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Coordinates

Volume X, Issue 11, November 2014

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

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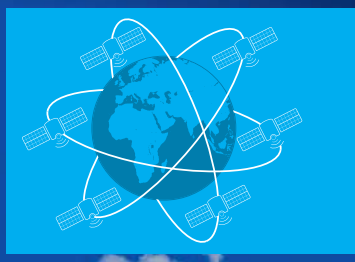

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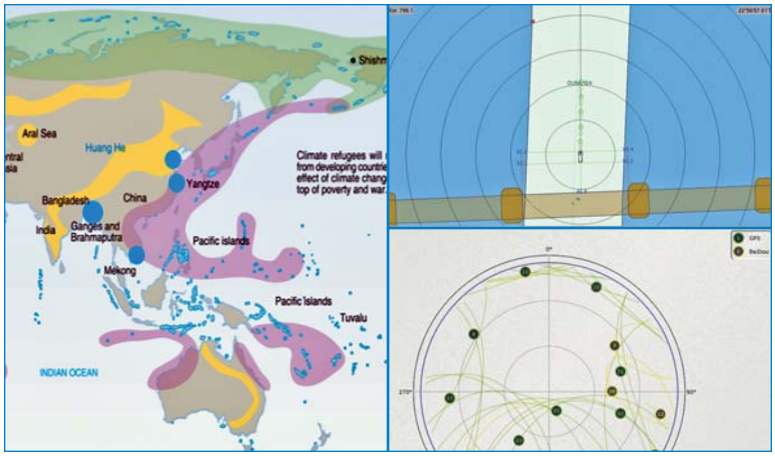

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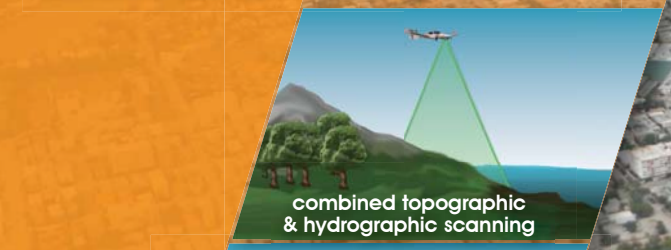

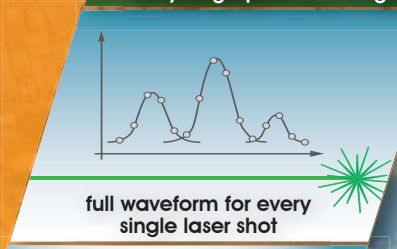

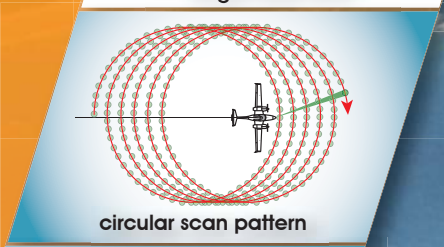

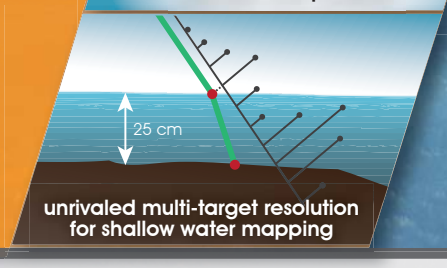

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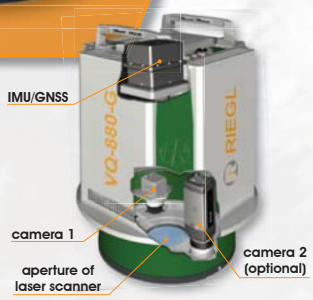

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UAVs: Set to fly high?

UAVs are set to fly high.

That can be said if we go by the buzz

At recently concluded Intergeo 2014 in Berlin, Germany.

Presence of several UAV technology providers

Not only added to the excitement of prospective users

But also indicated the promising potential.

However, will the lead taken by some of the market players,

Get the effective backing of the policy makers,

Is yet to be seen.

Policies which as of now appear to be

More restrictive than facilitative

Need to evolve with technological developments

And be more responsive to the user needs.

Bal Krishna, Editor
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'The role of the map has changed'

Says Prof Georg Gartner, President, International Cartographic Association (ICA) in an interview with Coordinates

What is the biggest challenge faced by the International Cartographic Association (ICA) in achieving its mission, 'to promote the disciplines and professions of cartography and GIScience in and international context'?

ICA is happy to see, that significant progress have been made in the attempt to be a global platform for modern cartography. It is a very good indicator, that ICA just recently have been accepted as a full union member of the International Council of Science (www.icsu.org), thus being seen on the same level of this exclusive circle then only 31 other international domains.

It is also a great honor and success, that ICA has been endorsed by the United Nations Global Geospatial Information Management (UN-GGIM) to run the International Map Year 2015/16 (http://internationalmapyear.org), with the aim to highlight the role of maps and cartography in society, economy and policy making, thus offering an instrument for all geo-domains to better explain the potential of geo-data, geo-information and cartography.

ICA is also happy to see, that research activities are increasing in respect to cartography, visualisation and related areas. This has lead to the foundation of a new flagship journal of ICA, the "International Journal of Cartography", which is about to be launched. We expect ground breaking research results to be published in this journal from now on as well and invite submissions already.

Although numerous progress have been achieved, challenges remain. These are especially related to the question on "How to we name what we do?". Several keywords exist and are used for describing eventually the same type of work, such as Geomatics, GIScience, Geoinformation, Geoinformation Management, Cartography etc. One of the goals of ICA is therefore, to provide platforms of discussion on this respect but also give guidance.

A further challenge has to do with the significant change of "players". While cartography, land administration, geodesy, geoinformation was done and developed eventually from governmental agencies and some companies much more players are on the market now, including companies from "non-geo" domains as well as volunteers and others. This leads to a structural problem for international organisations, as the big "national membership" might not be the most appropriate only form of representation in the future as well as to internal problems, as demands and needs of those new players might need different instruments and forms to be offered from an international organisation. On both challenges ICA is working hard and tries to develop further and further into a truely modern, international and umbrella organisation for the sake of our domains.

> The maps are eventually more prominent than ever, but cartography is losing ground in institutions

What could be the explanation for this diminishing presence of Cartographers in an increasingly spatially aware society?

I agree, the challenge cartography is facing is, that maps are eventually more prominent than ever, but cartography is losing ground in institutions.

For all of us being around in our domain for a while we have witnessed quite some transitions not only in what we do and how we do it but especially also how we name it. We have seen the move from terms like "cartography" to terms like "GIS", "geomatics", "geoinformation science", "geoinformation", "geovisualisation", "visual analytics", "geospatial information management" just to name a few. All those terms have a short history that basically dates back to the inauguration of using computers to make maps. Maybe you experience as well that it is hard sometimes to describe this "geo-spatial-visual something" to non-industry insiders, but there are universal term that everyone recognizes, and that's maps and cartography.

Maps are big news right now. Influenced by companies like Google, Apple and Microsoft and the status of maps as a must-have on smart phones and web applications they are very attractive to many. The term "map" seems to see its repeated revival as a contemporary,

relevant and attractive term for something contemporary, relevant and attractive.

However, it seems as if the term "cartography" is seen differently. Interestingly enough, often especially by those, who are the experts, the specialists and closely related to the domain. Maybe it is because it feels like it needs a different name to describe that the job we are doing in dealing with maps has become different. Often different technologies and methods are used, something which demands new and often very complex competences. How can it then still be named the same? Is it not necessary that the name describing what an industry is doing, what an expert in a discipline is doing needs to somehow reflect these changed competences which change methods and technologies? Is it not very much needed that I can name what I am doing as something most modern, complex, contemporary, as this will lead to respect, appreciation and recognition? And if I am calling myself a "cartographer", being involved in "cartography", will this lead to the same respect, appreciation and recognition, or will I rather be associated with something old-fashioned, out-dated?

There are for sure a lot of rationales for terms being used in our domains, and they all have their relevance. However, it seems as if the term "cartography" seems to become avoided, especially by cartographers, while many of the things being done under the umbrella of other terms could easily simply be called "cartography".

In communication science we use the theory of semiotics to explain communication processes. In this model, syntactical, semantic and pragmatic dimensions are used. Unlike semantics, which examines meaning that is conventional or "coded" in a given language, pragmatics studies how the transmission of meaning depends not only on structural and linguistic knowledge of the speaker and listener, but also on the context of the utterance. In this respect, pragmatics explains how language users are able to overcome apparent ambiguity, since meaning relies on the manner, place, time etc. of an utterance.

A modern map is also an interface that gives human users access to information stored in the map and beyond the map in databases

If this is true, then it is an always ongoing process in how we use and understand terms. This use and understanding is influenceable. This applies to the term "map" and "cartography" as well. It is therefore in the interest of ICA to contribute to this process, which fits into the ongoing "renaissance" of maps and map making.

In your opinion has technology enhanced or diluted the purity of the discipline of Cartography?

Modern cartography is everything we do in our daily life as a cartographer or GI Scientist in order to produce maps, or to be more precise to design cartographic communication processes. The role of the map has changed. Maps used to be artifacts, they had to look beautiful, well-designed, they had to store information for a long time because it needed to be used over a long period of time. In modern cartography there is an increasing number of functions to a map. Besides its old function of an artifact, a modern map is also an interface that gives human users access to information stored in the map and beyond the map in databases. The map has therefore the function of a table, structuring information through spatial attributes. And if a modern map is such an interface, giving access to structured information, then the concept of modern cartography in one sentence would be 'efficient communication of geospatial information'.

That's why a modern cartographer needs to be an interdisciplinary professional. For cartographers it is most important to know about computer sciences, but also about GIS, photogrammetry, remote sensing and geodesy. He has to know about design, art, modeling and analysis techniques as well as to be able to adopt new technologies. All these fields are influencing the product that the cartographer delivers in the end. You could best see this in a triangle: art, research and technology that will make up for the best cartographic products. The modern cartographer is in the middle, better in the heart, of that triangle. He is skilled, trained and able to deal with Geo-data, newest technologies and design principles. Unfortunately there are less and less cartographers with those skills available, but rather experts of geo-data handling, lacking design skills eventually, or programmers, lacking a profound understanding of "geo" or a mixture of all those. This is due to the lack of dedicated education as well as due to the focusing on particular aspects of skills.

But what we can witness is, that those competences and skills, to handle geo-date, apply newest technologies of data management, data modelling and data dissemination and the "language skills" of designing and communication geoinformation in a most efficient and pleasing way a taken off by many from other domains, this is why many computer scientist start to get interested in cartography.

The ICA has twenty eight Commissions. Would you please elaborate on them and their purpose?

ICA is very much a bottom-up organization, thus instead of trying to define in a top-down approach which topics and themes should be worked on our structure and policy allows for new and innovative topics to be picked up by a new group and commission eventually quicker while other topics might not be sustained and confirmed from the decision making body of ICA, the General Assembly.

The 28 current Commissions cover an enormous range of topics, from

What we need are experts, which are equally competent with data, with technologies and processes and with communication and design skills

History of Cartography, Maps and Society towards Technology-oriented topics like GeoVisualization, Maps and the Internet, Ubiquitous Cartography, towards Human-centered topics like Cognitive Issues in Cartography, Use and User Issues, towards Methodology-oriented topics like Map Generalisation, Map Projections, Toponomy Questions, towards questions of SDI like Map Production, Standards, OpenSource Geospatial Technologies to name a few.

The Commissions are truly the powerhouse of ICA. They are inclusive in nature, thus everybody is welcome to join and to check out in which way a contribution and participation is possible. They are heterogeneous in nature, as how they work depend always on the Commission Community, following our bottom-up policy. And they are very active, you might find books, journal, publications, workshops or conference results being available on the topic of the Commissions.

At every General Assembly of ICA (every fourth year) the Commissions are set in place. We are right in the phase of preparing the next GA 2015 in Rio de Janeiro. Thus, this is the moment to come forward with eventual ideas for new or changed commission topics through the national members of ICA, if there are ideas on that.

Could you please tell us about the Research Agenda of the ICA and why it needs to be a 'living document'?

The field of Cartography already has a wide range of conceptual and theoretical knowledge in a broad set of areas. Some areas, such as map projections, map design and history of cartography have existed for centuries. Others, in a representative list, such as symbol design, data scaling, map perception, map generalization, cartographic communication, analytical cartography, geovisualization/visual analytics, Geographic Information, metadata and Spatial Data Infrastructures have arisen largely in the 20th century. Some in the latter part of this list are fairly recent conceptual areas. Hence, Cartography already has an implicit, although dispersed, Body of Knowledge in existence. What needs to be done now is to create an explicit and organized Body of Knowledge which can encompass all of the theory and concepts in the full field of Cartography. The Research Agenda of ICA is a first step towards this. It has to be a living document as we want everybody to be able to contribute as well as having the Research Agenda to be able to reflect new insights and perspectives.

Which do you think presents a greater challenge for the ICA in the coming years – assimilating the growing number of 'rudimentary' cartographers into the fold or establishing the authority of trained cartographers?

There are many challenges for an international voluntarily organization like ICA. But at the end of the day it is dependent on our activities, profile, commitment, instruments and offers how attractive we are for amateur cartographers, experts, governmental institutions, companies, other domain experts etc. In that respect there are two strategies needed always, we need to listen to the needs, demands, questions of those which are related to maps and cartography, and secondly we need to offer something.

In this respect I am most pleased that for example the research community related to maps and cartography has been addressed by ICA instruments more prominently. The full ICSU membership gives our domain a higher profile, a high-quality journal gives our domain an additional voice, the research agenda directs our scientific questions, the ICA research scholarships allow young scientists to present their work and get into contact.

Similar actions and instruments are in place or planned for the amateur mappers and cartographers. The most successful Geo4All initiative out of the ICA-OSGeo Labs, fostering OpenSource Geospatial Technologies, is such an example as well as the activities of the Commission on NeoCartography.

We also have our ear on the demand, needs and questions of developing countries. A soon to be launched instrument of "ICA Capacity Building Grant" will allow for supporting activities in this respect.

Would it be correct to refer to the maps which are being generated by all and sundry as falling under the realm of cartography?

Of course. This is great news for Cartography, that more maps than ever are produced. Producing and using maps as a tool for information presentation, as a tool to express yourself, as a tool to map themes etc are important functions. When amateurs or non-cartographers use this instrument that is definitively under the realm of cartography, as the tools, methods, techniques are eventually provided and will be developed by modern cartographers, thus those which build on systems that allow those application.

What do you think is needed to be done at the academic level to address the needs of the new breed of Cartographers?

It is very important that more programmes and courses for Modern Cartography exists. What we need are experts, which are equally competent with data (thus dealing with geodata in the sense

that they know about data acquisition technologies and methods, that they know how to model and structure data and that they know how to manage data), with technologies and processes (thus dealing with methods and technologies to analyze, extract, aggregate, mine data for getting information or knowledge about spatial phenomena) and with communication and design skills (thus dealing with methods and technologies to disseminate, visualize and communicate spatial information in an efficient (context-dependent, location-based, media-adequate, user-centered) way. This is what is needed in the modern "geo domains", and this is what I call a "modern cartographer".

A most successful example exists. The International master programme on "Cartography" is a joined effort of the Technical Universities Munich, Vienna and Dresden. The aim of this programme is to reach those mentioned competences, thus producing "modern cartographers". The success is overwhelming. Although it is a competitive programme many applications are received every year to gain one of the restricted places. The alumnis being produced so far have been absorbed by the market quickly in all those areas being described above. Because of this success the European Commission has decided to prominently support the Master programme financially in the upcoming years, allowing scholarships and grants for International Students as well as the University of Twente to join in. Check out http://cartographymaster.eu/.

2015–2016 has been endorsed as the International Map Year by the ICA. Please tell us about this initiative.

The International Cartographic Association has been endorsed by United Nations Global Geospatial Information Management (UN-GGIM) to celebrate an International Map Year during the years of 2015 and 2016. The ICA expects that all ICA member countries will participate in order to give their citizens a broader knowledge of maps – how they are produced and used for many purposes in society. Another goal is to give school children and university students an opportunity to learn more about cartography and about its neighbouring geospatial sciences geodesy, photogrammetry, remote sciences and surveying. ICA has about 80 national members, and the UN will be helpful in establishing contact with all other countries in the world, so that International Map Year will be celebrated worldwide.

International Map Year will be officially opened at the ICA conference in Rio de Janeiro in August, 2015 and then continue until December 2016

The purpose of International Map Year is to:

- Make maps more visible to citizens and school children in a global context;
- Show how maps and atlases can be used in society;
- Show how information technology can be used in getting geographic information and how to produce one's own maps;
- Display and show different types of maps and map production;
- Show the technical development of mapping and atlas production;
- Show the necessity of a sustainable development of geographic information infrastructures;
- Increase the recruitment of students to cartography and cartography-related disciplines.
- International Map Year shall become a trademark for mapping and boost the identity of the ICA and highlight its mission in the international arena

Target groups for International Map Year are:

- General public;
- School children;
- Professionals;
- Government employees;

International Map Year will be officially opened at the ICA conference in Rio de Janeiro in August, 2015 and then continue until December 2016. But, preparation has to start earlier, especially activities to get national contributions for the Barbara Petchenik Competition in Rio.

Please describe your journey as a Cartographer over these past years and share with our viewers your vision for Cartography as a discipline.

My vision

Think of having 2030. Information is available anytime and anywhere. In its provision and delivery it is tailored to the user's context and needs. In this the location is a key selector for which and how information is provided. Cartographic Services are thus wide spread and of daily-use in a truly ubiquitous manner. Persons would feel spatially blind without using their map, which enables them to see who or what is near them, get supported and do searches based on the current location, collect data on site accurately and timely. Mobile technologies have demonstrated their huge potential and changed how we work, how we live and how we interact.

My journey

Starting as geographer and cartographer dealing with details on how to deal with signs, graphic variables and basically modelling the syntax of cartographic language I have evolved into becoming interested in the meaning of this from a more semantical perspective and finally end up in being interested in the enormous power and potential of the pragmatic dimension of cartography, thus understanding maps not only as a collection of signs and graphics, but that those signs carry a specific meaning for a particular human in a particular situation, thus is an immersive way of human communication.

Integration of Short Range Measurements into a standard Inland ECDIS navigation display

The paper describes the integration of the computed distances (called Short Range Measurements) between a barge convoy hull or passenger vessel hull and the surrounding riverside infrastructure, into a standard Inland Electronic Chart Display and Information System (ECDIS)

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Approaching river locks, passing under bridges, and approaching riverside berths and ports were identified as the situations at inland waterway transportation with the highest risk with respect to the collisions with surrounding infrastructure [1]. The first one is the most difficult because of the obstructions on both sides and sometimes the lock width is only one meter wider than the hull of the convoy. A convoy can be composed of a certain number of (un-motorised) barges which are pushed by a cargo vessel or a push boat. Passing under the bridge is not easy since the convoy has to pass a narrow corridor (between bridge pylons) at normal cruising speed and may cause problems especially during bad weather conditions, e.g., rain, fog, etc., when no clear view to the bridge is possible.

In order to support the skipper to take the right navigation decisions when he faces these three scenarios, a system was designed, within the NAVWAT 2 project [1], [2]. It provides accurate and reliable navigation information in a kind of visual guidance system. Based on the information about the river infrastructure and the convoy itself, short ranges between them are measured and shown. Thus, the skipper has a better overview of the whole situation, and by knowing these ranges, he can perform correct manoeuvres in order to avoid any collisions or accidents.

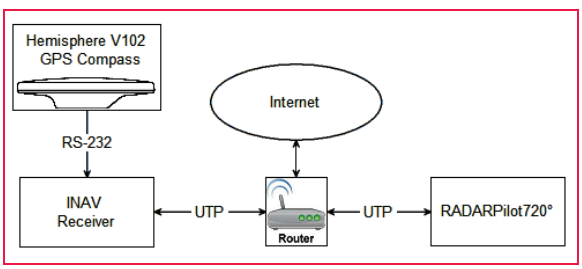

Figure 1: Hardware components

Inland ECDIS viewer software displays Inland Electronic Navigational Charts (Inland ENCs) to visualize the surrounding infrastructure, other convoys currently sailing and other important information for inland waterway navigation. One of the services which are not available at Inland ECDIS viewer software is measuring the distances to surrounding river infrastructure and thus, this was the main goal of the NAWVAT 2 project. Therefore, an integration of Short Range Measurements (SRM) into Inland ECDIS was realized. The research work and the integration which are described in this paper are conducted within the 'Implementation of River Information Services in Europe 3 (IRIS Europe 3)' project [3].

Hardware components

Figure 1 shows the devices and connections of the overall integration of the system. The system developed in the NAWVAT 2 project is located in the so-called INAV receiver. It uses raw data, heading and Rate-Of-Turn (ROT), sent by the Hemisphere heading device to generate navigational data, i.e., position, velocity, time, integrity, etc. The INAV receiver runs on a Linux Operating System and provides different interfaces such as Ethernet, UART, USB and four status LEDs. The SRM computed by the INAV receiver are sent to the Inland ECDIS

navigation system (RADARPilot720° [4]) through a router. The router also provides possibilities to external services which can be used by both devices.

Software implementation of INAV receiver

The software consists of two parts. The first one generates the navigational data and the second one uses this data in combination with the riverside infrastructure to compute the short ranges.

Position estimation

The Position, Velocity and Time (PVT) software of the INAV receiver is responsible for computing the navigation solution and the predicted convoy track, and provides them to the SRM module. The PVT collects all necessary data from the Hemisphere GPS compass - raw measurements (pseudoranges, phases, Doppler measurements and carrier-to-noise ratios) and ephemeris information for all GPS satellites in view, heading information (roll, pitch and heave), ROT and course over ground (COG). The heading information and ROT are not processed within the PVT, but they are passed to the SRM module.

The PVT uses GPS measurements and ephemeris to continuously compute the convoy position, velocity and COG. Raw measurements are analyzed for anomalies, outliers which can be removed accordingly. The position estimation is based on a Kalman filter with automatic selection of appropriate models for convoy dynamics (static, kinematic). The PVT includes a RAIM algorithm which is able to detect the erroneous data from satellites.

The PVT also computes the integrity information – vertical (VPL) and horizontal protection level (HPL). The HPL is used to proof the necessary integrity and reliability of positioning.

The predicted track is computed using actual position, velocity and ROT. The PVT computes the predicted track and the corresponding COG with a regular interval. The length of the predicted track can be changed, however reasonable values are in the range of 30-50 seconds.

In order to increase the positioning accuracy, the PVT can utilize DGPS corrections in RTCM 2.3 format. The INAV receiver has an embedded NTRIP client which is able to communicate with a correction broadcaster [5]. DGPS corrections can be received via Internet or directly from the RADARPilot720°.

SRM module

This module contains the most important functions and algorithms for SRM. It is also responsible for communication with the RADARPilot720° and visualising the SRM on its viewer. The SRM module receives navigational data as NMEA sentences from the PVT software (each epoch). The important parameters, i.e., position, velocity, heading, ROT, COG, etc., are extracted out of these NMEA sentences and are used for determining the position, orientation, moving direction, etc., of the whole convoy.

Two connections (A1 and A2) are established between the SRM module and RADARPilot720°. A1 is a unidirectional connection where all available NMEA sentences are forwarded as a data stream to the RADARPilot720°. Whereas A2, a bidirectional one, uses the Simple Object Access Protocol (SOAP) and is used for SRM computation. The first information sent through A2 are the data about the convoy shape, i.e., its length and width, position of GPS antenna mounted on the convoy and all vertices of the convoy real shape with respect to its body reference frame. These data are mandatory and without receiving them correctly, no further computation can be performed. Using the real shape, a reference one is created, which actually is a kind of best-fitting envelope. In Figure 2, the polygon consisting of vertices 1, 2, 3, 4, 5 and again 1, represents the real shape, whereas the reference shape is a quadrangular polygon created by the most external vertices of the real one, i.e., the vertices: 6, 7, 3, and 4. Therefore, the width and length of the convoy are represented by distances between vertices 4 and 3, and 4 and 6 respectively. The vertex 8 represents the position of the GPS antenna.

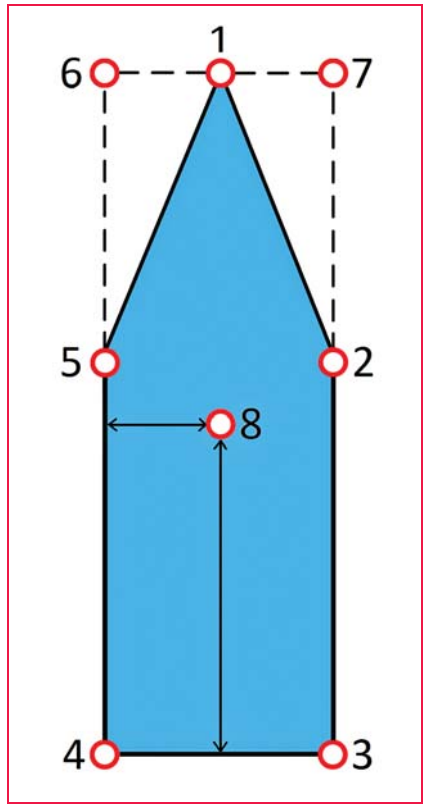

Figure 2: Convoy shapes and GPS antenna position

All distances will be determined between the reference shape and the riverside infrastructure. This convoy information is received by the SRM module at anytime the skipper modifies the real shape or changes the position of the antenna.

After the first correct position of the convoy is estimated and forwarded to the RADARPilot720°, it gathers from its Inland ENC all available river infrastructure elements (so called Inland ENC objects) detected within a circle with a predefined radius (e.g. 1 km) and sends them through A2 to the SRM module. Each time the convoy exceeds this circle, the RADARPilot720° searches for new Inland ENC objects and sends them again to the SRM module. There are two most important parameters for each Inland ENC object, i.e., Object Class (e.g., bridge, bridge pylon, lock basin, shoreline construction or pontoon) and the register of WGS84 coordinates of all vertices that form the real contour of that element. Now, knowing the current position of the convoy and the river infrastructure around it, SRM module searches for the closest Inland ENC object

and measures the distances to it. The SRM module computes distances only when the convoy gets closer to the Inland ENC object than a predefined threshold, e.g., 200 meters. Since Inland ENC objects have different type of geometry, i.e., point, line, polyline, polygon, etc., and only their geometry is provided through their vertices, it was challenging to develop a common algorithm which extracts the correct points out of this geometry to measure the distances. If the convoy is inside the Inland ENC object, e.g., inside a river lock, the short ranges will be measured directly to the object geometry, and if it is close to the riverside infrastructure distances will be measured to the predefined approach reference lines. No matter the geometry, position and orientation of the Inland ENC objects, moving direction and orientation of the convoy (forward or backward, i.e., when convoy gets closer to the object with its rear side), the SRM module is able to measure the distances - to bridges with no pylons at all and bridges with one or more pylons, to pylons which do not belong to any bridge (bridge was removed), to shoreline constructions, river locks and pontoons, see Figure 3. The short ranges are measured between projected points of the convoy reference shape onto the Inland ENC object geometry and/or onto the approach reference lines.

For each epoch, the SRM module sends this information to the RADARPilot720° through A2:

1. Convoy reference shape, and
2. Predicted track

If the convoy is close to any Inland ENC object, it computes the distances and sends this information also:

1. Approach reference lines (if predefined),
2. Distance values in meters, and
3. Warning messages

During normal operation mode, the reference shape, predicted track and the lines of distances are visualised in green colour. If the integrity of the position solution is not given, the skipper is informed through a warning message on the RADARPilot720° screen and colours change to red. Another warning message is shown to the skipper when the convoy is too close to an object and could collide accordingly.

Another message sent by the RADARPilot720° through A2 is the shutting down message to inform the INAV receiver to automatically shut down on its own because the whole system will be turned off.

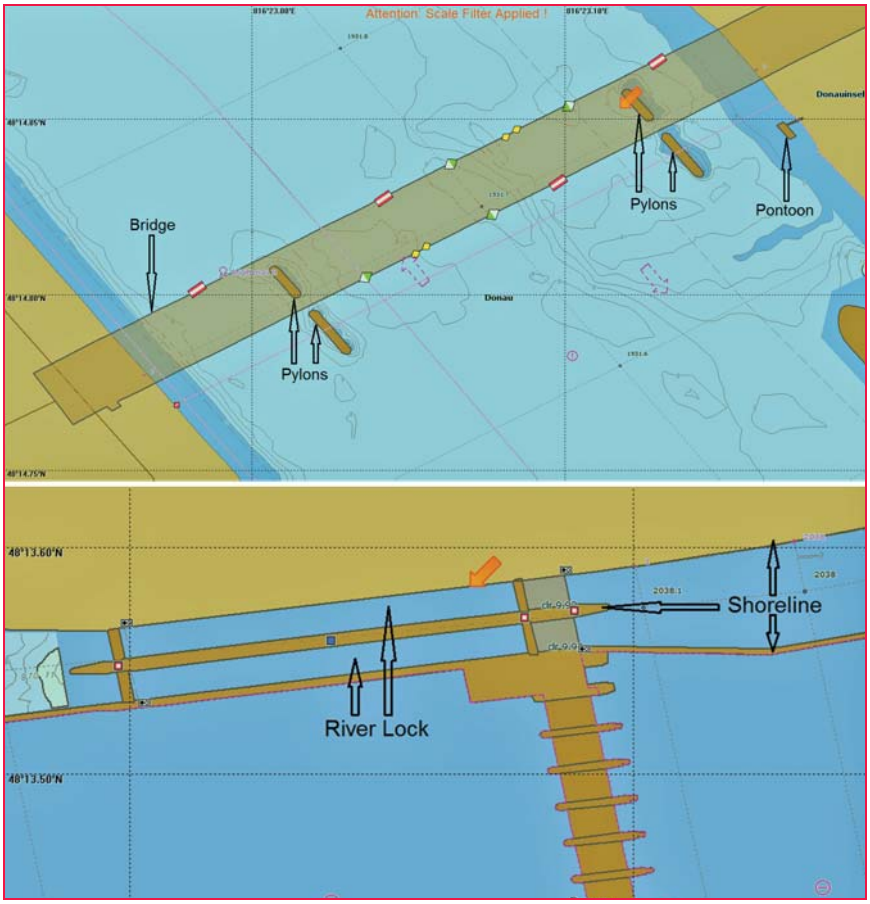

Figure 3: Inland ENC objects: bridge, pylons, pontoon, river locks and shoreline constructions

Tests and results

A real-time testing campaign was organized in September 2014 on the Danube River in three countries, in Hungary (from river km. ~1639 to ~1660), Austria (from river km ~1998 to ~2040) and Romania (from river km ~785 to ~805). Depending on the availability and quality of the Inland ENC objects in each testing area, different test cases were carried out.

The overall position estimation, reception and use of GNSS corrections, the overall computing procedures as well as accuracy of SRM, integrity and usability tests were carried out within this campaign.

Static tests were performed by installing Hemisphere device at a point with known coordinates. The NMEA data and some statistical information (e.g., correlation matrix) from the INAV receiver were collected during 8 hours. The Root Mean Square (RMS) error for this case (Kalman filter with dynamic model for static case) is 1.5 m. The sigma values estimated by PVT were consistent with computed RMS error.

The errors (for plane coordinates) computed by the PVT in kinematic mode (at moving convoy) were 1.8-2.5 m. Solution quality in vicinity of bridges is normally worse than normal due to satellite signal shading caused by the bridge and receiving reflected signals from metallic constructions. Such anomalies are very well detected by the integrity algorithm and an alarm message is displayed on the RADARPilot720°. Tests showed that a selected priori alert limit of 2 m is reasonable for the application.

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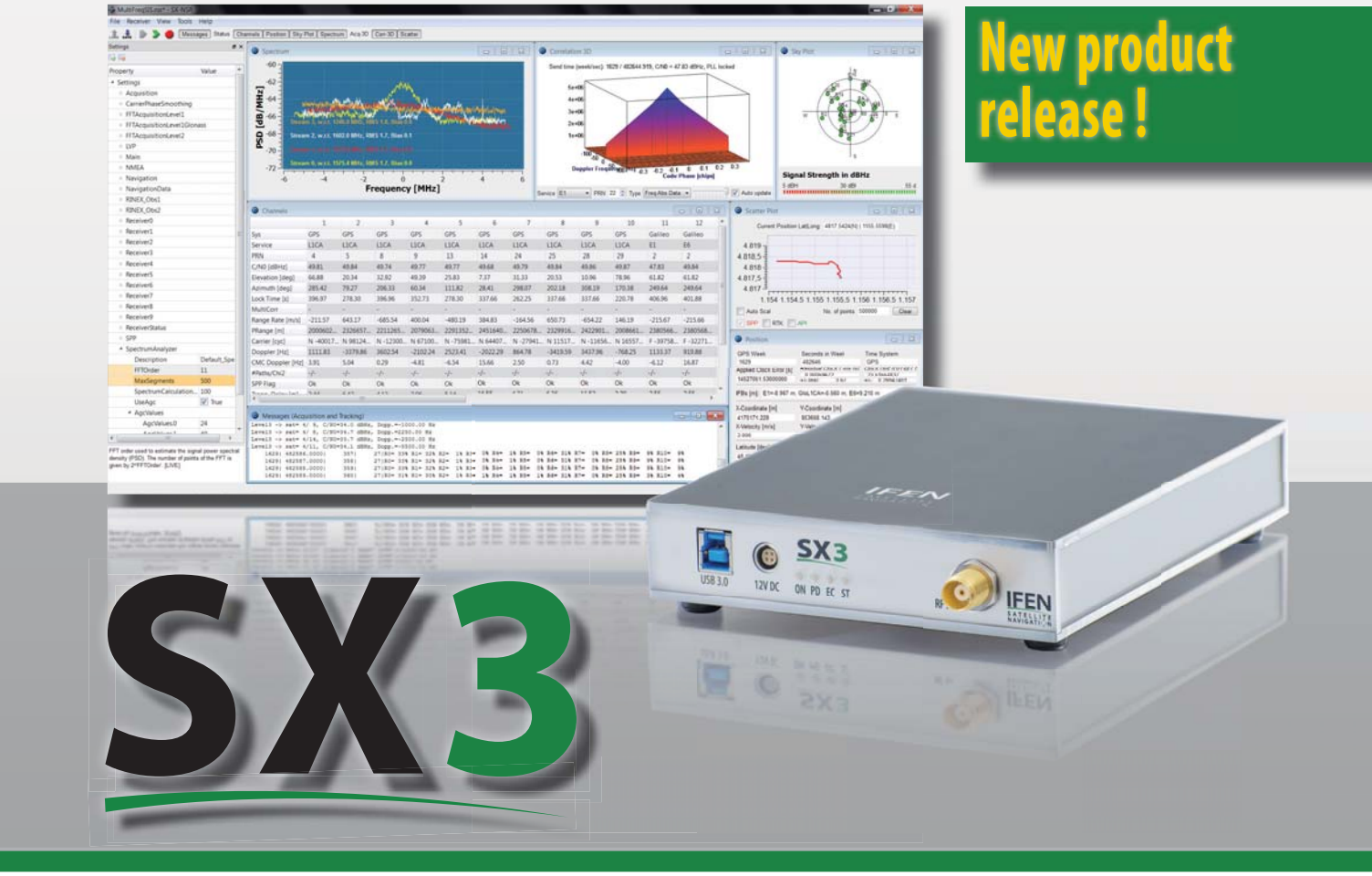

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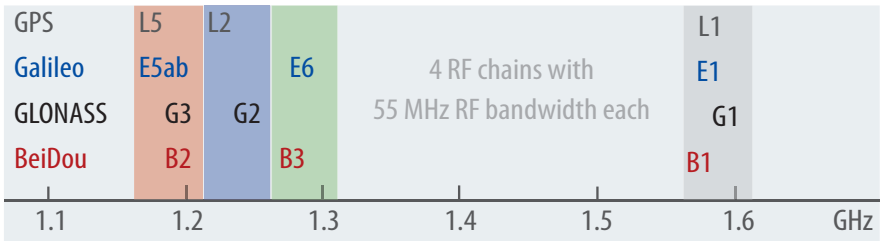

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In Austria, DGPS corrections were available. The INAV receiver obtained corrections using an internet connection. The correction information was sent every second (RTCM-message 1) and information about reference station position was sent every 20 seconds (RTCM-message 3). The device switched automatically to stand-alone solution if the correction reception is interrupted due to any reason (solution types are indicated by status LEDs). The DGPS corrections reduced the RMS error to about 1 m.

Figure 4 shows a screenshot of the RADARPilot720° visualising the computed distances. The distances are measured to the nearest Inland ENC object, in the present case to the Széchenyi Chain Bridge which has two pylons. The black pentagon is the convoy's real shape and the green envelope represents the reference one. The GPS antenna mounted on the convoy is marked with a blue cross. At both sides of the convoy, the approach reference lines (the red ones) are displayed which are predefined virtual lines based on the geometry of the pylons. As soon as the convoy gets closer to the bridge, the approach reference lines get shorter. The thin green lines connect the vertices of the reference shape with their projected points on the bridge and on both approach reference lines. Whereas, the values placed on the projected points show the distances in meters. The predicted track of the convoy is also provided in *Figure 4*. The small green circles represent the predicted positions of the GPS antenna and the green pentagons are the predicted positions of the real shape. The following Figure 5 shows a screenshot after the convoy passed under the bridge. It shows the same information as Figure 4 except the distance to the bridge now is measured from the rear side of the convoy.

In case of approaching a lock, the SRM module provides accurate distance information visualized on the Inland ECDIS display. Figure 6a, shows the convoy getting closer to the lock from its eastern side. At the right side of the convoy, the distances are measured to the shoreline construction and for the left side an approach reference line to the lock chamber is used. Also, the distance to the eastern entrance is shown. As soon as the convoy is inside the lock (Figure 6b), the distances are measured to the geometry of the lock itself.

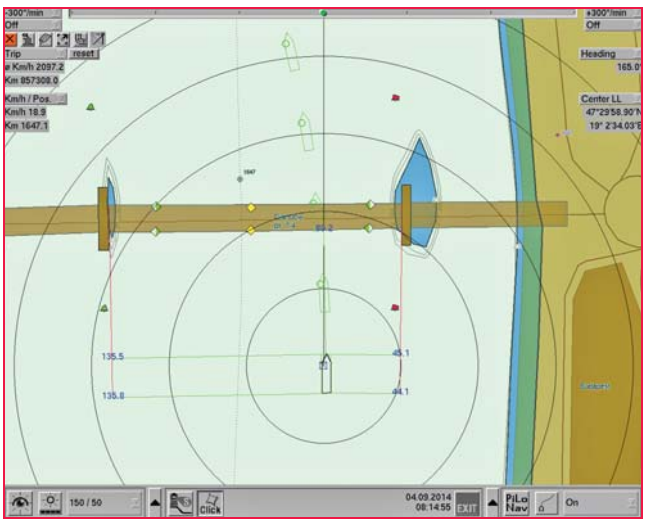


Figure 4: SRM to "Széchenyi Chain Bridge" (Budapest, Hungary)

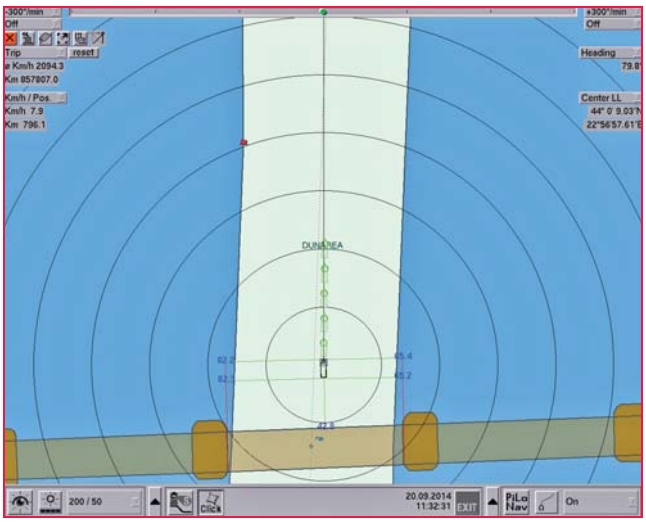
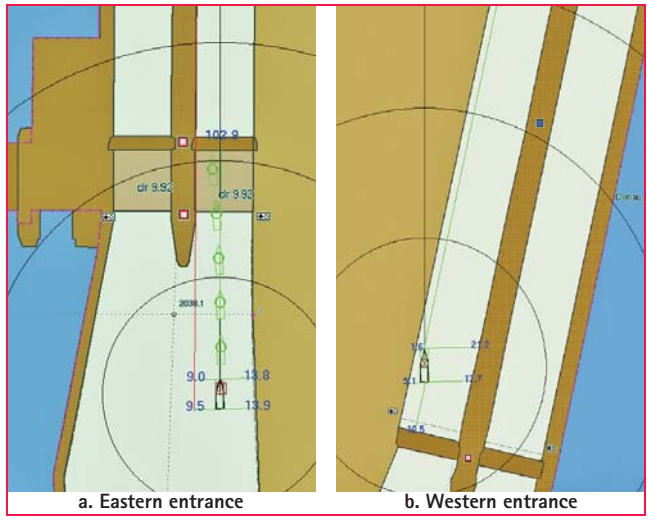
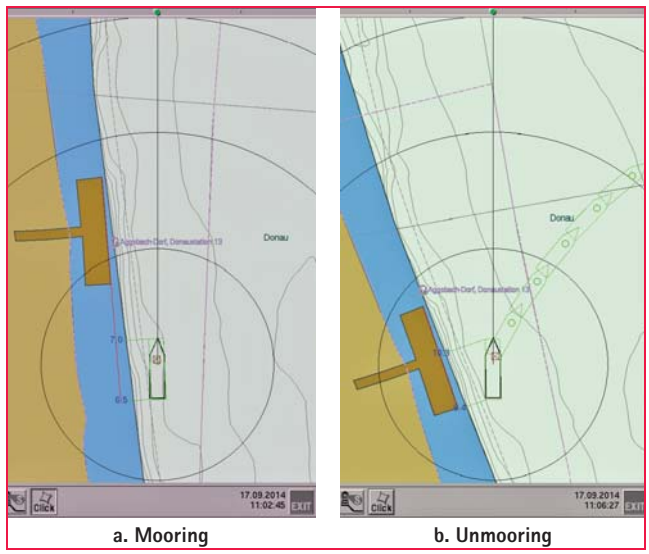


Figure 5: SRM to "Vidin – Calafat" Bridge (Calafat, Romania)



a. Eastern entrance b. Western entrance

Figure 6: Left chamber of lock Melk (Melk, Austria)



a. Mooring b. Unmooring

Figure 7: Pontoon (Donaustation 13 Aggsbach-Dorf, Austria)

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A screenshot during a mooring manoeuvre to a pontoon is shown in Figure 7a. Since the convoy did not reach the pontoon, an approach reference line is used again to provide the skipper the relevant distance information. A threshold is used for the predicted track, i.e., if the convoy velocity is smaller than this threshold, the predicted track is the same as the current position (Figure 7a). When the convoy gets closer to the pontoon, the distances are measured directly to the pontoon object (without approaching line), Figure 7b.

The computed distances were compared with distances measured by laser distance meter unit (Leica DISTO™ D110) in real-time and the differences between them were in decimetre-level. Skippers and the participants at the test campaign evaluated this service (SRM) as very practical, useful and helpful. They also reviewed the performance of the INAV receiver as very satisfactory.

Two problems with higher influence in SRM accuracy were detected during the tests: Loss of satellite tracking under bridges for a short time and the inaccuracy of the Inland ENCs. Very precise measurements of river infrastructure are required.

Reports and video record files about the test campaign will be published on the IRIS Europe 3 project webpage [3].

Conclusion

Despite the development and modernization of the waterway sector in the last years, some different scenarios still provide high risk with respect to collisions with surrounding infrastructure. In this paper, the integration of an additional service (SRM) to the Inland ECDIS navigation display is presented in order to support the skippers with real-time information about passing and docking manoeuvres, and to help them in avoiding any collisions with the riverside infrastructure.

The accuracy of the PVT solution in kinematic and static cases is reasonable. However, in case of approaching bridges, the GPS error increases due to satellite signal shading. In most cases, the receiver loses the satellite signals for about 2-3 seconds. In order to mitigate these problems, additional measurements from inertial sensors available on the GPS compass maybe used. Furthermore, the predicted track algorithm can also overcome the problem. Finally, it is worth to mention that the short signal outages are not a real problem since the overall system is supporting the approach to a bridge and thus, the functionality is not negatively influenced.

Differential corrections improve the position accuracy. It was demonstrated that the connection between the broadcaster and PVT via mobile Internet was stable and fast enough to receive correction information every second.

The SRM module uses the navigational data generated by the PVT software and the Inland ENCs to measure the distances between the convoy reference shape and the Inland ENC objects. The amount of information about the Inland ENC objects provided to SRM module is enough to compute the distances, but with more detailed information about them (knowing if Inland ENC object or part of it is above the water or on ground, waterways, notice marks, etc.,) the performances of the SRM module and the overall INAV receiver can be increased.

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At a Glance

- Leica Geosystems launches company blog
- Phase One Aerial Adds iXA-R Camera Platform; Introduces the iX Camera Controller
- Latest SuperSurv 3.2 Boosts Convenience of Geospatial Data Collection
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- MIMOS Berhad, Esri to collaborate for R&D activities
- Bentley launches new MineCycle software applications NGA awards $770mn geodata contract to Harris
- Taiwan launches petascale database for assessing climatic conditions
- Airbus wins MetOp-SG contract worth $1.7 billion
- Topcon releases latest geodetic reference receiver and antenna
- UK space industry worth £11.3 billion: Report
- Mapbox and Pix4D partner up to allow one-click upload of orthomosaics
- China to help Venezuela develop EO satellite
- First Copernicus satellite starts operating
- Xiomi invest $ 14mn in GPS based mapping company Careland
- Chinese exports to Indonesia OTH radar priced $ 160 million

We provide solutions that transform work processes

Says Christopher W. Gibson, Vice President, Trimble in an interview with Coordinates

Trimble has recently made several acquisitions. Could you tell us how the Geospatial Solutions have benefited from these acquisitions?

Over the past several years, acquisitions have played a role in our strategy, principally as mechanisms to establish beachheads in new market spaces, fill in product line gaps, or add new technologies to our solutions portfolio. More importantly, continued innovation and industry domain experience are the primary drivers, which allow Trimble to focus on organic growth as our principal strategy in our core market segments and multiple industries—such as Engineering and Construction, Surveying, Agriculture, Oil and Gas, Heavy Civil, Mining and many more.

Trimble's growth strategy is centered on developing and marketing innovative, complete solutions to its existing customers, while also marketing them to new customers and geographic regions. In some cases, this has led to partnering with or acquiring companies that bring technologies, products or distribution capabilities that will allow Trimble to establish a presence in a market, penetrate a market more effectively, or develop solutions more quickly than if they had done so solely through internal development. For example, Trimble has formed four joint ventures, with Caterpillar, Nikon and Hilti, and acquired over 100 companies to date. Fundamentally, emerging technologies, unique products, ability to meet regional needs and distribution capabilities are a few examples of characteristics that we look for that benefit our geospatial solutions, in general.

Geospatial technology plays an ever-increasing role in the development and operation of our physical infrastructure and environment. From mapping and planning for new railroads and transportation systems down to optimizing the performance of individual delivery vehicles, the work to gather, manage and utilize geospatial information has demonstrated that it can play an important—if not visible—role in the world economy.

In analyzing the success of geospatial systems, it's clear that a key advantage comes from the ability of the technologies to serve different applications. Global Navigation Satellite System (GNSS) positioning sensors can range from small, handheld devices similar to smartphones or calculators up to ultra-rugged receivers installed on trucks and earthmoving equipment. Optical systems including LiDAR and 3D scanning can collect data in areas that range from quarries and streetscapes down to the interior spaces of aircraft and industrial plants. High-speed digital imaging provides images for aerial and ground-based photogrammetry as well as enhancing the data from GNSS and scanning. The various positioning technologies can be combined into high-performance systems for mobile mapping and machine guidance, or utilized individually to support specialized applications.

Trimble has taken a variety of approaches—acquisitions being one of them—to assist our customers and increase the benefits and uses of spatial data, in an ever-changing world. Our technology philosophy is designed to embrace complexity inside the technology space, the solution space and also the deployment. Our teams are also applying deep mathematical, science and physics expertise to generate advantage for our customers and their projects. Developing for global multi-local markets is an approach chosen, combined with open and flexible data structure.

How has the use of UAS been integrated into Trimble's surveying solutions?

In April of 2012, Trimble acquired Gatewing of Gent, Belgium, a provider of lightweight unmanned aerial vehicles (UAV) for photogrammetry and rapid terrain mapping applications. The acquisition broadened Trimble's industry-leading platforms for surveying and geospatial applications, and the aerial solution currently integrates with several of Trimble's software solutions such as Trimble Business Center Aerial Photogrammetry Module, Trimble Access Field Software, and Inpho UASMaster.

How do you see the growth of UAS-based surveying business?

The UAS market is an emerging market with significant growth opportunities in a variety of industries—surveying, agriculture, oil and gas, mining, construction, environmental and natural resource management as well as many others. UAS in combination with photogrammetry are a rapidly emerging technology providing an innovative platform for flexible aerial imagery acquisition. As a result, Trimble has invested in research and development,

and training efforts to create a safest and reliable UAV/UAS platform for our geospatial customers. For use in surveying there are many opportunities since UAS are easy to use, flexible and cost efficient. They can enable geospatial professionals to create orthophotos and Digital Surface Models (DSM) from aerial imagery for mid-sized areas previously only accessible at higher costs and with longer planning cycles. UAS are used in a variety of applications including preliminary surveys for corridors and rights-of-way, volumetric surveys, high-level topographic surveys, land fill inspection, and much more. The use of UAS for aerial mapping is yet another tool in Trimble's portfolio of solutions for geospatial professionals.

"Trimble's mix of businesses has progressively moved away from a "box product" mentality towards a portfolio of products and solutions that enhance productivity." Would you please give us an example?

Trimble's focus is to provide solutions that transform work processes through the application of innovative technology. By integrating GNSS, optical measurement, imaging and inertial technologies with industry-specific application software, wireless communications and services, Trimble solutions allow users to collect, process, analyze and deliver intelligent geospatial information to improve productivity, enhance quality, lower costs and reduce rework. Today, we are providing solutions that streamline our geospatial customer's workflow—to help them efficiently manage data, equipment, and personnel involved in a project.As an example, a surveyor may require readily access to many types of data in order to plan a survey project. Previous surveys, government data, Web maps, and other data sources are vital to project planning, and having that data readily discoverable and accessible is a valuable time saver.

We have built a robust tool, the InSphere™ platform for geospatial information management to meet the needs of survey, engineering, and GIS professionals. It's a cloud-based platform of software, data, and services for geospatial enterprises. Today InSphere provides access to multiple applications, including three productivity-enhancing apps: Trimble InSphere Data Manager, Trimble InSphere Equipment Manager and Trimble TerraFlex™ to simplify field data collection. In addition, Trimble Access™ Services provide a seamless data connection between surveyors in the field and managers in the office. InSphere allows organizations to manage everything in one place, accessible anytime and virtually anywhere. In addition we have recently launched the Data Marketplace, where users can find and use additional free and premium spatial data layers, including aerial and satellite imagery, terrain, elevation and topographic maps, building footprints and other third-party data. The goal is to enable more robust workflow deliverables.

> The various positioning technologies can be combined into high-performance systems for mobile mapping and machine guidance, or utilized individually to support specialized applications

In the long term, we see InSphere as a platform for more applications and services that are interoperable to meet the unique challenges of geospatial professionals.

What are the key driving factors for growth of your business in the emerging economies?

I believe the key driving factors for growth in emerging economies is breaking the paradigm of slow technology adoption, education and evangelism, and the ability to adapt to local culture and market requirements for customers. Developing, emerging economies/countries have the opportunity to skip generations and adopt state-of-the-art technology. Since there is no legacy that has to be considered in most of the cases, there is a potential of being revolutionary and radical in terms of conceptually embracing technology. The opportunity lies in reversing the typical paradigm of being slower to accepting more advance technology. However, creating change is not easy. From Trimble's standpoint, the key is to adapt to local conditions and respect them. At the same time, we need to take on a bit of missionary role and try to evangelize our vision to the local circumstances based on our experiences from around the world. We need to present our views as alternatives to engage in these leapfrog activities.

For example, strengthening our development capabilities and reach into emerging markets is important to us, as it enables our solutions to meet the critical needs and local requirements of our customers. The foundation of successful emerging economies begins with land management and ownership as well as the strategic use of available natural resources. Geospatial technologies can play an important role.

I am relatively optimistic that if we play an active role, we may be able to contribute in creating some leapfrogs in technology for emerging economies in the markets we serve.

Today, on one hand there is integration of technology and on the other there is customization for particular applications, how does Trimble address this dichotomy?

The increasing role of geospatial information has been driven by a wide spectrum of technology change. The relevant changes have included improvements in sensors, in mobile

computing power, in software and in wireless communications. The net result of these technological changes requires geospatial information to not only be specialized, but also be available and cost effective for a wide variety of applications that have not typically been intensive users of geospatial data.

Beyond the geospatial information that is useful for one application it can also provide a vector of exchange among different industries, which share a need for a consistent context. At Trimble we have focused on how to improve productivity in a wide range of industries by applying geospatial intelligence such as: cadastre and survey, transportation and logistics, heavy construction, building construction, and agriculture.

Trimble understands that there will always be a need for both—integration of technology to streamline the workflow—and specialization for particular applications pertaining to specific industries. Geospatial technology is continuing to serve horizontal applications while being more integrated in verticals due to the understanding and support of governing organizations and other associations.

What are the technological challenges that Trimble comes across as far as customer demands are concerned?

The role that geospatial information plays in everyday life continues to expand. As the availability of geospatial information increases, traditional consumers of geospatial data (architects and engineers, utilities, governments and transportation agencies) are presented with new demands for geospatial information. In addition to precise, accurate data, customers are looking at new and better ways to utilize it, which is currently the biggest technological challenge.

For surveyors, GIS, mobile mapping and other geospatial professionals, this trend is shifting the value of their work away from simply gathering information. The focus now lies in understanding how customers use information to provide deliverables that best fit those needs. At Trimble, we believe that the information can go even farther. Because we know that data being collected is also being sent to the office—many times directly from the field—we have placed a great deal of emphasis on developing technology and products to seamlessly connect workflow processes with software applications.

> The UAS market is an emerging market with significant growth opportunities in a variety of industries—surveying, agriculture, oil and gas, mining, construction, environmental and natural resource management as well as many others

Do you think that the present generation of surveyors is ready to reap the benefits of advancement in surveying technology?

We see that the traditional survey industry boundaries are blurring. The field and office are overlapping as data processing and engineering expertise move closer to projects. Surveyors are adding data management abilities to their skills portfolio. Engineering and spatial data are being tracked with project timelines and accounting data. Survey instruments are combining GPS, optical and imaging capabilities. Construction projects are utilizing GPS and lasers to enable allowing automatic, accurate real-time 3D positioning for construction operations.

Surveyors are recognizing the changes and are responding in ways that can enhance and grow their businesses. Changes in the use of technology in both sensors and digital data transfer offer new opportunities—and new challenges.

Many surveyors see themselves as project information or data managers. Rather than just providing the brick-and-mortar tasks of property line surveying, mapping and stakeout, forward-thinking surveyors are managers of the critical data required by the entire team throughout the construction cycle. Surveyors are usually on site from start to finish, from construction staking to as-built. These progressive surveyors are some of the most valued team players in the management of design documentation and the creation, revision and archiving of data throughout the project.

But while surveyors have performed the data management role for some time, the format in which the data is managed—and even the data itself—has changed. Until more recently, surveyors have worked primarily in the 2D space. GNSS, RTK, robotic field equipment, imaging and desktop computers' enable surveyors to manipulate, store and transfer vast amounts of data. Wireless communications and cloud-based servicea and solutions have opened significant new ways to manage, plan, transfer and use data.

Surveying organizations can embrace their role as data managers by enhancing their skills set through ongoing education, making the necessary technology investments and looking at how they can take advantage of growth opportunities provided by emerging industry trends. To prepare for the new generations of surveying professionals, educational institutions ranging from apprenticeships and vocational training up through university programs need to be aligned with the rapid changes in instrumentation, software and stakeholder interaction.

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At the present the society is dependent on accurate and reliable Position, Velocity and Time (PVT) information acquired using Global Navigation Satellite Systems (GNSS). GNSS signals travel a long way from the satellite transmitter to the user receiver antenna on the Earth and therefore the signal power level is extremely low at the user receiver. The low signal level makes the GNSS technology highly vulnerable to intentional interference, called jamming. Jamming is anticipated to proliferate simultaneously with the increase of number and relevance of the applications relying on GNSS. Although jammers are illegal in most of the countries, many people still use them for the protection of personal privacy, i.e. preventing the operation of GNSS receivers that could track their location (Pullen and Gao, 2012). Jammers transmit signals with power and characteristics disturbing acquisition and tracking of GNSS signals (Mitch et al. 2011). The use of easy-access low-cost jammers results in degraded positioning accuracy or total loss of GNSS signals and, therefore, may cause serious damage if the jamming signals are not properly detected and their effects mitigated (Kuusniemi et al. 2012).

Interference is normally classified into narrowband (NB) or wideband (WB) (Kaplan and Hegarty, 2006). Narrowband interference occupies usually less than the entire available spectrum of GPS C/A-code having a bandwidth of 2.046 MHz (Jiang 2004). Sources for narrowband interference are jamming devices but also other RF sources, such as Amplitude Modulation (AM) or Frequency Modulation (FM) transmitters. Unfortunately, the cheap jammers transmit mainly wideband interference signals occupying the entire C/A-code spectrum. In addition to the appearance of large position errors or positioning loss, the presence of such interference may also be evaluated by monitoring e.g. the Carrier-to-Noise density ratio (C/N_0) quantifying the signal quality. The typical nominal C/N_0 value for GPS signal is 44 dB-Hz and with such signals the obtained position solution is sufficiently accurate for most use cases, i.e. 5-10 meters, when single-frequency single-receiver performance is considered. In this paper the effect of jamming is evaluated in terms of position solution accuracy and the estimated C/N_0 values.

The United States Global Positioning System (GPS) has been in use already for over two decades and is still the most used satellite navigation system. In 2011 the Russian GLONASS navigation satellite system achieved the full operation capability. At the present moment the European Galileo has four satellites in operation and the Chinese BeiDou fourteen; both systems are anticipated to have the full operation capability latest in the year 2020. The wider range of new signals will improve the availability and accuracy of the PVT solution computed using GNSS. Besides, the modernized signals have improved signal characteristics providing better performance, also at lower carrier-to-noise density ratios, either due to attenuation in urban environments or jamming. The modern GNSS signals have longer codes, pilot signals that do not encompass data modulation and higher transmission powers. However, despite the careful re-design of the navigation satellite signals e.g. Galileo signals were

found to be affected similarly to GPS by wideband jamming (Borio et al. 2013). This is due to the wideband jamming having similar spectral separation with respect to GPS (L1) and Galileo (E1) modulations. However, BeiDou signals have specific features (Bhuiyan et al., 2014) making the system more tolerant of jamming, especially because the center frequency of the civilian B1 signal is 14 MHz off from the GPS/Galileo L1/E1 center frequency, as jamming is still most of the time directed towards the most used system GPS. The use of more than one GNSS interoperable system provides a multi-GNSS position solution being much more robust than any system alone, also when interference is encountered. However, when multi-GNSS integrating more than three systems is used, the enhancement of position solution accuracy and availability might be compromised with the increase of the Radio Frequency (RF) noise floor hindering the GNSS receiver signal processing (Gibbons, 2011) unless carefully designed.

Herein the effects of a cheap commercial jammer on the BeiDou signal will be assessed. In (Baek et al. 2012), jamming of BeiDou signals was simulated and its effects on the signal were evaluated based on the signal quality factor, tolerable jamming power level and propagation range. As far as the authors know, this paper, on the other hand, presents the first BeiDou interference study performed in Europe. The study presented in this paper was committed using real-world signals for evaluating the effect of jamming on the signal quality and the position solution accuracy. First, the specific features of the BeiDou system and signals will be discussed. Then, the software defined multi-GNSS receiver used for experimenting and demonstrating the effects of jamming, FGI-GSRx, will be introduced. Then, experimental results of BeiDou positioning in the presence of intentional interference are presented and compared to the respective results obtained using GPS and multi-GNSS. Finally, concluding remarks and future work are discussed in Section 5.

Chinese navigation satellite system beidou

At present the Chinese navigation satellite system BeiDou consists of 14 satellites and has an operational capability in Asia region. The system is anticipated to be complete in 2020 with 35 satellites. BeiDou will have a mixed space constellation, which means that in addition to the prevailing constellation of 27 Medium Earth Orbit (MEO) satellites, the system will contain five Geostationary Earth Orbit (GEO) and three Inclined Geosynchronous Satellite Orbit (IGSO) satellites. As conveyed by the name, the GEO satellites are located in orbit at an altitude of 35786 kilometers and therefore seem to stay stationary with respect to the Earth. The orbits of IGSO satellites have the same altitude as GEOs and an inclination of 55 degrees to the equatorial plane improving the availability of high elevation satellites in densely populated areas (Montenbruck et al., 2013). The mixed constellation will bring better satellite to user geometry and therefore

improve the accuracy of height estimation. However, in Northern areas, as in Finland, GEO satellites are at low elevations which could degrade the BeiDou position solution remarkably. Fortunately, previous research carried out at the Finnish Geodetic Institute has shown that despite the challenges introduced by the Northern location, the position accuracy obtained using BeiDou system is comparable to GPS already in this early stage in favorable conditions (Bhuiyan et al., 2014).

BeiDou signal characteristics are similar to GPS; their spreading code periods are both 1 milliseconds (ms) long and their coordinate systems and the navigation message structure have only minor differences (China Satellite Navigation Office, 2012), (IS-GPS-200G, 2012). BeiDou B1 signal has twice the chipping rate and the code length than those of the GPS L1 signal. The center frequency of BeiDou B1 signal is 1561.098 MHz, when for GPS and Galileo the nominal center frequency is 1575.42 MHz, although there is a plan to shift the center frequency at 1575.42 MHz in the future (Gibbons 2013). However, the BeiDou signal has one improvement also affecting its narrowband jamming resistance, namely the signal has an additional layer of modulation between the PRN code chips and navigation data; Neumann-Hoffman (NH) code modulation. The use of the NH code modulation improves the data bit rate and it has already been adapted to other modernized GNSS signals, such as GPS L5. Due to the NH code modulation the BeiDou signals have more tolerance to narrowband jamming when its power is tolerable.

FGI-GSRX software defined gnss receiver

Software defined GNSS receivers are beneficial platforms for GNSS research and algorithm design. In software receivers all signal processing and navigation functions are delivered by software, making it possible to modify and develop new algorithms as well as elicit information about the signal properties at all processing stages. While using a software defined receiver, GNSS signals are captured using a radio front-end, which digitizes the analog signals down converted into the intermediate frequency (IF). From then on, all processing is performed by software (Kaplan and Hegarty, 2006).

FGI-GSRx is a Matlab based software defined GNSS receiver built by the Finnish Geodetic Institute on an open-source platform (Borre et al. 2007). At present, the receiver is capable of computing a navigation solution using GPS (L1), BeiDou (B1) and Galileo (E1) independently, as well as providing a multi-GNSS solution using all three systems. The implementation of Glonass-compatibility is ongoing. In recent years, also algorithms for interference detection (Kuusniemi et al. 2013) and mitigation, using deeply coupled INS/GNSS integration (Ruotsalainen et al. 2013), have been developed and implemented into FGI-GSRx.

Signals processed in FGI-GSRx are collected using a dual-board GNSS front-end *stereo v2* from Nottingham Scientific Limited (NSL) capable of capturing simultaneously GPS (L1), Galileo (E1) and BeiDou (B1) signals (Nottingham Scientific Limited 2013). Stereo comprises two front-ends, the other one was used for capturing the B1 signal using a bandwidth of 4.2 MHz and the other one for GPS signal using a bandwidth of 6.61 MHz. Galileo signals may also be captured simultaneously with GPS using the same front-end.

Experimental results

The data used in the experiments was collected in Finland on March 19th 2014. Figure 1 shows a Trimble GNSS Planning Online skyplot for the satellites visible at the time of the data collection with elevation cut-off angle 5 degrees. The skyplot shows that even in Northern Europe six BeiDou satellites (in yellow) out of the fourteen operational may be seen simultaneously. Occasionally, at favorable times even seven or eight satellites can be visible to southern Finland.

GNSS signals were collected using a roof antenna and the *stereo-v2* radio front-end introduced above. At first no intentional interference was present. After collecting the data for about 48 seconds GNSS signals were exposed to interference by using a cheap commercial single frequency jamming device, presented in (Kuusniemi et al., 2012), transmitting wideband signals at the L1/E1 frequency. The bandwidth of the jammer is about 16.3 MHz and the maximum output power 13 dBm. However, as the use of a jammer is illegal also in Finland, the experiments were conducted inside the navigation laboratory of the Finnish Geodetic Institute with a special permission from the Finnish authorities using an attenuated output power of -30 dBm.

Below, the effect of jamming is examined based on the C/N_0 values and the position solution accuracy, first for GPS, then for BeiDou and finally for a multi-GNSS solution using GPS and BeiDou signals.

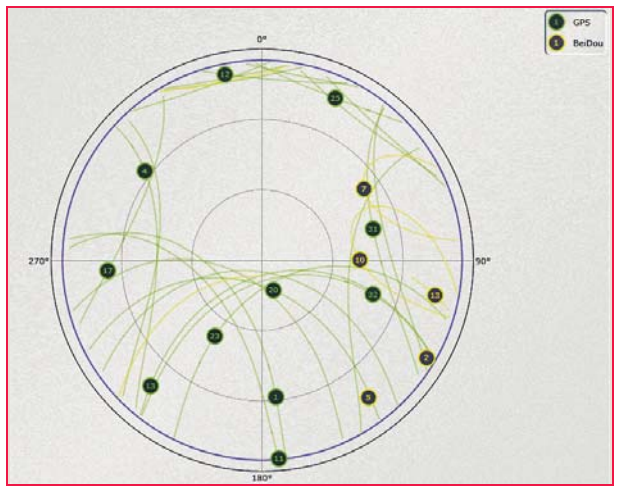

Figure 1: Trimble GNSS Planning Online skyplot at 7:30 AM (UTC) at Finnish Geodetic Institute, Finland (Lat, Lon) on March 19th

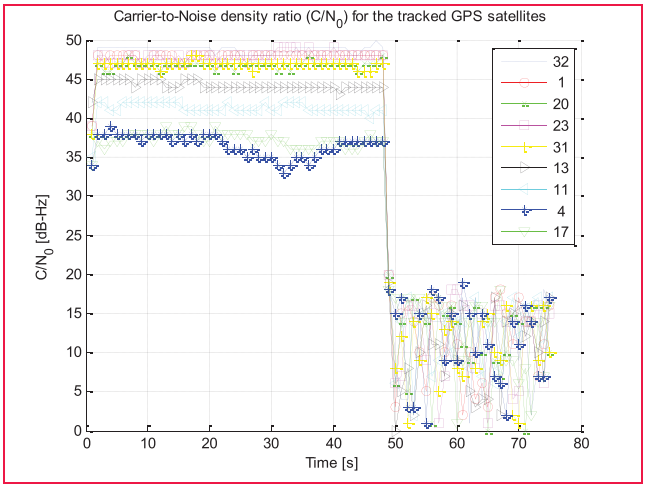

Figure 2: C/N_0 values for GPS satellites, jamming started at 48 seconds

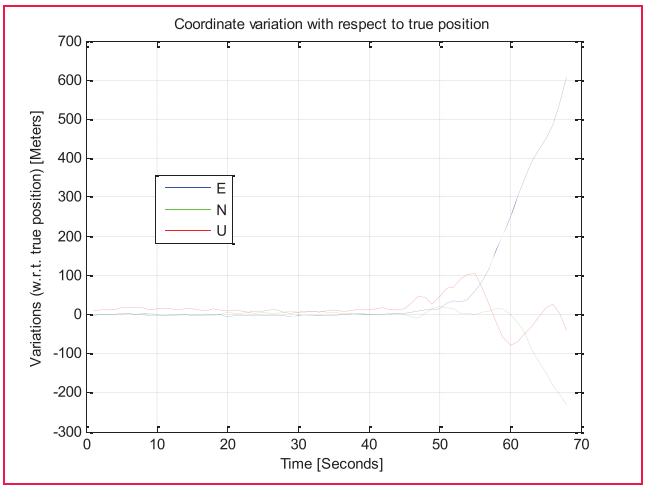

Figure 3: Position errors for east (E), north (N) and vertical (up, U) components for GPS

Jamming GPS

First, the collected data was processed using the FGI-GSRx for acquiring, tracking and computing the navigation solution from GPS signals. At the time of the data collection, nine GPS satellites were visible offering a good user-to-satellite geometry expressed by a low position dilution of precision (PDOP) value, namely 1.86. Figure 2 shows the C/N_0 values for the signals. For the first 48 seconds, when no jamming was present, the C/N_0 signals were in adequate level; mainly between 35 and 50 dB-Hz. At the time when the jammer was turned on, at the 48th second, the values dropped drastically; below 20 dB-Hz for all satellites. Such low C/N_0 values indicate that the positioning solution will be inaccurate, and there are chances that the receiver may eventually lose lock after some time.

Figure 3 shows the position error obtained using GPS signal measurements. Before jamming was started, the position errors stayed in the nominal level, namely below 10 meters for horizontal components East (E) and North (N) and below 12 meters for the vertical component (U). The Root Mean Square (RMS) error was 6.2 meters for the horizontal position and 10.5 meters for the vertical. After the jamming device was turned on at the48th second, the position accuracy started degrading fast. The error in the East component increased to a maximum of about 600 meters, North component to a maximum of about 200 meters and the vertical component to a maximum of about 100 meters. The horizontal RMS error of the whole data set, including also the 48 seconds of good quality data, was 168.9 meters and the vertical RMS was 41 meters. Table 1 shows the error statistics. As a conclusion it may be stated that the wideband jamming has drastic effects on single-frequency single-receiver GPS positioning.

Table 1: Position error statistics for GPS

Statistics	No jamming	With jamming
Horizontal RMS (m)	6.2	168.9
Vertical RMS (m)	10.5	41.0
Horizontal error 95% (m)	8.8	473.6
Vertical error 95% (m)	16.7	79.4

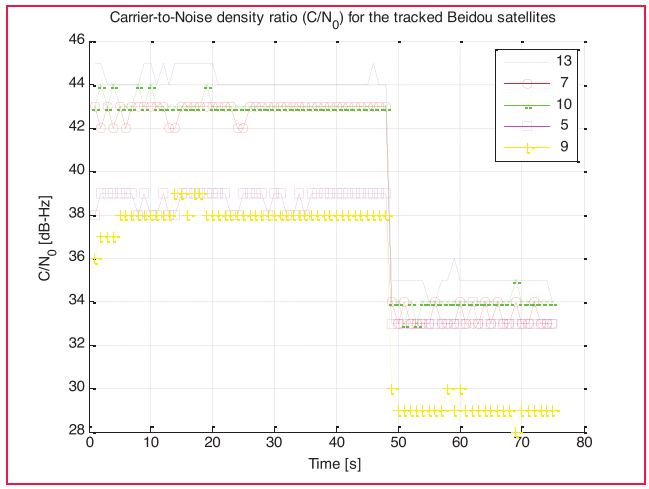

Figure 4: C/N_0 values for BeiDou satellites, jamming started at 48 seconds

Jamming BeiDou

The effect of jamming on the BeiDou signal was examined also by using the wideband jammer presented above. Six BeiDou satellites were visible at the time of data collection; however one of them was very low elevated, (less than 5 degrees), and therefore the software receiver was unable to acquire one satellite, the satellite with PRN number 2.

After 48 seconds had elapsed from the start of the data collection, the signal was exposed to jamming. Figure 4 shows the C/N_0 values for the tracked BeiDou satellite before and during jamming. The C/N_0 values were good for three satellites, namely over 42 dBHz and moderate for two satellites, namely between 38 and 40 dB-Hz. The jamming device transmits a chirp signal centered at L1/E1 frequency with a bandwidth of 16.3 MHz. It was anticipated that the jammer would have no or very little effect on the BeiDou signal with a center frequency 14 MHz off from

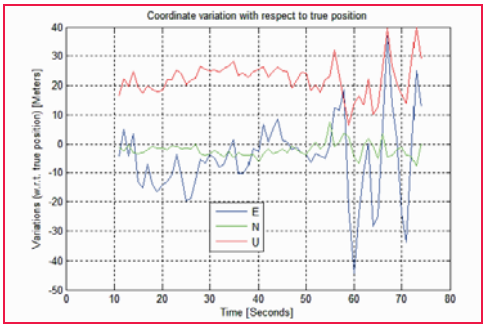

Figure 5: Position errors for east (E), north (N) and vertical (up, U) components for BeiDou

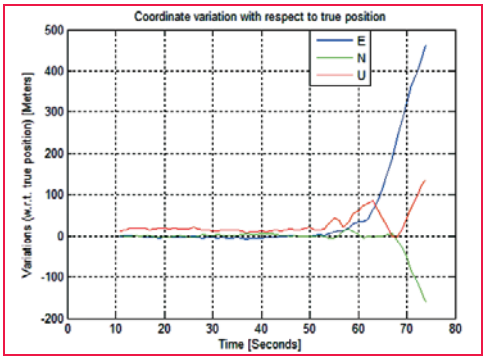

Figure 6: Position errors for east (E), north (N) and vertical (up, U) components using a multi-GNSS solution

the GPS center frequency. Surprisingly, as Figure 4 shows, there was a drop of maximum 10 dB on the C/N_0 values for each individual BeiDou satellite.

Unfortunately, one of the five satellites observed was not signed healthy (PRN 13) and therefore was not used for computing the position solution. The predominant situation at the time of data collection, i.e. the possibility to use only four satellites and having a poor user-satellite geometry (PDOP was 7.3) resulted in a deteriorated position solution as can be seen in Figure 5. The BeiDou satellite vehicles used in the experiment were PRNs 5, 7, 9 and 10. PRN 5 is a GEO satellite and all others are IGSO satellites, and therefore the signals had to travel much longer distances than the signals transmitted from the MEO satellites. Therefore the BeiDou signals used in the experiments were noisier than those from GPS. The error in the position vertical component was around 20 meters and varied a lot in the East component, being 20 meters in the worst case, even when no interference was present. The error in the North component stayed acceptable, below 10 meters at all times. The horizontal RMS error was 16.5 meters and vertical 18.8 meters. When the jammer was turned on the position solution degraded, the effect was significant especially on the East component. The RMS errors for the whole dataset were 19.4 meters for horizontal and 18.9 meters for vertical position. Table 2 shows the error statistics. As a conclusion it may be stated that the BeiDou position solution is also affected moderately by a wideband jamming device manufactured to interfere the GPS signals despite of the 14 MHz difference in the center frequency of the systems.

Table 2: Position error statistics for BeiDou

Statistics	No jamming	With jamming
Horizontal RMS (m)	16.5	19.4
Vertical RMS (m)	18.8	18.9
Horizontal error 95% (m)	19.0	28.5
Vertical error 95% (m)	26.6	29.1

Table 3: Position error statistics for multi-GNSS

Statistics	No jamming	With jamming
Horizontal RMS (m)	8.4	133.4
Vertical RMS (m)	13.8	25.4
Horizontal error 95% (m)	7.2	374.1
Vertical error 95% (m)	20.4	86.1

Jamming Multi-GNSS

Lastly, the data was processed using a multi-GNSS approach, namely by combining the GPS and the BeiDou signals. The benefit of the multi-GNSS solution is that due to the greater amount of satellites being used the user-satellite geometry is improved resulting into smaller DOP values. In this multi-GNSS experiment, the PDOP was namely 1.55. However, the number of unknowns to be solved in the navigation equations increases by one, as also the time difference between the two systems has to be accommodated for. Therefore, the number of independent measurements decreases and in a sense we lose the measurements of one satellite.

Figure 6 shows the errors in the multi-GNSS position solution. The position root mean square errors increased using the multi-GNSS solution with respect to GPS only solution, the horizontal RMS error being 8.4 and vertical 13.8 meters, when no jamming was present. This was possibly due to the fact explained above that measurements from one satellite are lost due to the increase of unknowns in the navigation solution equations as well as the lack of the receiver autonomous integrity monitoring (RAIM) for satellite selection allowing the inaccurate BeiDou measurements distort the position solution. Using RAIM the navigation solution could be computed using the most profitable combination of satellites; selecting the ones providing the best quality signals and the best user-to-satellite geometry. The development of RAIM algorithms into the FGI-GSRx is a subject for future research. When the jamming device was turned on, the horizontal RMS error obtained using the whole data set was 133.4 meters and vertical 25.4 meters, both being worse than obtained using BeiDou only (19.4 and 18.9, respectively). The RMS errors obtained using multi-GNSS were less than with GPS-only (horizontal 168.9 and vertical 41 meters using GPS). Table 3 shows the error statistics.

As a conclusion it may be stated that even without RAIM the multi-GNSS solution provides better performance than BeiDou only solution, when no jamming is encountered and better performance than GPS in a jamming situation.

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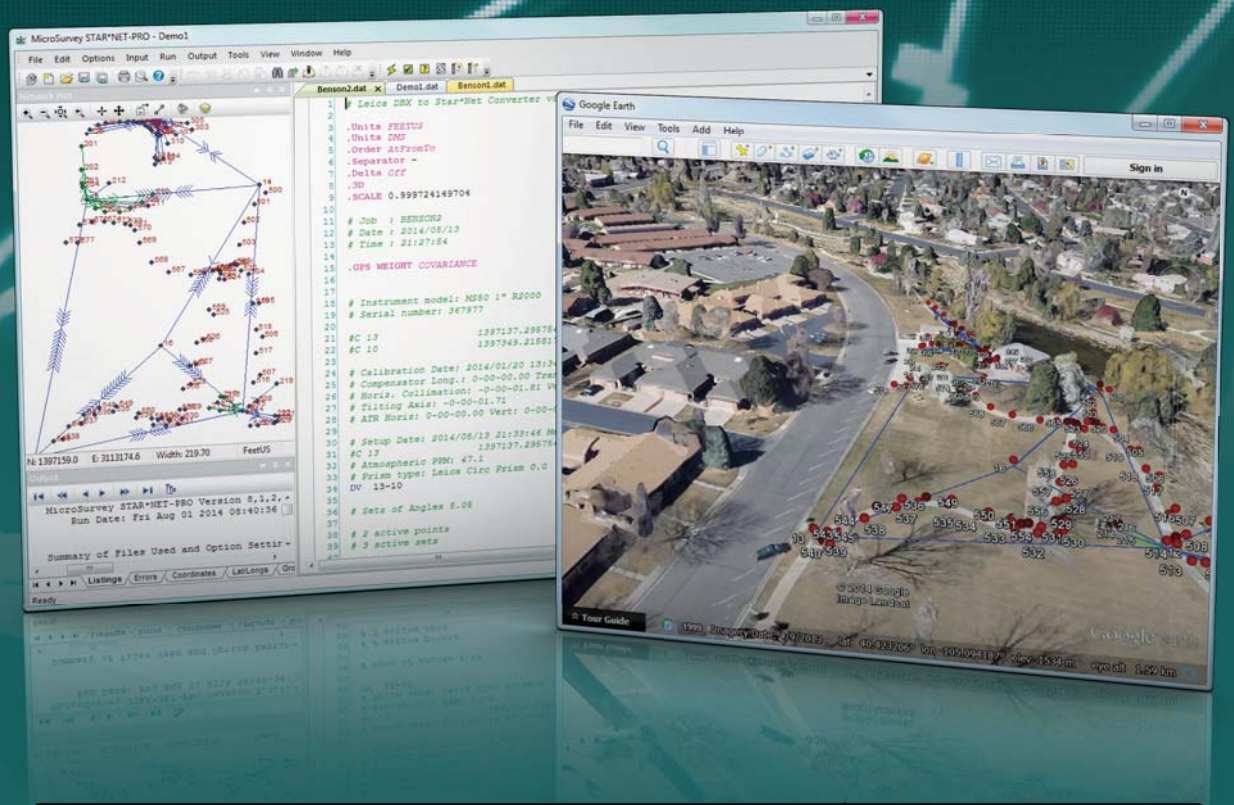

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Conclusions

This paper assessed the impact of a cheap commercial jamming device on the BeiDou signal. The effects were monitored by examining the C/N_0 values and the obtained position solution. The results were compared to the corresponding results obtained using GPS. The impact of the jammer was significant on GPS, as was known from previous research, but surprisingly it deteriorated the BeiDou performance slightly too. However, the impact was not as drastic as on GPS, the increase of the position errors was in the range of meters, as for GPS there was an increase of hundreds of meters.

A multi-GNSS solution using both GPS and BeiDou interoperable was computed. The position accuracy was worse with respect to GPS only, but much better compared to BeiDou only solution, when no jamming was encountered. However, when the jamming device was turned on, the accuracy was improved with respect to GPS solution, both on the horizontal and vertical components. BeiDou position solution was better on both position components even when jamming device was used due to the specific signal characteristics. The degraded performance of the multi-GNSS solution compared to GPS only, when no jamming was present, was probably a result from the use of all satellites available, and therefore the signals with poor quality deteriorated the solution. Future work consists of implementing the receiver autonomous integrity monitoring (RAIM) algorithms into the software defined receiver, FGI-GSRx. Using RAIM the best combination of satellites, regarding the quality of signals and geometry, could be selected for use and therefore a much better position accuracy obtained.

Acknowledgements

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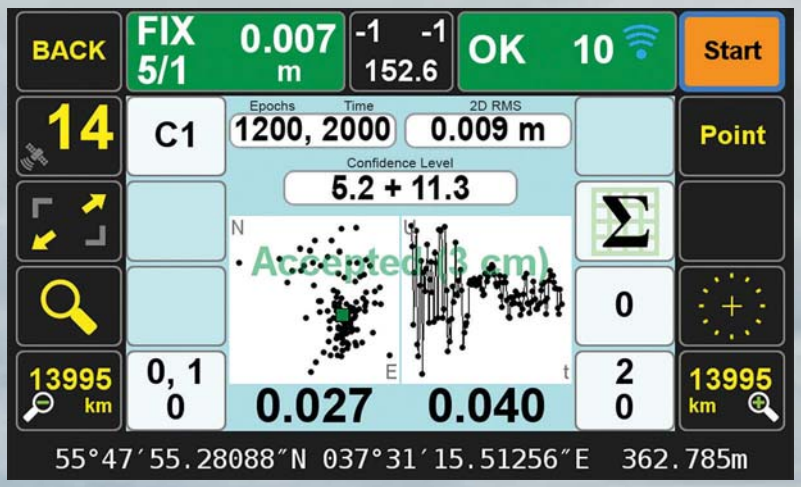

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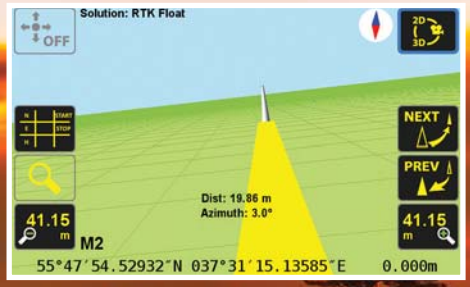

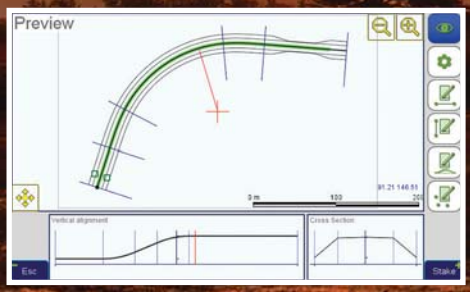

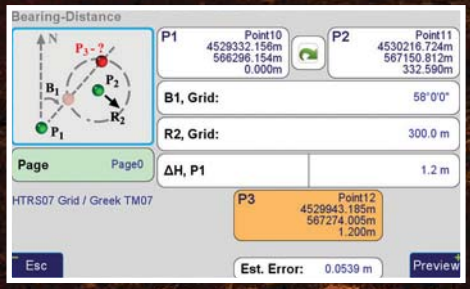

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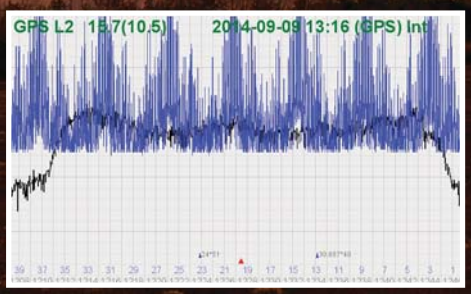
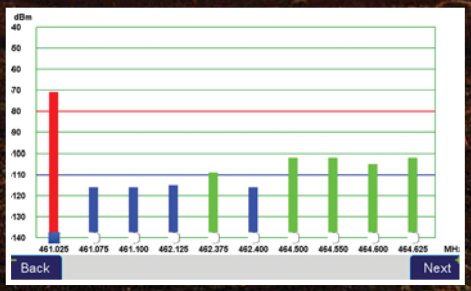
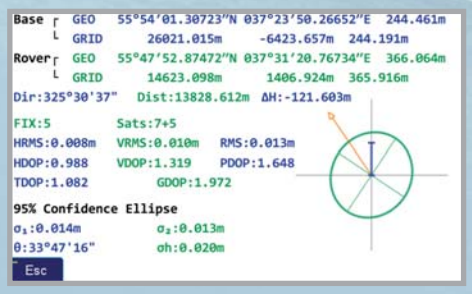


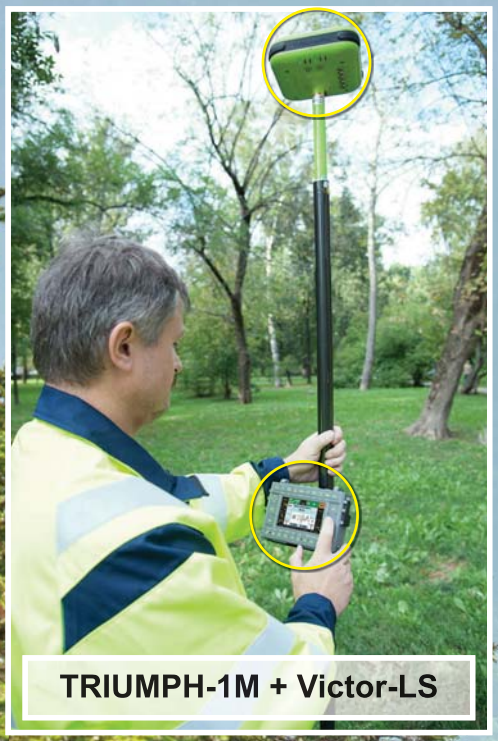


Victor-LS

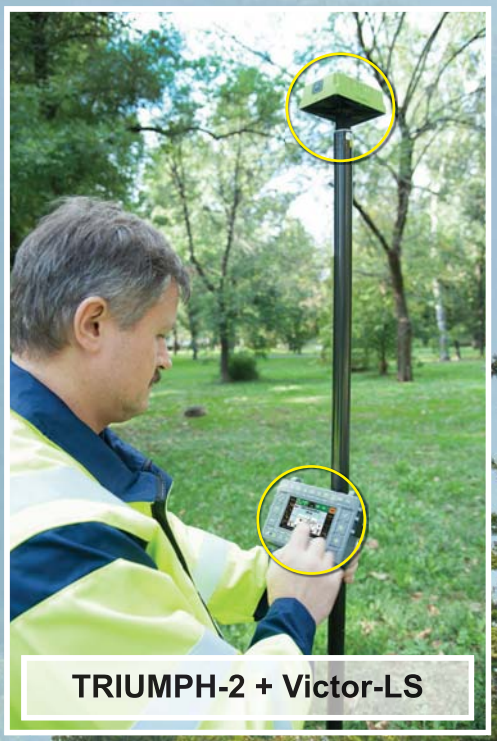
The Rugged Field Controller

Victor-LS is a rugged field controller. It runs J-Field and can be used with TRIUMPH-1 and TRIUMPH-2.





TRIUMPH-1M + Victor-LS



TRIUMPH-2 + Victor-LS

OMEGA

Rugged GNSS Unit

OMEGA + Victor-LS + GrAnt

OMEGA is the most advanced GNSS receiver. It does not include integrated antenna and controller. It is suited for applications like **machine control** and in **marine** and **avionics** applications.

Adding GrAnt and Victor-LS makes a complete RTK system.

It is well suited for **monitoring and network stations**.

TRIUMPH-2

Scalable GPS

Static → GLONASS → RTK Base → RTK Rover

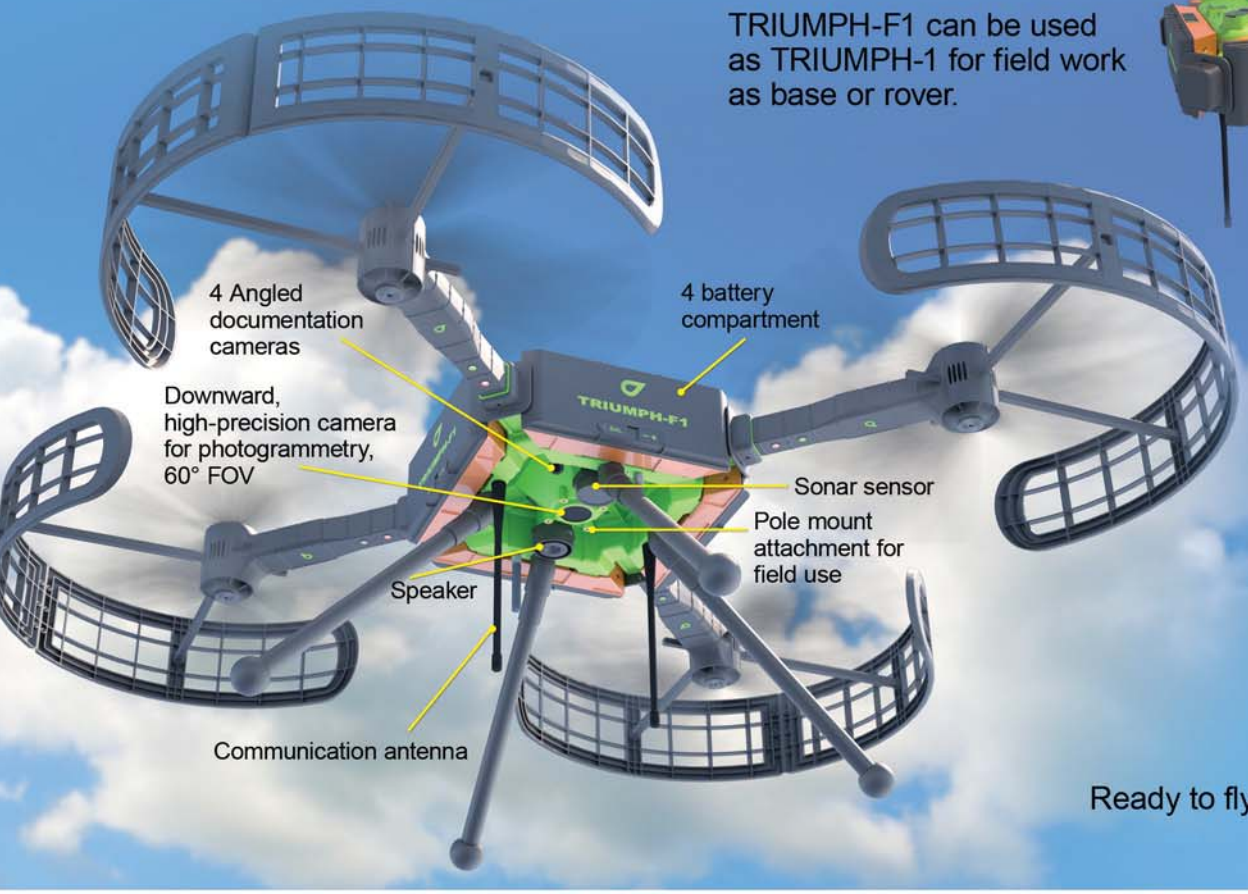
TRIUMPH-2 tracks GPS L1/L2,
GLONASS L1/L2 and Galileo L1.

TRIUMPH-2 + Victor-LS

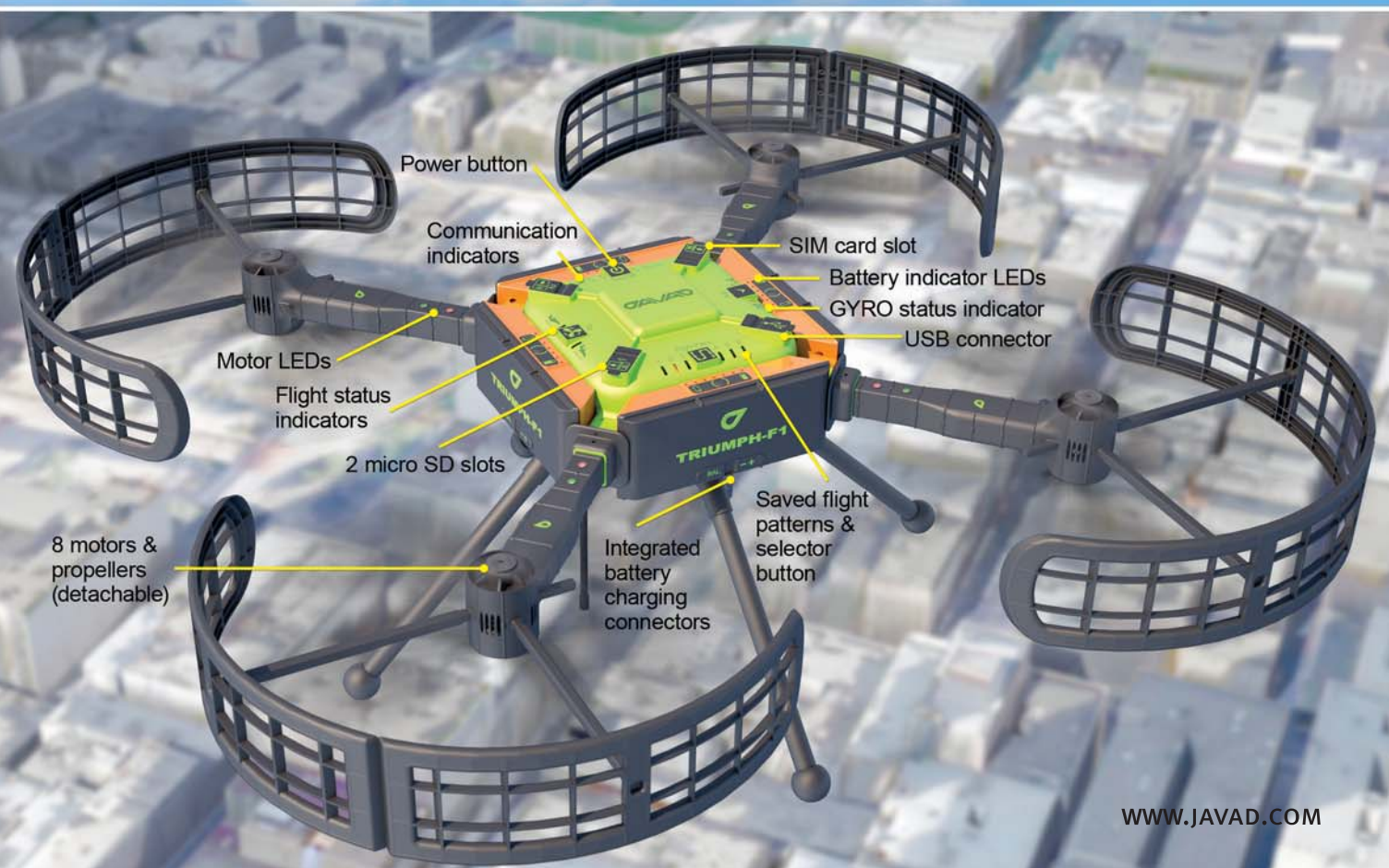
TRIUMPH-F1

864 Channels, All GNSS Signals, Bluetooth, WiFi, UHF, GSM, Spread Spectrum

TRIUMPH-F1 can be used as TRIUMPH-1 for field work as base or rover.



Ready to fly in Q1 2015.



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Our influence on sea level is negligible

IPCC (1990-2013) has adopted an often alarmist stance on the climate question, favouring extreme predictions both of future temperature change and of the consequences of global warming, especially sea-level rise

Christopher Monckton of Brenchley
Director, Monckton Enterprises Ltd, Secretary, Scottish Research Society, Edinburgh, Scotland

Sea level rise is the chief pretext for alarm about Man's influence on climate. Agencies such as the Intergovernmental Panel on Climate Change (IPCC, 1990-2013) have adopted an often unscientifically alarmist stance on the climate question, favouring extreme predictions both of future temperature change and of the consequences of global warming, especially sea-level rise. Those predictions have proven exaggerated.

In October 2005, for instance, a United Nations University press release said: "Amid predictions that by 2010 the world will need to cope with as many as 50 million people escaping the effects of creeping environmental deterioration, United Nations University experts say the international community urgently needs to define, recognize and extend support to this new category of 'refugee'. … Such problems as sea-level rise, expanding deserts and catastrophic weather-induced flooding have already contributed to large permanent migrations and could eventually displace hundreds of millions."

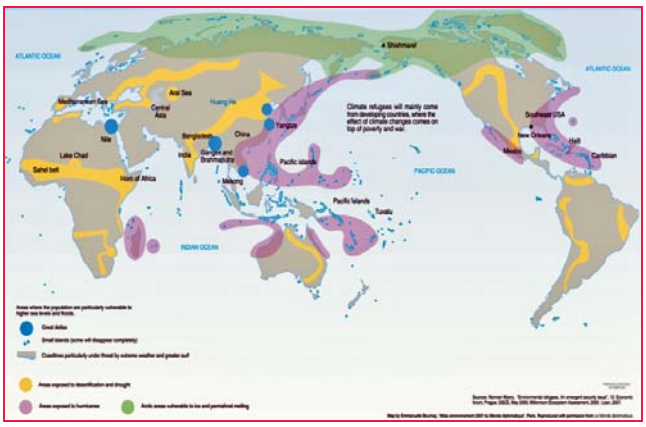

Figure 1: Graph accompanying a prediction of 50 million climate refugees by 2010, some of them from sea-level rise. One of the legends reads: "Small islands (some will disappear completely)". Sources: Myers (2005); Bournay (2007).

Earlier that year the Organization for Security and Co-operation in Europe had published a report by Professor Norman Myers, an environmentalist campaigner at Oxford University (Myers, 2005), predicting 50 million "climate refugees" by 2010. In 2007 the report was reproduced in the annual environmental atlas published by *Le Monde Diplomatique (*Bournay, 2007), with a map (Figure 1) that found its way on to the website of the UN Environment Program, one of the IPCC's two sponsors.

In 2008 Srgjan Kerim, then president of the UN General Assembly, predicted 50-200 million environmental migrants by 2010. When this forecast failed (population increased in many of the areas said to be under climate stress), UNEP removed the map from its website. The same year James Hansen, the now-retired head of NASA's Goddard Institute for Space Studies, told *The Guardian*, a UK newspaper, that sea level would rise by 75 m (almost 250 feet) as a result of manmade global warming (Hansen, 2008):

"If you leave us at 450ppm for long enough it will probably melt all the ice - that's a sea rise of 75 metres. What we have found is that the target we have all been aiming for is a disaster - a guaranteed disaster."

Fortunately, science has now dismissed such extreme projections as mere rodomontade. For the sole mechanism by which the activities of Man might in theory raise sea level significantly is CO2-driven global warming. CO2 now occupies just 1/10,000 more of the atmosphere than in 1750.

Every month the index of global temperature change, based on the RSS satellite global lower-troposphere temperature-anomaly dataset, shows the longest period ending in the present showing a zero the least-squares linear-regression trend. The latest index

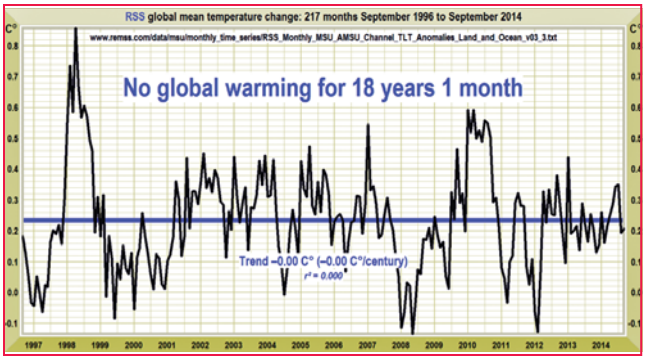

Figure 2: RSS monthly global mean lower-troposphere temperature anomalies (dark blue) and trend (thick bright blue line), September 1996 to September 2014.

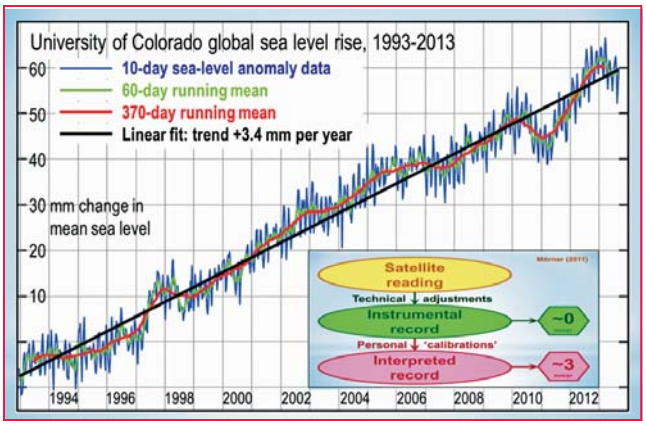

Figure 3: Altimetric sea-level rise measured by the Jason/Topex/Poseidon satellites, 1993–2013, showing sea level rising at a rate equivalent to 1 m per 300 years (Colorado University, 2014). Inset: how raw satellite readings, which show no sea-level rise, come to show 3 mm/year sea-level rise via "personal calibrations" of the data (Mörner, 2014).

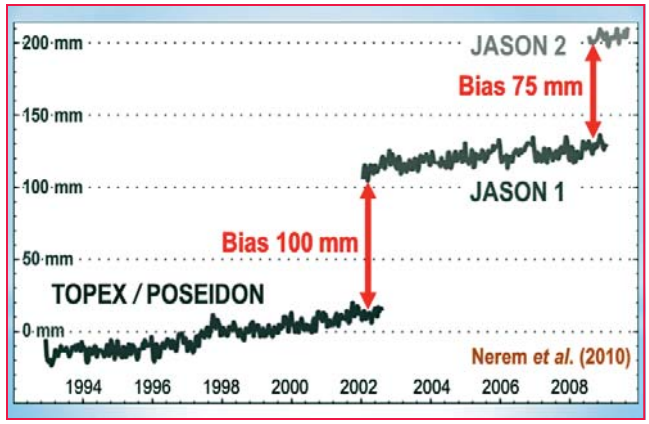

Figure 4: Intercalibration biases between the Topex/Poseidon, Jason 1, and Jason 2 laser-altimetry sea-level monitoring satellites substantially exceed the sea-level rise they purport to have measured. Source: Nerem et al. (2010).

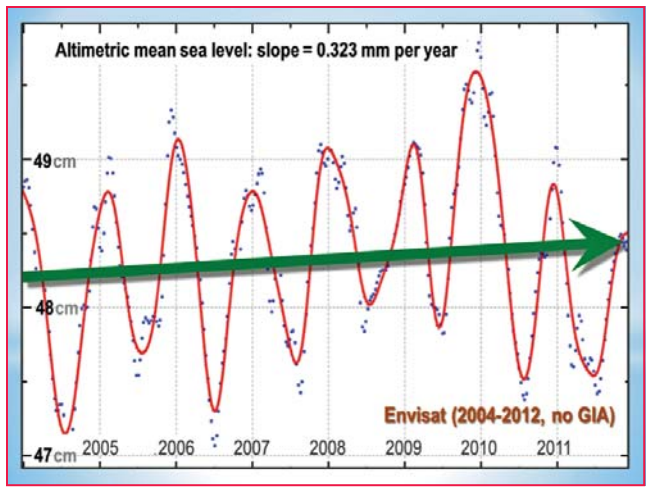

Figure 5: The Aviso ENVISAT satellite, before applying glacial isostatic adjustment, showed sea level rising at a rate equivalent to 3.2 cm/century from 2004–2012.

(Monckton of Brenchley, 2014) shows no warming during the 18 years 1 month September 1996 to September 2014 – more than half the satellite record.

The mean of the GISS, HadCRUT4, NCDC, RSS and UAH global-temperature datasets shows no warming for 13 years. Accordingly, any sea-level rise that may have occurred over the past decade or so is unlikely to have been much influenced by our greenhouse-gas emissions. Since there has been no global warming this millennium, any sea-level rise since 2000 must have been caused either by some natural factor (such as increased activity among the 3.5 million subsea volcanoes most of which have never been visited or monitored) or by what Professor Niklas Mörner, the world's pre-eminent sea-level expert, has described as "personal calibrations" by the record-keepers (Mörner, 2011). Professor Mörner has contributed almost 600 papers to the scientific literature in a professorial career spanning almost half a century. It is arguable that the "personal calibrations" that he describes are the chief cause both of uncertainty in the sea-level data and of apparent sea-level rise itself.

The "official" sea-level record (Colorado University, 2014) is based on altimetry from the Jason/Topex/Poseidon satellite series. It purports to show a sea-level rise of 3.4 mm/year, or approximately 1 ft/century (Figure 3). This rate of increase, stable throughout the period of satellite monitoring since 1993, is less alarming than the Myers and Hansen predictions. The "official" published rate of current sea-level rise, though it is well below the headline-grabbing extreme projections that have been made, may itself be an exaggeration. For tide gauges show sea level as having risen in recent decades at a rate of about 1.7 mm/year or 1 m in 600 years. That is half the satellite value. That lower rate shows no increase since 1900.

Furthermore, the (inevitably upward) intercalibration biases between the Topex/Poseidon, Jason 1 and Jason 2 laser-altimetry sea-level monitoring satellites, at 175 mm, exceed twice the total sea-level rise the satellites have purported to measure.

Two important independent satellite data series confirm the tide-gauge

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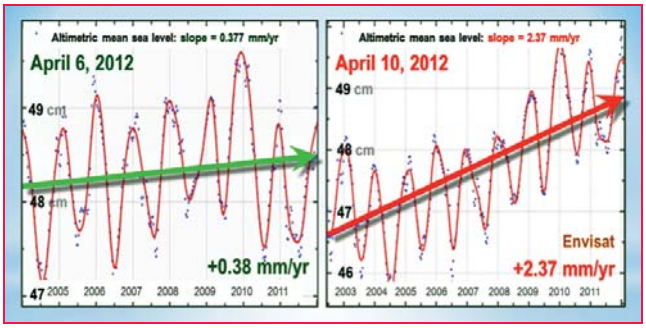

Figure 6: In four days, the rate of sea-level rise reported from the Envisat satellite jumped from 0.38 mm/year to 2.47 mm/year, after various adjustments were made.

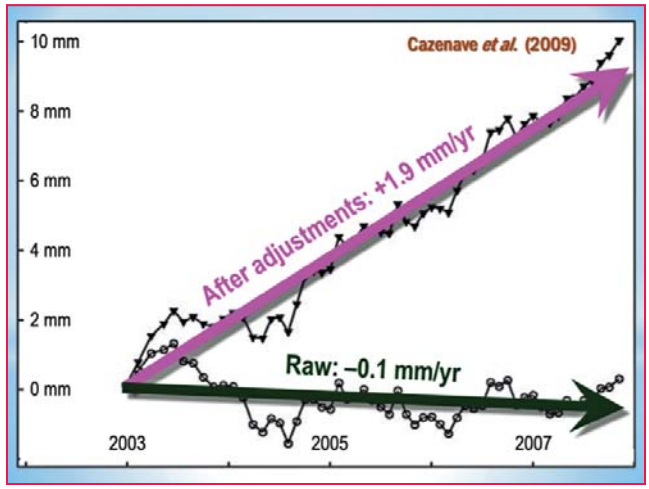

Figure 7: From 2003–2008, the GRACE gravitational-recovery satellites showed sea level falling by 0.1 mm/year. However, after "glacial isostatic adjustment" and other "personal calibrations", sea level was made to rise by 1.9 mm/year. Source: Cazenave et al. (2009).

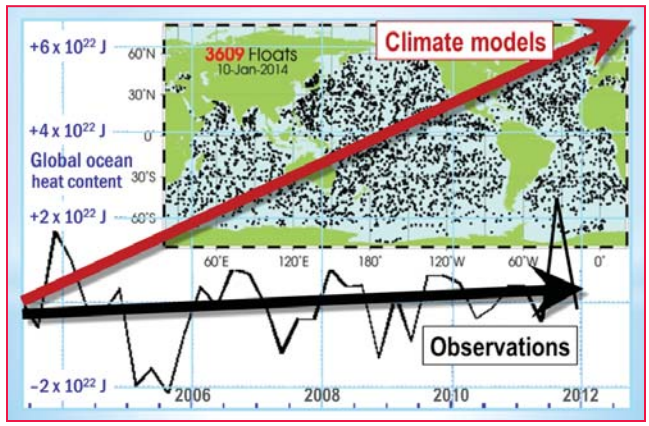

Figure 8: Observations (ARGO network) against modeled predictions (graph by Dr David Evans, pers. comm.). Inset: distribution of the ARGO bathythermographs.

results and disagree with the "official" satellite series. First, unadjusted data from the Aviso ENVISAT satellite, a $3.5 bn flagship EU project which operated from 2004 till it inexplicably failed in April 2012, showed sea level rising at a rate equivalent to only 3.2 cm (1.3 inches) per century (Figure 5).

However, the ENVISAT record, like those of all other satellites, was subjected to (inevitably upward) revision arising from "personal calibrations" calculated to bring the data more closely into line with the "official" sea-level record (Figure 6).

Secondly, the GRACE gravitational-anomaly satellites, perhaps the most accurate method of measuring sea-level change, also show little warming since 2001. However, again there were (inevitably upward) adjustments, this time to incorporate a "glacial isostatic adjustment" for the continuing slow rebound of the great land masses after the last Ice Age (Figure 7).

Even after "personal calibrations", the rate of sea-level rise shown by the GRACE satellites accords with the tide-gauges but not with the "official" sea-level record.

Systemic sea-level rise is driven by melting land ice and thermosteric expansion. However, satellite altimetry shows that the volume of land-based ice in Antarctica has changed little in 35 years, for there has been little warming there, and that the Greenland ice mass increased substantially from 1993-2004 (Johannessen *et al.*, 2005) and declined somewhat thereafter.

Thermosteric expansion only occurs if the ocean warms. However, the 3500 automated ARGO bathythermograph buoys deployed throughout the world's oceans show little increase in the heat content of the global ocean – one-sixth of what had been predicted (Figure 8).

Furthermore, the failure of the atmosphere to warm this millennium is a powerful indication that the ocean to which it is coupled, three orders of magnitude denser, cannot have warmed appreciably: for if the ocean had warmed the atmosphere must have warmed too.

One frequently-publicized explanation for the near-total yet near-totally unpredicted absence of global warming recently is that the coupled ocean-atmosphere system has continued to accumulate heat as models had predicted, but that recently the ocean has removed the heat from the atmosphere by the ocean. Since globally the near-surface strata show far less warming than predicted, it is hypothesized that the "missing heat" has traveled to the little-measured benthic strata below 2000 m, whence it may emerge one day.

The ocean "missing heat" theory is chiefly advocated by a single group in the United States (Meehl *et al.*, 2011; Balmaseda *et al.*, 2013; Trenberth *et al.*, 2014a), who say that during periods without global warming the ocean above 300 m takes up significantly less heat, whereas the ocean below 300 m takes up significantly more, compared with periods when warming is occurring, and that more than nine-tenths of any overall "thermal imbalance" in the climate is expressed in a rise in ocean heat content. On this theory, global warming has not stopped: it is continuing, but not in the atmosphere. Instead, it is harmlessly accumulating in the deep ocean, from which it may one day re-emerge, somewhat in defiance of the laws of thermodynamics, which prohibit the

transfer of heat from a colder body to a warmer body with which it is in contact.

To date, however, no empirical, theoretical or numerical method has plausibly specified a mechanism to explain either how the heat generated by anthropogenic greenhouse-gas enrichment of the atmosphere has reached the deep ocean without much altering the heat content of the intervening near-surface strata or how the heat from the bottom of the ocean may re-emerge to perturb the near-surface climate conditions relevant to land-based life.

Most ocean models erforming coupled general-circulation sensitivity analyses cannot resolve most of the physical processes for capturing heat uptake by the deep ocean. Ultimately, the second law of thermodynamics requires that any heat accumulated in the deep ocean will dissipate slowly and harmlessly by diffusion. It is not plausible that any heat taken up by the deep ocean will suddenly warm the upper ocean and, via the upper ocean, the atmosphere.

Even if heat were reaching the benthic strata without warming the near-surface strata on the way, the transient near-surface response has proven insensitive to rising atmospheric CO2.

The mean depth of the global ocean is 3700 m. Wunsch & Heimbach (2014), implicitly questioning the "missing heat" group's assertions, say the resolution of samples at various depths and the length of the record are insufficient either to permit reliable measurement of ocean heat content or monitoring of oceanic radiative fluxes:

"About 52% of the ocean lies below 2000 m and about 18% below 3600 m. By defining a volume as having been 'probed' if at least one CTD station existed within a roughly 60 x 60 km^2 box in the interval 1992-2011 … [a] bout 1/3 (11% of total volume) of water below 2000 m was sampled … Of the [region] lying below 3600 m, about 17% was measured. … [M]any papers assume no significant changes take place in the deep ocean over the historical period … "The history of exploration suggests, however, that blank places on the map have either been assumed to be without any interesting features and dropped from further discussion, or at the other extreme, filled with 'dragons' invoked to explain strange reports' [de Jode, 1578]. …"

Furthermore, almost all current analyses of ocean heat content and budget lack an accurate accounting of spatial, temporal and other systematic errors and uncertainties (Cheng & Zhu, 2014; Cheng *et al.*, 2014ab).

The suggestion that sea-level-rise-inducing heat accumulation in the deep ocean explains the standstill in global warming is far from accepted. Many competing and often mutually exclusive explanations, chiefly involving near-surface phenomena, are offered: (1) coverage-induced cool bias in recent years (Cowtan & Way, 2014), rebutted by Fyfe *et al.*, (2013) and, with respect to Arctic coverage, by Chung *et al.* (2013); (2) anthropogenic aerosols from coal-burning (Kaufmann *et al.*, 2011), rebutted by Kühn *et al.* (2013) and Neely *et al.* (2013); (3) decline in the warming caused by black-carbon absorption (Neely *et al.*, 2013); (4) emission of aerosol particulates by volcanic eruptions (Santer *et al.*, 2014), rebutted by Heywood *et al. (*2014); (5) reduced solar activity (Stauning, 2014); (6) effectiveness of the Montreal Protocol in controlling emissions of chlorofluorocarbons (Estrada *et al.*, 2013); (7) a lower-than-predicted increase in methane concentration (Estrada *et al.*, 2013); (8) a decrease in stratospheric water vapor concentration (Solomon *et al.*, 2010); (9) strengthened Pacific trade winds (England *et al.*, 2014) (previously, Vecchi *et al.*, 2006, had attributed weaker Pacific trade winds to anthropogenic global warming); (10) stadium waves in tropical Pacific circulation (Glaze *et al.*, 2013); (11) coincidence (Schmidt *et al.*, 2014); (12) aerosol particulates from pine-trees Ehn *et al.*, 2014); (13) natural variability (Watanabe *et al.*, 2014; Lovejoy, 2014); (14) cooler night-time temperatures in the Northern Hemisphere (Sillmann *et al.*, 2014); (15) predictions by those models that allowed for the possibility of a pause in global warming Risbey *et al.*, 2014; Guemas *et al.*, 2013); (16) the negative phase of the Pacific Decadal Oscillation (Maher *et al.*, 2014; Trenberth *et al.*, 2014b; Dong & Zhou, 2014); (17) the Atlantic meridional overturning circulation (Schleussner *et al.*, 2014); (18) global dimming following the global brightening of 1983-2001 (Rahimzadeh *et al.*, 2014); (19) relative frequencies of distinct el Niño types (Banholzer & Donner, 2014); (20) surface cooling in the equatorial Pacific (Kosaka & Xie, 2013); (21) Pacific cooling amplified by Atlantic warming (McGregor *et al.*, 2014); (22) a combination of factors, including ENSO variability, solar decline and stratospheric aerosols (Huber & Knutti, 2014); (23) underestimated anthropogenic aerosol forcing (Hansen *et al.*, 2011); (24) a new form of multidecadal variability distinct from but related to the ocean oscillations (Maclas *et al.*, 2014); and (25) failure to initialize most models in order to conform with observation, particularly of oceanic conditions (Meehl & Teng, 2014).

Given the conflicting testimony as to the explanation for the long and unpredicted hiatus in global warming, it is impossible either to assign a single cause to the pause or to assume that the missing heat is in the deep ocean and will thus raise sea level at the high rates predicted by IPCC (2013).

Conclusion

On the evidence, global temperature has not risen at all this millennium, so that there is no reason to expect any sea-level rise above the established, small and harmless long-term rate. It is difficult to discern any manmade contribution to sea-level rise in the raw data. Only in the "official" record, and then only after "personal calibrations", does faster sea-level rise appear, and only then at the moment of the changeover from tide-gauge to satellite-altimetry measurement in 1993. The acceleration may well be a mere artefact of the altered method of measurement. The notion that the absence of global warming this millennium is attributable to the accumulation of heat in the ocean is not demonstrable by sufficiently-resolved measurements and is

in any event hotly contested in the climate journals. It is likely that sea level will rise over the coming century or two at a rate no greater than the 1 m per 600 years observed by tide-gauges since 1900. That rate is slow enough to allow ready and inexpensive adaptation almost everywhere.

Lord Monckton was an expert reviewer for the IPCC's Fifth Assessment Report (2013), and contributes papers on climate sensitivity and climate economics to the learned and specialist journals.

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Integrated infrastructural design and management using BIM and GIS

A protocol should be developed that a GIS specialist is to be associated with any infrastructure apart from engineers

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Saudi Arabia is a land of rush infrastructure development. Billions are spent in construction of huge projects like smart cities, universities, etc. The activities and facilities include intricate tasks in all levels of their life cycle. The money is spent in improving quality of these activities and facilities, and their safe execution. But in reality, the resources are exploited. These resources are valuable and must be allocated efficiently and not wasted. In construction industry, the money spent for the waste created is more than 50%, and when compared to the manufacturing industry, it is only 26% [1]. Figure 1 illustrates this fact. Another fact is that there has been no productivity gain in the construction industry over the last 40 years (Figure 2) [2].

The foremost element to be offended is the current method of drawings created as just 2D, since the current construction practice relies upon drawings. Softwares like AutoCAD, Microstation are used for creating 2D images of the construction features. Using this rough design, the process of bidding becomes a major problem. The models created will not give detailed information of the features in a short time since they do not have the database - the repository of data. These concerns will lead to cost overruns, stays, aversion and errors. Also all the work is tedious too. The alternative to this method is GIS and BIM.

Present Scenario

The deployment of GIS in Saudi Arabia is expected to rise rapidly in the coming years. Construction boom is occurring daily, and the prime encounter is managing the information about

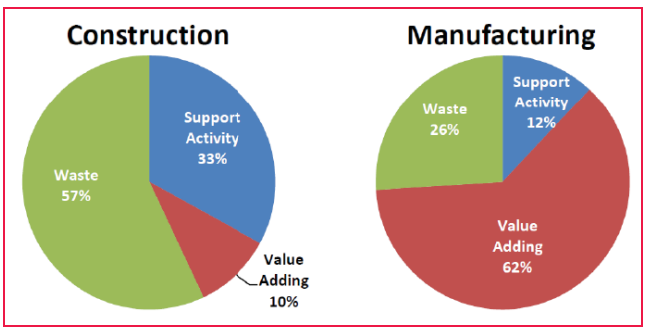


Figure 1: Sector diagram comparing the percentage money wasted for construction and manufacturing (Source: Eastman et al, BIM Handbook, John Wiley and Sons, 2009)

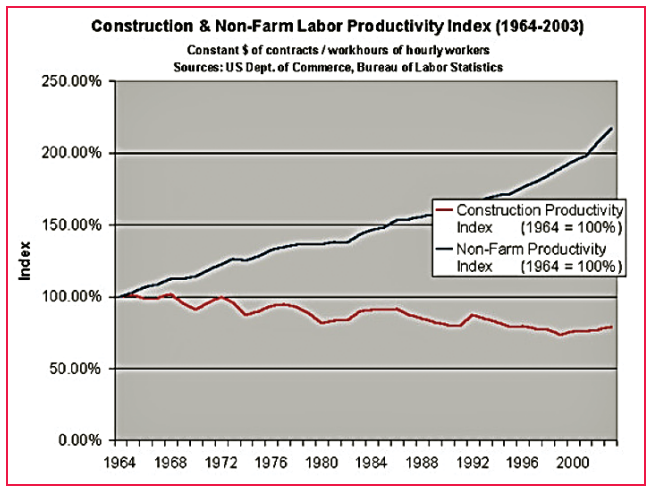


Figure 2: Labor productivity index for US construction industry and all non-farm industries from 1964 through 2003 (Source: Researchby Paul Teicholz at CIFE)

improving infrastructure. We suggest that the application must be proliferated for infrastructure development. The current demand of the construction industry requires a highly efficient project management team with accurate planning, scheduling and management of resources of a project which can lead to the successful completion of specific project goals and objectives. The primary challenge of project management is to achieve all the project goals and objectives while adhering to classic project constraints, usually scope, quality, time and budget. The secondary and more ambitious challenge is to optimize the allocation and integration of inputs necessary to meet pre-defined objectives. A project is a carefully defined set of activities that use resources (money, people, materials, energy, space, provisions, communication, motivation, etc.) to achieve project goals and objectives [3].

The traditional approach for scheduling and progress monitoring techniques like Bar Charts, Critical Path Method (CPM), Programme Evaluation Review Techniques (PERT), etc., are still being used by the project managers for planning. This primarily affects the decision-making purpose as they fail to provide the necessary spatial aspects and data [4]. The project manager will be overburdened by the immediate requirements of the client to shorten the delivery period. and minimize the cost without compromising on the quality and efficiency of the product. All these problems can be solved by integrating GIS with the current methods of project management. Researchers have suggested that project managers can use 4D methods and simulation for effective resource allocation [4]. Even 5D methods are being developed now. Bansal and Pal have described the linking of the activities in a critical path schedule with the 3 dimensional model, which makes the project sequence easier to understand. Some commercial tools allow the planner to build a 4D model and create the graphical simulation, though it still lacks features like generation and manipulation of a 4D model within a single environment [4].

CAD drawings do not provide a consistent document like a database listing of different aspects like bid and contract documents, Bills of Materials (BOMs), timelines, specifications, price lists, installation and maintenance guides, cable lists and labels. Also if documents are available, it will be dozens or hundreds as separate ones. This won't help for proper communication between all stakeholders. And again, the facilities or activities can't be maintained properly.Traditional CAD drawings may reduce certain bidding costs where variation orders may not be communicated between all contractors, but the change orders or errors can't be excluded.

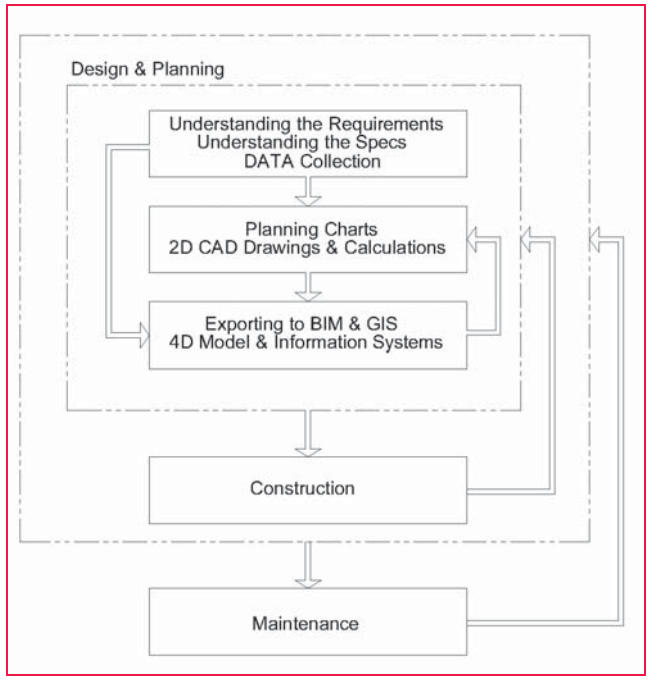


Figure 3: Diagram showing GIS supported BIM Construction Method

BIM with the help of GIS

The innovative approach for construction tracking is by leveraging tools like BIM and GIS. BIM in its present state is commonly used for complex projects like high rise buildings, smart cities, etc. The term is commonly applied for planning, design, construction, and management of buildings; however its capabilities can be extended to challenging and complex civil engineering projects [5].

Competitive Advantages of BIM in a Down Economy

[6] McGraw-Hill Construction research shows that in the face of an economic recession, BIM users expect to significantly ramp up their investment in BIM in 2009. Experienced users are realizing greater productivity, improved communications and a competitive edge when bidding for work. As development opportunities tighten, these users continue to differentiate themselves from those who have yet to adopt the technology, bringing value to clients while improving their bottom line.

Key Findings

- 62% of BIM users will use it on more than 30% of their projects in 2009
- 82% of BIM experts believe that BIM has a positive impact on their company's productivity
- 72% of BIM users say that BIM has had an impact on their internal project processes

Building Information Modeling (BIM) and Geographical Information Systems (GIS) can be used to model an artifact in 3D with time related data stored in fourth dimension, and cost related data stored in fifth dimension. This is accomplished with the help of specific softwares. We have already discussed the present scenario. In the new method, we will prepare a real 3D model supported by a geo-coded information system. Figure 3 below explains how this method is executed in construction projects from its initial design to its maintenance.

This geo-coded information system provides a unique identification number

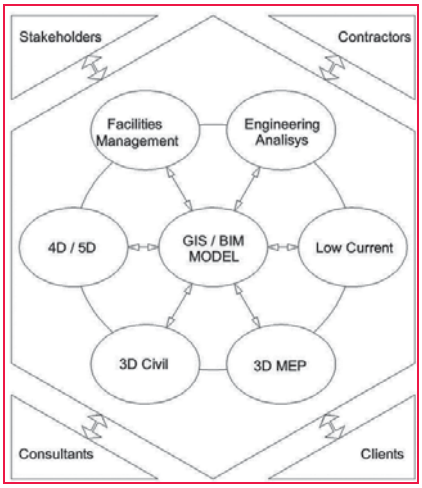


Figure 4: Diagram showing Utility of BIM

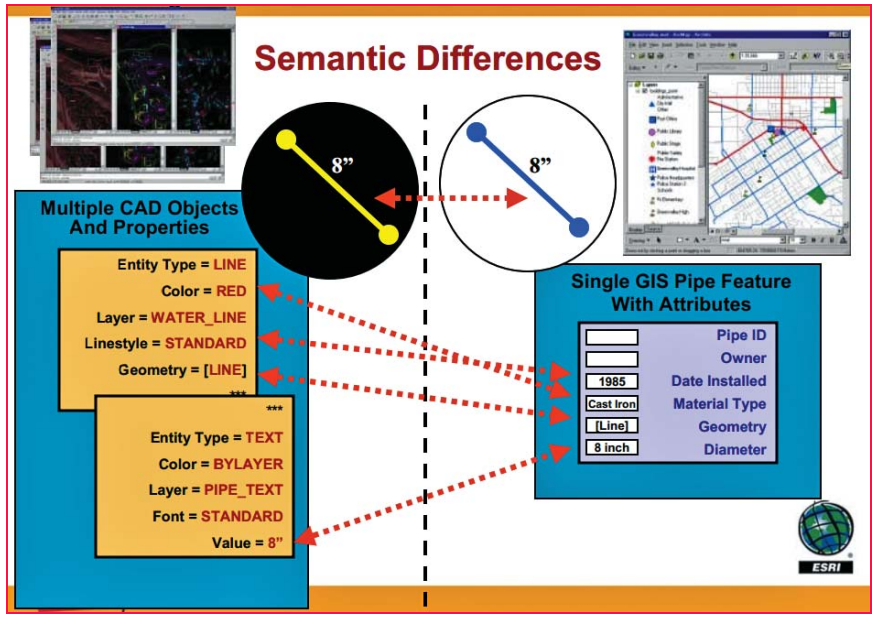


Figure 5: Exchange of attributes of data between CAD and GIS (Source: ESRI)

to each and every artifact of the project. To every artifact we can add spatial and non-spatial data including the five dimensions and attributes like specifications, details, etc. BIM provides explicit information with the aid of a powerful database regarding facilities management, engineering analysis, 3D MEP, 3D Civil, 4D/5D and low current to all stakeholders, contractors, clients and consultants (Figure 4).

Top Benefits of BIM

- Easier coordination of different software and project personnel
- Improved productivity
- Improved communication
- Improved quality control [6]

First of all, we will discuss the interoperability issue arising while shifting from 2D to 3D data. The practical implementation of the above method is explained with the help of a case study. In this, ArcGIS software developed by ESRI is used. The advantages of this approach are explained later along with the challenges in its implementation.

Interoperability

It is imperative that CAD and GIS is to be integrated; but bridging a link between them is more challenging. This is because both deliver evidence of the same real world assets in every level of their lifecycle. The need for an integrated approach is illustrated by applications as plan development and visualization, data collection, Location Based Services (LBS), and Virtual and Augmented Reality (VR & AR) [7]. The inadequacy of interoperability stands as a stumbling block for the integration. This is due to the following facts - existing CAD and GIS platforms have been developed independently with different purposes resulting in significant differences in terms of data formats they support, terminology they used, semantics of concepts they represent, reasoning techniques on which they are based, different scale representations, and transformation of the local (CAD) coordinates into reference system for both horizontal and vertical coordinates, geometry modelling in both systems. CAD software provides all kinds of primitives to create geometric (and their visual attributes). It represents objects with different representations such as CSG and Sweeping. However these primitives are not supported in GIS (e.g. parametric primitives), while geospatial models mainly use BRep as the main geometrical representation method. Furthermore, CAD models usually do not store topologic information which is in fact an important characteristic of geospatial models (i.e., geospatial models use topology to store geometric information in a more efficient manner) [8].

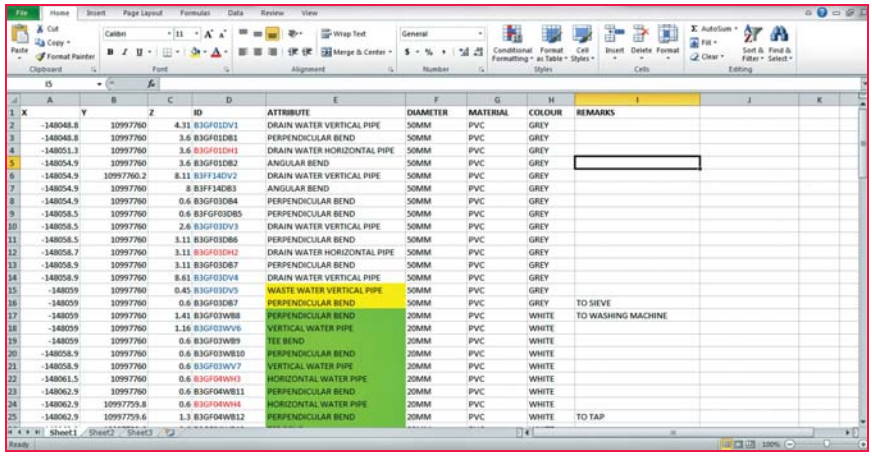
A true solution for an integrated CAD/GIS framework concerns formal and shared semantics and integrated data management. The development of formalized semantics is crucial in achieving the true CAD/GIS integration. First, the semantics of geometry and other information within a domain need to be formalized, that means domain ontology has to be developed. Next, these domain ontologies have to be matched for exchanging meaningful information. This can be realized through an integrated and defined ontology covering the CAD and GIS concepts in one framework [7]. The next step is to create compatible datasets that can serve multiple CAD and GIS purposes. So, a prototype created in one software can be exported to other softwares.

Modern softwares are now compatible with GIS, such that data can be exchanged in both directions in a real time basis. A representative figure (Figure 5) developed by ESRI is shown below which explains how attributes of data is exchanged between CAD and GIS.

Typical tools for the exchange of attributes proposed by ESRI [9] include:

- Cyclical/Bi-Directional Translation
- Direct Read CAD data in GIS
- Direct Read GIS data in CAD
- Legacy CAD to GIS Data Migration

In this way, many softwares for engineering analysis are now compatible with GIS. So, data exchange between analysis software and drafting software can be done in one platform using a single model. This is one of the astonishing benefits of GIS so that real time analysis can be done. For example, power flow analysis software developed by ETAP is capable of importing data from GIS model, and after analyzing, exporting it to the proposed GIS model [10]. As a shared knowledge resource, BIM can reduce the need for re-gathering or re-formatting information. This can result in an increase in the speed and accuracy of transmitted information, reduction of costs associated with a lack of interoperability, automation of checking and analysis, and unprecedented support of operation and maintenance activities [11].



	X	Y	Z	ID	ATTRIBUTE	DIAMETER	MATERIAL	COLOUR	REMARKS
2	-148048.8	10997760	4.31	B3GF01DV1	DRAIN WATER VERTICAL PIPE	50MM	PVC	GREY	
3	-148048.8	10997760	3.6	B3GF01DB1	PERPENDICULAR BEND	50MM	PVC	GREY	
4	-148051.3	10997760	3.6	B3GF01DH1	DRAIN WATER HORIZONTAL PIPE	50MM	PVC	GREY	
5	-148054.9	10997760	3.6	B3GF01DB2	ANGULAR BEND	50MM	PVC	GREY	
6	-148054.9	10997760.2	8.11	B3FF14DV2	DRAIN WATER VERTICAL PIPE	50MM	PVC	GREY	
7	-148054.9	10997760	8	B3FF14DB3	ANGULAR BEND	50MM	PVC	GREY	
8	-148054.9	10997760	0.6	B3GF03DB4	PERPENDICULAR BEND	50MM	PVC	GREY	
9	-148058.5	10997760	0.6	B3GF03DB5	PERPENDICULAR BEND	50MM	PVC	GREY	
10	-148058.5	10997760	2.6	B3GF03DV3	DRAIN WATER VERTICAL PIPE	50MM	PVC	GREY	
11	-148058.5	10997760	3.11	B3GF03DB6	PERPENDICULAR BEND	50MM	PVC	GREY	
12	-148058.7	10997760	3.11	B3GF03DH2	DRAIN WATER HORIZONTAL PIPE	50MM	PVC	GREY	
13	-148058.9	10997760	3.11	B3GF03DB7	PERPENDICULAR BEND	50MM	PVC	GREY	
14	-148058.9	10997760	8.61	B3GF03DV4	DRAIN WATER VERTICAL PIPE	50MM	PVC	GREY	
15	-148059	10997760	0.45	B3GF03DV5	WASTE WATER VERTICAL PIPE	50MM	PVC	GREY	
16	-148059	10997760	0.6	B3GF03DB7	PERPENDICULAR BEND	50MM	PVC	GREY	TO SIEVE
17	-148059	10997760	1.41	B3GF03WB8	PERPENDICULAR BEND	20MM	PVC	WHITE	TO WASHING MACHINE
18	-148059	10997760	1.16	B3GF03WV6	VERTICAL WATER PIPE	20MM	PVC	WHITE	
19	-148059	10997760	0.6	B3GF03WB9	TEE BEND	20MM	PVC	WHITE	
20	-148058.9	10997760	0.6	B3GF03WB10	PERPENDICULAR BEND	20MM	PVC	WHITE	
21	-148058.9	10997760	0.6	B3GF03WV7	VERTICAL WATER PIPE	20MM	PVC	WHITE	
22	-148061.5	10997760	0.6	B3GF04WH3	HORIZONTAL WATER PIPE	20MM	PVC	WHITE	
23	-148062.9	10997760	0.6	B3GF04WB11	PERPENDICULAR BEND	20MM	PVC	WHITE	
24	-148062.9	10997759.8	0.6	B3GF04WH4	HORIZONTAL WATER PIPE	20MM	PVC	WHITE	
25	-148062.9	10997759.6	1.3	B3GF04WB12	PERPENDICULAR BEND	20MM	PVC	WHITE	TO TAP

Figure 6: Database of Plumbing Accessories created in Excel Software

Case Study

In this study, a 3D model and a geo-coded database is created. The model is created of a residential two-storeyed building. The database is created for plumbing accessories. Normally, 3D model is created from 2D drawings created in softwares like AutoCAD. The challenges of interoperability have to be overcome. In this case, since it is a simple structure, using GIS itself the 2D plan is created. ArcGIS of ESRI is used. Over this 2D drawing, the 3D model is generated after creating different layers. ArcMap of ArcGIS is used to create the 2D plan. The 3D views are obtained in ArcScene of ArcGIS. modeling is just one aspect of BIM that has hogged the limelight, but its real strength and power lies in the knowledge database that can be used in conjunction with other software to deliver quick and reliable information in areas of sustainability, estimating, structural analysis, demolition and reconstruction [12]. GIS can be well integrated in those

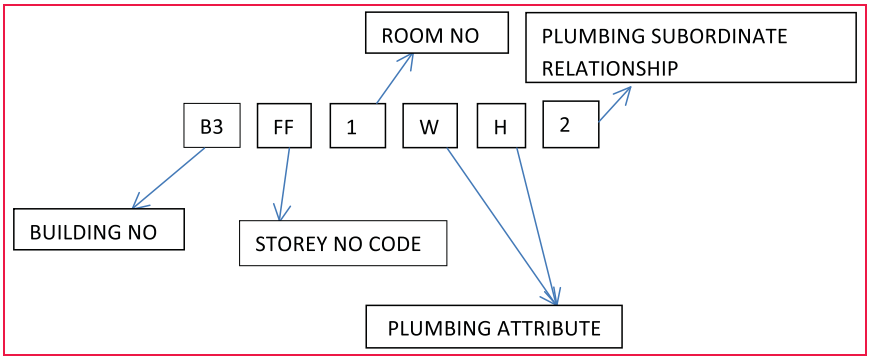


Figure 7: Contents of Plumbing ID

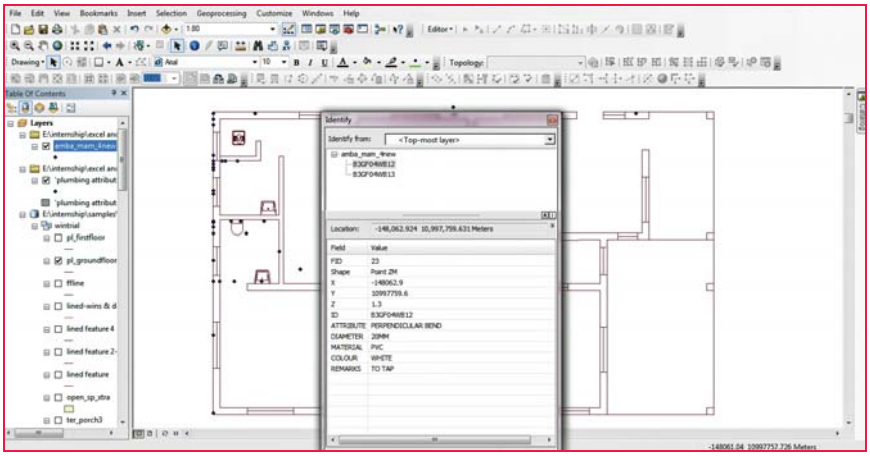


Figure 8: Information of a Plumbing Accessory displayed by clicking on the command "Identify"

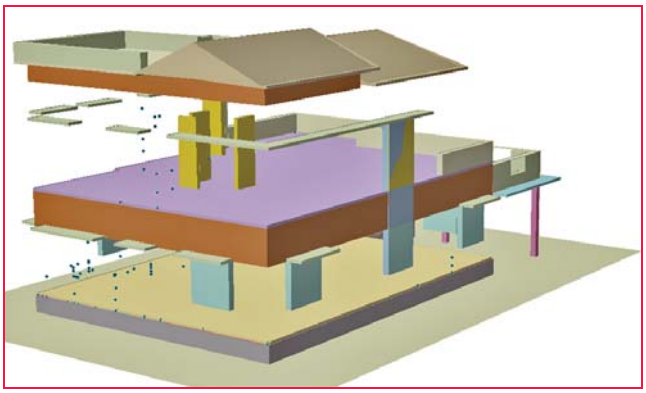


Figure 9: 3D Model of the Residence along with the Points

platforms where there is distributed nature of construction work [13]. Plumbing layouts involve many pipes, bends, joints, etc. Since the plumbing system carries fluid, thorough inspection and care to be maintained throughout its lifecycle. A small leak can lead to heavy damage of the many construction facilities, thereby affecting their lifecycle too. In the study, the position of bends and sanitary items were noted down as points, and the position of pipes in a stretch (vertically and horizontally) were noted down as a set of points. The other fact to be noted down while inspecting is the coordination among individuals who may be unfamiliar with the project or are managing many projects. Information management of activities at the construction site are typically done with construction drawings, daily journals, photographs, and a variety of paperwork associated with testing (i.e., pressure testing). Retrieval of this information is not generally an easy task and can take a considerable amount of time to assemble and manipulate into a presentable format [13].

This study assigned an identification number to the plumbing accessories that identify its position and function. Every component has its own number. This number is created in the database (Figure 6) which is created in Excel software. Since the building can be viewed in 3D and the plumbing accessories as points, this allows us to understand the plumbing layout. Every point will have just one three dimensional value which is obtained according to the origin set for preparing the plan of building. When a component fails, it can be found in the database along with all pertinent information. Since the plumbing accessories can actually be 'seen' in 3D environment, we can easily determine the component's location and information via the number and database. This is helpful in effectively maintaining and managing a plumbing system. At the same time, if we need to know the location of a plumbing accessory, we can use the database to determine it. This reduces search and test time at the site during maintenance [14].

General building plumbing is divided into water supply, drainage stack and sewage stack. Each division becomes a field, listing the attribute of a pipe with the plumbing code making it easy to recognize. Besides shaft plumbing has vertical pipes while most plumbing has a horizontal configuration. This study assigned the code, 'V' with vertical pipes, 'H' with horizontal pipes and 'B' with bends. This GIS database not only can control and understand the subordinate relationships between the pipes, but also their arrangement location [14]. Plumbing attribute is described by 'D' for drainage pipe, 'S' for sewer pipe and 'W' for water pipe.

For example, with regards to component code 'WH22', 'W' represents water pipe, 'H' represents horizontal pipe and the number 22 represents that it is the 22nd horizontal pipe. For this component code framework, one can ascertain location of the pipe. Water distribution and drainage configuration is complicated in buildings since the area is large. It is not enough to describe the component location by just the forward code. This study assigns building codes and spatial codes before the component code. The building is

the third one in a lane, so this study assigned it the code name 'B3'. After the building name code, a four digit code is used to describe the spatial number. For example, the component code for the 22nd horizontal water pipe passing room no 12 in the first floor of the building is 'B3FFWH22' (Figure 7).

Thus for this study, component codes need ten numbers. The front two numbers are the building code. The next two is the storey number. The fifth and sixth numbers indicate room number. The seventh and eighth are attributes of plumbing accessories, and the last two numbers indicate the subordinate relationship of network components. If every component uses this framework it will be easy to recognize.

After creating an ID for different components, the database is set up. In this study, the database has the point coordinates, IDs, attributes, diameters, materials, color and remarks. All the information is saved in an xlsx file format in excel file. This excel file is directly exported to ArcGIS. Thus, a shapefile is created from a series of x, y, z locations in the excel file. Users can easily point to any component (point) using the command 'Identify' and connect and display all of its information (Figure 8) in the ArcMap.

In the 3D environment, the points are viewed as shown in the following figure (Figure 9) in ArcScene, where the model can be rotated, moved and zoomed.

When the structure is built, the follow up service and maintenance can be done by just taking photographs of the plumbing accessories and loading it in the same database.

Traditional shop diagrams are limited by the size of the paper on which it is drawn. However, GIS can connect files and information so that it is not as limited as paper. The plumbing illustrated by GIS can also benefit the community by providing complete configuration information for local plumbing systems [14].

Advantages

Here we are trying to emphasize that GIS benefits can be well enjoyed by clients, contractors, consultants and stakeholders dealing with a project from its initial planning to its implementation and to its scrap value. By implementing GIS in the construction field, all disciplines are profited in the areas of planning, designing, implementation, facilities management and maintenance. Obviously, 3D data is more beneficial for everyone compared to 2D data. 4D and 5D models can be created in GIS by incorporating time and cost constraints. This aids complete optimization. Utilizing GIS increases the coordination among various disciplines involved in construction and also communication. This avoids the inter-disciplinary/contractor or related time delay and disputes [15]. This is a transition from tedious 2D works to a highly co-ordinated 3D model supported by a geo-coded database. As GIS provides the updated model, an expert team can observe it even from a remote area. The other aspect is that the spatial and non-spatial data can be used to make representations which are easily understood by any sector of people (not specifically engineers).The complexity of construction is increasing day by day such that enormous data is to be dealt with. This can be done effortlessly with the geo-coded database. As multi-dimensional updated data is available, as per requirement activities they can be scheduled. Thus, GIS aids facilitation management and supply chain management [16]. For large scale buildings, the required supply of material may be ignorant at a particular point of time. Nobody knows where the material is. Speculations will lead to wastage of time. By just looking at the database and viewing in 3D, everything becomes evident. Time is saved. Rundell (2006) suggested that owners and operators can mitigate their portion of the cost by using the high-quality building information from a Building Information Modelling (BIM) design process during the longer, more expensive maintenance and operation phase of the building's lifecycle. A good example is that BIM may allow asset managers to enter the decision-making process at a much earlier stage, where they can influence the design and construction [17].

In the construction field, most of the work may be under sub-contract. The method of GIS and BIM can increase better understanding, coordination and communication between sub-contractors. This leads to saving more money and time, and quality improvement. As the responsibility is laid down for each sub-contractor, the client can authorize the faults exactly of the victim. Suddenly if an organization terminates their operations, the database of GIS will aid the new organization to comprehend the history of operations with complete details. The new firm can do the instant bidding too. For a newcomer to a firm, he himself can grasp the project effortlessly with the aid of a 3D model and database of this model. If it was just 2D and devoid of a database, it would have been time consuming. The concept will be fruitful in countries where the people working in such construction sites alternately changes. If a high level meeting is underway and sudden analysis and further decision is to be taken, GIS database comes to the rescue. The 3D perception gives more information too. As drawing developed by this method is much more informative than 2D, because each and every aspect of the construction is recorded in the database. Normally, the head office of a company may be situated far from their construction site. This method aids in better understandability between head office and site. Changes or variations or client specific instructions are inevitable in any project. But the fact is that client or consultant may not be in a position to accept the fact when it comes to money matters, or they might reject it citing concurrent delays from the contractor. In many case, contractors are also facing difficulties in providing proper back up documents. As a result of this, huge correspondence is going back and forth between contractor and consultant or client without any fruitful result [18]. At the design stage itself variation order management is to be done. Change management can be efficiently tracked by this method which provides the full back-up documents.

Nowadays, as people have become familiar with GPS-enhanced equipments, the project management team can exploit this

situation to the fullest. As GIS is capable of interlinking with different parameters like climatic conditions, global warming, water data, etc., the design team can utilize this on real time basis. According to building SMART Australasia, concerted government support for the use of BIM by the notoriously fragmented Buildings Network could increase usage by 2025 by six to sixteen percent according to conservative estimates from industry representatives. This accelerated rate of BIM adoption would produce an economic benefit equivalent to $5 billion added to Australia's GDP [19].

Challenges of BIM

- Adequate training
- Senior management buy-in
- Cost of software
- Cost of required hardwareupgrades [6]

In order to implement this method adequate training is required. Designing becomes much more complicated and time consuming. Purchasing software and hardware is a must. The manager may not be ready to cope up with the new method of implementation as they have to shift from their current practice. As with any new technology, the cost of software and required hardware upgrades are common hurdles. Clearly, the major concern for implementing the method is money and training. For small projects, this may not be a profitable business.

Conclusions

BIM and GIS are significant uprisings in the construction industries. According to building SMART Australasia [19], BIM and GIS should coexist and harmonize. With increased profitability, reduced professional risk, less waste, less rework,better time management, improved communication and improved efficiency, the construction firms can use BIM and GIS to create new revenue streams and add to profitability. [6] Research shows that users see clear benefits of BIM and they respond by deepening their use of the technology. At a time when the overall development market is tightening, these users are looking for BIM to help them gain a competitive advantage. The government should try to implement BIM supported by GIS in all big projects in an immediate basis to save billions of riyals and bringing the work force to cope with new technology.

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GIS survey finds councils would benefit from GIS

1Spatial Group, Australia has released the results of a survey of Australian local government organisations' use of geospatial data. Key findings include:

52% of the 29 NSW councils surveyed spend most of their time performing manual processes when working with or managing geospatial data;

- Staff and skills limitations (48% of councils) and/or budget constraints (48%) are the most common factors preventing councils from doing more with GIS systems or maps to provide more map-based solutions to their staff and to the public;
- 38% also say data quality levels mean geospatial data is not currently fit for providing more map-based solutions and 28% have no clear GIS/mapping strategy to guide future geospatial objectives;
- 76% say they would benefit from in-field mobile/table data capture/editing of geospatial data and 66% from data quality validation/improvement; and
- 69% of councils say they would benefit from an automated public-facing system for Section 149 Certificate pre-assessments. *http://1spatial.com/au/campaign/1spatial-australian-local-government-gis-survey/*

National portal for geospatial data launched in Bhutan

National Geospatial Portal of Bhutan launched. It will serve as a gateway for users across Bhutan to discover, access, and share geospatial data and information. With the portal, users will be able to access data related to Bhutan in one place. The portal takes Bhutan a step closer to fulfilling its vision of building a coordinated national spatial data infrastructure.

Initiated by the NLC and the Centre for GIS Coordination, the portal was built with support from ICIMOD under the framework of the SERVIR-Himalaya Initiative. The global SERVIR programme, jointly supported by the USAID and the NASA, integrates science and technology into development programmes. SERVIR-Himalaya is implemented by ICIMOD. *www.icimod.org*

India to speed up green approvals

The Government of India's ongoing efforts to streamline green clearance process for industrial, infrastructure, mining and power projects will soon get another boost with the environment ministry planning to launch a GIS based decision support mechanism this month which will help decision-makers in taking informed decision quickly and in a transparent manner. The GIS-based DSS will contain high resolution satellite imagery and ground details of forest cover, types of green patch, eco-sensitive zones of protected areas, biological richness, landscape and net present value (NPV) of the region and state-wise forest cover that needs to be diverted for non-forest works.

Galileo update

EC and GSA sign agreement on Galileo Service Provision

The European GNSS Agency (GSA) and the European Commission (EC) have concluded an agreement that delegates a range of exploitation tasks for Galileo to the GSA, providing a framework and budget for the development of services and operations through 2021.

According to the governance structure set out for the Galileo program, the EC is responsible for the overall program supervision, the European Space Agency (ESA) is entrusted with the deployment phase, while the GSA is responsible for the exploitation phase.

The maximum current EU contribution amounts to US$621.8 million, which will cover the GSA's procurement and grant activities, including the GSA-ESA working arrangements, a program management reserve, and related research and development activities.

Future Galileo launches suspended until 2015

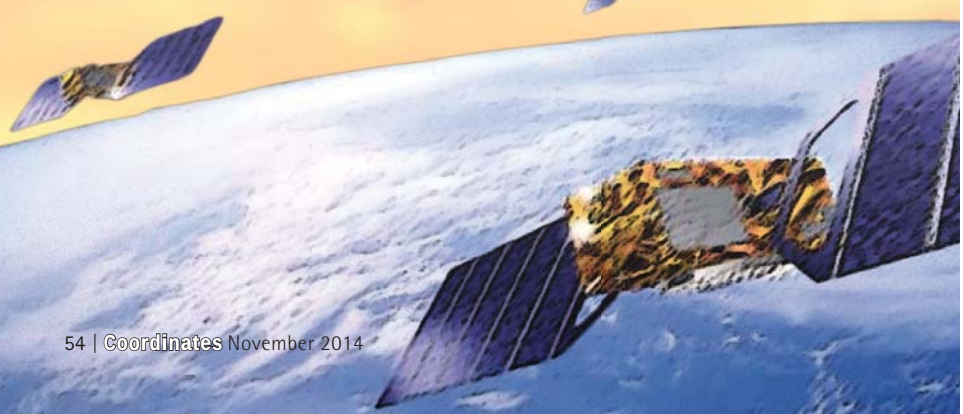
The ESA and the European Commission have decided to postpone the planned December launch of two more Galileo satellites. This decision has been made despite the findings of an enquiry that the August failure was caused by an easily correctable design flaw due to continuing concerns about the Soyuz launch vehicle. The two satellites needed up in a bad orbit as a result of a frozen fuel pipe responsible for the delivery of hydrazine to thrusters necessary to align the Fregat upper stage ready for correct orbital injection. Both satellites also suffered issues with solar panel deployment. Whilst these issues may have been caused by the incorrect orbit, investigations are continuing to confirm the cause.

Meanwhile work continues to protect the two satellites that are now in an incorrect orbit. A series of manoeuvres is planned for Oct/Nov to to raise the perigee of their orbit and remove them from the Van Allen radiation belt. Unfortunately there is insufficient full on board for the satellites to be moved into the correct orbits. *arianespace.com*

2014 GSA Prize awarded to the design of a new Galileo Module for Project Ara

The 2014 edition of the European Satellite Navigation Competition (ESNC) European GNSS Agency (GSA) Special Prize was awarded to Deimos Space for their Galileo for Ara - Design of a new Galileo Module for Ara.

Project Ara is led by Google with the aim of developing a smartphone comprised of individual modules. Galileo for Ara is the solution for demanding smartphone users looking to use one of Galileo's most important features: the unique E5 broadband signal. The idea is to design an E5 Galileo receiver module for the Ara platform. While mass market smartphones will use the E1 signal, the availability of high end phones offering enhanced accuracy through the use of the E5 signal will be appealing to many users. The project was selected from over 152 submissions. *www.gsa.europa.eu*



Developed by the Dehradun-based Forest Survey of India (FSI), the system will also have details on notified tiger corridors, other important migratory corridors, habitat of rare and endangered flora and fauna amongst others. *http://timesofindia.indiatimes.com/*

Japan updates topographic map of Northern Territories

A topographic map of the disputed Northern Territories off the coast of Hokkaido has been updated for the first time in 92 years using satellite images, since territorial issues render them off limits to Japan for ground and aerial surveying.

The mapping of the islands, which were seized by the Soviet Union at the end of World War II and claimed by Tokyo, marked the completion of a 1:25,000 scale topographic map of Japan. The Geographical Information Authority of Japan (GSI) began a nationwide geographic survey to create a map in accordance with its Long-Term Plan for Basic Survey in 1964. *http://ajw.asahi.com/*

Chennai Corporation makes another bid to digitally map city

For the third time in six years, Chennai Corporation in India will embark upon the task of digitally mapping the entire 426 sq km of the city. The massive exercise, an attempt to establish the position of every building, road, pavement, trees, street light, drain and pipeline as well as hospitals and schools, is part of a drive to re-assess properties, particularly in the extended areas where many buildings are unassesed or under-assessed. *http://timesofindia.indiatimes.com/*

Global Mapper SDK v16 released

Blue Marble Geographics has announced the release of the Global Mapper Software Development Kit (SDK) version 16. It features a significant improvement in data processing speeds and several exciting new options for working with 3D data. *bluemarblegeo.com*

senseFly brings next-generation rotary UAVs

senseFly has introduced eXom, the rotary drone that offers professional users unprecedented situational awareness. In addition to seeing what its *TripleView* camera head sees, its five vision sensors also enable you to see in the direction the drone is moving for enhanced awareness and safe operation. These sensors work in harmony with five ultrasonic sensors to ensure you always know the drone's distance from nearby objects. It includes the extra security of automated proximity warnings, and shock-absorbent carbon fibre shrouding protects eXom's rotors in case of surface contact.

Aibot X6 uses Leica Nova MultiStation

Leica Geosystems and its sister company, Aibotix, have introduced a solution for accurate positioning of the Aibot X6 without GNSS. The UAV can be tracked accurately with the Leica Nova MultiStation to define the exact position. Using both together can inspect top surfaces of aircrafts in hangars, enabling users to rely on its proven functionality without the support of GNSS. The UAV flies over the aircraft and takes high-resolution images of its surface. This solution helps, for example, to ascertain lightning strikes and effectively document them. *www.leica-geosystems.com*

FAA gives drone exemption to Hollywood production firms

The Federal Aviation Administration has approved exemptions that would for the first time allow six aerial photo and video production companies to use "unmanned aircraft systems". The decision is the first step in allowing the film and television industry to use drones. Drones used for such operations do not need an FAA-issued certificate of airworthiness based on a finding they do not pose a threat to national airspace users or national security.

The agency already allows law enforcement agencies, fire departments and other public agencies to use drones but has, in effect, banned their use for commercial purposes since 2007. *www.latimes.com*

Applanix APX-15 UAV Single-board GNSS-Inertial System

Applanix has introduced a new solution that enables major improvements in unmanned airborne mapping: the Applanix® APX-15 UAV GNSS-Inertial System. It is designed to maximize the efficiency of mapping from small UAVs by reducing - or even eliminating - Ground Control Points (GCPs). Sidelap is also significantly reduced, increasing the area flown per mission. It provides unparalleled performance in an extremely small package and, with the included POSPac UAV post-mission software, produces a highly accurate position and orientation solution for direct georeferencing of cameras, LIDARs and other UAS sensors. *www.applanix.com*

USAA seeks FAA approval to test UAS

USAA has asked the Federal Aviation Administration for permission to research how unmanned aircraft systems could be used to help improve how quickly it settles insurance claims for its members during

natural disasters. Specifically, USAA is seeking FAA exemption from Section 333 of the FAA Moderation and Reform Act of 2012 to immediately begin testing small unmanned aircraft systems, using industry-accepted best practices and guidelines compiled during research conducted over the past four years. *usaa.com.*

RIEGL enters UAV market with RiCOPTER

RIEGL Laser Measurement Systems has stepped into the UAV market with the launch of RiCOPTER — a high-performance UAV equipped with the RIEGL VUX-1 survey-grade LiDAR sensor. RIEGL, which is one of the leading companies in research, development and production of terrestrial, industrial, mobile, bathymetric, airborne and UAS-based laser scanning systems, also launched a new airborne LiDAR system, VQ-880-G, for topo-bathymetric surveying applications.

DGCA issues notice against civil use of UAVs over Indian airspace

The Office of the Director General of Civil Aviation has posted a notice on its website regarding the use of Unmanned Aerial Vehicle (UAV)/ Unmanned Aircraft Systems (UAS) for civil applications.

While the notice acknowledges the drone fancy that has caught on in the market, it cautions that in the absence of a clear policy and regulation on the usage of UAS, it is mandatory to acquire approval from the Air Navigation Services (AAIANS), defence, Ministry of Home Affairs, and other concerned security agencies, besides the DGCA.

"UAS has potential for large number of civil applications. However, its use besides being a safety issue, also poses security threat. Of late, lots of interest is being shown for civil use (both commercial and recreational) of UAS in the country. International Civil Aviation Organization (ICAO) is yet to publish Standards and Recommended Practices (SARPs), as far as certification and operation of civil use of UAS is concerned. The airspace over cities in India has high density of manned aircraft traffic. Due to lack of regulation, operating procedures/ standards and uncertainty of the technology, UAS poses threat for air collisions and accidents," the notice stated.

"DGCA is in the process of formulating the regulations (and globally harmonise those) for certification and operation for the use of UAS in the Indian civil airspace. Till such regulations are issued, no non government agency, organisation, or an individual will launch a UAS in Indian civil airspace for any purpose whatsoever," warns the notice issued to the public. *DGCA*

First company to apply for European civil certification of UAV

Airbus Defence and Space has formally submitted its Atlante unmanned aerial vehicle (UAV) for civil type certification – the first ever such application in Europe. The application was made to the European Aviation Safety Agency (EASA), the body responsible for certifying all aircraft designed or operated in Europe

The Atlante is a 570 kg, single-engined, propeller-powered UAV with a wingspan of eight metres of which the second example recently made its first flight. It is intended to fulfil a wide variety of commercial roles such as: surveillance of oil pipes, powerlines, railways, natural disasters, forest fires or sporting events.

Delhi Police use drones to keep eye on riot-hit Trilokpuri, Delhi

Drones were deployed to scan rooftops in Trilokpuri. Drone-mounted cameras were used in riot-affected Trilokpuri, Delhi by the police for monitoring the fragile situation and identifying potential trouble zones in the east Delhi locality.

The gadgets were deployed to monitor rooftops for bricks and empty bottles in the troubled area, the police said, adding that the measure would bring down chances of stone pelting. The drones also helped the police to seize weapons after identifying potential trouble in the area. *http://indiatoday.intoday.in/story*

New tsunami warning system set for 2015 India launch

A new groundbreaking tsunami warning system, based in Hyderabad, has been scheduled for launch in the first quarter of 2015. RegPoint is the European company that has created the technology. The warning service will have the ability to send SMS messages immediately to all mobile phones in a designated locality, pinpointing precise warnings, guidance or other information to a specific geographical region before a disaster strikes. It will be able to provide citizens, in the case of a tsunami, with accurate and rapid information on the size, scale and expected time of the disaster, as well as with advice on how best to secure their safety.

China launches Remote Sensing Satellite

China launched the Yaogan-22 remote sensing satellite into scheduled orbit from Taiyuan Satellite Launch Center. The satellite will be used for scientific experiments, natural resource surveying, estimating crop yields and disaster relief. It was carried by a Long March-4C rocket. The launch is the 195th mission for the Long March rocket family. *www.spacenews.com*

Iran to launch three remote sensing satellites

Deputy Head of Iran Space Agency (ISA), Hamid Fazeli, announced that Iran plans to launch three new satellites with indigenously-designed carriers into space in the near future.

"The launching of satellites such as Sharif Sat, Zafar (Triumph), Tolou (Sunrise) and Pars with powerful locally-designed carriers in the near future is on the agenda," said Hamid Fazeli. Zafar is a monitoring satellite, which will be sent into a geostationary orbit around 36,000 kilometres above Earth's equator. The satellite will reportedly have a lifespan of 18 months. Tolou satellite will also carry out remote sensing and topography missions, and will travel in an orbit of 500 kilometres above the equator. *http://www.spatialsource.com.au/*

India, Mexico sign MoU on space cooperation

India and Mexico have signed an MoU on space cooperation under which both sides will work together in remote sensing, satellite communication and areas relating to the peaceful use of outer space, besides taking the overall ties to a higher trajectory. Mexico has initiated reforms in the energy sector and both private and public sector Indian companies are looking for opportunities in the sector. *http://articles.economictimes.indiatimes.com*

SimActive Introduces new technology for Mosaic creation

SimActive Inc. is pleased to announce Correlator3D™ version 5.4, with significantly faster mosaic creation and a further increase in quality. The process has been entirely revamped to profit from multi-core CPUs and solid-state drives (SSD), leading to a 600% increase in processing speed from previous versions. In addition, the new version introduces a DSM-based option for true orthorectification. Also, the automatically-generated seamlines now follow the most nadir trajectory. Moreover, an increase in color balancing robustness allows processing challenging projects where radiometry varies significantly.

Integrated airborne camera boresight and mobile INS drift control by Optech

Optech Inc released Lidar Mapping Suite (LMS) for airborne and mobile workflows, Optech LMS 3.0. It represents a major advancement for users of Optech ALTM, Lynx and digital imaging product lines for high-precision surveying applications. For the first time ever, a major sensor manufacturer has incorporated complete camera boresight and calibration capability within the same workflow as that of airborne and mobile lidar. This merging of complementary active and passive imaging technologies is a huge leap forward in processing productivity, with the opportunity to generate truly coincident datasets within a single workflow.

Singapore company plans to conduct airborne survey of India

A Singapore-based geology and oil company plans to make a presentation to the Indian governement on doing an airborne remote-sensing geophysical survey of the country to gather data for resource exploitation. The survey could help increase the potential of mineral resources in the country, said Sudipto N Mukerji, business development director at McPhar International, an airborne survey company of Neterwala Group. *http://freepressjournal.in*

CARIS releases HIPS and SIPS 9.0 and Bathy DataBASE 4.1

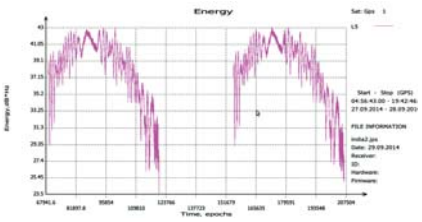
CARIS released its hydrographic data processing and bathymetric data management and analysis solutions. The latest releases of HIPS and SIPS 9.0 and Bathy DataBASE 4.1 feature significant enhancements, as well as providing streamlined connectivity and smart utilization of shared functionality.

India launches third navigation satellite

On 16th October 2014, India's Polar Satellite Launch Vehicle (PSLV-C26) had put the Indian navigation satellite, IRNSS-1C into its perfect, pre-designated orbit. This was the 28th successful launch of the Indian Space Research Organisation. The IRNSS-1C, the third of the seven navigation satellites in the Indian Navigation Satellite System (IRNSS), has wide-ranging applications in terrestrial, aerial and marine navigation. From vehicle tracking to fleet management and from disaster management to mapping, the satellite extends services to its clients. The IRNSS-1C carried two types of payloads, one for transmitting navigation service signals to the users and another consisting of a C-band transponder to facilitate Cube Retro Reflectors for laser ranging. *www.thehindu.com*

JAVAD GNSS tracks IRNSS signal

JAVAD GNSS has published a chart showing that it has tracked the IRNSS (Indian Regional Navigational Satellite System) L5 signal. Shortly after the Indian Space Research Organization (ISRO) released its IRNSS Signal in Space Interface Control Document (ICD), JAVAD GNSS was able to track the L5 BPSK signal from both 1A and 1B satellites. Ability to track IRNSS L5 will be added to all JAVAD L5-capable receivers in the near future, the company said.



SNR of two passes of 1A satellite (IGSO) over Moscow

Land stability service for the exploration industry wins copernicus masters

The first Earth observation service for extensive and uninterrupted coverage of land stability monitoring and mapping with millimetre-precision has been named the winner of this year's Copernicus Masters competition. This year's overall winners, Dr Andrew Sowter and Paul Bhatia from the University of Nottingham, have developed PUNNET, which facilitates large-scale coverage of land deformation that occurs due to mining, groundwater extraction, or drilling. This represents a major step forward for users such as the oil and gas industry, exploration companies, and the construction industry, as well as for public authorities and environmental protection organisations. *www.esa.int/copernicus*

GNSS based Road-Pricing System

The Land Transport Authority (LTA) of Singapore is developing Singapore's next-generation electronic road-pricing system, based on GNSS technology. The contract to design and develop the system is likely to be awarded in 2015. The GNSS-based system will implement distance-based pricing along certain congested roads, where motorists will be charged proportionate to the distance traveled. An interactive and intelligent on-board unit in motorists' vehicles will support additional services such as real-time traffic information and electronic payment for parking fees.

Airbus Defence & Space Innovation wins ESNC2014

The big winner of the European Satellite Navigation Competition (ESNC) 2014 was Airbus Defence & Space, which won over the jury of experts from around the world with its ground-breaking and cost-effective receiver for the Galileo Public Regulated Service (PRS). The award-winners Dr Wolfgang Kogler and Dr Jan Wendel from Airbus Defence & Space have taken a cutting-edge approach to designing a low-cost receiver that enables police departments, fire brigades, emergency medical services, and other public entities to make use of the Galileo PRS system. Its core innovation involves the development of a special network architecture that combines the receiver with an assistance server. The concept accounts for all the required security aspects and significantly reduces costs and the complexity of user receivers, thus facilitating broader use of PRS in the realm of public security. *www.esnc.eu*

NY Assembly members propose GPS tracking ban

Dozens of New York legislators have proposed outlawing placement of a GPS device on someone's car without their consent. The legislation, sponsored by the Assembly Rules Committee, would make it a misdemeanor and allow civil suits. There's an exception for parents when their children have the car. It follows reports that Republican operatives secretly put a GPS tracker on a Long Island Democrat's car to determine whether he lived in his district. It's already illegal to use a GPS to stalk someone in New York. *http://wivb.com/*

China's Beidou navigation satellite system poised to spread wings

China's Beidou navigation satellite system, whose positioning accuracy will reach 2.5 meters by 2020, will soon provide services to more countries. The National Administration of Surveying, Mapping and Geoinformation said China will cooperate with several countries, including Mexico, Israel and Sweden, to improve establishment of the Beidou system and geoinformation database.

Miao Qianjun, executive vice-president of the Global Navigation Satellite System and Location-Based Service Association of China, said the country will cooperate with Singapore, Malaysia and other Asian countries to promote the Beidou system. *http://english.peopledaily.com.cn/*

GeoScience Australia to upgrade GNSS tracking network

Geoscience Australia has called for tenders to update the receivers and antennae infrastructure used to track GNSS satellites. The tender issued is part of the government's planned initiative to upgrade Australia's global positioning technology and bring it in line with existing global systems. The infrastructure is expected

to densify and improve the GNSS Network in Australia and be capable of observing signals from the range of new GNSS constellations including GPS and GLONASS, as well as the newer Quasi Zenith Satellite System, BeiDou and Galileo. *www.spatialsource.com.au/*

European Rail, Supported by European GNSS

As European satellites offer a possibility to improve the efficiency of train control systems, GNSS technology is starting to gain momentum in the rail sector. EGNOS can and, in the future, Galileo will provide continuous and highly reliable positioning service - helping increase the competitiveness of rail among other modes of transportation. Currently GNSS in European rail is primarily used within non-Safety of Life applications, including asset management and passenger information services. However, the latest technological developments show that augmented GNSS, together with specific sensors, can help satisfy the stringent CENELEC Safety and Integrity Level requirements.

GPS IIF-7 satellite begins providing navigational services

The GPS IIF-7 satellite has completed the checkout phase on orbit and has entered into service with the rest of the Block IIF spacecraft already in orbit. GPS IIF-7 was launched on Aug. 1, 2014 atop a United Launch Alliance (***ULA***) Atlas V 401 rocket from Cape Canaveral Air Force Station's Space Launch Complex 41 (***SLC-41***) in Florida. As noted by the "7″ in its name, this is the seventh of the Block IIF satellites to have reached orbit. Twelve total are planned for the fleet. The official designation by the U.S. Air Force, whose 50th Space Wing in Schriever Air Force Base, Colorado is tapped with managing the GPS IIF constellation, is Space Vehicle Number-68 (SVN-68). *www.spaceflightinsider.com*

Frozen fuel caused Galileo orbit error

The problem was caused by a problem with pipes Fuel that froze on the Russian Soyuz rocket is what caused two satellites from Europe's troubled Galileo navigation system to be sent into the wrong orbit in August, an investigation revealed recently. The freeze was caused by a problem in fuel feeding pipes on the rocket's fourth, Fregat, stage "a design flaw" that can be easily fixed, launch firm Arianespace's chief executive officer Stephane Israel said.

Hydrazine propellant froze, which starved the altitude control thrusters of fuel, causing a loss of power and a misorientation of the Fregat upper stage. *http://www.rte.ie/news/*

Geomagnetic navigation technology alternative to GPS, GLONASS

Saratov scientists have developed the first domestic geomagnetic field navigation technology system that may become an alternative to the currently existing satellite-aided navigation systems GPS and GLONASS, according to Alexander Ignatyev, head of the design bureau at the Institute of Critical Technologies. The geomagnetic navigation system may be indispensable, for example, in the event of disappearance of a satellite signal. From the viewpoint of orientation accuracy, our (newly-developed) system is up to the selfsame GLONASS, Ignatyev emphasized. Valery Anikin, Dean of the Physic Department at Saratov University, Russia stressed, "This does not refer to an assumption that one of systems would edge another one out. However, from the safety point of view, it is better for them to co-exist and mutually complement one another if, for example, something happens with communications satellites".

The development of geomagnetic navigation systems is one of upcoming trends of research, Anikin pointed out. The Saratov school of magnetoelectronics has a long record. This is why it is no wonder that a practical development of a new navigation system is under way precisely over here, he said. *http://en.itar-tass.com/*

Russia to launch new GLONASS satellite by year end

"In November–December, 2014 we will launch the new GLONASS-K spacecraft. The launch is planned to be implemented from the Plesetsk Cosmodrome [in northern Russia] using a Soyuz 2.1b carrier rocket," according to Yury Vygonsky, deputy general designer for space systems development, general engineering and satellite control at JSC Information Satellite Systems, Russia.

"If the launches are successful, three more GLONASS-Ms will be launched at the end of 2015 using Proton rockets," Vygonsky said. *http://en.ria.ru/russia/*

5 billion rubles for GLONASS

The Russian state development bank Vnesheconombank (VEB) is set to offer financial support for domestic companies to develop projects using the GLONASS navigation system in Russia and abroad pending government approval. VEB's sister fund –"VEB Innovations" will set up the "GLONASS Fund" within the fourth quarter of this year; funds will be made available by next February-March. The fund will include 5 billion rubles (about $122 million) from VEB itself, together with 3 billion rubles ($73.1 million) from private investors, whom the fund hopes to attract by the end of 2016. *http://en.ria.ru/business/*

Top international honour for Indian navigation scientist

Dr G Satheesh Reddy, eminent scientist and Director of DRDO's Research Centre Imarat, India has been conferred the prestigious fellowship of the Royal Aeronautical Society, London for his outstanding contributions in the field of aeronautics and aerospace engineering.

The society, a professional body dedicated to the aerospace community, has nearly 2,780 fellows elected and inducted from all over the world and Reddy is one of the only five from India, according to Defence Research amd Development Organisation. As a top navigation scientist in the country, he holds the distinction of being conferred with the full member diploma from the Russian Academy of Navigation and Motion Control and has been inducted into it as a foreign member.

Leica RCD30 Penta Oblique system

RCD30 Penta Oblique system is now available with new optics. The camera is now available with 80 mm and 150 mm focal length respectively. In combination with the new 80 MP CCD sensor, it now provides data with even more detail. These new features make the RCD30 the only oblique system able to acquire 4-channel RGBN multispectral data with 10 centimetre Ground Sampling Distance (GSD) from an altitude of 3,000 metres.

Altus APS-NR2 GNSS RTK receiver

Altus Positioning Systems, a Septentrio company has announced the commercial availability of its next-generation APS-NR2 GNSS RTK receiver. According to Altus CEO Neil Vancans, the new Altus APS-NR2 provides an unprecedented combination of performance and features that make it ideal for a wide range of applications. It is high on RTK performance, high speed and light weight. It also has dual cellular antennae, hence automatic switchover eliminates downtime due to signal loss. It is also Esri Compatible and has an Open architecture. *www.altus-ps.com*

KVH receives $19 million order from a military customer

KVH Industries, Inc. has received a $19 million contract for the delivery of a new fiber optic gyro- (FOG) based tactical navigation system for use by an international military customer in an armored vehicle application. A variant of KVH's TACNAV® FOG product and KVH's new TACNAV 3D, the system provides continuous high-accuracy position and orientation even when GPS is lost or jammed.

Hemisphere GNSS announces new survey grade GNSS antennas

Hemisphere has announced two low profile, multipurpose antennas. With unique filtering patterns and precise attention paid to mitigation of multipath and interference, the A25 and A45 antennas complement all GNSS products, from L1 GPS to multi-frequency, multi-constellation. Both have been designed to support millimeter accuracy for land and marine applications and support present and future GNSS signals. The A25 supports the previously mentioned signals at a single-frequency level, while the A45 supports these signals at a multi-frequency level. *www.HGNSS.com*

Juniper Systems & Effigis partnership

Juniper Systems and Effigis have partnered to provide a powerful, yet inexpensive solution to easily capture and post-process GPS data to attain sub-meter accuracy. Effigis' OnPOZ Precision Positioning Software suite takes advantage of the superior GNSS performance Juniper Systems' Archer 2™ rugged handheld provides to collect high-accuracy GPS data. First, EZTag CE™ software is used on the Archer 2 to capture GPS field data points. The data is then sent to a desktop computer, where EZSurv® Post-Processing Software automatically post-processes the data to achieve results with sub-meter accuracy. EZSurv takes the hassle out of post-processing, requiring only the click of a button to run. *www.junipersys.com.*

New 3D mobile mapping technology

Routescene has launched a new turnkey 3D mobile mapping solution, the Routescene LidarPod, which will save time, achieve more detailed and faster results. It will enable quick, accurate, safe and cost effective surveys. There is an increasing demand for 3D data, which is taking over from traditional 2D maps and this trend will accelerate in the next few years. There is also an increased need to update mapping information more frequently, with customers displaying an ever increasing sophistication using a variety of applications which need 3D data. *www.routescene.com*

OxTS launches smallest and lightest INS to date

The xOEM500 is the latest offering to OEMs and system integrators and is the first system from OxTS to come as an embedded GNSS/INS board set configuration. Boasting a weight of just 120 g which includes dual GNSS receivers, a custom built MEMS based IMU, on-board processing, and internal logging and storage, the xOEM500 is perfectly suited for all applications where size and weight as well as performance matter. It is ideal for use on UAVs and other weight constrained applications. A full software package including post-processing is included at no extra cost allowing instant access to the best possible data. And being free from export control, there really are no obstacles when integrating the xOEM500.

Carlson Software Introduces Surveyor2 Data Collector

Carlson Surveyor2 is the newest model of Carlson Software's Carlson Surveyor line of data collectors. It is completely ruggedized, with an IP68 water and dust resistant Ingress rating. Still weighing just 900g, the Carlson Surveyor2 offers increased program memory (now 512MB) and increased non-volatile data storage (now 8 gigabytes) — and a 1.0 GHz processor to provide the effectiveness surveyors need in the field. It also comes equipped with significantly increased Bluetooth range – up to 450 metres when paired with a class I device.

ProMark 800 aids demining operations in Bosnia-Herzegovina

Bosnia and Herzegovina is burdened with one of the world's most severe land mine problems as a result of the four years of hostilities from 1992 to 1995 that left an estimated two million unexploded landmines and munitions scattered in 28,699 locations throughout the country. In one district in the northeast of the country, Posavina.

Without Mines (PWM), a humanitarian, non-profit NGO, is under contract with the government of the District of Brcko to warn residents of mined areas by permanently marking suspected contaminated areas, removing the lethal objects and helping mine-affected victims. The task of marking suspected areas to warn residents begins when Posavina Without Mines (PWM) receives mapping information from the Bosnia and Herzegovina Mine Action Center (BH

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MAC), the nation's central landmine research and coordinating authority.

Posavina Without Mines uploads the data it receives from BH MAC into its Spectra Precision ProMark 800 recently purchased through a grant it received to acquire a GNSS capability. Each warning sign is positioned with the aid of the ProMark 800 and assigned a unique serial number. A list of the serial numbers, coordinates and photos of each site comprises a permanent record and database that is submitted to BH MAC.

Trimble News

Inpho® version 6.0

Trimble has announced a new version of its photogrammetric software suite—Inpho® version 6.0, which provides highly automated workflows for photogrammetry and remote sensing professionals so they can process thousands of airborne images with high precision. Inpho version 6.0 increases efficiency by reducing project turnaround times and improves the quality of deliverables via new automated and interactive tools and satellite triangulation functionality.

NetR9

The Trimble NetR9 Geospatial has been configured as a comprehensive modular GNSS receiver for the professional survey market. Its lightweight form factor comes fully loaded with performance enhancements including: Trimble HD-GNSS technology, Trimble 360 technology, Trimble CenterPoint RTX correction service support and Trimble xFill technology.

Geo 7X with Trimble Access

Designed for surveyors facing a variety of workflow requirements to accomplish both high-accuracy surveying and handheld point measurement, the Geo7X is now available with Trimble Access field software onboard.

MARK YOUR CALENDAR

November 2014

11th International Symposium on Location-based Services
26 -28 November
Vienna, Austria
www.lbs2014.org/

December 2014

PTTI 2014: Precise Time and Time Interval Systems and Applications Meeting
1 – 4 December
Boston, Massachusetts, U.S.A.
www.ion.org/ptti/future-meetings.cfm

European LiDAR Mapping Forum
8-10 December
Amsterdam, The Netherlands
www.lidarmap.org/europe

Esri India User Conference
9-11, December
Delhi, India
http://www.esriindia.com/events/2014/indiauc

February 2015

The Unmanned Systems Expo
4 - 6 February
The Hague, The Netherlands
http://www.tusexpo.com

International LiDAR Mapping Forum (ILMF)
23-25 February
Denver, Colorado, USA
www.lidarmap.org/international

The International Navigation Conference
24-26 February
Manchester, UK
www.internationalnavigationconference.org.uk/

March 2015

Locate15
Brisbane, Australia
10 – 12 March
www.locateconference.com

Munich Satellite Navigation Summit 2015
24 – 26 March
Munich, Germany
www.munich-satellite-navigation-summit.org

April 2015

European Navigation Conference 2015
7 – 10 April
Bordeaux, France
http://enc-gnss2015.com/

Interexpo GEO-Siberia-2015: Open-Source Geospatial Solutions for Public Benefits
20 – 22 April
Novosibirsk, Russia
http://expo-geo.ru/event/4-Interekspo_GEO-SIBIR/

2015 Pacific PNT Conference
20 – 23 April
Honolulu, HI United States
www.ion.org/

May 2015

AUVSI's Unmanned Systems 2015
4-7 May
Atlanta, USA
http://www.auvsi.org/

RIEGL LiDAR 2015 Conferences
5 – 8 May
Hong Kong and Guangzhou, China
www.riegllidar.com/

MundoGeo Connect
May 5 to 7, 2015
Sao Paulo - Brazil
http://mundogeoconnect.com/2015/en/

36th International Symposium on Remote Sensing of Environment
11-15 May
Berlin, Germany
http://www.isrse36.org

FIG Working Week and General Assembly
Sofia, Bulgaria
17 – 21 May
www.Figure net

GEO Business 2015
27 - 28 May
London, UK
http://geobusinessshow.com/

June 2015

HxGN LIVE Las Vegas 2015
1 – 4 June
Las Vegas, Nevada USA
http://hxgnlive.com/las.htm

TransNav 2015
17 - 19 June
Gdynia, Poland
http://transnav2015.am.gdynia.pl

July 2015

13th South East Asian Survey Congress
28 – 31 July, Singapore
www.seasc2015.org.sg

September 2015

INTERGEO 2015
15 – 17 September
Stuttgart, Germany
www.intergeo.de/intergeo-en/

October 2015

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

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