 and E5 frequencies. Subsequent sections briefly describe the efforts and the results obtained.

Orbitron is a free satellite tracking software for radio amateurs and observing purposes [11]. Using Orbitron with updated NORAD two-line element sets for the Galileo satellites from Celestrak website [12], simultaneous visibility of all 4 IOV satellites is predicted for tracking. The predicted 4-satellite visibility pattern as found from the simulation is shown in Figure 1. It may be noted that with the current constellation status, 4-Galileo visibility has a typical pattern from India. Observation day #0 is 31 May 2013 as seen in Figure 1.

Since early June, 2013, efforts have been concentrated on simultaneously tracking 4 Galileo IOV satellites for Galileo-only, 3-D position fix. Data for 01, 02 and 03 Galileo satellite(s) tracked in tandem with other constellation(s) (GPS/GLONASS) was also recorded. After the outage of IOV-4 (PRN #E20) satellite during 14 June to 25 June 2013 [2] and some initial receiver setting problems, on 03 July 2013 all the four Galileo IOV satellites were tracked simultaneously for the first time from India for more than three hours during 16:00 to 19:00 hrs IST (+05:30 UTC) providing 3-D position solution. Corresponding screenshots of the Orbitron prediction software and the NetView utility of the receiver are shown in Figures 2 and 3 respectively.

Table 2: Galileo-only 3-d position solution results

Observation Date, Time (UTC)	Standard deviation σ of (mt)			Peak to Peak variation of (mt)			PDOP	
	Latitude	Longitude	Altitude	Latitude	Longitude	Altitude	Max	Min
03 July, '13 10:35-12:05	6.19	0.74	8.25	18.71	2.40	24.77	3.7	3.41
03 July, '13 12:22-13:32	0.78	0.18	0.66	3.81	0.80	2.68	5.58	3.42
12 Aug, '13 12:22-13:32	2.09	0.67	2.55	7.75	3.01	10.54	5.5	3.99

Observations and discussion

Data was recorded in 1 Hz frequency for Galileo-only position solution for 03 July 2013 in two slots of duration 90 min and 70 min respectively and for 25 min on 12 August 2013. Data for


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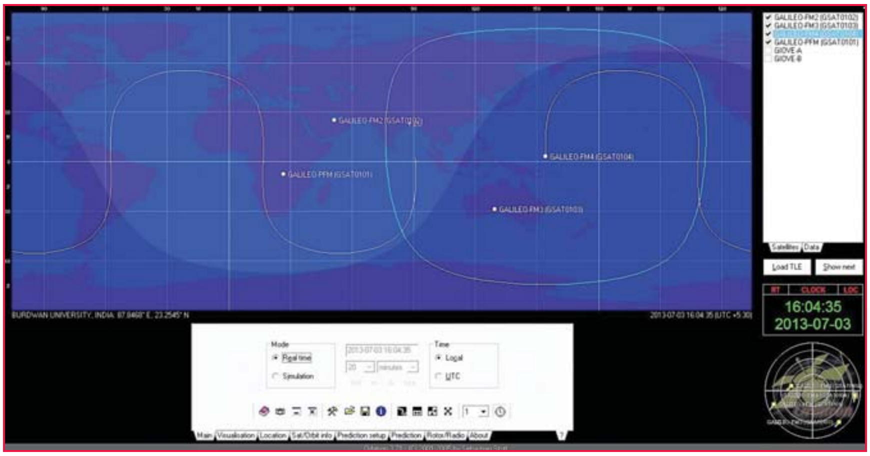

Figure 2: Screenshot of Orbitron prediction software showing 4 Galileo IOV satellite visibility

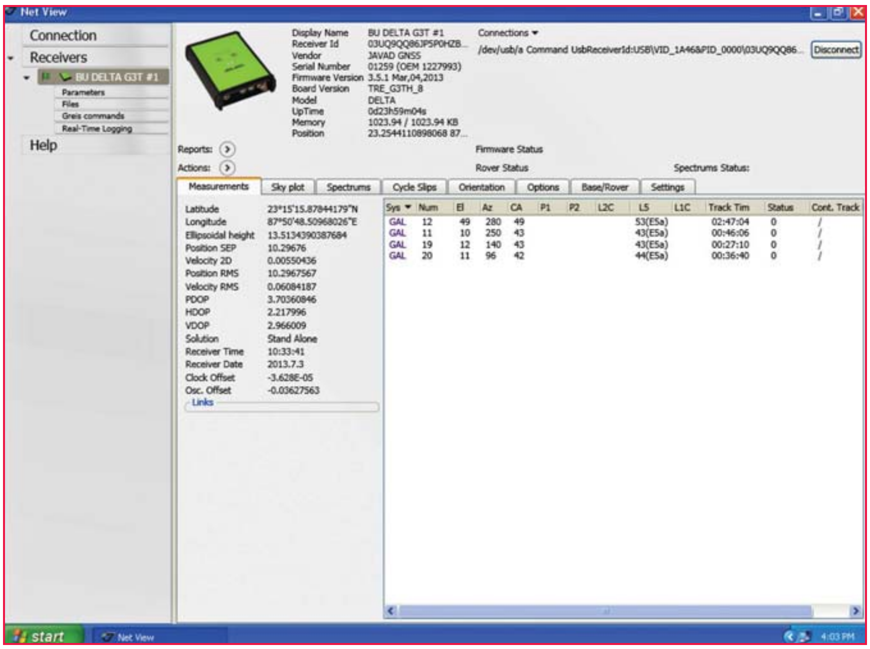

Figure 3: NetView software screenshot showing simultaneous tracking of 4 Galileo IOV satellites from Burdwan, India using E1 and E5 signals

Galileo with other constellations were also recorded for observing the multi-GNSS capability. 2-D Position solution results obtained from Galileo-only fix is shown in Figure 4 while Figure 5 shows the comparison of 2-D position solution using Galileo-only and all usable GNSS (GPS+GLONASS+ 4 Galileo) satellites.

Results obtained by analyzing the data for the Galileo-only position solution are presented in Table 2. Inspection of results shown in Table 2 reveals that, the operational IOV satellites, when available simultaneously, is capable of providing 3-dimensional position solution with modest stand-alone accuracy even with slightly degraded Position Dilution of Precision (PDOP) values. Peak to peak variation of Latitude is found to be higher than that for Longitude values. The situation may also be observed from Figure 4.

Galileo data is also recorded at 1 Hz frequency along with other available GNSS signals- GPS, GLONASS and GPS+GLONASS. Data obtained from the observations would provide the initial results of multi-GNSS interoperability as obtained from India. Galileo operation in tandem with one or more other available GNSS signals definitely would attract attention of the users for future successful integration of all available systems towards a robust and efficient multi-GNSS environment. One, two, three of four Galileo satellites, as available, have been used together with

Table 3: Position solution results obtained using Galileo satellites and other constellations

Constellation* used	No of Samples	Variation of (mt)						PDOP		Remarks (Mean number of other sats)
		Latitude		Longitude		Altitude				
		σ	Max	σ	Max	σ	Max	Mean	σ	
1G AP	3952	0.66	2.72	0.14	0.84	0.50	2.44	-	-	GPS>9
2G 2P	2055	0.21	1.00	0.55	2.08	5.07	7.97	5.07	0.16	
2G 2L	1837	13.94	46.51	14.34	50.36	11.57	45.47	6.92	2.39	
3G 1P	745	0.17	0.54	0.17	0.78	0.43	3.31	4.28	0.31	
3G 1P	2454	1.08	4.06	2.77	9.94	4.28	15.47	7.09	1.57	
3G 1L	1797	0.49	1.84	0.25	1.12	0.61	2.69	4.67	0.40	
3G AP	750	0.13	0.51	0.05	0.24	0.002	0.93	1.14	0.07	GPS>9
3G AL	941	0.14	0.59	0.21	0.88	0.22	0.99	1.63	0.02	GLO=8
4G AP AL	739	0.09	0.41	0.11	0.58	0.26	0.82	1.06	0.01	GPS+GLO>18

** G=Galileo, P=GPS, L=GLONASS satellites; 1/2/3/4 = No of satellites used for a constellation, A=all satellites in a constellation (e.g. 1GAP= 1 Galileo satellite used with all usable GPS satellite, 2G 2L = 2 Galileo and 2 GLONASS satellites used for solution; 3G AL= 3 Galileo satellites used with all usable GLONASS, 4G AP AL= all 4 Galileo satellites used with all available GPS and GLONASS satellites); σ denotes standard deviation of observation.*

usable GPS and/ or GLONASS satellites to obtain at least four satellites or more. While using only 4 satellites, efforts have been there to select a well scattered set of satellites over the sky as far as practicable. Results obtained from the observations as presented in Table 3 point towards a successful integration of multiple systems. Use of all available GNSS signals (4 Galileo with all useable GPS and GLONASS) provides at least 23 satellites for use with encouraging solution accuracy and satellite geometry represented by PDOP values.

Observations presented in the paper reports the first successful Galileo-only position solution from India that indicate towards the much-awaited multi-GNSS signal availability for the Indian users increasing the possibility of redundancy and system independence. After successful GLONASS availability from India, Galileo availability would call for more detailed and long-term studies with fully operational Galileo along with GPS and GLONASS.

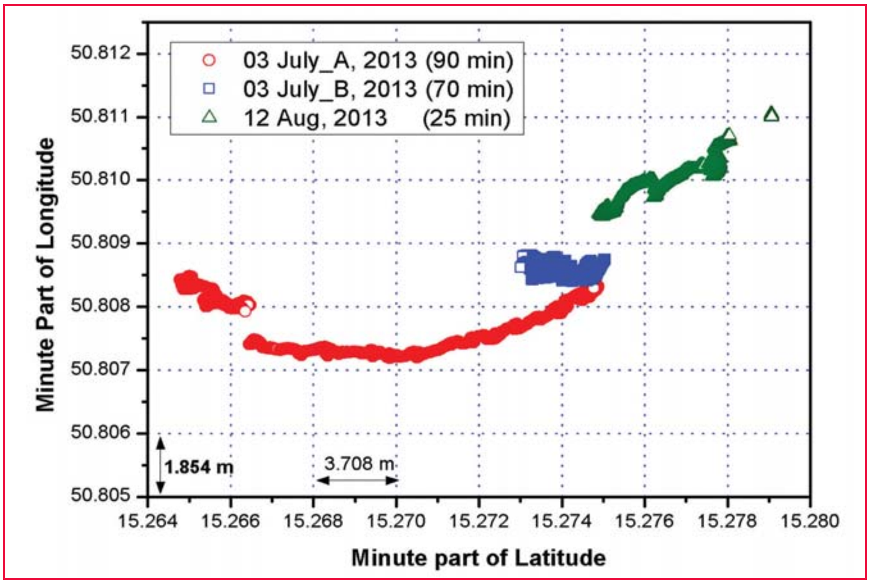

Figure 4: Galileo-only position solution for different data collection slots from Burdwan, India

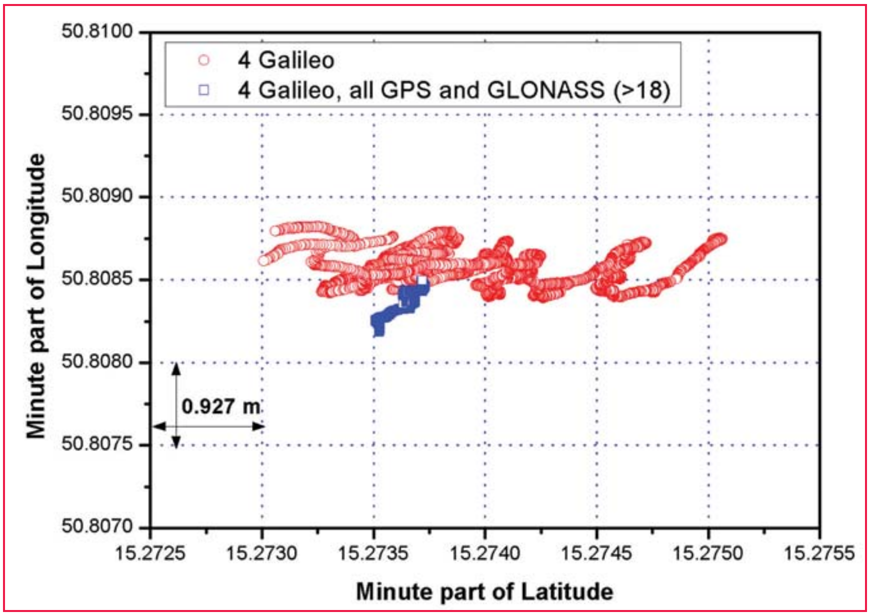

Figure 5: Comparison of Galileo-only position solution with Galileo+GPS+GLONASS solutions

Acknowledgement

The authors would like to acknowledge the free software tool Orbitron (© by S. Stoff) that has been used for plotting Fig. 2

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On the search algorithm of independent baselines

This paper first introduces six search algorithms of independent baselines and realizes them by program, then the search algorithms are compared with real examples

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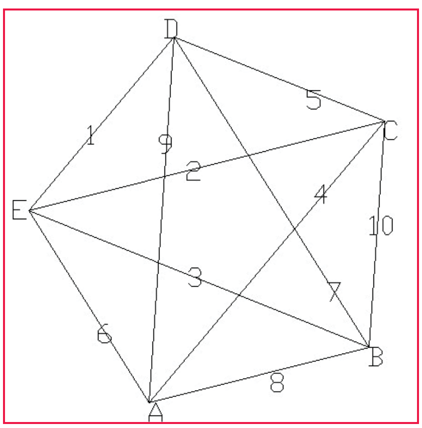

Figure 1: With all the right baseline connected graph

Theoretically in the simultaneous observation of the high-precision GPS network solution mode, the selection of the independent baseline vector can be arbitrary with the same adjustment. But in the real situation, the results varies in different selections for the model of baseline solution is imperfect[1]. Solving this problem requires two steps, to determine the weight of the baseline and to search for the independent baseline with the maximum weight[2]. This paper is to describe six ways used in the search algorithm of independent baselines and realizes them by C++ language, by comparing, we know Prim algorithm, Kruskal algorithm[3] and matrix rank solution[1] are able to get the independent baseline set with maximum weight. Based on the matrix rank solution, the weight is respectively determined by the length, precision and relative precision of the baseline[4], then the adjustment results are analyzed.

Introduction of several Search Algorithms of Independent baseline

Ray method

The ray method is to select a reference point from n points and the independent baselines are the ones from the reference point to the remaining n-1 points. Then the independent baseline set with maximum weight is obtained by comparing n kinds of independent baseline set. This search algorithm is relatively simple to get the independent baseline set with maximum weight with only the weight of ray sets derived from n reference points.

Wire method

The wire method starts from a point and select the baseline with maximum weight connected to it , then starts the other endpoint to search for the baseline with maximum weight until all the n points are connected.

Prim algorithm

Prim algorithm is to select the side of the minimum weight with one end in the tree while the other is not in the tree and add it to the tree until n-1 sides are in the tree[5]. The realization of the process is shown in Figure 2.

Kruskal algorithm

Kruskal algorithm examines each side according to the increasing order of the weight of the side. If the side and the selected ones do not constitute a loop, then reselect the baseline and repeat the process until the spanning tree appears[5]. Take Figure 1 as example, the specific process is represented by Figure 3.

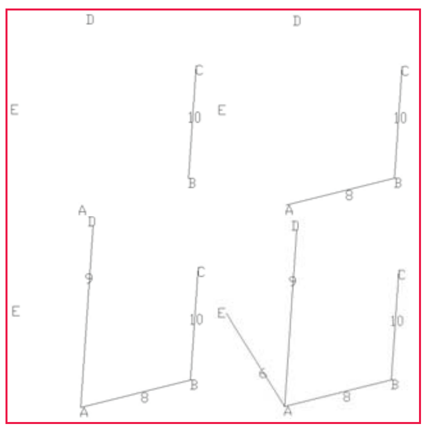

Figure 2: Independent baseline set generation process

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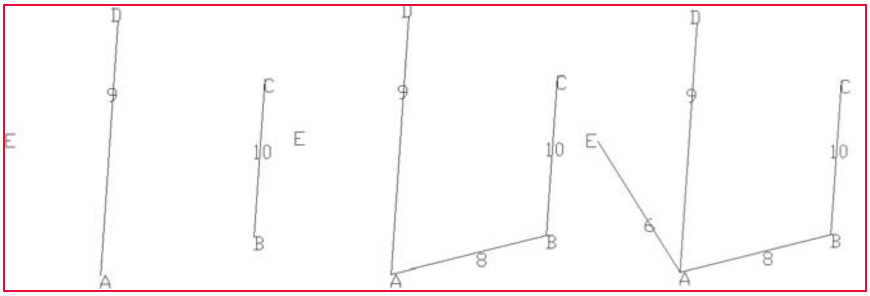

Figure 3: Independent baseline set generation process

Matrix rank solution

Assume there is a point set Point[n], Vector V[j] represents the directing relationship between any two points, in which j=1/2[n(n-1)]. The overall idea of the matrix rank solution is to maintain a gradually increasing optimal set of independent vectors by continuously updating the correlation matrix until the completion of the search[1].

The following method is used to construct the pth row (p=3, 4, …, n-1) of the correlation matrix:

$$a_{pq} = \begin{cases} 1, (q = i) \\ -1, (q = j) \\ 0, others \end{cases} \quad (1)$$

Set the starting point as 1 while the end - 1_o

If V_{13} and V_{35} are the baselines with maximum weight and the second largest weight, then the correlation matrix is:

$$M_{2\times n} = \begin{bmatrix} 1 & 0 & -1 & 0 & 0 & \cdots \\ 0 & 0 & 1 & 0 & -1 & \cdots \end{bmatrix} \quad (2)$$

If the third baseline $-V_{12}$ is included, the correlation matrix becomes:

$$M_{3\times n} = \begin{bmatrix} 1 & 0 & -1 & 0 & 0 & \cdots \\ 0 & 0 & 1 & 0 & -1 & \cdots \\ 1 & -1 & 0 & 0 & 0 & \cdots \end{bmatrix} \quad (3)$$

If the third baseline -- V_{15} is included, the correlation matrix becomes:

$$M_{3\times n} = \begin{bmatrix} 1 & 0 & -1 & 0 & 0 & \cdots \\ 0 & 0 & 1 & 0 & -1 & \cdots \\ 1 & 0 & 0 & 0 & -1 & \cdots \end{bmatrix} \quad (4)$$

Calculate the rank of the correlation matrix. If the rank equals to the number of independent baseline set, keep it in the set as the vector V12, if not, it will be removed from the set as V15 for it contributes to a dependent set.

Repeat the above steps until the rank of the matrix becomes n-1which means all the n-1 independent vectors have been found and the search of independent vector set is finished.

Programming

This paper introduces six kinds of algorithms and uses C + + language to program the six kinds of search algorithms, then determine the weight of the simulate GPS control network (40 sites, 780 baseline) by baseline length (the longer, the smaller) to search for the independent baseline set. Figure 4, Figure 5, Figure 6 and Table 1 is the network chart and total length of baseline with six independent baseline search methods.

Examples

Profiles of survey area

The data is the GPS observation data released by the SOPAC. The 36 observation stations lie in an area of 80km at 34W , 116W , and the observation duration is from 189(2011) to 193(2011) with 24 hours every day and data of 12 observation stations is used in each day. As follows:

The 189th day: bmhl, ldes, opbl, opcl, opcp, opcx, oprd, p598, p599, p610, p795, sdhl, total;

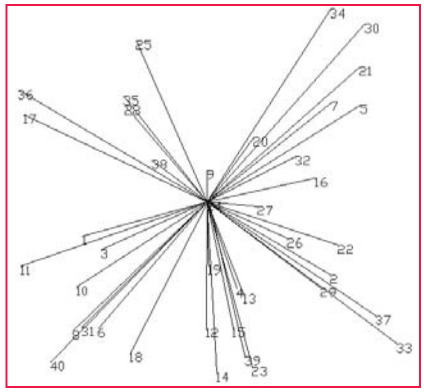

Figure 4: Ray Method

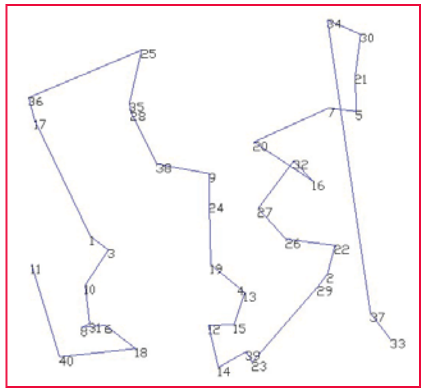

Figure 5: Wire method

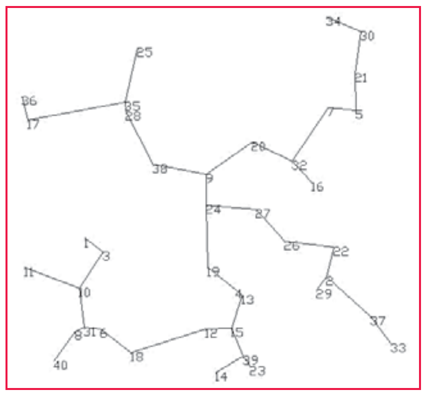

Figure 6: Prim, Kruskal and Matrix rank solution

The 190th day: bemt, bmhl, ctms, ldes, oaes, opcl, p585, p598, p599, sdhl, widc, wwmt;

The 191th day: bemt, bmhl, cact, hnps, oaes, opbl, opcp, p504, p511, p607, p608, p610;

Table 1: Baseline length of five separate baseline search method

Algorithm	Ray	Wire	Prime	Kruskal	Matrix rank solution
Total length of baseline(m)	138055.23	49202.84	40122.79	40122.79	40122.79

The 192th day: bemt, cact, cotd, kyvw, p504, p600, p601, p607, psap, thmg, widc, wwmt;

The 193th day: cotd, p490, p491, p504, p600, p741, pin1, pin2, psap, thmg, tmap, wwmt;

Calculating

The O file calculated by GAMIT is the input file. Based on the matrix rank solution, the weight is respectively determined by the length, precision and relative precision of the baseline then search for the independent baseline set in the synchronous loop. Each synchronous loop contains 12 IGS stations and 66 baselines, 11 of which are independent

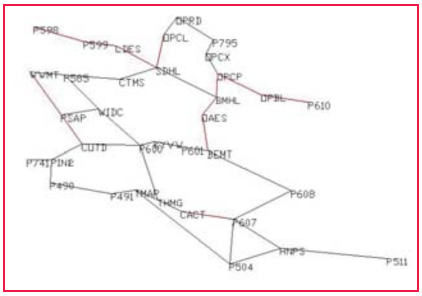

Figure 7: Weight determined by the length of the baseline

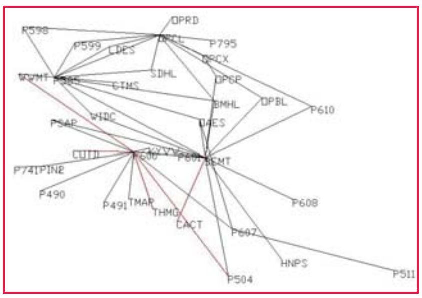

Figure 8: Weight determined by the precision of the baseline

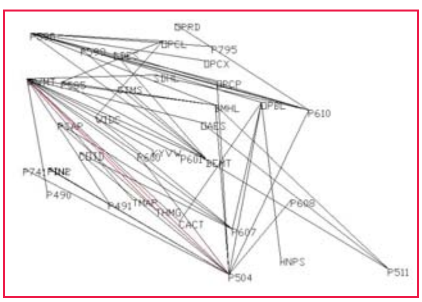

Figure 9: Weight determined by the relative precision of the baseline

ones, so in the whole 5 time durations 55 independent baselines are included. The following search results are obtained respectively by the above 3 methods of weight determination. Figure 7, Figure 8 and Figure 9 are the control net figures, red line represents the repetitive baseline.

The first weight-determining method concludes 12 repetitive baselines, the second 5, the third 2. The network we get by the first method is simple and the baselines that constitute the net are very short ; the network we get by the second method is relative compact and stable; the network we get by the third method a is complicated and the baselines that constitute the net are relatively long.

Analysis of results

Analysis of external fit precision

Make adjustment of the independent baseline sets processed by the three

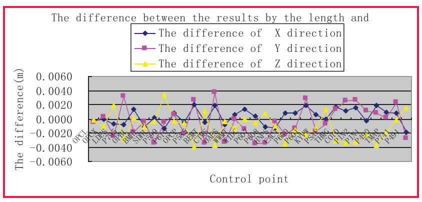

Figure 10: The difference between the results with the first weight-determining method and the real value

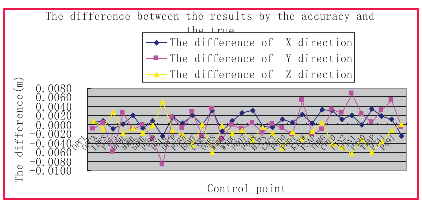

Figure 11: The difference between the results with the second weight-determining method and the real value

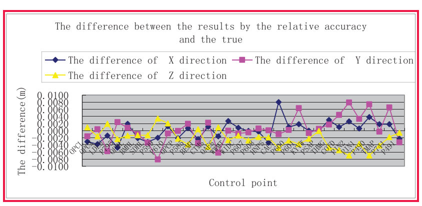

Figure 12: The difference between the results with the third weight-determining method and the real value

methods with COSA. Set P504, P511, OPRD and P598 as the known points. Compare the results with the 32 IGS station coordinates published by the SOPAC. As shown in figure 10, figure 11 and figure 12.

As we can see from figure 10-12, the results from the second weight-determining method (by precision) are better than others for differences with real value are not obvious, which are less than 2mm in X direction while 4mm in Y and Z direction. The results from the second The results by second weight-determining method differs from the true value with 6mm in Y and Z direction and some points can reach 8mm, it means that the net obtained by this The results by second weight-determining method is not very stable and there exits jump at some points. The results obtained by the third The results by second weight-determining method (by relative precision) differ from the real value as much as 6mm in Y and Z direction.

Analysis of internal fit precision

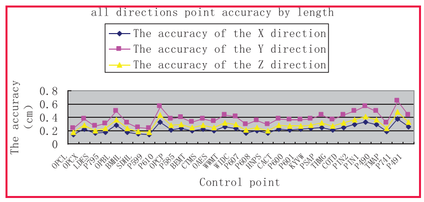

Figure 13: The results by the first The results by second weight-determining method (by length)

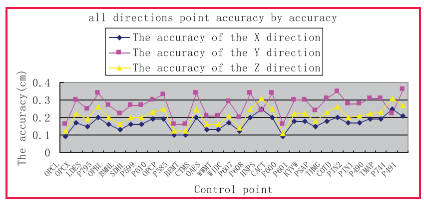

Figure 14: The results by second weight-determining method (by precision)

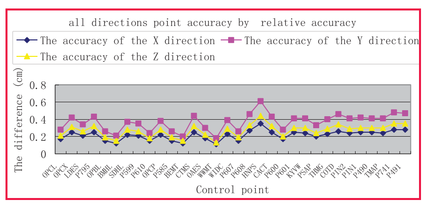

Figure 15: The results by third weight-determining method (by relative precision)

Three control network adjustment results are shown in Figure 13, Figure 14 and Figure 15:

Taking the point precision in all directions as standard, the results of the second weight-determining method (by precision) are better than the other two.

Summaries

This chapter first introduces six search algorithms of independent baseline in detail, namely the Ray method, the Wire method, the Prim method, the Kruskal method and the matrix rank solution, then the weight is determined by length of baseline for the following program, finally we get the conclusion that the Prim, Kruskal and the Matrix rank solution can get a independent baseline set with maximum weight.

By analyzing the external and internal fit precision of three methods, we can get the following conclusions: (1) Results from the three methods vary marginally, all at the level of mm; (2) In the real situation, the results varies in different selections for the model of baseline solution is imperfect. By analyzing the external and internal fit precision of the adjustment results, the second weight-determining method (by precision) can get a relatively better independent baseline set.

Acknowledgments

This research was funded by National Natural Science Foundation of China (No. 41374012) and the 2012 undergraduate comprehensive reform and teaching research project of School of Geodesy and Geomatics, Wuhan university (201220).

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GIS Generalization

GIS Generalization makes data less-detailed and less-complex for better analysis and representation at reduced scales

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Classification deals with creation of class, which corresponds to a meaningful grouping of locations. Grouping performs combination of two or more area features into a single area feature. Symbolization is polygon to point symbolization process. Simplification removes unwanted detail from a linear geometry by determining which points are critical to its portrayal and removing all other points. Smoothening decreases the rough and jagged edges of a linear geometry so as to produce a more aesthetically pleasing appearance. Exaggeration increases the size of features than usual to make them legible in the generalized map, especially for important landmarks. Elimination deletes polygons with area less than minimum area or lines with length less than a specified minimum length.

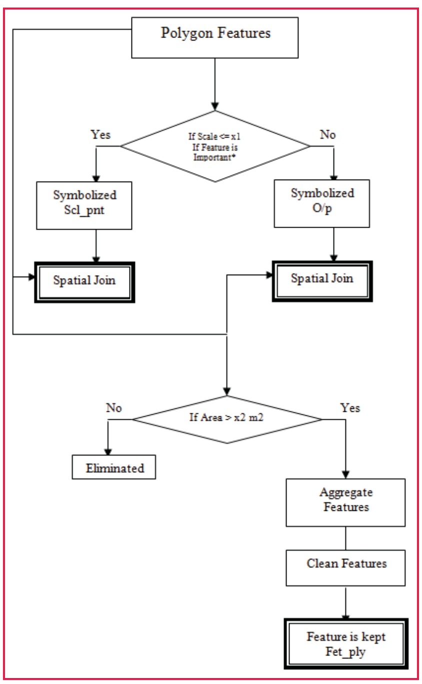

Figure 1: Generalization Procedure for Polygons Features (GPPF)

Advantages and problems associated with map generalization

1. Plotting time is often a bottleneck in many GIS applications. So, as the amount of data is reduced through the generalization process, the plotting speed is increased.
2. The generalization process reduces storage size. Coordinate pairs are the bulk of data in many GIS. Hence, simplification may reduce a data set by 70% without changing the perceptual characteristics of some features. This results in significant savings in memory.
3. The generalization process increases the processing speed.

This can be done through the following:

- Faster vector-to-raster conversion;
- Faster vector processing. The time needed for many types of vector processing includes translation, rotation, rescaling, and cartometric analysis will be greatly reduced with a simplified data set; and
- Many types of symbol-generation techniques will also be speeded up, e.g., many shading algorithms that calculate intersections between shade lines and polygonal boundaries. A simplified polygonal boundary will reduce both the number of boundary segments and also the number of intersection calculations required.

On the other hand, when map generalization is applied we will have the following problems:

1. Problems with plotter resolution when the scale is reduced.
2. As the scale of a digital map is reduced, the coordinate pairs are shifted closer together.
3. With significant scale reduction, the computed resolution could easily exceed the graphic resolution of the output device. For example, a coordinate pair (0.1, 6.3) reduced by 50% to (0.05, 3.15) could not be accurately displayed on a device having an accuracy of 0.1.

Research objectives

When considering the theoretical elements of why one should generalize, six such elements may be distinguished.

- The first theoretical element is that of **reducing complexity**. Here, complexity is a measure of the visual interaction of various graphic elements within a map. It is of paramount importance that the central result of the cartographer's analysis is passed on to the end-user of the map. The number and the diversity of graphic elements within a given area affects the map's ability to communicate the mapped information to the reader. The complexity of an area increases as the scale is reduced and features within that area become cluttered in appearance.

- **Maintaining spatial accuracy** is the second theoretical element that motivates generalization. It is possible to measure to what extent this goal is reached, as spatial accuracy may be directly related to the displacement between the original and the generalized features of a map. This retention of spatial accuracy deals with geographical data — the cartographic features, such as points, lines and areas.
- The third theoretical element is **maintaining attribute accuracy**. In addition to considering the maintenance of spatial accuracy, one must also consider the accompanying attribute data that is associated with these spatial representations. This goal is, for the most part, purely numerical in nature. It makes use of both classification methods and statistical analysis. The overall objective is to minimize the unintentional alteration of feature attributes, which will affect the spatial representation of the features.
- The fourth objective is **maintaining aesthetic quality**. The aesthetic quality of a map is not an absolute measure, as it is a combination of a multitude of factors. These factors include appropriate and consistent use of figure–ground relationships, overall balance, layout, typography styles and positioning and color or gray tones. A great deal of effort has been spent by the cartographers to establish guidelines for good cartographic design and, even though it is difficult to formulate specific rules, general guidelines are now being established.
- **Maintaining a logical hierarchy** is the fifth theoretical element. It reflects the need for an ordering of the mapped features. A large city must be more readily noticeable than a small city and highways should be more prominent than country roads. This seems easy to achieve when considering a single class of features, but may become more difficult when the whole map is considered in a more holistic sense.
- The sixth element is that of **consistently applying generalization rules**, which seeks to ensure consistent and unbiased generalizations. The selection and application of generalization rules is a very subjective process and there is much variation in the way different cartographers choose to solve these problems.

So the main objectives of this research are:

- Study different map series and their characteristics.
- Formalize the Data Model of various map series.
- Study, evaluate, and analyze existing generalization software.
- Develop an expert system which can carry out some generalization processes in a semi automatic process.

Development of the GIS generalization module

There is a need for developing new powerful algorithms integrated with widely used GIS software packages, such as ArcGIS, to perform generalization processes in the integrated spatial and attribute database. This is very important for many reasons, such as reduction of database size for storage and processing purposes, performing certain types of analysis on small-scale digital maps and GIS databases, integration of multi data sources with different scales and formats, the need of semi automatic generalization module taking the input scale and the output scale to do the generalization model automatically without any human errors, and the need to take into consideration the standards of Egypt maps.

In the next section, a new technique is developed for performing some generalization tasks using the Visual Basic for Application (VBA) programming language, associated with the ArcGIS software package. These tasks are elimination, symbolization, grouping, and simplification. The proposed technique is capable of performing data abstraction and GIS database generalization. Many experiments are performed to evaluate the proposed technique using different GIS data sets that are developed separately in different projects from various sources with different scales and types.

Generalization Procedure for Polygon Features (GPPF):

The generalization procedure for polygon features is performed as follows:

1. Polygons are kept with the same feature definition
2. Polygons with area less than (Accuracy in mm* Reverse of Output Scale) will be eliminated unless they are important. In this case they will be Symbolized (transformed to point feature) and then Eliminated
3. Polygons with in between distances less than (Accuracy in mm* Reverse of Output Scale) will be Grouped (Aggregated). If any of these features are important, they will be also Symbolized
4. The polygons which have segments with length less than

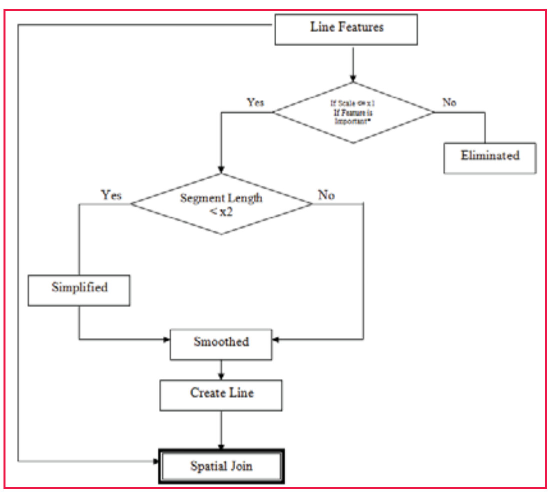

Figure 2: Flow chart of the Generalization Procedure for Linear Features layer (GPLF)

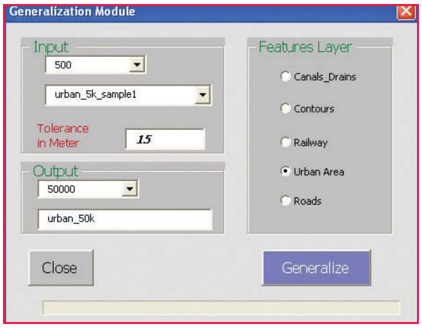

Figure 3: Generalization Module

(Accuracy in mm* Reverse of Output Scale) will be Simplified

The Figure (1) shows the flow chart of the adopted procedure.

Generalization Procedure for Linear Feature (GPLF):

The generalization procedure for linear feature is performed as follows:

1. Lines are kept with the same feature definition
2. Lines with length less than (Accuracy in mm* Reverse of Output Scale) will be Eliminated
3. Lines with segments length more than (Accuracy in mm* Reverse of Output Scale) will be Simplified and Smoothened

The Figure (2), shows the flow chart of the adopted procedure.

GIS Generalization Module Development:

The comprehensive GIS module (Figure (3)) is developed using Visual Basic for Application (VBA) programming language on the top of the ArcGIS ArcInfo software.

GIS database development for case study area

The GIS databases for the case study area are developed from various hardcopy map series with scales ranging from 1:5,000 to 1:1,000,000 using the following procedure:

1. Acquire maps for the case study area in Cairo with scale (1:5,000 & 1: 50,000 & 1:250,000 & 1:1,000,000)
2. Convert the maps to digital format with WGS84 datum and the Egyptian Coordinate System (ETM)
3. Apply the edge matching concept to form one layer for each feature class
4. Build the topology for all feature classes
5. Build the GIS database for all feature classes
6. Add field with name 'scale' in all layers which defines the important feature in various scales. This value is equal to 1,000,000 or 250,000 or 50,000
7. The following rules are taken into consideration during work:

- All hospitals and schools in layer urban in scale 5,000 must be converted into landmarks in small scale (50,000). This means that all hospital and schools in layer urban in scale 5,000 store value (50,000).
- All roads exist in scale 1:5,000; the main roads only are kept in scale 1:50,000 (store 50,000 in the scale field).
- The railways connecting main villages are kept in scale 1:250,000 and 1:1,000,000 (store 1:250,000 or 1:1,000,000 in the scale field)
- All canals exist in scale 1:5000. The main canals are kept in scale 1:50,000 (store 50,000 in the scale field), while the large canals connecting main villages are kept in scale 1:250,000 and 1:1,000,000 (store 1:250,000 or 1:1,000,000 in the scale field).

More details are given in the following sections.

Data storage and processing

GIS data are organized in layers and levels. Individual data/levels are stored in individual data files. Each layer is stored in a group of files. ArcGIS software stores the layers in Geo-database file. It is physically organized for proper and easy data management and retrieval.

Data required for this project are available in two different forms: spatial and attributes. Spatial data are related to specific locations and represented in a vector format. Vector data includes maps with various scales in a hard copy format.

Hard copy maps of scale 1:50,000, produced by the Egyptian Survey Authority (ESA) and the Military Survey Department (MSD), are used for the case study area in Cairo. Hard copy maps of scale 1:250,000 and scale 1:1,000,000 produced by the Military Survey Department (MSD) will be used for the same area. Attribute data are those related to geographic features. They are linked to the features in the layer's table.

Table 1: GIS database layers utilized for evaluating the developed GIS generalization module (Polygons – Points)

Scale	Example	Source	Projection	Layer_Name	Definition	Attributes	Date
5,000	Cairo	ESA	ETM	Builds Urban areas Lakes	Polys polys	Some Names Some Names	1988
50,000	Cairo	Military Survey	UTM	Urban areas Graves	polys	Some Names Some Names	2000
250,000	Cairo	Military Survey	UTM	Urban areas Agriculture	polys	Some Names Some Names	1997
1000,000	Cairo	ESA	Geographic	Capitals City Villages Markaz	Points Points Points Points	Type , class	1968

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or 15s/GTA1315

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<0.5 m 95% confidence (DGPS)
F52 H-accuracy: 1-3m

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Table 2: GIS database layers utilized for evaluating the developed GIS generalization module (Lines)

Scale	Example	Source	Projection	Layer_Name	Definition	Attributes	Date
5,000	Cairo	ESA	ETM	Road Edges Canals Drains	Lines	Some Names, Class	1988
50,000	Cairo	Military Survey	UTM	Roads Railway	Lines	Some Names, Class	2000
250,000	Cairo	Military Survey	UTM	Roads Railway	Lines	Some Names, Class	1997
1000,000	Cairo	ESA	Geographic	Roads Railway	Lines	Some Names, Class	1968

The developed layers are:

1. 1 : 5,000 GIS database
2. 1 : 50,000 GIS database
3. 1 : 250,000 GIS database
4. 1 : 1,000,000 GIS database

GIS Attribute Data Handling

GIS attribute data are numerous. They include numerical and text data. Numerical and text data are often recorded on paper and scattered amongst a multitude of different conventional registers and files. Attribute data handling includes three successive procedures, namely data preparation, entering, and editing. Quality Control (QC) procedures must be applied through these operations.

Data acquisition is controlled with data availability at different organizations, roles and regulations, data characteristics, and good preparation of data collection structure. The data fields of the collection forms should correspond to the data fields of the database.

Quality control procedures are done manually and using automatic verification functions. Automatic verification functions retrieve only formal errors. Incorrect information can only be detected and edited by manual copy reading. The links between spatial and attribute data is checked at the end. The following tables summarize the characteristics of the used GIS database layers in the practical experiments for evaluating the developed comprehensive GIS generalization module.

Evaluation of the developed GIS Generalization Module

Many experiments are performed to evaluate the developed modules using different data sets. In the following sub-sections, experiments details, the study area, and input data are given. According to the procedures which are described later, we will run the module and test the outputs, and then the assessment criteria have been outlined. Figure 4 summarizes these experiments.

Polygon Features

After the GIS data preparation, we make the following experiment using the developed application. The input is urban areas for scale 1:5000. Figure 5 and the output should be urban areas for scale 1:50,000. We have some attribute data should be kept in scale 1:50,000. In figure 6 also we have some landmarks that should be kept in scale 1:50,000, Figure 7. We can see that the tolerance is automatically calculated using the output scale, but it can be edited, so the user can change the tolerance.

Selecting the input scale, Figure (5-11), feature layer is urban area, input layer, writing the output name, selecting the output scale, and click on the generalize button. The output of urban map after running the generalization Procedure for Polygons Features (GPPF) can be shown in Figure (8). The important landmarks like schools, hospitals, and police stations are symbolized and converted into points with all the attributes, Figure (9).

We can compare between the input attributes and output attributes using Table (3).

The comparison between generalized urban layer and the actual urban layer with scale 1:50,000 is made to evaluate the performance of the GIS generalization module including spatial and attribute components -

- The spatial difference
- The attributes differences is discussed

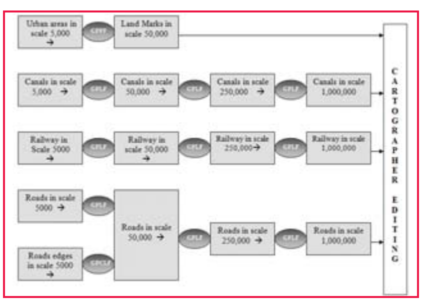

Figure 4: Experimental work for testing the developed GIS generalization module

Figure 5: Urban map (scale 1:5000) before Generalization

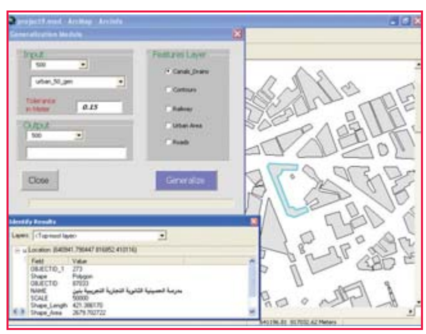

Figure 6: Viewer for Urban map scale (1:5000)

Figure 7: Urban map scale (1: 5000) with Land Marks generation after Generalization

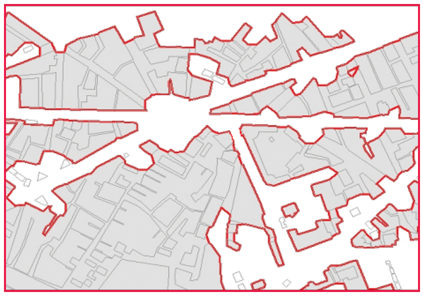

Figure 8: Urban map scale (1:5000) After Generalization

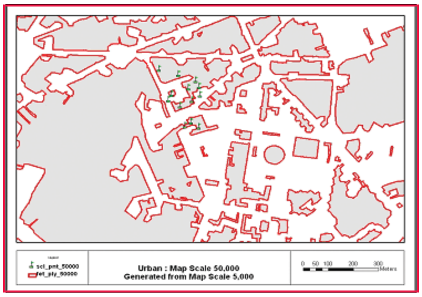

Figure 9: The final Generalized Urban map scale (1: 50000)

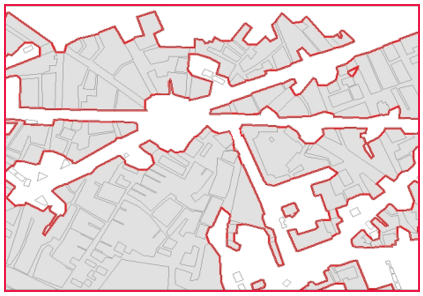

Figure 10: Urban with scale (1: 5,000) and the Generalized Urban with Scale (1: 50,000)

Analysis of results

After analyzing the results, the following remarks could be made:

- The output of the generalization is more accurate than the maps of scale 50,000 because the source of data is more accurate and no shift in coordinates is performed.
- The output of generalized map has shifted than the maps with the same scale
- The attributes of the urban layer in scale 5,000 is kept in the generalized layer
- The processing time is short compared with manual generalization
- The effort made is little compared with manual generalization
- No human decisions during the generalization are required
- We can concentrate on the maps with large scale, and then we can produce the small scale maps from it using the developed module
- The overlaying between small scale and large scale will be very easy

Linear Features

After the GIS data preparation, we make the following experiment using the developed application. The input is roads for scale 1:50,000, Figure 12 and the output should be roads for scale 1:1,000,000, Figure

Table 3: Attributes of Urban Areas Before and After Generalization

Input Data Description	Output Data Description
Type of object: Polygon Feature	Type of object: Polygon Feature
Class	Class
Number of records: 2456	Number of records: 299
Attributes:	Attributes:
FID	FID
Shape	Shape
AREA	AREA
PERIMETER	PERIMETER
BUILD5KZ#	URBAN50K#
BUILD5KZ-ID	URBAN50K-ID
BUILDINGS5K-ID	URBAN50K-ID
BUILD5K_AREA	URBAN50K_AREA
BUILD5K_ PERIMETE	URBAN50K_ PERIMETE
ARABIC_NAM	
Scale	

14. We can see that tolerance is automatically calculated using the output scale but it can be edited, so the user can change the tolerance.

Selecting the input scale, Figure 13, feature layer is urban area, input layer, writing the output name, selecting the output scale, Figure 13, and click on the generalize button. The output of roads after running the generalization Procedure for Line Features (GPLF) can be shown in Figure14.

We can compare between the input attributes and output attributes using the Table 3 and 4.

Analysis of results

After analyzing the results, the following remarks could be made:

- The generalized roads date is 2000 and the actual roads date is 1968
- The output of generalization is more accurate than the maps of scale 1,000,000 because the source of data is more accurate
- The output of generalized map is shifted than the maps with the same scale

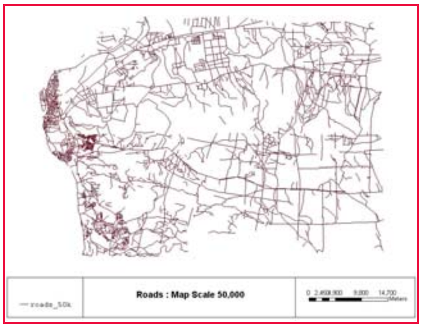

Figure 11: Roads map scale (1:50,000)

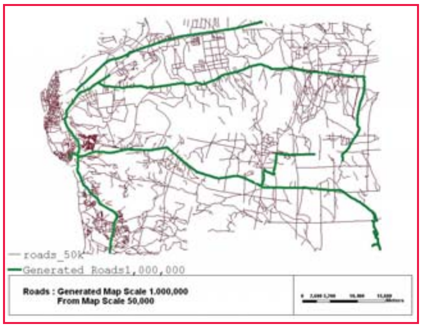

Figure 13: Roads with scale (1:50,000) and the Generalized Roads with Scale (1:1,000,000)

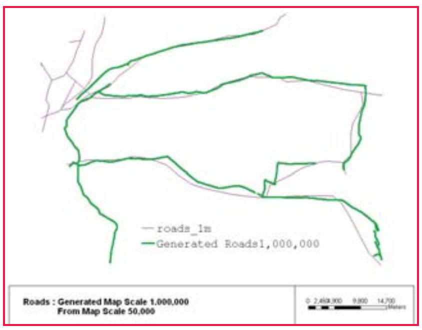

Figure 15: Comparison between the Generalized Roads and Roads in Maps with Scale (1:1,000,000)

- The attributes of the roads layer in scale 1:50000 is kept in the generalized layer in scale 1:1000000
- The processing time is short compared to manual generalization
- The effort made is little compared with manual generalization
- No human decisions during the generalization are required
- We can concentrate on the maps with large scale, and then we can produce the small scale maps from it using the developed module
- The overlaying between small scale and large scale will be very easy

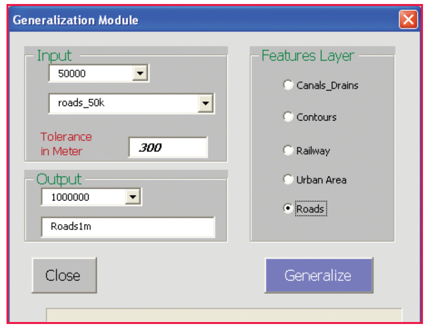

Figure 12: The parameters Used in Generalizing Roads map scale (1:50,000)

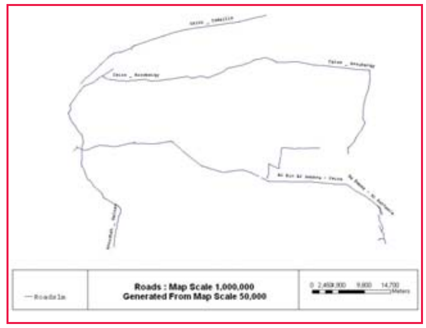

Figure 14: The Generalized Roads of Scale (1:50,000)

Table 4: Attributes of Roads before and after Generalization

Input Data Description	Output Data Description
Type of object Line Feature Class	Type of object Line Feature Class
Number of records: 328	Number of records: 328
Attributes:	Attributes:
HD	HD
Shape	Shape
FNODE#	FNODE_
INODE#	INODE_
LPOLY#	LPOLY_
RPOLY#	RPOLY_
LENGTH	LENGTH
ROADS50K#	ROADS_1M#
ROADS50K-ID	ROADS_1M-ID
NAME	NAME

Conclusion

1. Generalization is the process of changing the form of map features, usually performed when the map is transformed from one map scale to a smaller scale. It is a scale-depended procedure. The smaller, the scale the greater generalization of map objects is necessary.

2. Generalization is very important for many reasons, such as reduction of database size for storage and processing purposes, performing certain types of analysis on small-scale digital maps and GIS databases as well as integration of multi data sources with different scales and formats.
3. Various algorithms have been developed addressing individual generalization tasks. However, there was very limited research for developing a comprehensive system that can handle integrated tasks and dealing with GIS database generalization where two types of generalization tasks are required - database generalization and cartographic generalization.
4. Generalization allows interactive and batch processes for selecting, analyzing, generalizing, and post processing data based on user-supplied specifications.
5. The attributes of GIS data layers are kept in the output maps.
6. A GIS database is developed from existing hardcopy Egyptian maps covering part of Greater Cairo governorate with scales ranging from 1: 5,000 to 1: 1,000,000. This database is utilized for carrying out all the experiments.
7. A robust generalization module should start with specifying input and output scales, processed layers, and tolerances, and then proceed with semi-automatic generalization process that executes necessary generalization functions in the correct manner.
8. A new comprehensive module is developed for performing some generalization tasks using the VBA programming language, associated with the ArcGIS software package. The proposed technique is capable of performing data abstraction and GIS database generalization. The efficiency of the developed generalized modules is assessed by comparing the outputs with the existing spatial and attributes databases within the pre-developed GIS. Experimental work proves that these modules are efficient and successful.
9. The developed GIS generalization module is ready to use in Egypt, and it might need some modifications to be used in other countries where other map specifications are used.
10. The developed GIS generalization module can work in different projection and different datum.
11. Using the developed GIS generalization module, the attributes of the generalized layers are kept
12. The developed GIS generalization module does not need much interactive work.
13. The output of the developed generalization module is more accurate than the maps with small scale because the source of the data is more accurate.

Recommendations

Some comprehensive recommendations for future research and development are as follows:

1. There is a need to develop full automatic generalization module taking the input scale and the output scale to do the generalization model automatically without any human errors.
2. The generalization is very important as it eliminates work duplication and saves money and time. So this technique should be used by the authorities, governmental agencies, and the private sector companies.
3. There is a need for developing generalization software using open source GIS softwares to reduce the cost.
4. There is a need to develop new summarized GIS attribute database related to the produced generalized digital map.
5. There is a need for developing generalization software to limit the interactive processes for the incomplete and unresolved features.

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Galileo update

OHB expects to know about Galileo delivery dates by late September

Satellite and rocket-component builder OHB AG on Aug. 14 said it should know by late September whether the tests of its first Galileo satellites are proceeding well enough to permit their delivery later this year.

In a conference call with financial analysts, Bremen, Germany-based OHB said Galileo's European government owners want to take the necessary time to validate the performance of the first OHB-built satellites so that production of the 20 remaining spacecraft can be done quickly.

The 20-nation European Space Agency (ESA) and the commission of the 28-nation European Union are the technical managers and owners, respectively, of the Galileo positioning, navigation and timing constellation. The first of the OHB-built satellites entered testing at ESA's European Space Research and Technology Centre (ESTEC) in Noordwijk, Netherlands, in May. The second was delivered to ESTEC August 9.

The OHB satellites bear a strong resemblance to the four Galileo in-orbit validation spacecraft now in medium Earth orbit. But the on-board power of the OHB spacecraft is greater than that of the validation satellites. Galileo managers made the modification in part to enable Galileo's encrypted Public Regulated Service signal to overcome a signal frequency overlap issue with China's Beidou constellation of navigation satellites.

The signal overlap means Europe would be unable to jam China's signals in a given region in a time of conflict without jamming the Galileo signals as well. It would not affect the functioning of the two systems otherwise.

OHB Chief Executive Marco R. Fuchs said during the conference call that the first two satellites could be delivered to ESA "in a matter of weeks" if the test campaigns at ESTEC go smoothly. *http://www.spacenews.com*

European Commission invites GNSS patents

The European Commission (EC) has invited firms to submit tenders for a four-year contract to monitor patent applications and grants both at the European Patent Office and at patent offices around the globe. The contractor's objectives, according to Call for tenders No ENTR/269/PP/ENT/ADM/13/7037, are to measure "the innovative and technological performance of EU GNSS Industry by setting up and performing the monitoring of its patenting activity vis-à-vis the world competitors" and identify "the consequent economic trends."

Once the data is compiled the contractor is to compare patent activity in the EU to that generated by companies, academic/research bodies and individuals in other countries and issue quarterly reports on how European organizations are faring in comparison. Bids for the contract are due by September 3. The study is set to begin in the third quarter of 2013.

India-centric navigation device by ANS and NNG

NNG and Ayana Navigation Solutions (ANS) have jointly introduced a new Personal Navigation Device (PND) called the ANS Navigator A-501. This new offering has been designed to find a way over the problems faced by commuters in India due to our rather 'unique' infrastructure. The device has a 5-inch screen that runs on NNG's iGO primo software. It is pre-loaded with the latest India maps and a total of over 7 million Points of Interest (POIs). The unit comes with a 1-year map update guarantee from NNG's update portal Naviextras. *www.zigwheels.com*

Ruckus location analytics R&D center in Singapore

Communications technology provider Ruckus Wireless is setting up its sixth global R&D center in Singapore, which will focus on developing location-based analytics products and services. This follows last month's acquisition of Singapore startup YFind, which specializes in indoor positioning and real-time location analytics. *www.zdnet.com*

Nokia's new indoor location-based experiences for QUALCOMM

HERE will make accessible its indoor Venue Maps to Qualcomm Atheros, Inc. It has been providing its venue maps services to its business partners like Bing for more than a year and now they are expanding their indoor mapping partnerships to Qualcomm Atheros, Inc. to help produce new indoor location-based services.

Two elements are required for the working for all location-based services: Positioning technologies, for instance GPS, deliver very precise location information. These numbers are then transformed by accurate maps and matches into something that we can all understand: a pin on a map. This works really well when people are outdoors and the things get less comprehensive whey they are inside a building. The signals of Satellite are not able to reach

LT400HS GNSS Handheld – Accurate, Productive, and Versatile Surveying & Mapping Solution

- ***RELIABLE AND EFFECTIVE***
  The LT400HS Handheld GNSS is a rugged GPS+GLONASS data collector designed to achieve sub-meter to centimeter accuracy in adverse mapping conditions with or without the external antenna.

- ***COMPETITIVE SURVEY SOLUTION***
  Bundled with Carlson's SurvCE software, the LT400HS is the perfect cost-effective GNSS RTK Survey Solution for survey and construction professionals.

- ***POWERFUL GIS SOLUTIONS***
  Combined with DigiTerra Explorer7 Mobile GIS software, the LT400HS GNSS handheld offers feature-rich solution for accurate GIS field data collection and maintenance.

www.chcnav.com

indoor locations and other technologies built on Wi-Fi or cellular networks are not as accurate. *www.efinancehub.com*

TomTom Navigation for Android arrives in India

The TomTom Navigation app India for Android is available to download from Google Play for the first time. TomTom's on-board maps and IQ Routes bring the freshest map and the fastest routes to millions more Android smartphone users. *www.business-standard.com*

Location Based Technologies signs agreement with Beijing Lava

LBT Inc signed a distribution agreement with Beijing Lava Technology Co Ltd, for its online brick and mortar stores and authorised distributors in Asia. *www.m2.com*

Autos to be GPS-fitted in Chennai, India

In a first-of-its-kind development in India, auto-rickshaws in Chennai will be fitted with a meter with GPS and electronic digital printer. It shall be free of cost, by the government. The meter will also have a 'panic button' so that a passenger can press it in case of any danger. *http://india.nydailynews.com/*

GPS devices to tackle food waste problem

Food waste collection trucks and trash cans will be outfitted with a computerized weighing and GPS device in Wuhan to deal with the problem of "gutter oil", illegally recycled cooking oil. According to the proposal for the project, 621 vehicles — 195 to be used for edible oil waste — and 25,800 garbage cans, which food facilities are required to use, will be prepared as part of the collection. To guarantee no food waste is collected to make gutter oil, Chen said, a computerized system that records GPS and weight data will be installed on the collection trucks, as well as garbage cans or oil cans of oil-water separators. *http://usa.chinadaily.com.cn/*

India's open data portal launched with over 3600 datasets

India has officially inaugurated Data Portal India, a portal for the public to access and use datasets and applications provided by ministries and departments of the Government of India. The Portal functions as a single access point for open government datasets across the country. Currently, there are about 3500 datasets from 49 government departments available for the public to access and use. The datasets include agriculture, commerce and industry, defence, finance, health, information and broadcasting, energy, transport and water resources, among others. *http://data.gov.in/*

South Korea to launch crime map

Ministry of Security and Public Administration has revealed its plans to invest US$17.9 m for the development of a "crime map" which will give local authorities access to reports and visualisations on crime hot spots. The map will also provide information related to accidents brought about by natural calamities so as to guide first responders in their resource mobilisation and decision making. *www.globalpost.com*

Lebanon launches system to develop health map

The Health Ministry of Lebanon has launched an information system meant to develop a geographic health map for the country. The project was implemented with the support of the World Health Organization. www.dailystar.com.lb/News/

Handheld laser mapping device with storage technology

ZEB1, the mobile laser mapping system developed by Australia's national science agency Commonwealth Scientific and Industrial Research Organisation, has now been equipped with data storage and access technology. The new version is called ZEB-DL2600. It uses a robotic technology called Simultaneous Localisation and Mapping (SLAM). The new ZEB-DL2600 data logger automatically records millions of individual laser scanned measurements captured by the ZEB1, eliminating the need for an additional laptop. It new version has been developed by 3D Laser Mapping. *www.prosurv.com*

Buddhist sites to be mapped

In a bid to promote tourism at Buddhist historical sites spread across South East Asia, including India, the National Atlas and Thematic Mapping Organisation (NATMO) in India is coming up with a detailed map along with loads of information on such hotspots located in 11 nations. "This is probably for the first time that such an initiative has been taken in the world. It is a joint initiative of the Indian and Thai governments and is being funded by the Centre's science and technology department. Work on the map started after green light was received from Prime Minister Manmohan Singh," said Baisakhi Sarkar, deputy director of NATMO. *www.hindustantimes.com*

185 crore IT project deal in Bihar, India for Reliance Infra

In a plan to save the Bihar Electricity Board from sinking into big loss, Chief Minister Nitish Kumar has taken action to digitalize the customer service partnering with Reliance Infrastructure. Both shook hands for the ₹185 crore deal. The project is expected to improve billing, load distribution and reduce the lose percent of revenue for the Government as most operations are currently executed manually. The infrastructure giant will also implement automatic meter reading for potential customers and key IT technologies like GIS and network service provision that will boost up the network. *www.siliconindia.com*

GIS for education and environment in Philippines

National Mapping and Resource Information Authority in the Philippines and the Department of Geodetic Engineering at University of the Philippines and FEATI University have employed SuperGIS Desktop 3.1a and the analysis extensions to promote the use of GIS and achieve positive educational and environmental outcomes. *www.supergeotek.com*

India's GAGAN to be operationalized for aviation in the coming months

GAGAN certification programme crossed yet another milestone on 13th August 2013 when. K.N.Srivastava, Secretary, Ministry of Civil Aviation released the GAGAN Certification documents to Arun Mishra, Director General of Civil Aviation in the presence of V.P. Agrawal, Chairman AAI.

According to Mr. V. Somasundaram, member (Air Navigational Services), AAI, the development of documents have been the collective effort of ISRO, AAI and DGCA for the past four years and is a milestone for Certification process of GAGAN. The GAGAN certification process is the first unique exercise where the regulator, DGCA officials have worked in tandem with service providers and system developers to reach the current milestone.

Russian Aerospace industry needs State help

The Russian space industry is plagued by such a great number of problems that the government cannot afford to leave it to its own devices, Deputy Prime Minister Dmitry Rogozin said. "Constant [government] assistance is needed to ultimately break the vicious circle of accidents and failures," Rogozin, who oversees the defense and aerospace sectors, said in a recent interview.

On July 2, a Proton-M rocket, carrying three satellites for the Glonass positioning system, fell to the ground in flames shortly after blasting off. The incident was the latest in a series of setbacks for Russia's space program. *www.spacedaily.com*

DGCA India to hire 100 airworthiness officers ahead of safety audits

The civil aviation regulator in India is scurrying to increase its technical workforce by a third as it prepares to face crucial safety audits by two global aviation bodies, which could potentially downgrade India's air safety rating.

A senior Directorate General of Civil Aviation (DGCA) official said the regulator is hiring 100 airworthiness officers to comply with the assessments of its safety oversight capabilities by the United Nations' International Civil Aviation Organization (ICAO) in Aug and Federal Aviation Authority (FAA) in September. 320 such officers, who oversee the flying conditions and maintenance of aircraft, against a sanctioned limit of 586. ICAO and FAA have in the past criticised DGCA's persistent manpower deficit, which affects the oversight of airline operations in India. An ICAO safety downgrade will restrict foreign airlines from flying into India and vice versa. *http://articles.economictimes.indiatimes.com/*

Using GPS for construction violations

The Jeddah Municipality in Saudi Arabia is planning to introduce electronic services, including GPS, to improve its working. The Municipality will now accept only electronic copies of land locations and proposed designs for buildings. Jeddah officials adopted the new strategy to achieve electronic governance and to update regulations relevant to building permits for the benefit of engineers and architects, who in turn deal with landlords on matters pertaining to building design. *www.arabnews.com*

NAVAIR tests GPS anti-jam antenna on UAVs

Engineers at the Naval Air Systems Command facility in Maryland, USA have found encouraging results while testing GPS anti-jam antennas on small UAVs. The team of engineers at the Communications and GPS Navigation Program Office mounted small antenna system and antenna electronics along with a Defense Advanced GPS Receiver (DAGR), representing a Selective Availability Anti-spoofing Module (SAASM)-capable GPS receiver on the UAV. The UAV was then placed in a room, lined with signal-absorbent material, where it was subjected to GPS jamming signals. These signals simulated both the GPS satellite constellation signals as well as multiple GPS jammers. Engineers believe that the tests have shown encouraging results. These initial tests were done while the UAV was in a fixed position. navair.navy.mil

GPS with Beidou satellites combined by Curtin University researchers

The Curtin University and the Cooperative Research Centre for Spatial Information have tried to link GPS with Chinese satellites. Skyscrapers can block GPS signals because the satellites used to find the user's location are positioned at a low angle in the sky, according to Curtin University professor Peter Teunissen. The same problem occurs in open pit mines, he said. Teunissen and the CRCSI believe they can eliminate that problem by mixing GPS with Beidou. *www.techworld.com.au/*

GPS companies sued for $1.9 billion by Harbinger

Philip Falcone's Harbinger Capital sued agricultural equipment maker Deere & Co and GPS companies and groups for damages of $1.9 billion as it looks to recoup its investment in bankrupt wireless company LightSquared. The lawsuit's defendants, who include GPS companies Garmin International and Trimble Navigation, had opposed LightSquared's plans to build a wireless network because of concerns it would interfere with GPS systems, which are used in everything from farming to airline navigation. Other defendants include industry groups the US GPS Industry Council and the Coalition to Save Our GPS.

Harbinger, which has spent billions of dollars on LightSquared, said in a complaint filed that it never would have made the investments if the GPS industry had disclosed potential interference problems between the LightSquared spectrum and GPS equipment between 2002 and 2009.

The hedge fund accused the defendants of fraud and negligent misrepresentation among other allegations, saying the defendants "knew years ago" all the material facts on which they based their opposition to the LightSquared network. *http://articles.timesofindia.indiatime*

Apple banned from taking aerial photography of Oslo

Norway's government is refusing to let Apple take aerial photography of the capital city Oslo to create 3D images for its Maps app, BBC News reported. There are security concerns about access to detailed views of government buildings. Anyone wishing to fly over Oslo to take pictures requires a license from the authorities, which has been declined according to official documents. However satellite imagery, as used by other map brands, is not protected. *www.panarmenian.net*

New Remote-Sensing Development could aid disaster relief

Thomas Oommen, assistant professor in the Department of Geological and Mining Engineering and Sciences, is using remote sensing in a new way, to assess the damage quickly and more accurately. His tool: crowdsourcing, or what he calls the "power of the volunteer crowd."

"The use of crowdsourcing to analyze earthquake-induced damages in remotely sensed imagery is a relatively new damage assessment approach," Oommen says. "It was developed in the wake of the 2008 Sichuan earthquake and formalized during the 2010 Haiti and 2011 New Zealand earthquakes."*www.mtu.edu/news/*

GPS-guided quadcopter for the masses

3D Robotics quadcopter is billed as a ready-to-fly, fully-autonomous, user-friendly UAV, the Iris supports simple GPS controls through any computer, tablet, or smartphone. The drone itself is fairly average in size, with a length of 55 cm (21.7 in) diagonally and a height of 10 cm (3.9 in). According to the developers, the main body is designed to be aerodynamic, durable, and lightweight, while still providing enough lift to carry a payload. The arms and feet are made from Zytel Nylon and are built to withstand impacts, but they can be cheaply replaced if needed. The motors and electronics are powered by an 11.1V 3.5Ah LiPo battery, which brings the quadcopter's total weight to 1282 grams (45.2 oz) when connected. www.*3drobotics.com*

Turkey's satellite images to open to public

The satellite images received by Turkey's RASAT satellite will be open to the public through an online portal, the state scientific research institute TÜBİTAK has said in a statement. TÜBİTAK's Space Technologies Research Institute (TÜBİTAK UZAY) started a geoportal project with support from the Development Ministry and it is expected to be opened this year. *www.hurriyetdailynews.com*

Croatia joins European Union Satellite Centre

The cabinet of Prime Minister Zoran Milanovic decided on Croatia's membership of the European Union Satellite Centre (EU SatCen), the mission of which is to support the decision-making of the European Union by providing analysis of satellite imagery and collateral data. The centre, an EU agency located in Torrejon de Ardoz, in the vicinity of Madrid, Spain, is one of the key institutions for European Union's Security and Defence policy, and the only one in the field of space. *http://dalje.com/*

LIDAR-based tool forecasts clear-air turbulence

An instrument based on the Light Detection and Ranging technology to help pilots detect dangerous turbulence has been developed by the German Aerospace Centre (DLR).

The device that can be mounted on aircraft emits short-wave ultraviolet laser pulses along the direction of the flight. Being reflected by the air molecules, the signal's back-scatter shows fluctuations in the density of the atmosphere. The pilots can thus see in real time whether there is any clear-air turbulence (CAT) in the region they are about to enter. The system is currently being tested on-board a specially modified Cessna Citation aircraft. The plane will be taking measurements travelling from Amsterdam to various European destinations until the end of August. *http://eandt.theiet.org/*

ISRO's geoportal Bhuvan goes mobile

The Indian Space Research Organization (ISRO) has launched a mobile version of its geoportal Bhuvan. ISRO has also taken the crowdsourced approach to generate data for its maps by including 'Add Content' option that allows users to add Points of Interest (POI) data under various categories. The app provides a satellite map on the screen. One can search for any location from the search bar on the top of the app or allow the app to track device location through phone's GPS. One can also add layers such as place names. It is accessible from bhuvan3. *www.nrsc.gov.in*

Giant leap for Unmanned Aircraft Systems

The Federal Aviation Administration has issued restricted category type certificates to a pair of UAS, a milestone that will lead to the first approved commercial UAS operations later this summer. The newly certified UAS—Insitu's Scan Eagle X200 and AeroVironment's PUMA—are "small" UAS weighing less than 55 pounds. Each is about 4 ½ feet long, with wingspans of ten and nine feet, respectively. The major advantage of having type-certificated UAS models available is that they can be used commercially. *www.faa.gov/news/*

Worlds Smallest Commercial Unmanned Aerial LiDAR

Phoenix Aerial Systems has successfully developed and demonstrated the world's smallest and lightest UAV LiDAR platform available. Weighing less than 10kg, the new LiDAR platform called the "Phoenix AL-2" combines the latest UAV, LiDAR and GNSS technology into a cost effective, accurate and safe micro-mapping solution. *www.velodynelidar.com.*

Trimble adds DG satellite imagery to Mobile Apps and Printed Maps

Trimble has entered into an agreement with DigitalGlobe Inc. to license its satellite imagery for offline use in Trimble Outdoors mobile apps, allowing outdoor enthusiasts to view and store imagery on their smartphones and tablets. *www.trimble.com*

LT400HS GNSS Handheld by CHC

CHC has announced the availability of the LT400HS a rugged 120-channel GPS+GLONASS Handheld Receiver designed to achieve sub-meter SBAS positioning to centimeter accuracy in RTK networks. It is the most cost-effective and powerful GNSS Solution for Survey, Construction and GIS Professionals. It is the perfect choice for companies which have not yet invested in GNSS technology due to cost or/and occasional equipment use. *www.chcnav.com*

DB Netz AG selects Intergraph®'s Geospatial Solutions

DB Netz AG, a subsidiary of Deutsche Bahn AG and responsible for the railway infrastructure in Germany, recently selected Intergraph®'s GeoMedia® Desktop Suite as part of its AGON GIS project initiative. Using Intergraph's system, DB Netz will be able to consolidate all if its legacy systems into one modern GIS environment. *www.intergraph.com*

IFEN and WORK Microwave to support BeiDou

IFEN in partnership with WORK Microwave have announced the release of software update V.1.9 for their NavX®-NCS GNSS multifrequency simulator product line. Users will have the flexibility to support a wide range of constellations, frequencies, and channels for research and development of GNSS safety and professional applications, as well as system integration and production testing of mass market applications. A key new enhancement to the NavX-NCS solution is comprehensive support of China's BeiDou-2 navigation satellite system. www.ifen.com

First live M-code signals to successfully navigate an aircraft

Rockwell Collins' Receiver Cards were recently used in an historic test flight resulting in the first time any aircraft has used live Military code (M-code) signals to successfully navigate. The M-code signal is one of the key elements in the modernization of military GPS capabilities. The flight, which took place at Holloman Air Force Base near Alamogordo, N.M., in June, successfully tested the Rockwell Collins GB-GRAM-M (M-code GPS Receiver) integrated into the RQ-11B Raven unmanned aerial system. *www.rockwellcollins.com*

GNSS receiver module for satnav and positioning

A low power GNSS receiver module available from Solid State Supplies combines GPS and GLONASS to deliver reliable, accurate satellite navigation and positioning. Measuring just 10.1 x 9.7 x 2.5mm, the L76 provides simultaneous open service L1 band (1575.42MHz) reception capability. With 33 tracking channels, 99 acquisition channels and 210 PRN channels, it is capable of ultra low power tracking (18mA) and acquisition (25mA) of any combination of GPS and GLONASS signals. *www.sssltd.com*

3-year PT Seascape Positioning Contract for Veripos

Veripos have been awarded a further three-year contract by PT Seascape Surveys Indonesia of Jakarta which has been commissioned to provide comprehensive positioning and survey support services over a similar period to a major oil and gas concern operating out of the Indonesian province of East Kalimantan. www.veripos.com

GMV wins cartographic production contract from Abu Dhabi

GMV has won a contract from the Abu Dhabi Environmental Agency for drawing up fine-scale terrestrial and marine Land Use/Land Cover (LULC) and habitat maps for the whole Emirate of Abu Dhabi. Within the project, primed by Proteus, GMV is leading the terrestrial part, including the development of the LULC and habitat maps that will serve as the primary baseline ecological dataset supporting EAD's environmental conservation activities over the next decade. *www.gmv.com*

Septentrio's receiver integrated with Tethered Aerostat Systems

Raven Aerostar, a manufacturer of Lighter-Than-Air (LTA) platforms that provide unmatched performance in challenging environments, has successfully integrated Septentrio's AsteRx2eH, a single-board dual-antenna GPS/GLONASS heading receiver into their tethered aerostat systems. Raven Aerostar recently completed a maritime persistent surveillance solution demonstration, deploying a TIF-25K™ aerostat system aboard the High-Speed Vessel – SWIFT (HSV-2), during which the AsteRx2eH performed remarkably. *www.septentrio.com*

ArcPad 10.2 Improves Integration with ArcGIS

Continuing its effort to connect desktop and mobile workflows in a seamless platform, Esri has released ArcPad 10.2. It is a mobile mapping and field data collection software designed for GIS professionals. Its new version improves synchronization with the ArcGIS platform and speeds data collection in the field with new automation options. It gives users the ability to directly open ArcGIS feature services in ArcPad and synchronize edits with hosted or on-premises GIS. *www.esri.com*

GNSS-Enabled PCIe Mini Card Supports GPS And GLONASS

A new PCI Express mini card, the PX1 from MEN Micro, uses a GNSS receiver to handle data transmissions from both GPS and GLONASS systems. The board, supporting both active and passive antennas via a U.FL connector, boasts superior satellite-based communication worldwide. A gyroscope sensor on the mini card enables dead reckoning functionality, ensuring accurate position identification even when a satellite signal is interrupted, such as driving through a tunnel. Various satellite-based augmentation systems that help improve the accuracy, reliability, and availability of the GNSS information are supported. *http://electronicdesign.com/*

Trimble News

Next-Gen Tablet PC for Surveying

Trimble® Tablet PC for surveying is a lightweight, rugged and highly mobile field computer that can operate with Trimble's suite of receivers and total stations to provide a complete surveying solution.

Ashtech High-Accuracy GNSS Module

Ashtech MB-One GNSS module delivers highly accurate GNSS-based heading plus pitch or roll in an advanced industry standard form-factor for system integrators. Its embedded Z-Blade™ GNSS technology uses all available GNSS signals equally, without any constellation preference, to deliver fast and stable solutions. It is an ideal solution for adding precise positioning and heading in a wide variety of applications.

AP15 GNSS-Inertial Board

Trimble® AP15 is the latest member of the AP series of OEM GNSS-Inertial board sets. It uses a custom Micro Electromechanical Machined (MEMS) based Inertial Measurement Unit (IMU). It is the first product to take advantage of Applanix' proprietary calibration process – Applanix SmartCal™, a new software compensation technology that allows Trimble to achieve exceptional performance from IMUs manufactured specifically for mobile mapping applications. *www.trimble.com*

Myanmar Survey Dept. purchases UltraMap and UltraCam Eagle

The Survey Department of the Myanmar Ministry of Environmental Conservation and Forestry (MOECF) has contracted to purchase a complete hardware and software aerial mapping package, including an UltraCam Eagle digital aerial camera system with an 80mm lens, the UltraMap DenseMatcher, Ortho Pipeline and Aerial Triangulation software modules, and the UltraNav flight management system. *http://news.silobreaker.com*

MARK YOUR CALENDAR

September 2013

FIG: LADM 2013
24 – 25 September
Kuala Lumpur, Malaysia
www.isoladm.org

International Symposium & Exhibition on Geoinformation (ISG 2013)
24 - 25 September
Kuala Lumpur, Malaysia
www.voronoi.com/isg2013

October 2013

Earth from space – the most effective solutions
October 1-3, 2013
Moscow, Russia
www.conference.scanex.ru/index.php/en/

Intergeo 2013
8 – 10 October
Essen, Germany
http://www.intergeo.de/en/index.html

UN-GGIM
16-18 October
Chengdu, Sichuan Province, China
http://ggim.un.org/

34th Asian Conference on Remote Sensing
20 – 24 October 2013
Bali, Indonesia
www.acrs2013.com/

ISGNSS 2013
22-25 October
Istanbul, Turkey
http://mycoordinates.org/isgnss-2013/

UN GGIM AP
28 – 30 October
Tehran, Iran

November 2013

GSDI World Conference (GSDI14) and the AfricaGIS 2013 Conference
4 - 8 November
Addis Abbaba, Ethiopia
www.gsdi.org/gsdiconf/gsdi14/

WALIS Forum 2013
7-8 November
Crown Perth, Australia
http://www.walis.wa.gov.au/forum

ICG-8: Eighth Meeting of the International Committee on GNSS
10 – 14 November
Dubai, United Arab Emirates
www.oosa.unvienna.org/oosa/en/SAP/gnss/icg.html

SPAR Europe/European Lidar Mapping Forum
11-13 November
Amsterdam, The Netherlands
www.sparpointgroup.com/Europe/

ISPRS: Serving Society with Geoinformatics
11 – 17 November
Antalya, Turkey
www.isprs2013-ssg.org

Geospatial EXPO 2013 Japan
14 -16 November
Tokyo, Japan
www.g-expo.jp

December 2013

5th Asia Oceania Regional Workshop on GNSS
1 - 3 December 2013
Hanoi, Vietnam
www.multignss.asia/workshop.html

ION Precise Time and Time Interval Meeting (PTTI)
2 – 5 December
Bellevue, WA, United States
www.ion.org

Fourth ESA Colloquium on Galileo
4 – 6 December
Prague, Czech Republic
www.congrexprojects.com/13c15/

6th European Workshop on GNSS Signals and Signals Processing
5- 6 December
Munich, Germany
http://ifen.bauv.unibw.de/gnss-signals-workshop/

January 2014

ION International Technical Meeting
27-29 January
San Diego, California, USA
www.ion.org

March 2014

Munich Satellite Navigation Summit 2014
25 – 27 March
Munich, Germany
www.munich-satellite-navigation-summit.org

April 2014

ENC-GNSS 2014
14 – 17 April
Rotterdam, The Netherlands
www.enc-gnss2014.com

2014 International Satellite Navigation Forum
23 – 24 April
Moscow, Russia
http://eng.glonass-forum.ru

June 2014

ION Joint Navigation Conference 2014
16 – 19 June
Orlando, United States
www.ion.org/jnc

XXV FIG Congress
16 – 21 June
Kuala Lumpur, Malaysia
www.fig.net