GIM INTERNATIONAL

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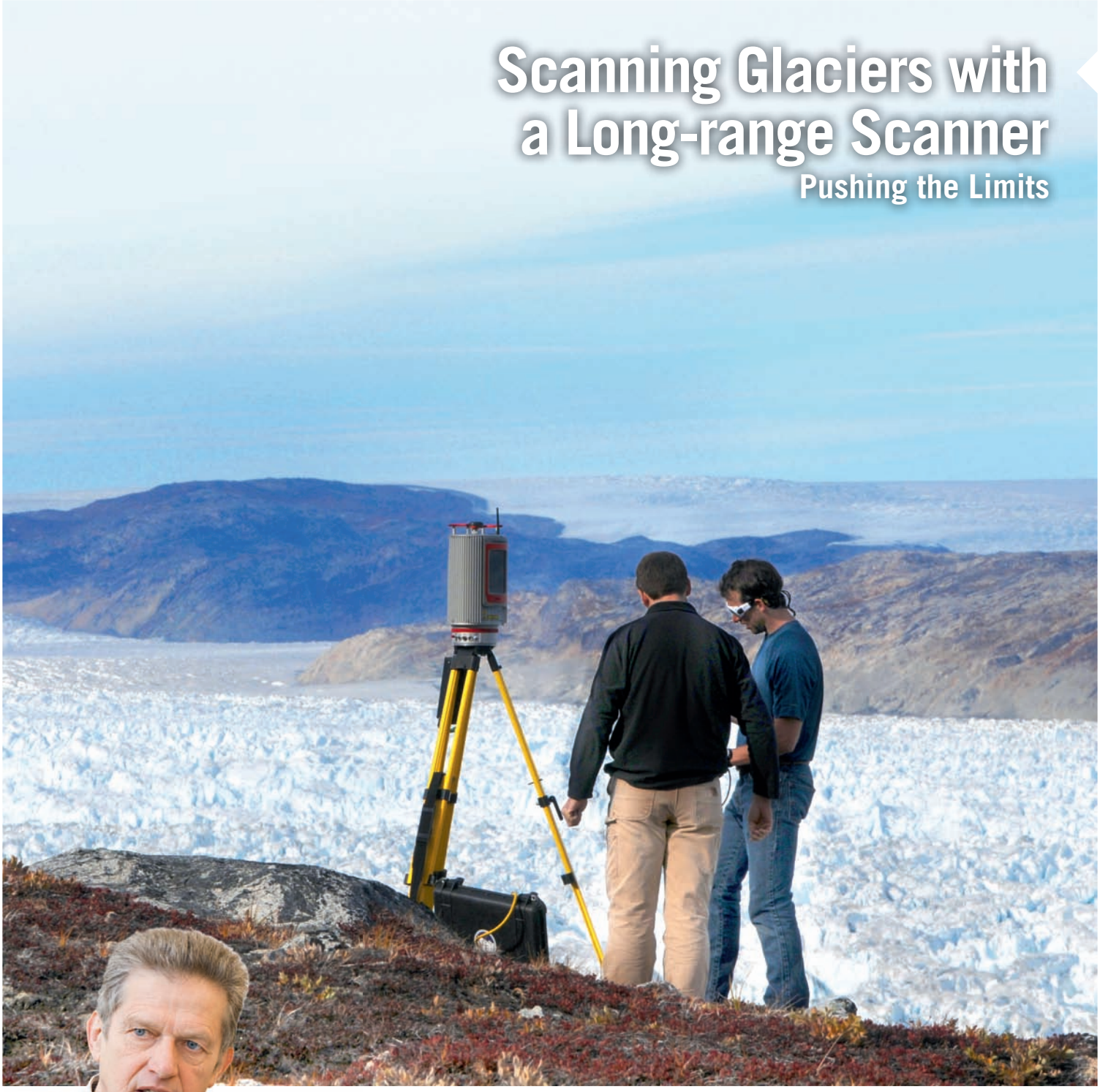
Scanning Glaciers with a Long-range Scanner

Pushing the Limits



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Why do leading aerial mapping and surveying companies, worldwide, fly with UltraCam?

Blue Skies Consulting
United States

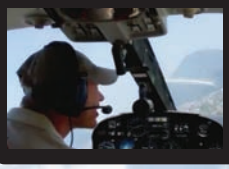
UltraCamLp

GeoAir
Mexico

UltraCamD

GEODIS
Czech Republic

UltraCamXp & Eagle



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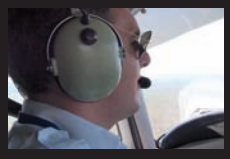
UltraCamD, X, Xp, & Eagle



AEROmetrex
Australia

UltraCamD & X

You've seen Microsoft's international "I Fly UltraCam" video series featuring UltraCam customers explaining, in their own words, why they chose award-winning UltraCam photogrammetric digital aerial sensor systems. But they weren't the only proud UltraCam users eager to share their experiences. Check out the new "I Fly UltraCam" videos that were personally created and submitted by UltraCam customers from around the world.

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No 2312

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Geomares Publishing
P.O. Box 112, 8530 AC Lemmer, The Netherlands
T: +31 (0) 514-56 18 54
F: +31 (0) 514-56 38 98
gim-international@geomares.nl
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BPA WORLDWIDE BUSINESS

Silent Revolution

Some revolutions happen in silence. That certainly holds true for one of the most recent revolutions in geomatics: the development of a new geoid by the Gravity field and steady-state Ocean Circulation Explorer (GOCE) team. In 2009 a preliminary geoid was unveiled, and the team is still developing it further today, adding more data and hence improving its accuracy. One of the initiators of this European Union satellite mission and head of the team researching the data, professor Reiner Rummel from the Technical University Munich, explains in this issue of *GIM International* that GOCE has been measuring the gravity field from space for the very first time (see page 14). The geoid derived from GOCE data will end up in a single system uniting many countries' height systems. Surveyors all over the globe will be basing their surveys on one height system, and large-scale levelling will very soon be history. While this in itself has an immediate and revolutionary effect on geomatics, GOCE has more far-reaching consequences. Thanks to being able to measure with millimetre accuracy, geodesy has now become a partner in research for climate change, tectonic change and changes due to urbanisation and infrastructural planning, says Rummel. For the first time in history, the total sea-level rise can now be divided into one part due to thermal expansion and another part due to meltwater from ice shields. Geodesy is becoming an integral part of not only hydrology, oceanography and hydrography, but also of land and disaster management. Professor Rummel points out that it is not just GOCE, but also the Global Geodetic Observing System (GGOS) that is contributing significantly to this silent revolution. He highlights the great importance and revolutionary scale of GGOS. He calls GGOS a major accomplishment – one global reference system on millimetre scale on an Earth that is not only wobbling and bobbling, but also very diverse in terms of its political systems. This immense project, very much pushed and lobbied for by the geodesists of the International Association for Geodesy (IAG), is a precondition for further progress in geodesy: it will connect terrestrial and satellite work in a global system. Rummel sees the success of projects and developments such as those mentioned above encouraging the geodesist to come out of his shell - where he has been carrying out his work in silence - and into the open. Boasting does not come naturally to most professionals in our field, which in itself is a good thing. However, with the interview in this issue of *GIM International* we would like to give credit, not just to professor Rummel but also to all his colleagues around the globe who are working to make these silent revolutions happen for the benefit of the whole world!

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No 2197

This month's front cover shows researchers Dave Finnegan and Ananda Fowler interpreting Terrestrial Lidar data as the RIEGL VZ-6000 scans Helheim Glacier in Southeast Greenland. On page 20 you will find their article on scanning glaciers with a long-range scanner.

GIM INTERNATIONAL
GIM International, the global magazine for geomatics, is published each month by Geomares Publishing. The magazine and related e-newsletter provide topical overviews and accurately presents the latest news in geomatics, all around the world. *GIM International* is orientated towards a professional and managerial readership, those leading decision making, and has a worldwide circulation.

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Where to Now for Surveying and Geospatial Education?

PROF. JOHN C TRINDER
University of New South Wales, Australia
j.trinder@unsw.edu.au

With the announcement of the possible disestablishment of the School of Surveying and Geospatial Engineering at the University of NSW (UNSW) in February 2013, the question is whether there will be sufficient graduates in Australia to replace the current cohort of surveying and geospatial professionals when they retire. While the programme at UNSW commenced in 1957 in the School of Civil Engineering, the School of Surveying and Geospatial Engineering, under various names, has had a proud history of more than 52 years. Its graduates can be found in many parts of the world, while its staff have output a substantial research quantum covering a large range of surveying and geospatial engineering topics.

The shortage of students entering the degree programme offered by the School of Surveying and Geospatial Engineering at UNSW has existed for more than 15 years. It is not clear why it has not been possible to attract more school-leavers onto the programme, but it may be because the community at large is unaware of the many career opportunities available. Improved marketing is clearly essential.

Education in surveying and geospatial engineering is provided by eight academic institutions in the various Australian states with, in most cases, very limited staff – some programmes are run by as few as three academic staff. This means that much of the teaching must be undertaken by part-time lecturers who are graduates with extensive practical experience, but who generally do not emphasise the theoretical background to the subjects. Likewise, of course, they are unlikely to carry out research. In 2007 in a paper written for *GIM International*, I wrote that the enrolment numbers at that time should be doubled until the shortage of graduates is overcome. Unfortunately enrolments at UNSW have continued to decline, resulting in the recently announced proposal to merge with the School of Civil and Environmental Engineering.

The disestablishment of surveying and geospatial engineering programmes around the world is not a new development. The question of the viability of education programmes in surveying and geospatial engineering has been raised by others over the past decade or so, with few improvements in the status of enrolments. In one action aimed at remedying the poor enrolment level, Australia's Surveying and Spatial Sciences Institute (SSSI) is supporting the two existing websites which describe pathways to the surveying and spatial sciences professions in Australia, namely *www.destinationspatial.org* and *www.alifewithoutlimits.com.au*. Both of these websites are regularly updated. International cooperation in the development of websites such as these would certainly be beneficial. Perhaps a concerted global effort is required to encourage more school-leavers to enrol in surveying and geospatial engineering programmes and hence improve the viability of the profession for the future.

NOVATEL ANNOUNCES BEIDOU SUPPORT ++ AIRBORNE UNMANNED SENSOR SYSTEM FOR UAVS ++ BLOM CAPTURES AERIAL IMAGERY IN GREENLAND ++ ROBOTIC TOTAL STATION FOR CONS
GEOEYE-1 ++ REMOTE SENSING ADDS VALUE TO MINING INDUSTRY ++ SATLAB DEALER MEETING IN CZECH REPUBLIC ++ GEOSPATIAL PLATFORM FOR AERONAUTICAL DATA MANAGEMENT

Airborne Unmanned Sensor System for UAVs

American researchers at the Georgia Tech Research Institute (GTRI) are currently working on the development of an airborne testing capability for sensors, communications devices and other airborne payloads. This aerial test bed is called the GTRI Airborne Unmanned Sensor System (GAUSS). GAUSS is based on an unmanned aerial vehicle (UAV) made by Griffon Aerospace and modified by GTRI.

http://su.pr/8lWfzQ

Research engineers Warren Lee (left) and Mike Heiges adjust the GAUSS (Photo courtesy: Gary Meek, Georgia Tech).

Robotic Total Station for Construction Industry

Topcon PS-AS.

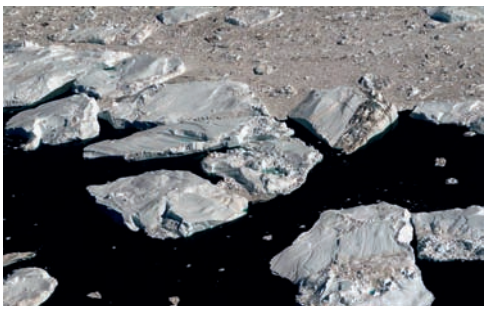
Topcon Positioning Systems has launched a new series of robotic total stations specifically designed and configured for the construction market. The new instruments are developed for applications such as stakeout and as a key component of a Local Positioning System, which is used for 3D machine control.

http://su.pr/1uHOe2

Blom Captures Aerial Imagery in Greenland

Despite challenging conditions, images of three towns in Greenland have been successfully captured as part of a photographic aerial survey project by European survey specialist Blom. The photographic survey was commissioned by NIRAS, an international multidisciplinary consultancy company, and will be used to update urban mapping within the region.

http://su.pr/33D1vT



Flying towards Greenland.

NovAtel Announces BeiDou Support

Canadian manufacturer of GNSS products NovAtel has added the support for the BeiDou Navigation Satellite System to its OEM6 family and select OEMStar GNSS receivers. The long-anticipated BeiDou Navigation Satellite System (BDS) Interface Control Document (ICD) release indicates a significant milestone that facilitates global acceptance of BeiDou into the growing range of satellite-based positioning applications.

http://su.pr/3FIpga

Geomatics-focused Solution for Geospatial Data Conversion

Blue Marble Geographics has merged the various modules of the Blue Marble Desktop into one software application. All of the features available in the Blue Marble Desktop are now available as the new Geographic Calculator 2013, including all the raster processing and spatial database tools found in the Geographic Transformer and Spatial Connect modules.

http://su.pr/7t39Fi

Hexagon Expands into Russia

2013 starts with another takeover by Hexagon as it has entered into a definitive agreement to acquire all outstanding shares in Russia-based Navgeocom. The company is the largest distributor for Leica Geosystems, a Hexagon brand, in the Russian Federation.

http://su.pr/1tvLMn

STRUCTION INDUSTRY ++ HEXAGON EXPANDS INTO RUSSIA ++ LEICA GEOSYSTEMS WINS DUTCH LAND REGISTRY CONTRACT ++ INDIAN RAILWAYS TO USE S ... M
++ GPS INTELLECTUAL PROPERTY ISSUE RESOLVED ++ GEOMATICS-FOCUSED SOLUTION FOR GEOSPATIAL DATA CONVERSION ++ MANAGEMENT BUY-OUT A ... ++

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No 2324

Indian Railways to Use Stereo Imagery from GeoEye-1

GeoEye, a leading provider of geospatial information and insight, has announced that it has received an order from the Government of India for stereo imagery from the high-resolution GeoEye-1 satellite to support development of India's freight railway corridor. Stereo imagery provides three-dimensional viewing and feature recognition for a number of engineering applications, including three-dimensional feature extraction.

http://su.pr/345Z9j

GPS Intellectual Property Issue Resolved

The Governments of the United Kingdom and the United States of America have reached a common understanding of intellectual property rights related to the Global Positioning System (GPS) and will work together to address broader global navigation satellite systems' intellectual property issues.

http://su.pr/1AbfHY

NASA GPS satellite.

Leica Geosystems Wins Dutch Land Registry Contract

Leica Geosystems and Kadaster, the Dutch Land Registry, have signed an agreement for the supply of land surveying data collection equipment for the coming five years. For Leica Geosystems, this marks a continuation of the relationship that it has built up with Kadaster over the years.

http://su.pr/1KY4Wm

Signing of the contract.

Geospatial Platform for Aeronautical Data Management

Esri has released ArcGIS for Aviation, a new solution to support users in aeronautical information management, air navigation service providers, and airport markets. This solution enables users to create, manage, review and share aviation data. ArcGIS for Aviation includes ArcGIS for Aviation: Charting, and ArcGIS for Aviation: Airports. Together, these products provide a comprehensive geospatial platform for aeronautical chart production and airport operations data management.

http://su.pr/2lMZeP

SatLab Dealer Meeting in Czech Republic

Technical training session at the SatLab dealer meeting.

On 17 and 18 January, SatLab organised its first Technical Dealer Meeting in Jičín, Czech Republic. The Sweden-based satellite positioning solutions company was somewhat unlucky with the weather, since snowy conditions caused some dealers to miss the event. Nevertheless, dealers from six countries were present in Jičín.

http://su.pr/2m3umO

LONGEST PERMANENT EARTH SURFACE DATA RECORD CONTINUES ++ CARLSON'S 30TH ANNIVERSARY USER CONFERENCE ALSO IN SPANISH ++ KOLIDA W MACAU
UNIVERSITY CAMPUS ++ NEW VERSION OF HANDHELD ULTRA-RUGGED ++ NOTEBOOK NOVATEL ANNOUNCES BEIDOU SUPPORT ++ AIRBORNE UNMANNED R UAVS ++

Longest Permanent Earth Surface Data Record Continues

NASA's Landsat Data Continuity Mission (LDCM), the eighth satellite in the Landsat series, is set to launch on 11 February from Vandenberg Air Force Base in California, USA. LDCM is a joint NASA and U.S. Geological Survey (USGS) mission and extends the longest continuous data record of Earth's surface as viewed from space.

▸ http://su.pr/2WGbcf

LDCM spacecraft.

Management Buy-out at Plowman Craven

The Plowman Craven website.

Directors at UK-based specialist measurement survey firm Plowman Craven have completed a management buy-out from the private investment business RCapital Partners LLP. The buy-out was led by the organisation's senior management team which includes managing director Andrew Molloy and fellow directors David Norris, Malcolm Donald and Peter Folwell. Matt Swan, property developer and previous board member of Alfred McAlpine, remains in his role as chairman.

▸ http://su.pr/1PPu80

Remote Sensing Adds Value to Mining Industry

LOOKNorth has released an overview of Northern Canada's mining industry. The overview is intended to provide a context for assessing the utility of remote sensing technologies for mining applications, as well as insight into potential commercial opportunities for the remote sensing technology sector in Northern Canadian mining.

▸ http://su.pr/2TuTuD

Carlson's 30th Anniversary User Conference also in Spanish

Carlson Software has added a total of 12 classes to be conducted in Spanish to its comprehensive line-up of training classes due to be held during the Carlson 30th Anniversary User Conference. The three-day conference will be held from 7 to 10 April 2013 at the Cincinnati Netherland Hilton Plaza Hotel in Cincinnati, Ohio, USA.

▸ http://su.pr/47Yfha

BLOM CAPTURES AERIAL IMAGERY IN GREENLAND ++ ROBOTIC TOTAL STATION FOR CONSTRU

LEICA GEOSYSTEMS WINS DUTCH LAND REGISTRY CONTRACT ++ INDIAN RAILWAYS TO USE S

Kolida Contributes to New Macau University Campus

Surveying instruments from Kolida have been used in building a new campus for the University of Macau, China, in the east of Hengqin Island, part of Zhuhai City. The construction project began in 2009 and will cover an area of 820,000 square metres.

http://su.pr/5nl58h

Kolida instruments were used in the construction project.

Most Shared

Most shared during the last month from www.gim-international.com

1. New Mobile Indoor Mapping System Launched
   - http://su.pr/2fdFzE
2. Airborne Unmanned Sensor System for UAVs
   - http://su.pr/8lWfzQ
3. Longest Permanent Earth Surface Data Record Continues
   - http://su.pr/7fUMUH
4. Sandy Island Mystery Solved 33 Years Ago
   - http://su.pr/2a9FI2
5. Robotic Total Station for Construction Industry
   - http://su.pr/1k33Yd

UCTION INDUSTRY ++ HEXAGON EXPANDS

STEREO IMAGERY FROM GEOEYE-1 ++ RI

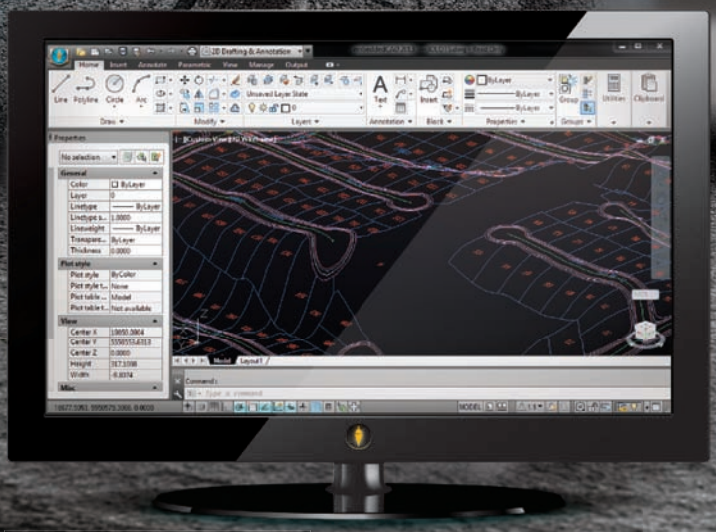
MicroSurvey CAD 2013

MicroSurvey inCAD 2013

MicroSurvey POINTPrep 2013

They're Here.

MicroSurvey embeddedCAD 2013



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No 2217

GIS Editor Application for Geographic Data

ThinkGeo, headquartered in Texas, USA, has launched its new Map Suite GIS Editor application, designed for GIS professionals who need an easy way to create, visualise, edit and analyse spatial data. The GIS Editor, now available to the public as a free download, makes GIS more accessible to a broader range of users with varying degrees of experience, and does so at a lower cost than comparable products.

http://su.pr/2EUxjj

New Version of Handheld Ultra-rugged Notebook

Handheld Group, the Swedish manufacturer of rugged mobile devices, has announced the launch of the new version of its popular Algiz XRW rugged notebook. Particularly interesting for users in the field is the optimised GPS performance. Furthermore, the Algiz XRW offers an array of mobile capabilities.

http://su.pr/2Qp1Bf

Massive Point Clouds

The progress of computer technology still obeys Moore's law. Likewise, the capacity of sensors and the number and size of pixels in cameras doubles nearly every two years. Yet the amount of data today's sensors produce is growing faster than the processing and storage capacity of Data Base Management Systems (DBMS). As a result, the full potential of point cloud data such as the x,y-related heights from airborne Lidar or the x,y,z coordinates from terrestrial laser scanners remains unexploited.

Lidar DTMs may be so detailed that their volume may exceed hundreds of billions of points. For example, the DTM of The Netherlands (AHN 2) has a density of one point per 50cm^2. To deal with the limits of their software, users may order reduced and aggregated datasets. They might be happy with high-definition point clouds but face in-house limitations which prevent the data details being fully exploited. Furthermore, transport from depository to the user may end up as a lengthy voyage since dissemination facilities are out of whack with massive data volumes.

MATHIAS LEMMENS
Senior editor, GIM International
mathias.lemmens@geomares.nl

To balance massiveness and limits due to processing and dissemination, clever algorithms are needed. Several approaches can be distinguished. One is to lower the number of digits needed to represent the x,y,h triplet. For example, the points can be arranged in spatial blocks in which the heights vary only slightly. When the height values vary between 12.07 and 12.92, the x values between 174,200 and 174,850 and the y values between 361,700 and 362,600, the first digits may be omitted and stored just once for each block. When using the data, these digits can be added. When the density is 4 points/m^2, this enables huge savings in terms of storage space and transport time.

Another approach is to convert the point cloud into a raster and to use JPEG compression just as is done for imagery, i.e. the raster is divided into tiles of 8 x 8 cells and then transformed to the frequency domain. This can be done either as lossy – i.e. heights cannot be restored exactly – or lossless compression.

A third method is segmentation of the point cloud, i.e. areas with similar heights are detected using region growing, a well-known method in pattern recognition. Next the vertices of boundaries are stored, together with the parameters of the polynomial describing the height variations. Meadows, streets and football fields may all be represented by a horizontal or a tilted plane. Such a parametric description allows areas containing thousands or even millions of points to be efficiently represented by a few values. Suppliers who provide such intelligently crafted point clouds as well as the associated software may be doing their clients a huge favour.

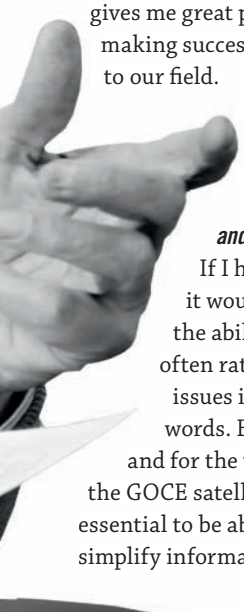
VALUE TO MINING INDUSTRY ++ SATLAB DEALER MEETING IN CZECH REPUBLIC ++ GEOSPATIAL PLATFORM FOR AERONAUTICAL DATA MANAGEMENT ++ ROPERTY
ISSUE RESOLVED ++ GEOMATICS-FOCUSED SOLUTION FOR GEOSPATIAL DATA CONVERSION ++ MANAGEMENT BUY-OUT AT PLOWMAN CRAVEN ++ LONGES

GIM INTERNATIONAL INTERVIEWS REINER RUMMEL

Space Geodesy Pioneer

The field of geodesy is changing dramatically. The recent decades' developments – not only GPS and INSAR but also the Gravity field and steady-state Ocean Circulation Explorer (GOCE) mission carried out by the European Space Agency – have immensely altered both how professional surveyors, researchers and developers are regarded and how they work. Professor Reiner Rummel, co-initiator of GOCE mission which is measuring the gravity field from space, observes that geodesists tend to be modest and that it is mostly others who harvest the fruits of their labours in this field. Now semi-retired, professor Rummel reflects on the past and looks to the future of a field he has always thoroughly enjoyed.

What has been your biggest contribution to the science of geodesy?
That's difficult. I think my contribution to the Gravity and Ocean Circulation Explorer (GOCE) satellite mission would probably count as the biggest. I was one of the initiators of that project and I am still responsible for the level-2 processing of the data. The mission itself is a great success. But my heart would say that my greatest contribution has been educating so many young people over the years. It gives me great pleasure to see them making successful contributions to our field.



What is your strength, both in your scientific work and in your teaching?
If I have a strength, it would probably be the ability to translate often rather complex issues into much simpler words. Both for teaching and for the work related to the GOCE satellite mission, it is essential to be able to rephrase and simplify information, because it can sometimes be easy to drown in its complexity.

Can you explain in a few sentences what GOCE does?
GOCE is measuring the Earth's gravity field in the greatest possible detail. This is the first time it has been done from space using the principle of gradiometry. The collected data enabled a new geoid to be derived, which was first unveiled in 2009. The accuracy of this geoid is being improved all the time using more and more data collected by GOCE.

What difficulties did you encounter?
To measure the gravity field from space – that is, from satellite altitude – you have to build in a few tricks, because gravity is strongly attenuated at satellite height. Gradiometry is used as measurement principle in order to counteract this damping effect. So this project represented the first attempt to use gradiometry from space, which has not been easy.

Can you give an example of how results from GOCE are already affecting geomatics?
A project for the European Space Agency involves unifying many countries' height systems into one single system. Each height system in each country currently refers to a benchmark or tide gauge – in The Netherlands, for instance, it is called the *Normaal Amsterdams Peil* or 'Normal Amsterdam Ordnance Datum'. While this datum has been adopted by several nations, other countries set their own standards. 'Mean sea level' at a tide gauge is usually adopted as height reference, but mean sea level varies from place to place. GOCE enables them to be brought together in one system; GOCE makes large-scale levelling history. In Germany, for instance, first-order levelling is being carried out, very likely for the last time, and GOCE results are already used in the United States and Canada.

Did trying to unify these height systems reveal any interesting findings?
Yes, we carried out a nice exercise with colleagues from Liverpool, UK, when checking the American height system in order to try and settle an interesting historical dispute between geodesists and oceanographers. When oceanographers calculate the slope of the sea level along the East coast, the sea level bulges towards the equator, whereas geodetic levelling shows the opposite: an increase towards northern latitudes. The new data enabled the discrepancy to be removed. The verdict: the geodesists were wrong, the oceanographers were right!

Reiner Rummel

Reinhard (Reiner) Rummel earned a degree in surveying at the Technical University in Munich, Germany (TUM) and thereafter did his doctorate at the Technical University Darmstadt, Germany, in 1974. From 1993 to 2011, he was professor of astronomical and physical geodesy at the TUM. From 1980 to 1993, he was professor of physical geodesy at the Technical University of Delft, The Netherlands. Rummel is co-initiator and principle investigator of the Gravity field and steady-state Ocean Circulation Explorer (GOCE) satellite mission of the European Space Agency. Rummel is a member of the Bavarian Academy for Sciences, the German Academy of Science Leopoldina and the Dutch Academy for Sciences.

✉ rummel@bv.tu-muenchen.de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Are there any other practical uses of GOCE findings?
Yes, you now can convert GPS height to physical height much more precisely than in the past. This will make life much easier in construction projects, such as when building a bridge between two countries separated by sea, etc. Especially in the lesser-developed world, such as African or Southeast Asian countries, it could have a stimulating effect on economies. Meanwhile, building in areas with a lot of islands or areas in which the height system was simply not accurate becomes much easier.

Can you share any early conclusions from GOCE in connection with geophysics?
We can now prove that the available gravity data in Africa, parts of South America, China and also parts of Southeast Asia is simply bad. I am in contact with a prominent geophysicist, Dan MacKenzie from Cambridge University, who tells me that they are now able to take a completely fresh look at Himalayan tectonics!

Will GOCE ultimately change geomatics dramatically?
A revolution is taking place in the whole field. This revolution is not just related to gravity and thus to GOCE, but also to GPS, INSAR and GRACE. We are talking about millimetre accuracy and we are even able to see temporal changes now. This is important, because for the first time geodesy is now able to contribute to issues such as climate change, to tectonic changes and also to changes due to planning. And for the first time in history, sea-level rise can now be divided into the percentage due to thermal expansion and the percentage due to meltwater from the ice shields; for the first time, we can quantify how much ice is melting in Greenland or Antarctica; for the first time, we can quantify changes in groundwater on the continents. That in itself is really sensational!

How do you see the future of geodesy?
I see that geodesy is penetrating many more fields that were not touched before, like hydrology, oceanography, hydrography and geophysics as well as land management and disaster management. The keyword for me is the Global Geodetic Observing System – it has been extensively described in this magazine before, but it is good to note once again that one global millimetre-scale reference system on an Earth that is wobbling and bobbling is a major accomplishment. We pushed this idea very strongly because it is a precondition for further progress in geodesy. First of all because this connects satellite and terrestrial work and secondly because it provides for a global system. Geodesists, who are almost by definition quiet and modest types,

are increasingly coming out of their shell and showing the world their good work. In geodesy we have the tendency to say, 'This is no longer our field of experience so we'll let the hydrographer or oceanographer continue with the application of our geodetic data.' Other fields, meanwhile, are less hesitant to practice geodesy.

We regularly cover land management in GIM International. Is the link between what you do – for instance, with GOCE – and proper land management clear to everybody in geodesy?

Proper land management is very close to my heart, because I am absolutely convinced that access to land rights is a precondition for progress. But geodesy is practiced in a spectrum of subfields. In the middle, there's engineering geodesy: photogrammetry, remote sensing, cartography. On the wings are – my part – gravimetric geodesy, and the other wing is the land administration part. When we talk about global change – not only climate change, but also population growth, water shortage, etc. – these very distinct fields should enter into a dialogue with each other to contribute to solving these problems, which is not always easy. A good example of practicing this dialogue is the ITC in The Netherlands. I wish there were similarly wonderful institutes in Germany or elsewhere, because it represents the natural bridge between land management, photogrammetry and remote sensing, benefiting the developing countries. As a side note, I would like to say that it is very short-sighted of the Dutch government to put an institute like ITC under financial strain. The students at ITC come from many different countries and, when they return to their respective home nations, they are ambassadors for Europe and The Netherlands. I could not imagine any better investment in developing countries than the work done by ITC, giving students a fantastic education and keeping in touch with them later.

Certain parts of the world are suffering a lack of geodesy students. What advice can you give to universities to help them attract more youngsters?

Overall one might say that geodesy is on a wave of success, due to all these technological advancements we mentioned. But on the other hand, the split in these subfields might endanger educational institutes. The number of students of geodesy is indeed very low in many countries. In Germany we are lucky to still have eight universities where youngsters can study geodesy. But in some countries, such as The Netherlands – which for me remains an example of one of the most advanced countries in our field – geodesy is no longer offered as a course of study in its own right. There are no easy answers to the question of why this is. In Munich, we started an international master's course aimed at satellite applications; it attracts a lot of students, but again, and underpinning what I said earlier, this is not a geodesy course. And as long as geodesy is only taught in disguise at secondary schools – within the subjects of geography, physics and mathematics – it will probably mean a continuous fight for new students. Geodesy remains in a niche.

Geodesy is on a wave of success, due to all these technological advancements

You have worked in many different countries in the course of your career. Which regions and countries stand out in terms of geodesy?

In the US, the level of geodesy is high. But it is only possible to study it at a few universities, which might have a negative impact on the geodetic infrastructure in the future. Meanwhile, Australia and New Zealand have evolved into some of the best geodetic countries. I expect China to launch geodetic satellites pretty soon as well. I visited Beijing and Wuhan last year and I was fascinated, not only by the number of students but also by the level of research. So maybe we will be sending our students to China in ten years, instead of the other way around. Africa as a whole stays problematic: there are a few good universities but, due to the economic situation, there has not yet been a breakthrough in geodesy on the African continent. And there are some fantastic developments in South America – in Brazil, Chile and Argentina, for instance.

Do you have a message for the readers of GIM International?

I have been in this field since 1966 and I have enjoyed every single day of it. I have been fascinated by the progress made, and I have met so many people in so many countries, all members of the geodetic family. I wish everybody could feel this way and experience the privilege of working in this great field, because if you love geodesy, it will trigger your imagination and enable you to do good work! ◂

PUSHING THE LIMITS

Scanning Glaciers with a Long-range Scanner

A team of scientists recently completed a research visit to Helheim Glacier in Southeast Greenland. The purpose of their research was to characterise the behaviour of the glacier using the latest technology in ground-based remote sensing, a long-range Terrestrial Laser Scanner (TLS). The team monitored the glacier over the course of a few days using a RIEGL VZ-6000 Ultra-Long Range which enabled fixed-time interval scans of the glacier to be completed automatically. This automation gave the team a time-lapse 3D dataset, which can be referred to as a 4D dataset. One of the key breakthroughs was their ability to safely measure the entire width of the glacier from one side of its 6km-wide fjord. Glaciers are some of the most powerful forces on Earth, so the ability to monitor them while remaining at a safe distance is essential.

Retreat, acceleration and thinning of tidewater outlet glaciers around the margins of the Greenland Ice Sheet have continually been observed over the last two decades. These changes coincide with an increase in surface melting and, together, have doubled the ice sheet's contribution to equivalent global mean sea-level rise. Specifically Helheim Glacier, located in Southeast Greenland, has exhibited significant change in the last decade and is typical of Greenland's large outlet glaciers which terminate in narrow and deep fjords (~5-10km wide, ~100km long and >500m deep). Between 2002 and 2005, Helheim Glacier retreated more than 7km, accelerated its near-terminus flow speeds from ~7km/yr to ~11km/yr, and thinned by ~200m. The glacier has since slowed down, although speeds have not returned to pre-2002 levels and they show considerable interannual variability. Characterising the flow speeds of such a glacier at safe stand-off distances is a significant challenge. Yet it is essential to acquire these data to better understand the daily and interannual variations so that they may be included in the next generation of coupled Earth system

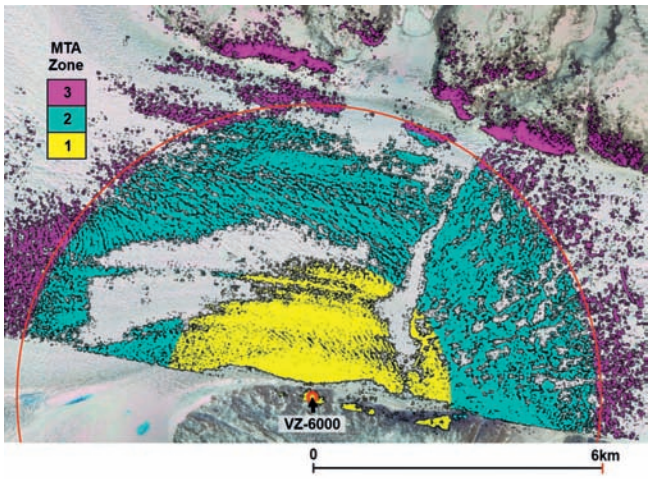
Ananda Fowler is a project manager of software development for RIEGL LMS in Horn, Austria. He has 10 years of experience in the geomatics profession and has worked on projects in The Bahamas, Ascension Island, Hawaii and other exotic locations over the years. He is currently working on automating field scanning workflows

✉ afowler@riegl.com

David Finnegan was born in Plattsburgh, NY, USA, in 1972. He holds a BSc in environmental physical sciences from Black Hills State University (1997), and an MSc in geology from Indiana State University (2001). His thesis work involved the use of airborne full-waveform Lidar in Southeast Iceland to characterise catastrophic flooding events and their geomorphic response. He has been employed at ERDC as a Research Physical Scientist since 2001. The results of his work have been published in numerous peer-reviewed publications.

✉ david.finnegan@erdc.dren.mil

▲ *Figure 1, Panorama view of Helheim Glacier with the VZ-6000 in foreground.*



◀ *Figure 2, Scan data displaying MTA Zones for 50kHz measurement rate overlaid onto Google Earth.*

models being developed which seek to better predict sea-level rise.

BACKGROUND

This is not the first time that the team has made a trip to conduct this kind of work. On previous trips to Helheim Glacier, they have performed precarious on-ice high-resolution GNSS surveys, and installed climate stations and time-lapse cameras to capture multi-temporal images of the glacier's behaviour. Along with these visual and spatial glimpses into the workings of the glacier, researcher David Finnegan from CRREL has previously utilised TLS in an attempt to determine flow velocities at numerous glaciers around the world, albeit with limited success. These previous efforts with existing technology had resulted in datasets with a maximum useful range of 3-4km. Although these data were groundbreaking for cryospheric sciences, they were of limited use since acquisition times were significant and, in the case of Helheim Glacier, the glacier was moving faster (>1m/hour) than the laser scanner was able to acquire data. An additional requirement was the necessity of acquiring the TLS data from a fixed, off-ice position to ensure the safety of the research team and to maintain confidence that any movement logged by the TLS was movement of the glacier only. One of the alternative methods considered was the use of airborne Lidar which would provide timely and comprehensive coverage of the glaciers. Using airborne Lidar in Greenland would require mobilisation and constant loitering by an aircraft equipped for Arctic missions, which is not cost efficient. Therefore a TLS with a range of at least 6km on snow and ice would provide the optimum balance between performance and cost efficiency. As no system existed which could address these requirements, a new instrument would need to be developed which could not only reach much longer ranges, but would also acquire data much faster. RIEGL Laser Measurement Systems took up the challenge of developing a system to meet these demanding specifications.

To put this type of development into perspective, it is helpful to have some reference regarding the existing technology and the effects of the atmosphere on the transmission of light. For a TLS with such substantially increased ranging capabilities, the atmospheric attenuation has a significant impact on the maximum achievable measurement range. Lower atmospheric visibility results in reduced maximum range; the energy from an emitted laser pulse is reduced due to absorption and scattering of the pulse's energy by molecules and/or particles in the air (i.e. dust, fog, snow, etc). Fewer particles in the air means greater visibility and therefore longer measurement range ability. Hence, the performance of a TLS is directly impacted by the physical conditions of its environment.

WAVEFORM

Time-of-flight laser measurement utilises a simple method to determine each measurement range. A laser pulse is emitted; this pulse travels until it encounters a surface, where it is partially reflected and echoed back to the instrument. This process is timed, and the distance is ▶

Figure 3, Scanning the Helheim Glacier

calculated using the speed of light multiplied by the travel time.

Typically, TLS systems called 'discrete return' systems make use of analogue electronics and simple schemes for echo detection and time-of-arrival estimation with results usually near the 10mm precision mark. The technique employed by more advanced systems is called waveform processing. This technology records a very precisely sampled representation of each returning echo so that sophisticated analysis can be done to calculate more precise ranges. While it is possible to keep these waveform records intact and analyse them offline, RIEGL's V-Line of instruments feature an advanced capability for real-time analysis. The analysis method is based on the knowledge of the expected echo signal waveform. When an echo returns, its actual shape is compared to the expected signal waveform. Put simply, the more similar the pulse shape and its echo waveform are, the lower the deviation value of each laser measurement. Correlation between these two shapes enables more precise range calculation.

This technology has improved the precision and accuracy performance of RIEGL TLS systems considerably. Since post-processing waveform data can be laborious, RIEGL has integrated this capability directly into modern scanners. This enables real-time waveform processing, called 'Online Waveform Processing', providing optimum performance without the need for post-processing.

WAVELENGTH

One of the major improvements to the system came from selecting an alternative wavelength for the system. Previous RIEGL instruments experienced limited range performance on snow and ice, primarily because they utilised an eye-safe wavelength of 1.5 microns which is almost completely absorbed by 1mm of water. An optimum balance between speed and performance on snow and ice is provided by the 1 micron wavelength. This wavelength means that the TLS is a non-eye-safe instrument, bringing it with it the responsibility of ensuring that system operators wear eye-safety equipment and maintain safe practices. However, the 1 micron wavelength enables the VZ-6000 to achieve measurements on snow and ice approximately 4 times further than a 1.5 micron laser pulse. As previously explained, some of this long-range performance is lost due to atmospheric attenuation, reducing the improvement from 4 to approximately 3 times the performance of a 1.5 micron system.

MIRROR SIZE

The physical properties of light dictate that larger optical surfaces are required to improve an instrument's light reception capability. This is the reason that the Hubble telescope is so large: larger optics means more light. Much the same as these large telescopes are used to peer into the far reaches of the universe, enlarged optics enable a TLS to measure greater distances. Therefore an increase in the mirror size of a TLS in combination with the corresponding optical improvements enables a marked improvement in range performance. The enlarged mirror and optics provide the VZ-6000 with a range performance improvement factor of 2 when compared to the RIEGL VZ-1000. This, combined

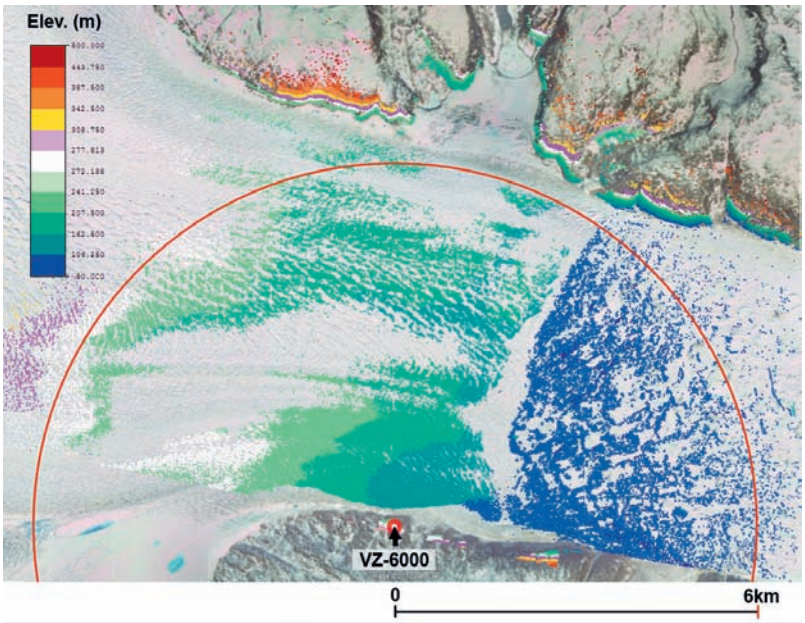


Figure 4, Scan data displayed by elevation (scale: 50-500m) and 6km scale overlaid onto Google Earth.

with the wavelength multiplier of 2, enables the system to achieve measurements on snow and ice more than 6 times as far as RIEGL's previous long-range TLSs.

MULTIPLE TIME AROUND

The magnitude of improvement made possible by improved optics, proper wavelength selection and advanced waveform processing left just one more challenge to be overcome: measuring these long ranges at high speed. When measuring distances of 6km, a system should theoretically be limited to 25,000 measurements per second (25kHz). The reason is simple: light simply is not fast enough to support measurement rates above 25kHz for ranges of 6km. To measure a distance of 6km, a laser pulse must travel a total distance of 12km, which takes the pulse approximately 0.00004 seconds (1/25,000th of a second). In this case, the pulse interval (time between measurements) would be limited to 0.00004 seconds. If this maximum pulse interval is surpassed, a condition known as Multiple Time Around (MTA) occurs. In such circumstances, when multiple pulses are travelling in the air at the same time, it becomes almost impossible to correctly associate each returning echo with its correct pulse emission. If the echo is matched to the wrong pulse (preceding or following pulse), the measured range will be off by a margin of one MTA Zone (one pulse interval) which, in this case, is 0.00004sec or 6km. To overcome this complexity, RIEGL developed a technique which enables laser scanners to operate at pulse rates above the MTA pulse rate threshold (25kHz in the above example) and to associate every echo with its correct pulse (with a confidence of better than 99.95%). MTA processing can give a user increased range and/or increased point density.

RESULTS

While accuracy and other factors must be considered, two main factors are important when measuring moving surfaces: time and sampling. The time of acquisition and time between samplings is critical, as is the number of measurements acquired from each sampling interval. On this project, the team acquired a point density of better than 1ppm2 on perpendicular surfaces at 6km range (Figure 4). The red line indicates the 6km range threshold, which was exceeded in several areas. The gaps inside the red line indicate shadows where a section of glacier nearer to the scanner eclipsed a region further away and caused missing data. The glacier was scanned more than 650 times by the stand-alone system, producing 30GB of data that the team will use to produce meshed surface models, direct point cloud comparisons and flow velocity models. Utilising a truly 4D (3D plus time) georeferenced dataset enables

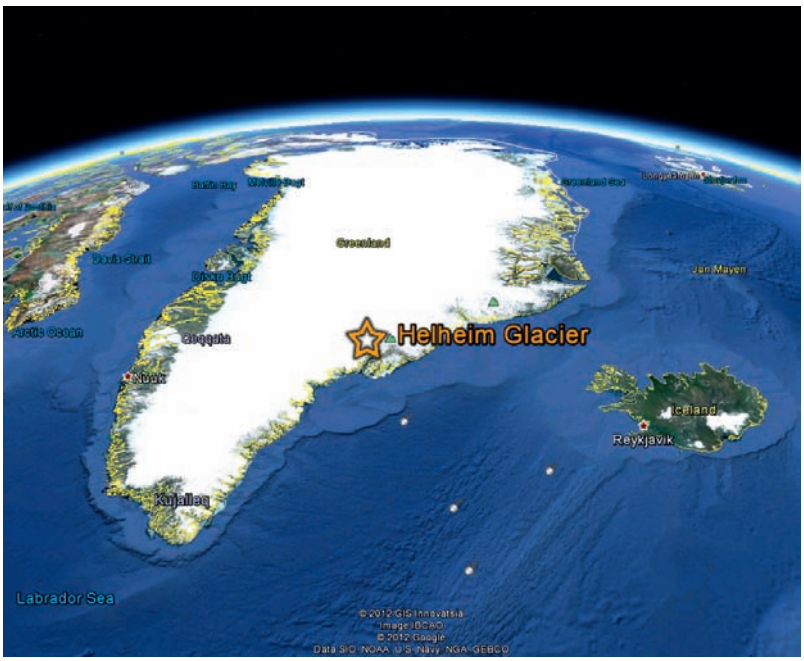


Figure 5, Location of Helheim Glacier in Southeast Greenland

experimental methods of analysis to be developed, such as friction models, torsion models and other physical models.

CONCLUSION

The VZ-6000 provided the researchers with an in-depth 4D perspective on the dynamics of the active Helheim glacier. The challenge now is to find new ways of examining this extensive 3D time-lapse data. The capability to scan large regions at high speeds opens new doors for exploring the stresses, strains, flow velocities, height trends and seasonal changes that glaciers embody. Exploring how these factors are influenced by global temperatures and a changing environment will doubtlessly result in innovative new methods and concepts which will shape the future Earth scientist's toolkit. This capability enables scientists to characterise small-scale features across large-scale terrain, without the complexities and expense of using aircraft in Arctic and Antarctic environments.

The challenge now is to find new ways of examining this extensive 3D time-lapse data

FURTHER READING

A New 1064nm Ground-based Lidar Instrument for Quantifying Dynamic Glacier Processes; First Results From Helheim Glacier, Southeast Greenland, 2012, AGU Proceedings, Finnegan, Stearns, Hamilton, Fowler.

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Improving the quality of laser scanning data acquisition through calibrated amplitude and pulse deviation measurement, 2012, SPIE 7684, Pfennigbauer, M., Ullrich, A.

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No 2323

A NEW LOW-ALTITUDE SURVEY TECHNOLOGY

Mapping a Landslide Using UAS

An Unmanned Aerial System (UAS) was used to acquire images of a small area in Italy for the purpose of post-landslide monitoring. The entire chain from aerial survey up to the automatic generation of maps and contour lines could be conducted within two days – one day surveying and one day processing – thanks to the use of sophisticated photogrammetric software. The quality of the final products is comparable with those achieved using conventional photogrammetry, while the throughput is faster.

After occurrence of a landslide, reliable, accurate and timely data is required in order to enable authorities to take proper measures. In the southern Italian municipality of Vibo Valentia (Calabria) located in the massif of Monte Poro, five areas are at high risk of landslides due to severe hydrogeological instability (Figure 1). Although these areas are rather small, the impact of landslides on infrastructure and urban

Unmanned Aerial Systems
This article is the second in a series of articles focusing on experiments carried out to test the aptness of Unmanned Aerial Systems (UAS) for a broad spectrum of potential applications. An Unmanned Aerial Vehicle (UAV) is the carrier of sensors and systems used for geodata acquisition. The platform together with the on-board sensors constitute a UAS. The applications may include land administration, map updating, landslide and dike monitoring, and biodiversity and heritage conservation. UAS technology is a low-cost alternative to classical manned aerial photogrammetry and is obviously growing mature. If you would like to contribute to the series, please contact wim.van.wegen@geomares.nl

Danilo Bellavita is head of the Department of Aerial Photogrammetry and director of the Cartography Laboratory at RPA, an Italian company focusing on engineering applied to planning, environment, hydrology and transport.

danilobellavita@hotmail.com

Francesca Ceccaroni is CEO of Menci Software. The company, based in Italy, is specialised in photogrammetry and develops a range of software products for photogrammetry, cartography, GIS and UAS.

francesca.ceccaroni@menci.com

Annalisa Mazzitelli holds a degree, with a specialisation in soil science, from the University of Perugia. After being employed by the Department of Civil and Environmental Engineering, Laboratory of Surveying and Photogrammetry (University of Perugia), she now operates on a freelance basis.

annalisamazzitelli@gmail.com

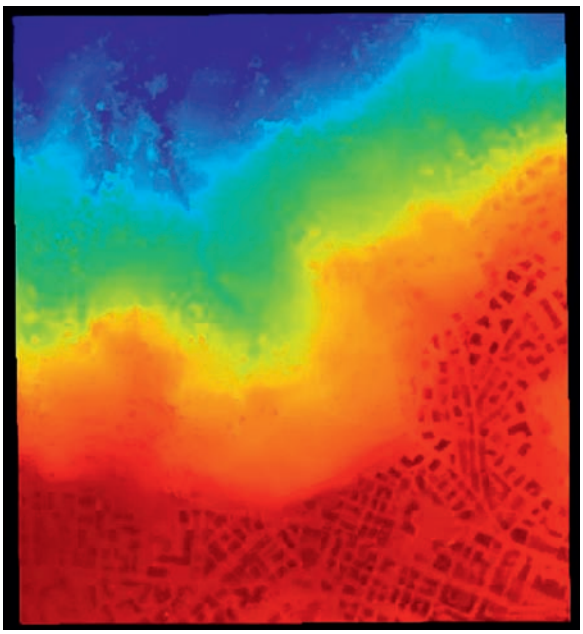
◀ *Figure 1, Vibo Valentia, San Pietro di Bivona, Piscopio, Triparni, and ex-track railway Calabro-Lucane are prone to landslides.*

▼ *Figure 2, Swinglet CAM micro UAV.*

centres may be large. The relatively large size of 1.43km^2 of the Vibo Valentia landslide area, where the height differences reach over 250m, and its proximity to the city triggered the authorities to carry out a survey after the occurrence of a landslide. The authorities chose Unmanned Aerial System (UAS) technology as they recognised its time-saving and cost-efficiency benefits.

UAS USAGE

UASs are piloted remotely. Depending on the sensor types on board, UASs allow monitoring of urban areas, archaeological sites and other areas. Since data processing can be carried out highly automatically, the use of a UAS enables quick and cost-effective multi-temporal analysis of small areas. In the Vibo Valentia project, a Swinglet CAM was used. This lightweight fixed-wing drone weighs 500g and has a flight endurance of about 30 minutes (Figure 2). The cruise speed is 36 km/h and the maximum wind speed for smooth operation is 7m/s (4 Beaufort; moderate breeze). It is remotely controlled via a PC and equipped with a 12 megapixel digital camera, GNSS and Inertial Measurement Unit (IMU). The latter consists of a combination of accelerometers and gyroscopes. The focal length of the camera is 24mm and typical flying heights lie between 50 and 1,000 metres, resulting in Ground Sample Distances (GSD) varying from 2 to 40cm. The images are taken automatically; since the maximum rate is one image per four seconds, around 400 images can be captured during one flight. The UAS lands



▲ *Figure 3, Colour-coded DSM with resolution 40cm.*

▲ *Figure 4, Orthomosaic.*

▲ *Figure 5, 3D representation: orthomosaic draped over DSM.*

by gliding down, circling around a waypoint with a minimum radius of 20m.

PREPARATION

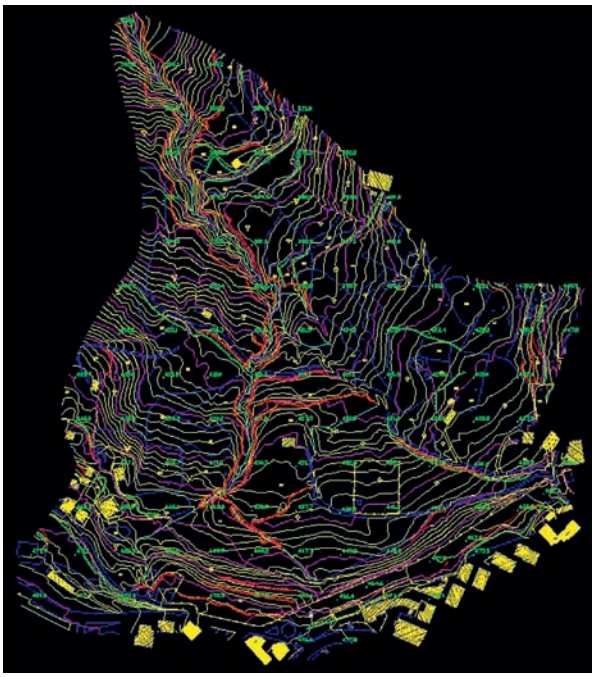
In the preparation stage, maps, aerial photos and other data were used to study the morphology of the Vibo Valentia landslide area and its changes over time. A proper landing place for the UAV was indicated and a flight plan prepared. The main tuning parameters of the flight plan are the rate of taking images, flying height, flying speed, and the interval between successive flight lines. The setting of the values of these parameters depends on the desired along-track and across-track overlap, the required GSD and the speed and direction of the wind. Both the along-track and the across-track overlap were set to 80%. The GSD was set to 5 to 8cm and the flying height to150m. Given the maximum battery life time at an altitude of 200m, three flights were conducted. Each flight lasted 27 minutes and the total flight time was 81 minutes.

ON SITE

On site, the flight plan was uploaded to the computer on board the UAS and pre-flight checks were carried out. The footprint of the images is continually displayed on the screen of the operator's PC, thus allowing checking of coverage and avoiding gaps. 932 images were taken in total. The use of ground control points (GCP) enables the precise reconstruction of the terrain in the form of a Digital Surface Model (DSM), contour lines and other derived products. Six GCPs were placed along the border of the area at locations clearly visible in the imagery. They were measured with DGNSS in RTK (Real Time Kinematic) mode with a precision of 5mm.

PRODUCT GENERATION

After the air survey, the quality of each image was examined. Using the APS Menci software and the GNSS-IMU data, the images were georeferenced through bundle adjustment. Tie points were automatically detected and matched using stereo image matching software. Stereo image matching was also used to generate a DSM from which contour lines, orthophotos and orthomosaic were automatically derived. The grid interval of the DSM was set to 40cm, i.e. five times the GSD of the images (Figure 3). The grid interval of the orthomosaic was set to 10cm (Figure 4). The orthomosaic was draped over the DSM to obtain a realistic 3D impression of the area (Figure 5). To obtain a better 3D impression, Z-map photo software allows overlapping images to be viewed in stereo. Furthermore, a detailed map – including contour lines – was generated of the Vibo Valentia landslide area, providing authorities with the necessary information to support recovery and reconstruction of heritage buildings in the city (Figure 6). The interval of the contour lines on this map was set to 1m. Conducting the chain from aero-triangulation up to the finalisation of the maps took 4 hours and 40 minutes.



▲ *Figure 6, Map including contour lines and heritage buildings in the Vibo Valentia landslide area.*

CONCLUDING REMARKS

The level of detail of the derived photogrammetric products meets the needs of the authorities. The experience we gained during the present study makes us confident that UASs may be fruitfully employed not only for landslide monitoring but also for a variety of other applications such as topographic and environmental mapping, surveying and monitoring of construction sites – including road and rail – and environmental impact assessment. ◀

FURTHER READING

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No 2314

MEASURING SHIP CONTROLLABILITY

GNSS for Sea Trials

The effective seakeeping performance of any watercraft is vital for safe navigation. Due to the long maritime tradition in Greece, the National Technical University of Athens (NTUA) has been a key player in developing tools and practices for conducting sea trials in open water. Since the introduction of the Mini-Ranger many years ago through to the recent introduction of the modern GNSS sensors, a number of new-built and commissioned surface ships of various sizes have been tested either in the interests of the shipbuilder or the owner. Currently, new navigation tools and techniques are being set in place to fulfil the demand for increased accuracy and reliability measures.

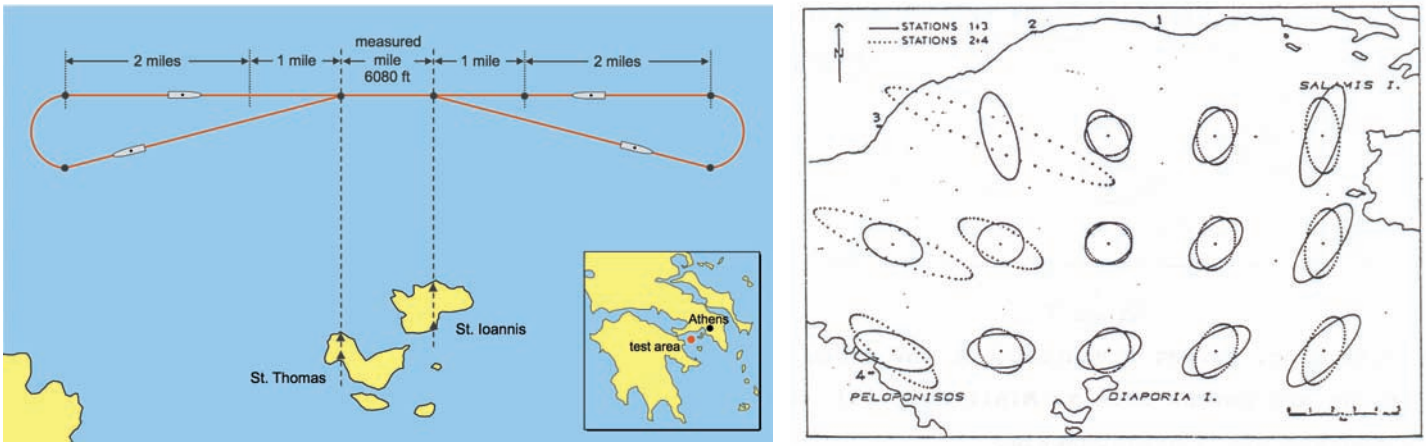
Ship controllability includes all aspects of regulating vessel kinematics (trajectory, speed and attitude). Sea trials are essential in the verification of critical course keeping and course changing capabilities, as well as emergency manoeuvrability characteristics, while others are intended to demonstrate the performance of vital machinery and regulatory requirements. With regard to the testing of the navigation capabilities of a ship, three distinct areas are involved; i.e. course keeping or steering, manoeuvring and speed changing trials. The first category aims to check the ship's ability to maintain a straight path in a predetermined course direction. Typical testing involves the execution of the Z-manoeuvre and direct / reverse spiral trials (Figure 1). Course changing or turning tests assess the manoeuvrability features of a boat. In this case, the turning circle and Z-manoeuvre are used to characterise the turning and yaw-checking potential of a vessel. Finally, speed changing tests demonstrate the ability to control vessel speed including emergency / inertia slowing, stopping and backing. Here, critical manoeuvre parameters relate to the ease, rapidity and travelled distance associated with a change. In addition, speed tests that characterise ship performance in relation to engine horsepower and propeller capacity are required.

Vassilis Gikas is an assistant professor in geodesy at the National Technical University of Athens. His previous appointments include researcher at the Department of Geomatics, University of Newcastle-upon-Tyne, UK, and navigation and positioning specialist in the UK and the USA offshore industries. He has also served the private sector in a number of positions in the surveying and transportation industries. His current research interests include geodetic monitoring of structures and sensor fusion for land and sea navigation.

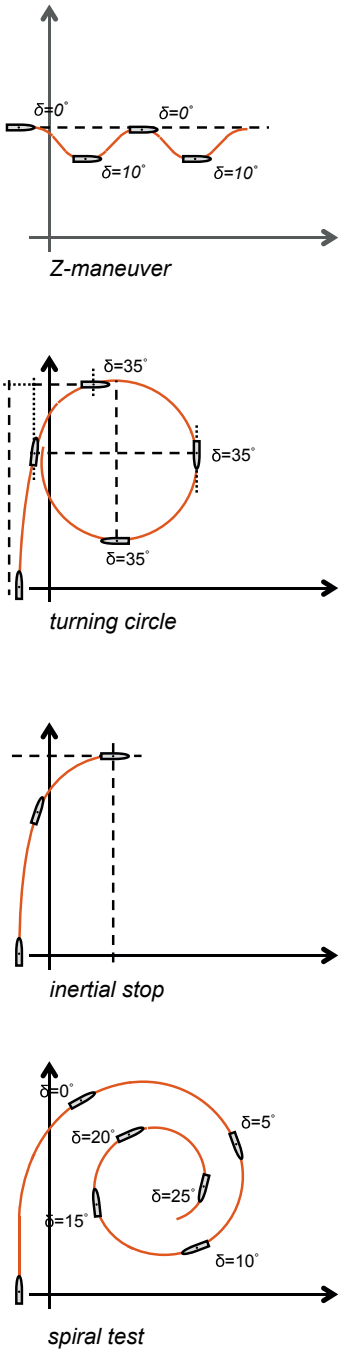
✉ vgikas@central.ntua.gr

Demitris Paradissis is a Professor in Geodesy at the National Technical University of Athens and Director of Dionysos Satellite Observatory. He has over 30 years' experience with GNSS data acquisition planning and analysis for geodynamic applications, and quality control of GNSS data for land and sea engineering applications. His current research interests include precise GNSS positioning and satellite interferometry.

✉ dempar@central.ntua.gr



▲ *Figure 2, NTUA test-site (left), and accuracy pre-analysis for MiniRanger III (right).*



▲ *Figure 1, Ship trajectory for main sea trials (δ: rudder angle).*

The procedures applied (in many cases adopted by flag states as national requirements) for conducting sea trials primarily rely on guidelines and standards produced by the Society of Naval Architects (SNAME) and the International Maritime Organisation (IMO). The last one provides (interim) standards for the planning, conducting and reporting of sea trials, as well as a set of parameter criteria used to assess seakeeping performance. Critical parameters for the turning circle of large ships require the "advance" (distance travelled along the direction of the initial course) at 90o change of heading and "tactical diameter" (transfer) at 180o change of heading to be less than 5 and 4.5 ship lengths respectively. A key parameter to assess the stopping ability of a vessel is the "track reach" (the distance travelled along a path until ahead speed changes sign) which should not exceed 15 ship lengths. Similarly, the "overshoot angle" (the exceeding angle of the ship's heading between the point the rudder is deflected and the point the ship's change of heading reverses) is used to assess the yaw-checking ability.

PAST PRACTICES

The first sea trials conducted by the NTUA go back to the early 80s. The test area is located in Saronikos Gulf, some 30km west of Athens, Greece. The area has been a test site for NTUA since 1978, when the officially measured nautical mile was established nearby Diaporia islands (Figure 2). The site was carefully selected due to its adequate water depths, low current strength, proximity and the generally good weather conditions. The limited accuracy of long-range, hyperbolic positioning systems at that time (such as Loran-C) could not match the precision requirements for the tests. Instead, the MiniRanger III short-range, pulse navigation system was used. The system employed four reference stations on shore (Figure 2 and 3), from which the distances from the shipboard station were measured via interrogation-to-reply time delay. The ranges were recorded in real time with final positions calculated at a later time. The on-board section consisted of the receiver / transmitter, a range console and a digital printer. The system operated in the 5.6 GHz frequency band producing ranges of about ±3m accuracy over ranges of up to 30km. If more than two ranges were available, final positions were computed using least squares adjustment, resulting in absolute position uncertainties less than 10-12 m (95% confidence level). Part of this error could be attributed to the time delay involved in multiple ranging, given that simultaneous observations could not be precisely taken. In effect, as shown in Figure 2, final navigational accuracy was also subject to the number and relative geometry of the reference

▲ *Figure 3, MiniRanger III shore station configuration.*

◀ *Figure 4, Turning circle path of a cargo vessel.*

stations used. Besides, shore stations had to be periodically calibrated for signal strength loss by measuring the turn-around delay for each beacon from a number of known locations.

MiniRanger III provided only a single point location at a time (the ship's bridge). In addition, given its low (0.25 Hz) sampling frequency, it was unrealistic to compute the ship's heading using subsequent point fixes. The ship's orientation was therefore obtained via time matching of vessel location with gyro information. In this process, inaccurate data synchronisation could induce errors of 5-10m in certain parameters, such as the "advance" and "tactical diameter" for a turning circle.

Apart from the limited positioning accuracy, sea trial operations at this time faced a great number of practical difficulties. It was, therefore, necessary to repeat a large number of test runs before final approval was attained, rendering a trial campaign costly and hard to complete in time. Temporal loss in ranging signal strength could result in data collection delays. Communication between the ship segment and shore stations was also hard, and it was therefore difficult to report problems and potential alterations in the testing schedule. Regarding the shore stations, instrumentation was heavy to carry, required high power needs, and therefore heavy charging units. Critical sea trial controllability parameter computation and graphical representation was done mostly through hand computations, whereas the use of computers was largely confined to vessel location calculations.

PRESENT STATUS

Today, sea trials are conducted in the same test area in accordance with IMO interim standards and its explanatory notes published thereafter. However, depending on client requirements, small-scale modifications may apply to the execution process according to shipyard guidelines or national organisation recommendations. Generally, care is taken to conduct trials in a calm sea state to eliminate excessive vessel crab angles (angular difference between heading and track) and in full load / even keel conditions. Also, specific engine power control and propeller revolution settings, approach run and test speed conditions apply depending on individual tests. Navigation data acquisition is typically undertaken employing Differential pseudorange GNSS techniques at sub-metre accuracy. Until the late 90s, the base station was temporarily installed ashore at a secure site nearby. Nowadays, correction data is taken from multiple permanently operating GNSS stations, established by NTUA in the broader area for geophysical monitoring purposes with an update rate of 1 sec. Several receivers have been used over the years, such as Trimble 4000 SSI and Javad Triumph. Depending on weather conditions and specific requirements, tests can last a few hours or several days.

Computation of ship turning and steering parameters (such as the "advance", "tactical diameter" and "overshooting angle" respectively) depends on the ship's heading. In the past, in order to study the impact of error in the ship's heading on manoeuvring parameters, we performed a limited number of tests based on heading values obtained in different ways, namely: gyrocompass measurements, successive point fixes of the ship's location obtained from a single GNSS device, and pairs of receiver locations retrieved simultaneously from GNSS units placed at the bridge and stern of the vessel. Cross-comparisons between the gyrocompass and GNSS-derived headings verified the total (dynamic and follow-up) gyrocompass uncertainty; for CMZ900 being about 1o at 40o latitude. For a turning test of a long boat, such delays induce an error in "advance" and "transfer" parameters in the order of up to 3m. Similarly, the differences observed in the turning parameters computed using a single GNSS unit from those derived based on two receivers were, in the worst case (high speed vessels), less than 2.5m. These differences are nevertheless acceptable (especially for large ships) and despite the ▶

fact that many shipborne gyros do not facilitate easy synchronisation with external devices in the field, an effort is made to record gyrocompass measurements for redundancy.

Using GNSS data and ship dimensional and operational (rudder angle, engine power and propeller revolution) information plots for the ship's trajectory, kinematics (speed, acceleration) and yaw / yaw-rate are produced. Data analysis relies on in-house software to compute critical parameters according to IMO standards, such as: the "advance", "transfer", "mean turning rate", "tactical / final diameter" for the turning circle; "overshooting angles" at predefined steering and engine power events for the Z-manoeuvre; "track reach", "head reach" and "lateral deviation" for the stopping tests; and "rate of turn" for the spiral test. The software can accommodate multiple receiver inputs and facilitates additional tools; for instance, least squares analysis for computing the turning circle radius. Figures 4 and 5 show typical screen plots for the turning circle and inertial stop tests for a large (225 m long) cargo vessel.

In recent years, in order to enhance the navigational accuracies, the Doppler shift (the apparent change in the wavelength of GPS signal due to relative motion between satellites and ship) on the GPS carrier frequency is measured. The GPS-Doppler observables urge a direct method of speed measurement that is largely insensitive to atmospheric disturbances. Using this method we found an overall improvement in ship kinematics of more than 50% (from 0.46o / 0.10 knots to 0.16o / 0.04 knots in heading and speed error respectively).

FUTURE PERSPECTIVES AND CONCLUSION

Currently applied navigation techniques and practices in most cases meet standing sea trial requirements and standards. In special cases that require increased navigational accuracies, such as small size, highly manoeuvrable and specific purpose vessels (patrol ships and hovercrafts); dual frequency GNSS receivers can be used in real-time kinematic mode. Future advancements include the use of multiple, collocated GNSS antennas operated at fixed lever-arm geometry to allow the capture of the six degrees of freedom of a ship's motion. These systems are currently used in various applications such as those in hydrographic surveys to correct bathymetric measurements for ship attitude. The use of four-antenna GNSS configurations in combination with inertial systems for sea trials will provide yaw, roll and pitch observations from which the ship's trajectory can be reconstructed as a solid body moving in 3D space. This will increase redundancy and improve reliability of test results, provide source information for theoretical studies and pave the way to draft procedures and guidelines for conducting sea trials under non-standard sea-state and water depth operating conditions.

In addition to full-scale trials in the open sea, current geo-technologies can prove particularly useful for use in restricted areas or laboratory ship model trials. Experimental results obtained with self-propelled model ships can provide source data for computing hydrodynamic coefficients to assist in the prediction of ship manoeuvrability at a design stage. Modern OEM GNSS / MEMS IMU configurations are very promising solutions, due to their small size and weight and sub-decimetre accuracy. Furthermore, in small scale laboratory conditions, other non-contact technologies can be used in addition to inertial measurements. This category includes video recording systems employing digital photogrammetry algorithms that can produce vessel trajectory at sub-centimetre accuracy.

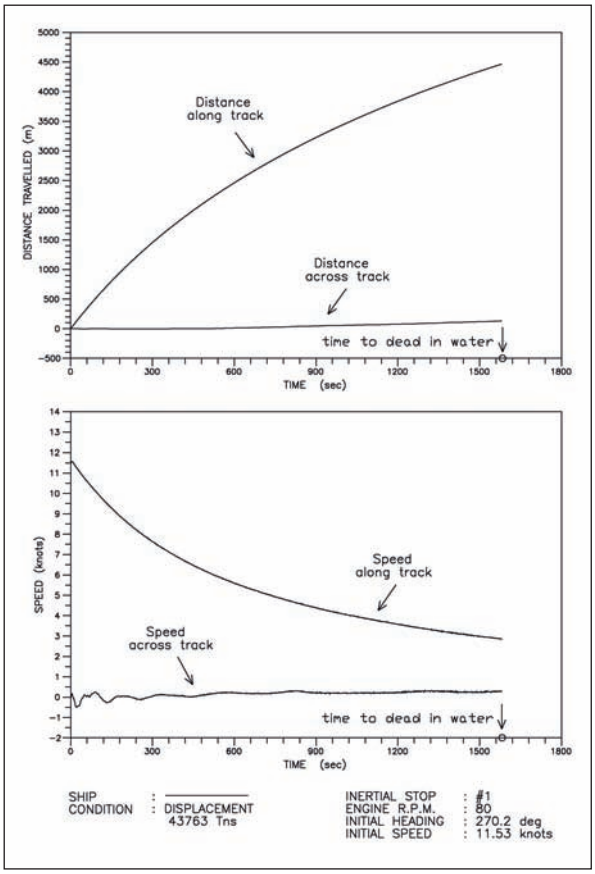


Figure 5, Travelled distance / speed change diagrams for inertial stopping.

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NORTH GROUP

Surveying and Positioning Systems

▲ *NXR total station.*

Every month *GIM International* invites a company to introduce itself in these pages. The resulting article, entitled Company's View, is subject to the usual copy editing procedures, but the publisher takes no responsibility for the content and the views expressed are not necessarily those of the magazine.

The world of surveying and positioning is experiencing an amazing transformation that began just recently, and goes hand in hand with the superior push in technology democratisation due to the popularity of consumer and professional hand devices. Almost any phone is now more powerful than our first desktop computers and satellite positioning seems to be permeating into everything from locating friends to autopilot planes and cars.

North Group has experienced this change in technology since its first totally automated truck fleet management system was put to work in 2000 in Europe, USA and Mexico. The hardware and communications involved in processing advanced positioning and data management has only decreased in costs while there has been an exponential increase in capabilities.
The development of surveying and positioning systems by North was a natural evolvement of its industrial and government customers that required higher accuracy and integrated usability. In 2001, this led to its very first instrument, called the Dataflow, which could perform analysis on the fly - 10 real-time water quality parameters while doing bathymetric work, and was used on offshore oil operations and high-volume dredging. The same high-end technology is used in their surveyor-type North Naviger D echo sounder that delivers double frequency readings up to 900m within a portable OS based unit.

NEW MARKETS

While North Group's core business was surveying, they began serving mostly non-surveying markets, and it quickly became clear that their instruments and systems should always be simple to use by anyone, regardless of the field work profile, and open enough to be modified in accordance with the customer's specific needs. The product line continued to grow in this direction, currently serving a strong base of geologists, electric engineers, miners, biologists, railway operators, risk managers, archaeologists, speleologists, machine operators, logistic and port managers, cadastral administrators, construction contractors, and, of course, land surveyors.

The highly capable R&D personnel of the company began developing instruments and systems as third party consultants for renowned

European and Asian surveying instrument manufacturers, working on total stations, handheld GNSS, RTK receivers, CORS systems, surveying echo sounders, and controlling software. This trend and experience resulted in the start of the North Surveying line in 2010, aimed directly at end-users, rather than corporations, thus offering high-level instruments to markets looking for the best cost versus benefit relation while integrating smart and easy to use solutions that are welcomed at every level.

For example, the NXR is the only mechanical total station in the market capable of realising laser scanning, and is so simple that any surveyor can operate it, while doing regular stake out work, running a point cloud in a snap, actually transmitting the data wirelessly in real-time using the user´s Android phone to then forward it by "Share" to the office email and continue working in the field; all in all, a time saver that does not add to the price tag.

USER FRIENDLY

North´s CORS system is also simple and powerful. The user simply needs to plug the Base receiver to the internet and our cloud service takes care of the rest, even showing the location of the receivers on Google Maps. No need for fixed IPs, expensive and hard to configure software, or dedicated servers to operate.

Another example of simplicity, although some details cannot be currently released, is the new system upgradable GNSS RTK line, to be introduced in 2013. The design is rugged enough for military and machine control applications while also being light and integrated enough as a full day portable rover. Some of its details such as its IP68 rating, double battery life, standard data communication protocols, full array of preconfigurations, the largest screen of its type, and on board transmitting UHF radio with 40W of transmission on the basic set, clearly sets it apart from others in its price range. Based on customer demand, the receiver was designed entirely with no rubber or membrane buttons that can weather away and break, no battery boxes and nothing that can compromise the operation of the receivers.

The new receiver line, like most instruments and components of the North product line, has been designed and manufactured entirely in Barcelona, Spain, and field tested in sub-zero temperatures in Europe and in the sun-baking 60°C saline weather of North's Mexican office. From desert to mountain, rainforest to open ocean, as rugged as a surveyor, North delivers results.

FLEXIBILITY

To be able to deliver technology of the highest level while remaining affordable to the loyal base of customers, North Group began working on the development of core technology two years ago, introducing three critical components on the full line of receivers this year. Firstly, the custom designed four-element GNSS antenna, created by partnering with aerospace suppliers for maximum accuracy and multipath rejection; this antenna is specifically designed to match the fine tuning of the patented algorithms of the new Stealth GNSS receiver board, that boost 330 channels receiving in full spectrum Landstar-GPS, GLONASS and the newly available Compass/ Beidou systems. In addition, its scalability makes it flexible enough to cover any application and budget while sporting top-notch technology. The Stealth receiver is not available for OEM applications, being exclusively available within North branded instruments or custom applications.
Another newly introduced core technology is the UHF radio-modem module, with a selection range of 0.5, 2, 25 and up to 40W power steps for maximum field data transmission flexibility and matching communication protocols that enables seamless connection with other receiver radio brands. North believes that closed proprietary formats make the technology acquisition for the end-user difficult, so, where possible, it enforces the adoption of common standards like NMEA, RINEX and RTCM as base for its systems.

▲ *Naviger D echo sounder.*

▲ *Stealth GNSS receiver board.*

North Group's strategy of expansion into the end-user markets will include the impulse of the North brand, through the North Surveying division, and the allocation of sales and support points for the EMEA market during 2013 using as entry point the introduction of the totally redesigned 2013 product line, with strong support of the well-received North and strategic partner's instrumental software, that is developed under their Continuous Improvement policy. ◀

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FIG Working Week 2013, Abuja, Nigeria

The FIG 2013 Working Week will be held between 6 and 10 May 2013 in Abuja, Nigeria. The event is jointly organised by FIG and the Nigerian Institution of Surveyors (NIS).

NIS is being supported by the Government of the President of the Federal Republic of Nigeria, the Office of the Surveyor General of the Federation - Nigeria (OSGOF), the Surveyors Council of Nigeria (SURCON), the Nigerian Institute of Quantity Surveyors (NIQS) and the Nigerian Institution of Estate Surveyors and Valuers (NIESV). This Working Week, with its theme 'Environment for Sustainability', is very appropriate at this juncture.

The profession recognises that we are operating within a complex and interconnected environment, where we need to engage societal, environmental, economic and political realities as the profession seeks to extend the use and usefulness of surveying towards the betterment of humanity. However, there is optimism as our professional community has the sciences, knowledge, technologies and practices to rely upon. And when this situation is operating in a synergistic manner, there can be an environment for sustainability, particularly for the profession.

In the belief that land still has the capacity to create opportunities which provide dignity and that good land rights infrastructures exist in only 35-50 countries according to one estimate, and considering that, according to another estimate, only three percent of Nigeria (along with very many other African countries) has cadastral coverage, participants at the Working Week will be urged to discuss and consider home-grown appropriate approaches and solutions which may well involve methodologies that are of lesser sophistication and accuracies, information from participatory and volunteered sources, technologies which are mobile and widely available, that may well be distinct from prevailing approaches and practices that are usually rigorous and could be outdated.

Nigerian parliament building.

FIG will continue to provide the global forum for professionals, practitioners and partners as it seeks to serve the places, the policies and the people together. FIG's 2013 Working Week will once again bring together participants from different cultures, from diverse surveying traditions and varying professional experiences. The organisers have received more than 230 paper proposals, continuing the very successful formula with options for presenting peer-reviewed, academic, technical and practical papers, and thus should be of interest to participants from all over the world. As in previous Working Weeks, there will also be social events, and the experiences in Abuja will undoubtedly be unique and memorable.

The Working Week will take place in the exciting new capital Abuja which is only around 30 years old. Designed by the Surveyor General Office, this is an interesting and marvellous example of how to build a new city. Capital security in Abuja is high on the agenda, which also applies for the Working Week. All efforts have been made to keep the fees as low as possible. Full registration includes admission to all technical sessions and exhibition, lunches, coffee breaks with refreshments, welcome reception, Opening Ceremony as well as the farewell reception.

Bode Adeaga (fnis), president Nigerian Institution of Surveyors, NISD CheeHai Teo, president of International Federation of Surveyors, FIG

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No 2222

SDI Best Practice in Chinese Taipei

Left to right: Joep Crompvoets, Roger Longhorn, Minister Lee and Jeremy Shen.

In mid-August 2012, Joep Crompvoets and Roger Longhorn were invited by the Government of Chinese Taipei to present the keynote speeches at the day-long seminar launching the Taiwan Geoportal One Stop (TGOS) portal (1). Longhorn spoke on the value of geospatial data and of Spatial Data Infrastructure (SDI) to the economy, to businesses and to citizens, and presented a list of recommendations of how to value SDIs. Crompvoets presented the assessment of Chinese Taipei's current SDI. To ensure a comprehensive assessment, he made use of four SDI-assessment approaches – SDI Readiness (Tatiana Delgado Fernández), INSPIRE State of Play (Danny Vandenbroucke, et al), Clearinghouse Suitability Index (Joep Crompvoets) and Organisational (Bastiaan van Loenen) – and compared the assessment results with other SDIs around the world.

The assessment shows that Chinese Taipei's SDI is highly advanced, having been under development for more than a decade, with strong government support from the Ministry of the Interior.

The pre-conditions for undertaking SDI were very good, especially organisational and technological readiness. Clear SDI leadership, vision and operational communication channels make the organisation of the Chinese Taipei SDI very strong. The TGOS portal is highly suitable for discovering, viewing and disseminating spatial data. Numerous web services are implemented based on international open standards. Based on the assessment, the SDI of Chinese Taipei can be considered one of the top SDIs in the world – an excellent example of best practice, offering valuable lessons. The topics requiring attention for sustainable development of the SDI relate to legal issues, sustainable funding and metadata implementation.

The August visit was well organised, and was hosted by Jeremy Shen, director of the Information Centre, Ministry of the Interior, who is also an active member of the GSDI Association Societal Impacts Committee. During the visit, meetings were held with Minister of Interior Dr Hong-Yuan Lee, and deputy or vice-Ministers from the Council for Economic Planning & Development, the Ministry of Foreign Affairs, Office of Science and Technology, the National Space Organization, the Taiwan Geographic Information System Center in Taipei, and the GIS Research Center at Feng Chia University – all of whom have an important part to play in the success of the NSDI. Special emphasis in Taiwan is on disaster planning, monitoring and mitigation due to the number of typhoons and earthquakes to which the island nation is subjected, with accompanying serious flooding and landslide incidents. ◂

Joep Crompvoets is a researcher at the Public Management Institute, KU Leuven, Belgium and secretary-general of EuroSDR. Roger Longhorn is information policy advisor for the Coastal & Marine Union (EUCC) and senior information policy analyst at Compass Informatics Ltd (Ireland). Both are vice-chairs of the GSDI Outreach & Membership Committee and serve on the GSDI Board.

MORE INFORMATION
1. http://bit.ly/VZtwVK
www.gsdi.org

The mission of the Association is the advancement of geodesy.

IAG implements its mission by:

- advancing geodetic theory through research and teaching,
- collecting, analysing and modelling observational data,
- stimulating technological development, and
- providing a consistent representation of the figure, rotation and gravity field of the Earth and planets, and their temporal variations.

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Since the predecessor of the IAG, the 'Mitteleuropäische Gradmessung', was established back in 1862, IAG is celebrating its 150th anniversary in 2012. Celebrations will climax in September 2013 at the IAG Scientific Assembly in Potsdam, Germany. This location is particularly significant since the first ever meeting, in April 1862, was organised by General Baeyer, as representative of the Kingdom of Prussia, in Berlin. The participants were several geodesists from the Kingdom of Saxony and the Austrian-Hungarian Empire.

Gravity, Geoid and Height Systems

Participants at the GGHS2012 symposium.

In October 2012, IAG Commission 2 'Gravity Field' organised the 'Gravity, Geoid and Height Systems' (GGHS2012) symposium, assisted by the International Gravity Field Service (IGFS) and the Global Geodetic Observing System (GGOS) Theme 1 'Unified Global Height System'. The symposium took place on the island of San Servolo in the Venetian Lagoon, Italy, and the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale – which is the current Central Bureau of the IGFS – was responsible for the local organisation. The event attracted 140 participants, including 30 students.

GGHS2012 was the fifth in the series of four-yearly conferences organised by IAG Commission 2 since 1996. The conference covered all Commission 2 activities except topics related to satellite altimetry, these were covered in a separate symposium in Venice two weeks prior to GGHS2012, called '20 Years of Progress in Radar Altimetry', in Venice two weeks prior to GGHS2012.

89 oral papers and 64 posters were presented in eight sessions. Peer-reviewed proceedings of the conference will soon be published in Springer's IAG Symposia series (Volume 140). A highlight of the conference was presentation of the results of the very successful satellite gravity missions GRACE and GOCE, and in particular their applications in oceanography, mass transport and solid Earth modelling, hydrology and the atmospheric sciences. Special attention was paid to results dealing with the loss of ice mass over Greenland and Antarctica and the resulting global sea-level rise. Since the GRACE and GOCE missions are due to end soon, another important topic of GGHS2012 was the prospect for continuation of gravity space missions. Fortunately it appears that plans for a GRACE follow-on mission are progressing well, involving a collaboration of American and European space agencies, with a possible launch date of 2017.

The Joint Working Group 'Vertical Datum Standardization' coordinated a meeting of those working on the realisation of a Global Height System (GHS). They presented their results of estimating the global vertical reference level parameter W0. The individual results are now in good agreement, in the order of a few centimetres of each other. This implies that agreement on the conventional value for W0 is close. This is a prerequisite to the definition of a GHS which can be presented for broad comment, and ultimately adopted by the scientific and geospatial communities. The development of a practical definition (and realisation) of the GHS has been an important goal of the geodetic gravity community for many years. The GHS will complement the purely 3D/geometric International Terrestrial Reference System (ITRS).

Another open issue of the gravity community is the replacement of the outdated International Gravity Standardisation Network IGSN-71 by the use of modern absolute measurements and time series of super-conducting gravimeters, through international comparison campaigns of absolute gravimeters. These activities will be progressed within the corresponding working groups over the next few years. ◂

Urs Marti

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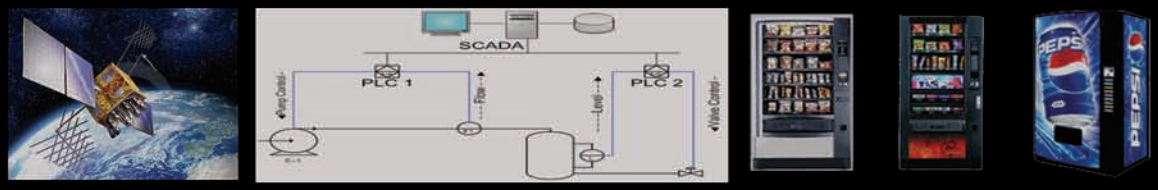

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The Conference Bonus

It is customary that, whenever the world's cartographers meet at the biennial International Cartographic Conferences (ICC), related activities also take place immediately before and after, taking advantage of the concentrated presence of experts and practitioners in one location. Most of these activities are organised under the auspices of the Commissions of ICA, and demonstrate the vibrancy of the international research community in cartography and its urge to meet whenever possible.

The Commission on Use and User Issues will present a workshop on eye-tracking in August 2013.

Such extra meetings tend to be more informal (presentations may not be refereed, for example), may be more free-format (as workshops or practical activities, for example) and may be cheaper (registration fees may be waived), but they will always take the work of Commissions forward and result in important progress.

In Paris, in 2011, for example, an extraordinary range of such activities (listed at 1) covered a wide spread of Commissions. Among the many events were: a walking tour by the Working Group (WG) on Art and Cartography, 'Patterns of a city exploring the invisible borders between the arrondissements of Paris'; a joint 2-day symposium, 'Looking to the future: Children, education and internet', organised by Commissions on Cartography & Children, Maps & the Internet, and Education & Training, Planetary Cartography, and WG on Cartography of Early Warning & Crisis Management, which resulted in a significant book publication (*Maps for the Future: Children, Education and Internet*, Eds. Laszlo Zentai and Jesus Reyes Nunez); a one-day practical workshop on 3D scanning of historical globes and deformed maps offered by the Commission on Digital Technologies in Cartographic Heritage; and an intensive 2-day brainstorming colloquium offered by the Commission on Generalisation & Multiple Representations. Many other similar meetings were held.

This August in Dresden, Germany, similar activities will be held in addition to the main ICC. There are already plans for a joint symposium involving Commissions on Cartography & Children, Education & Training, Maps & Graphics for Blind & Partially Sighted People, and Planetary Cartography, on 23 August. Further, the Commission on Use & User Issues, with the Commissions on Cognitive Visualisation, and on Geovisualisation, have announced a workshop on 'Working with Eye-Tracking' on 23-24 August. The workshop includes a Data Challenge, for which data can be accessed through the Commission website at 2. In addition, the active Commission on Generalisation & Multiple Representations has announced an ambitious programme for its 2-day workshop, also on 23-24 August. The following topics have been presented as the focus of this event: User- or data-driven approaches?; Application-dependent delivery of variable data; Generalisation in support of integrating NMA data with other data; Service-Oriented Architecture approaches to rendering variable scale data; Characterising and reasoning about geographic phenomena; The role of web services in sharing algorithms; New IT methods to promote Service-Oriented Mapping; Quality assurance in generalisation; and Cartographic generalisation of 3D objects.

MORE INFORMATION
1. www.icc2011.fr/scientific-programme/workshop-and-tutorials/
2. www.icaci.org

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CIPA 2013 Symposium

CIPA Heritage Documentation is a dynamic international organisation that has twin responsibilities: keeping up with technology and ensuring its usefulness for cultural heritage conservation, education and dissemination. This dual role linking culture and science is echoed in CIPA's parent organisations: International Council of Monuments and Sites (ICOMOS) and International Society of Photogrammetry and Remote Sensing (ISPRS).

CIPA accomplishes these two sometimes conflicting goals in a variety of ways. Its bi-annual congress provides a platform for the exchange of ideas, best practices as well as scientific research papers. This year's event, the XXIVth International Symposium in Strasbourg, France, from 2 to 6 September 2013, will mark CIPA's 45th anniversary. The CIPA 2013 Symposium will be a unique opportunity to listen to key figures in cultural heritage documentation and conservation from around the world, including:

- Dr Stefano De Caro, director general of the intergovernmental organisation, International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM) (1). Dr De Caro's presentation will underline the need for training in the field of conservation and the key role of documentation
- Dr Fabio Remondino, ISPRS Commission 5 president, who will give a keynote about developments and technology advances for 3D recording and modelling cultural heritage
- From industry, Ramtin Attar, principal research scientist, CTO Autodesk Research (Canada) will contribute with an overview of the latest development of information technology that could assist conservation experts in documenting endangered heritage resources around the world
- The Getty Conservation Institute (GCI) will present ARCHES, a system supporting heritage inventory and management, which has been developed by GCI and World Monuments Fund (WMF) to provide the international heritage field with a purpose-built, web-based GIS to help inventory and manage immovable heritage.

Poster announcing the XXIVth CIPA Symposium.

Along with these keynote speeches, several ICOMOS international scientific committees will be joining CIPA in organising joint sessions. This will include a session on Energy Efficiency in Heritage Buildings chaired by Peter Cox, president of this committee. This activity will be an opportunity to explore tools supporting the assessment of performance in this key area. Moreover, the committee on Risk Preparedness and the Stone Conservation committee will also provide a platform for evaluating the role of documentation tools for the mitigation of risk to cultural properties and the conservation of stone monuments.

Finally, a documentation of World Heritage Sites will be jointly organised with the collaboration of the International Association of World Heritage Professionals.

Scientific papers for peer review or practical project papers are welcome, and the submission deadline is 1 April 2013. Both sets of papers will be published in the proceedings, helping CIPA to accomplish its twin goals of developing and using technology and ensuring that it is applicable for cultural heritage. We invite you to get to know CIPA and attend our symposium.

Mario Santana, CIPA president
Pierre Grussenmeyer, symposium director

MORE INFORMATION
1. www.iccrom.org
http://cipa.icomos.org
www.isprs.org

Future events

FEBRUARY

Second High Level Forum on Global Geospatial Information Management
Doha, Qatar
from **03-06 February**
For more information:
W: http://ggim.un.org

International Lidar Mapping Forum
Denver, CO, USA
from **11-13 February**
For more information:
E: info@lidarmap.org
W: www.lidarmap.org

17. Internationale Geodätische Woche
Obergurgl, Austria
from **17-23 February**
For more information:
E: geodaetischewoche@uibk.ac.at
W: www.uibk.ac.at/vermessung/veranstaltung/obergurgl.html

Geospatial Conference in Tunis (GCT)
Tunis
from **18-22 February**
For more information:
E: GCT@3g-consult.de
W: www.gct-tunisia.com

Munich Satellite Navigation Summit 2013
Munich, Germany
from **26-28 February**
For more information:
E: info@munich-satellite-navigation-summit.org
W: www.munich-satellite-navigation-summit.org

GeoNext 2013
Sydney, Australia
On **27 February**
For more information:
E: info@geonext.com.au

MARCH

GeoViz_Hamburg 2013: Interactive Maps That Help People Think
Hamburg, Germany
from **06-08 March**
For more information:
E: geoviz@geomatik-hamburg.de
W: www.geomatik-hamburg.de/geoviz/

8th International Congress on Geomatics 2013
Havana, Cuba
from **18-22 March**
For more information:
E: raul@geocuba.cu
W: www.informaticahabana.cu

APRIL

Geomatics Meeting
Rabat, Morocco
from **08-09 April**
For more information:
E: rsc2013@amjgistes.org

8th EARSeL Imaging Spectrometry Workshop
Nantes, France
from **08-10 April**
For more information:
W: http://bit.ly/Tpa6TS

AAG Annual Meeting
Los Angeles, CA, USA
from **09-13 April**
For more information:
E: meeting@aag.org
W: www.aag.org/annualmeeting

JURSE 2013
São Paulo, Brazil
from **21-23 April**
For more information:
E: jurse2013@dpi.inpe.br
W: www.inpe.br/jurse2013

35th International Symposium on Remote Sensing of Environment
Beijing, China
from **22-26 April**
For more information:
E: isrse35@ceode.ac.cn
W: www.isrse35.org

Interexpo GEO-Siberia-2013
Novosibirsk, Russia
from **24-26 April**
For more information:
E: nenasheva@itcsib.ru
W: http://geosiberia.ssga.ru

8th International Symposium on Mobile Mapping Technology (MMT 2013)
Tainan, Taiwan
from **29 April-03 May**
For more information:
E: mmt2013@conf.ncku.edu.tw
W: http://conf.ncku.edu.tw/mmt2013/

FIG Working Week
Abuja, Nigeria
from **06-10 May**
For more information:
W: www.fig.net/fig2013

8th Annual International Symposium on Environment
Athens, Greece
from **13-16 May**
For more information:
E: atiner@atiner.gr
W: www.atiner.gr/environment.htm

ISPRS Hannover Workshop
Hannover, Germany
from **21-24 May**
For more information:
E: secretariat@ipi.uni-hannover.de
W: www.isprs.org

Calendar Notices
Please send notices at least 3 months before the event date to:
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