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BPA WORLDWIDE BUSINESS

Two Pillars

Almost every technical field rests on two main pillars: academia and the private sector. The first pillar comprises universities across the globe who run research programmes, educate students to become the professionals and academics of the future, and feed the world with information; the second pillar is formed by thousands of manufacturers, old and new alike, of hardware and software to be used in that particular field. These two worlds often operate as completely separate entities, with their own languages, practices and traditions. To put it bluntly, professionals and scholars are mostly not on the same level.

But geomatics is a completely different story. Academia and the private sector have always worked together. Lots of companies have spun off from universities, maintaining strong ties well into the future. There is significant interaction at several levels, both globally at conferences and trade shows and at regional and national levels with many companies collaborating with universities on R&D programmes. In turn, publishing companies are doing their bit at all levels by keeping the sector informed and disseminating details of joint projects through their communication channels: books, trade journals, websites, etc.

Photography: Arie Bruinsma

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The need for further co-operation has continued to grow in the last few years, as the economic crisis has meant that government research funds have dried up and private-sector sales have declined. Natural partners have needed to work even more closely together to be able to face the future, perhaps with a different sense of urgency depending on the geographical location. In the USA, for instance, universities have never enjoyed the same level of governmental support as their counterparts in continental Europe or Asia. Universities in the UK as well as other parts of the 'Old Commonwealth' have always leaned more towards the American model, meaning they are more inclined to look to the private sector as their principal source of finance.

Those universities that are used to looking to the private and non-profit sector for funding might have a head start. Increasingly, to ensure a successful hybrid model that enables further development of the field of geomatics as a whole, academics are required to draw on their entrepreneurial skills and talk to private-sector professionals on their level: to understand their needs and questions, and to translate them into cutting-edge research projects leading to ready-to-market products. Academics and researchers have to step outside of their purely scientific world and be able to account for the funds they receive. Read the interview with Dr Peggy Agouris on page 12 in this edition of *GIM International* to learn more about her views on the closely intertwined private-sector and academic worlds and on how to develop an entrepreneurial approach.

WFD
Technology

Introducing the new Leica ScanStation P20 ultra-high speed laser scanner

Quality Matters
Leica ScanStation P20 uses an optimal combination of angular and range measurements to deliver unrivalled 3D point accuracy and product reliability.

Productivity Matters
Using time-of-flight range measurements enhanced by modern Waveform Digitising (WFD) technology, Leica ScanStation P20 measures out to 120m at up to 1 million points per second using an eye-safe class 1 laser.

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With an operating temperature range of -20° C to +50° C and an Ingress Protection rating of IP54, Leica ScanStation P20 is designed and manufactured by Leica Geosystems to master extreme conditions.

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An onboard "Check & Adjust" routine allows you to check and adjust instrument accuracy parameters electronically, ensuring continuous optimal performance.

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No 2506

This month's front cover shows an ortho-image detail of an Interspect IS 3 multispectral aerial camera. On page 21 you will find an article on a series of multispectral aerial cameras that has been developed in Hungary over the past few years. The cameras allow large areas to be captured at very high aircraft speed.

(IMAGE TAKEN BY GÁBOR BAKÓ - INTERSPECT)

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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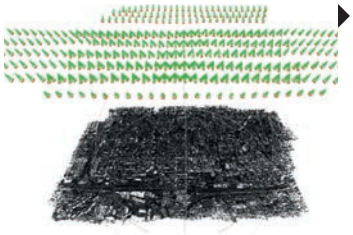

Investment in Solar Power Generation

Following the East Japan Earthquake and Tsunami and the accident at the Fukushima nuclear power station, about 70 percent of Japanese citizens are against nuclear power generation, which has now been stopped completely due to fears about the preparedness for future natural disasters. Although the country's present government has a great wish to restart nuclear power generation, renewable energy generation and particularly solar power generation is now booming, because the previous government guaranteed to purchase the solar power at a high rate of about USD4 per kWh for 20 years. Solar power generation in Japan is growing by about 5 million KW per year thanks to this economic benefit. In addition, construction is relatively easy and a 1,000kW or a megawatt solar power plant can be finished within a few months. There is only one problem: the rental of suitable land for the plant.

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In our family, we are supporters of solar power generation as we are against nuclear power generation due to the unrecoverable risk of radioactive contamination in the case of an accident. Larger companies are constructing megawatt plants because they can get a loan to do so from the bank, while smaller companies are targeting small-scale solar power generation with units of not more than 50KW as they can obtain local-government subsidies. However, it is not always easy to get a loan from the bank for the necessary construction work, in which case companies ask individual investors to provide funding towards a minimum unit of 50KW. The total amount of power generated varies depending on the location of the solar power plant and the local weather conditions, but the average income will be about USD18,000-20,000 a year from a 50KW unit. Our family decided to invest in a 50KW solar power project for 20 years. The total balance at the end of the 20 years will be a surplus equivalent to an interest rate of about 6 percent.

Geospatial techniques are useful for finding suitable sites for solar power generation; digital elevation models and weather models are required, and considerations include land ownership, coverage of trees or forests, etc. Cadastral surveys and negotiations with land owners will generate good business for surveyors. GIS is also very useful for feasibility studies. The solar project is now looking very promising in Japan.

LOCATION-BASED BIG DATA SOLUTIONS FOR GOVERNMENT AGENCIES ++ AUBREY BARKER FUND TO SUPPORT STUDENT ORGANISATIONS ++ LAND ADMINIST ... JECT
BENEFITS LAND OWNERS IN LESOTHO ++ VOLVO CAR GROUP'S MAGNUS RÖNNÄNG TO BE KEYNOTE SPEAKER AT SPAR INTERNATIONAL ++ UAV CAPABLE OF CA ... AGERY

Location-based Big Data Solutions for Government Agencies

GCS, a geoanalytics company, is teaming up with Global Touchpoints to develop big data solutions combining business intelligence and geospatial analytics for state and local government agencies. Specifically, GCS and Global Touchpoints will be targeting government offices with big data challenges related to healthcare, energy/utilities and water resource management.

http://tw.gs/Rcz0h3

Aubrey Barker Fund to Support Student Organisations

The trustees of the Aubrey Barker Fund have announced that the fund will consider applications from student organisations within the field of land surveying, quantity surveying and land economy to support student meetings. Land surveying can be interpreted as including subjects now generally described as geomatics. Funds to support student meetings can be used as travel bursaries to attend a meeting, to support tutors on training courses, or for specific costs associated with setting up a conference or training course.

http://tw.gs/Rcz0hW

Students at Intergeo.

Most Shared

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

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   - http://tw.gs/Rcz00Y
2. 'World's Smallest' Commercial Unmanned Aerial Lidar Platform
   - http://tw.gs/RczfBa
3. Mount Vesuvius Wins Image Contest
   - http://tw.gs/RczfC2
4. Accurate 3D Maps of Indoor and Outdoor Environments in Real Time
   - http://tw.gs/R3V8iy
5. A Student's Reflections on Intergeo
   - http://tw.gs/RbV0h5

ISPRS Tracking and Imaging Challenge 2014: Call for Participation

The ISPRS Tracking and Imaging Challenge 2014, TIC'14, is aimed at stimulating research and creativity between communities such as image processing, spatial computing and GIScience. The organisers are now calling for participation. Deadline for submission of projects is 27 July 2014. The workshop is to take place in conjunction with the ISPRS TC III Mid-Term Symposium PCV, to be held from 7 to 9 September 2014 in Zurich, Switzerland.

http://tw.gs/Rcz0Ax

New *GIM International* UAS Special in Spring

In view of the rapid emergence of UAS in the geomatics sector, *GIM International* plans to publish a second extra UAS edition this year! No other geomatics technology has become so popular among surveyors so quickly, and the market is evolving all the time. The magazine is scheduled for publication in spring 2014 and will be distributed at many relevant shows throughout the year. To learn more about the various advertisement packages on offer, contact *GIM International*'s account manager Sybout Wijma: sybout.wijma@geomares.nl.

http://tw.gs/RcT3D5

American Bill Deals a Blow to Russian GPS Alternative

US President Barack Obama has signed a bill prohibiting Russia from constructing any stations in the country that could improve the precision of GLONASS, the Russian alternative to GPS. This was announced by leading newspaper *The New York Times*.

http://tw.gs/Rcz0B5

FIG 2014 Congress Registration Open

Registration has opened for the XXV International FIG Congress 2014, to be held in Kuala Lumpur, Malaysia, from 16 to 21 June 2014. This edition promises to be a culmination of the four-year FIG Work Plan as well as the start of a new four-year term under a new FIG president who will be elected at the 2014 General Assembly.

http://tw.gs/Rcz0By

++ ISPRS TRACKING AND IMAGING CHALLENGE 2014: CALL

ADDS EDITING TOOL AND SUBSCRIPTION MODEL ++ LOCAT

UAV Capable of Capturing Oblique Imagery

senseFly's drones eBee and swinglet CAM, both designed for mapping missions, are capable of capturing oblique images quickly to complement a mapping project or to add additional documentation. This patent-pending technology is based on a proprietary control algorithm that takes oblique images of photo targets without the need for a camera gimbal, enabling senseFly's ultralight mapping drones to take aerial shots with up to 45° inclination from the photo target.

http://tw.gs/Rcz00Z

senseFly oblique imagery.

Dr Michael Hauck Appointed as ASPRS Executive Director

Dr Michael Hauck has been announced as the incoming ASPRS executive director. Outgoing executive director, James Plasker, announced his retirement from ASPRS, effective as of 10 January 2014. Hauck becomes only the fourth executive director in the past 47 years of the organisation's history. Both incoming and outgoing executive directors are looking forward to working together to ensure a smooth and effective transition.

http://tw.gs/Rcz0A3

Dr Michael Hauck.

Volvo Car Group's Magnus Rönnäng to be Keynote Speaker at SPAR International

Magnus Rönnäng.

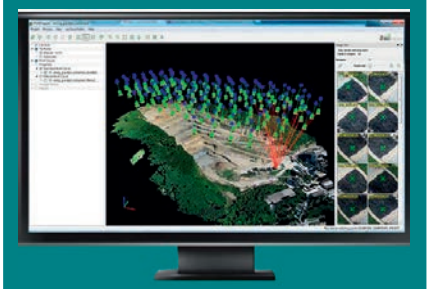
Magnus Rönnäng, technical expert on virtual manufacturing at Volvo Car Group, will deliver a keynote address entitled 'Living in the Point Cloud' at the SPAR International 3D Measurement & Imaging Conference. The 11th edition of the event will take place from 14 to 17 April 2014 in Colorado Springs, Colorado, USA.

http://tw.gs/Rcz00W

Pix4D Adds Editing Tool and Subscription Model

Pix4D, Switzerland, has released Pix4Dmapper, a software package with a fully integrated editing tool providing extended CAD and GIS possibilities. The rayCloud, included in Pix4Dmapper, combines the 3D point cloud with the original images for easy viewing as well as highly accurate semantic annotation and project improvement. Pix4Dmapper now is available both as a one-time-charge licence and on a monthly or yearly subscription basis.

http://tw.gs/Rcz0B1



Pix4Dmapper.

Support for Intention to Nominate Suzette Kimball as USGS Director

US Secretary of the Interior, Sally Jewell, has praised President Obama's intent to nominate Dr Suzette M. Kimball to serve as director of the U.S. Geological Survey, Interior's chief science agency. Kimball has led the agency in an acting capacity since February 2013. If confirmed by the U.S. Senate, Kimball would lead the science agency of more than 8,000 scientists, technicians and support staff in over 400 locations across the United States.

http://tw.gs/RcR5AY

. FOR PARTICIPATION ++ DR MICHAEL HAUCK APPOINTED AS ASPRS EXECUTIVE DIRECTOR ++ AMERICAN BILL DEALS A BLOW TO RUSSIAN GPS ALTERNAT NGRESS R
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KOREC to Develop Software In-house

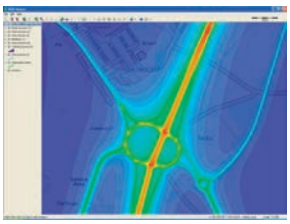
The KOREC Group, UK, is to create a new division dedicated to software development. This in-house capability will enable KOREC to customise Trimble solutions to meet specific customer requirements and applications. The division will assist with a wide range of requests under the geospatial banner, from GIS workflows and integrations through Trimble Access modifications to processing scan data from Trimble's mobile geospatial system, the MX8.

http://tw.gs/RcR5B5

Air Pollution Modelling with 3D Visualisation

UK-based environmental engineering company Cambridge Environmental Research Consultants (CERC) has been using the TatukGIS Developer Kernel (DK) ActiveX edition since 2007 to develop the GIS mapping module for its ADMS air pollution modelling software. The mapping module developed from the TatukGIS DK, called ADMS Mapper, is used to visualise and edit input data for the ADMS modelling software.

http://tw.gs/RcR5A1



The Mapper can render pollutant concentrations output from the ADMS model.

++ VOLVO CAR GROUP'S MAGNUS RÖNNÄNG TO BE KEYNOTE SPE

APPOINTED AS ASPRS EXECUTIVE DIRECTOR ++ AMERICAN BIL

Land Administration Reform Project Benefits Land Owners in Lesotho

For the past five years, Kadaster International has been responsible for project managing the 'Land Administration Reform Project' (LARP) in Lesotho, Africa. Laws and regulations have been altered and a new Land Act adopted. Land owners can now receive a lease which proves that the land is rightfully theirs.

http://tw.gs/Rcz00v

Bringing Powerful Esri Location Analytics to Customers

Esri has announced that Signal Data has incorporated Esri Location Analytics into its business intelligence platform, Signal Retail. Signal Data is a venture-backed financial technology company located in New York City that helps investors and retailers analyse the quality of retailers' and restaurants' store locations and track competitive activity.

http://tw.gs/RcR5Ax

Caption: Esri Location Analytics.

Robotic Mapping

Reflecting the migration of people from rural areas to cities, the need to monitor and maintain urban spaces and corridors – both outdoors and in – is expanding. Automation of (3D) mapping of such spaces from overlapping digital images and Lidar point clouds has heavily benefited from fundamental research in the realms of computer vision and artificial intelligence. Recently, robotics has been added to this series as a powerful engine for driving further new developments in automatic mapping. In robotics, one is faced with the problem of determining the path of a robot through a room, shopping mall or other indoor space and simultaneously acquiring a 3D representation of that space to prevent the robot colliding with walls or other obstacles. The path could be easily determined using GNSS, except that concrete, soil and other materials block the signals, thus impeding GNSS use indoors to inspect pipelines, subways or other underground corridors for instance. Since in many cases no adequate map of the space is available, determining the robot's location and creating a map are both done using on-board sensor data. At first glance this seems an impossible task, a chicken-or-egg dilemma: the robot's location and orientation are essential for generating the map, yet a map is needed to pinpoint the robot's position. The solution lies in 'guessing' the position and representing the space based on sensor data and prior knowledge. Next, these guesses are iteratively refined using data collected while the robot is moving. This approach uses smart algorithms, based on what is known as the iterative closest point (ICP) algorithm aimed at minimising the difference between successive point clouds and the extended Kalman filter. Central is the use of landmarks; these are objects which are distinct from the background. Simultaneous localisation and mapping (SLAM) solutions are also beneficial for mapping indoor and subsurface spaces. The main positioning sensors useful for indoor localisation and orientation are odometers, inertial navigation sensors and lasers. Odometers count wheel spins enabling speed and distance travelled to be computed. When they are mounted on the two wheels either at the front or at the rear, odometers also provide data about directional changes. Inertial navigation provides directional and displacement information and lasers detect obstacles in front of the robot. SLAM does not consist of a particular algorithm but is rather an approach in which a diversity of solutions are employed depending on on-board sensors, the nature of the environment and possibilities to connect the trajectories with ground control points. SLAM has been one of the most prominent successes of robotic research in the past 30 years. It has found its way into unmanned aerial vehicles and autonomous underwater vehicles, and will certainly contribute to mapping indoor spaces, either in 2D or 3D, in the near future.

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LL DEALS A BLOW TO RUSSIAN GPS ALTERNATIVE ++ FIG 2014 CONGRESS REGISTRATION OPEN ++ PIX4D ADDS EDITING TOOL AND SUBSCRIPTION MODEL D BIG DATA

GIM INTERNATIONAL INTERVIEWS DR PEGGY AGOURIS

The Challenges of Collaborative Mapping

The growing web phenomenon known as 'user-generated content' is impacting the collection of geospatial data in ways never before imagined as a result of volunteered geographic information (VGI). Data is being provided voluntarily by individuals at a prodigious rate, but what are the implications when it comes to standards and accuracy? *GIM International* spoke to Dr Peggy Agouris, acting dean of the College of Science at George Mason University in the USA, to find out more.

What are your current research interests?
My research focuses on the automation of processes for spatiotemporal information extraction – including digital imagery, change detection and the integration of remote sensing and digital image processing & analysis within geospatial information systems. In general, my interests lie in how to make sense of imagery collected through various media and sources, and how to extract useful information from that. Considering our community's pedigree, accuracy is a key issue. And the other key issue is the automation of processes to extract useful information from images, video and other sensory data in order to address the challenge of steady increases in data availability coupled with a shrinking workforce.

What are the latest trends and developments in these areas?
From digital image processing and analysis to remote sensing, spatiotemporal information modelling and management, geospatial information systems and photogrammetry, all of these sub-disciplines of our field have progressed significantly individually, advancing our ability to extract geospatial information from various sources. However, it is arguably the emergence of volunteered geographic information (VGI) which is having the most substantial transformative effect in our field by affecting all these sub-disciplines simultaneously.

As open-source VGI continues to gain popularity, the user community and data contributions are growing too. OpenStreetMap, for example, has become a base layer for several mapping applications. However, because of the lack of cartographic standards, we have to question the accuracy of the database; we should be asking not whether but rather how we will be able to use this vector data for more geopositionally sensitive applications, like GPS navigation, in future.

What has your research into this trend revealed?
In a paper published last year by my colleagues Roberto Canavosio-Zuzelski, Peter Doucette and me, entitled 'A Photogrammetric Approach for Assessing Positional Accuracy of OpenStreetMap Roads', we took a photogrammetric approach to determining the positional accuracy of OSM road features using stereo imagery and a vector adjustment model. The OSM database provides a unique, dynamic environment to use as the test subject for this research because its underlying purpose of providing open-source mapping by the people, to the people emphasises the importance of knowing how good the data is.

OSM contributors are mostly voluntary non-professionals who have an interest in mapping a local area they are familiar with. In addition, there are no cartographic or data quality standards in place to ensure that all the contributors 'map' in a similar fashion or adhere to any specific equipment requirements (GPS), field collection procedures, image mensuration standards or map accuracy standards.

In the past, mapping information was collected by experts according to specifications and standards. Now, non-expert users are collecting valuable information, but our understanding of the accuracy of this information is limited. Nonetheless, this is valuable information and our challenge is to figure out how best to integrate expert and non-expert information for the benefits of all users.

Researchers like myself and others in this field are conducting research to see what we can learn and what conclusions we can draw. Integration will not be easy, but it is a most interesting and challenging subject.

Who are the non-expert contributors and how do they collect the data?
There is as yet no profile for the 'typical' user who contributes this type of information. There are

Dr Peggy Agouris

Peggy Agouris was appointed acting dean of the College of Science at George Mason University in the Virginian suburbs of Washington D.C. in 2013. Prior to that, she was the chair of Mason's Department of Geography and Geoinformation Science from 2008 to 2013. She is also the director of the Center of Earth Observing and Space Research (CEOSR). Dr Agouris has authored more than 100 articles in the image analysis and computer science literature. She is the past recipient of a National Science Foundation (NSF) CAREER award from the Computer and Information Science and Engineering Directorate. Her work has been supported by numerous research grants and contracts from NSF, NASA, the National Geospatial-Intelligence Agency (NGA), National Reconnaissance Office (NRO), Army TEC, BAE Systems, USGS and others. She has also consulted for the CIA, Milcord, Intergraph, BAE Systems and other companies. Dr Agouris has received external research funding amounting to more than USD28 million. In 2010, Dr Agouris received a six-year appointment to serve on the board of directors of the U.S. Geospatial Intelligence Foundation. She has also served as an expert witness in high-profile technology legal cases. For her scholastic and research achievements, Dr Agouris has received numerous national and international awards.
She received her Diploma in Engineering from the National Technical University of Athens, Greece, and her MSc and PhD from the Dept. of Civil and Environmental Engineering and Geodetic Science, Ohio State University. Prior to joining George Mason University in 2007, she was with the Department of Spatial Information Engineering, University of Maine, and before that with the Swiss Federal Institute of Technology (ETH) in Zurich.

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GIM International's
UAS Special

To be published
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Supporting geoprofessionals in mapping the world

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more than one million contributors to OSM, making it the most extensive and most successful VGI platform available. We need to learn more about the contributors and their reasons for contributing, and we need to study the demographics. One of our PhD students recently attempted such a study, but it can become complicated. You have to take into account factors such as location, literacy and socio-economic status. We're testing various hypotheses to learn more about what motivates people to contribute and where they do so, but we do not yet have conclusive answers. Often, people in smaller communities like to contribute as they know they are far off the beaten track. They take matters into their own hands because they want to see descriptions of their world and their neighbourhood. They take pride in where they live and what they are trying to do, as was the case for example with the mapping of Kenya's Kibera slum.

All we can do to improve accuracy and enable integration is to continue our research and find better ways to accommodate both expert and non-expert contributions. It's important to point out that we are not 'behind' as such, but that the uptake of the technology is so fast that we have to keep moving even faster.

Are there marked differences between Europe and America when it comes to these trends and developments?
We have not noted specific differences. Non-expert contribution is taking place globally, although the scale is dependent on the technology available in different regions of the world, and on the number of users who have access to the internet and an interest in this type of data. There is a huge amount of geospatial information available in the pictures and text messages that people send to each other via the internet. Again, we need to learn more about how to integrate it with professionally gathered data.

Why is the need for geospatial technology research and development so manifest in the US?
What is much more pressing in the US is the approach to research and development. There are two reasons for this. Firstly, universities in the US do not have the level of government support that tertiary institutions have in Europe. We have to be far more entrepreneurial and competitive when it comes to securing funding. We need to research advancements before they become mainstream. By being first in your field and first to recognise trends – as well as the potential of those trends to assist government and communities – you can approach funders more effectively.

The second reason is that in the US there's great awareness of the need for technology to support crisis management – for events such as hurricanes, forest fires, disease outbreaks, chemical spills and terrorist attacks. In a country as geographically vast and diverse as the US, and with so many different types of natural disasters, geospatial information is key to understanding more about an event, its causes, the people and infrastructure affected, and the resources available to respond. Thus, there is financial pressure to develop new solutions, coupled with the need to improve technology to make emergency response to disasters more efficient and effective.

To secure funding, you must be first to recognise trends

How does a researcher develop an entrepreneurial approach?
To pursue cutting-edge research activities, we resort to highly competitive proposal writing, and very often this takes place outside the traditional geoinformatics funding environments. This requires us to be

particularly proactive. We have to identify a future requirement that we know we can meet – essentially responding to what our communities will need, often before they even know that the need exists. You have to think ahead, and then convince funders that you have a solution.

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CONNECTIVITY GRAPH TO COPE WITH TILTED VIEWS

Automated Processing of Oblique Imagery

Oblique multi-camera systems are rapidly maturing and expanding the market for airborne technology and services. Because datasets of oblique images are large, automated processing is a necessity. Here, the authors present a workflow for the automated orientation of large oblique blocks using a connectivity graph and discuss automated dense matching of oblique images.

Oblique airborne multi-camera systems are increasingly complementing traditional vertical views. Previously hidden façades and building footprints are unveiled in oblique views, which makes oblique imagery useful for 3D city modelling and cadastral purposes as well as emergency rapid response and scene interpretation. In the past, the spotlight was on visualisation and inspection of oblique images by human operators. However, today's interest is focused on the metric capabilities.

TILTED VERSUS VERTICAL

Tilted views are richer in content compared to vertical views, but they bring more occlusions and degradation in similarity between image features as well as significant scale and illumination differences. Oblique images are also more prone to hot spots and sun glints which arise when looking towards or away from the sun. Additionally, instabilities in the flight trajectory are more harmful. As a result, efficient execution of large-scale projects requires reliable solutions, automated extraction of tie points and dense matching for 3D reconstruction.

TIE POINTS

Interior and exterior parameters of

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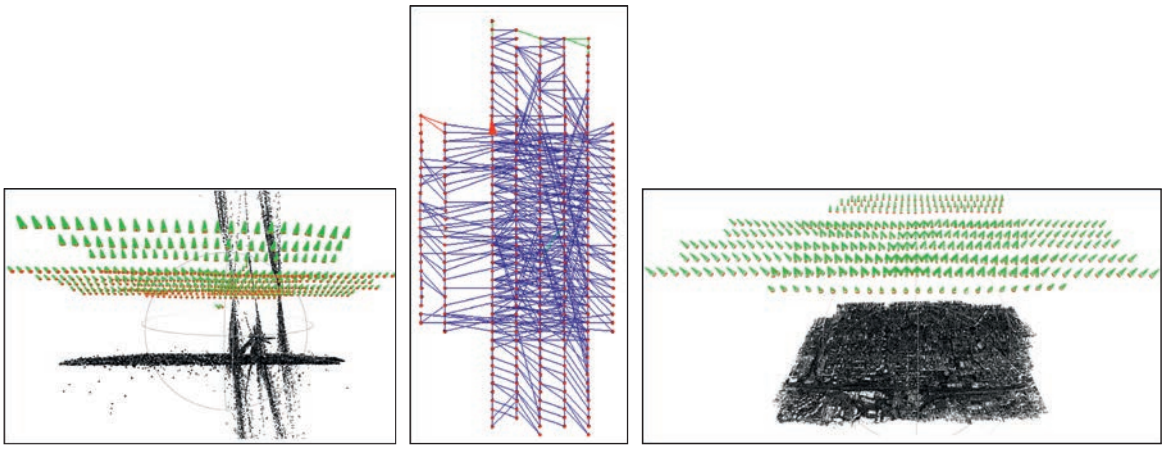

Figure 1, Maltese-cross obliques show orientation failures if no connectivity graph is used (left) but with such a graph (middle) the correct parameters are produced.

aerial images are commonly known beforehand. Interior parameters are retrieved through lab calibration and exterior parameters are measured directly with on-board sensors (GNSS/IMU). Nevertheless, these parameters are just approximates for metric and automatic applications; therefore, an adjustment in a least squares sense has to be conducted. Direct georeferencing of oblique images without using ground control points is still an issue to be resolved. Experiences gained in processing terrestrial images – which, just like oblique aerial images, are convergent and unordered – provided enough insight to adopt and adjust the terrestrial methodologies for use in processing airborne oblique imagery. The main obstacle is the time-efficient generation of putative correspondences between overlapping images. Pairs, triplets or larger sets of images with maximum similarity are first identified using GNSS/IMU information and a connectivity graph and subsequently matched. A connectivity graph expresses the spatial relationships between the images, speeds up the determination of image correspondences and reduces the number of outliers. The connectivity between images is described in the form of a graph of which the nodes represent images and the edges represent their relationships, i.e. two images are linked with an edge if they are spatially compatible. An image pair has to fulfil three conditions in order to be connected: (1) their footprints coincide by a given percent, (2) cameras' look directions are similar or one of the cameras is nadir, and (3) the number of extracted homologous points exceeds a threshold.

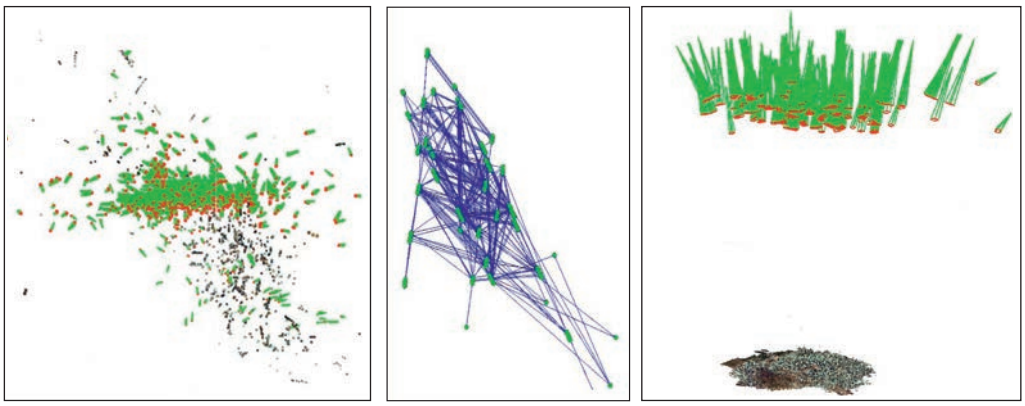

Figure 2, As Figure 1, but here for fan-type obliques.

Series on Oblique Photogrammetry

This article is the second in a series on oblique photogrammetry, a joint initiative of EuroSDR Comm. 1, Delft University of Technology and University of Twente (ITC). Edited by Mathias Lemmens, the series is intended to cover concepts, applications and camera systems currently available on the market. You are cordially invited to contribute. To do so, feel free to contact the editorial manager at wim.vanwegen@geomares.nl or the senior editor at m.j.p.m.lemmens@tudelft.nl.

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BUNDLE BLOCK ADJUSTMENT

The connectivity graph limits the number of mismatches. But the complexity of a network's geometry of oblique image blocks and the non-linearity of collinearity equations require good initial approximations of unknowns. The Apero bundle adjustment software the authors usually employ allows a concatenation of direct methods (spatial resection, essential matrix) which avoids the need for precise initial approximations and allows unknown camera positions and 3D object coordinates to be derived (Figures 1 and 2). The bundle adjustment of multi-camera images must handle n different cameras with different interior (IO) and exterior orientation (EO) parameters. The camera parameters can be retrieved without constraints – each image is oriented using an independent EO for each acquisition – or with constraints, which describe the relative rotations and displacement between cameras and are added to the mathematical model, lowering the number of unknowns and stabilising the bundle solution. Additionally, the IO of each camera can be assumed known from a lab calibration or simultaneously be computed in the bundle solution through self-calibration. The large redundancy in oblique images (Figure 3) helps to select the best correspondences and achieves high accuracy in 3D reconstructions.

DENSE MATCHING

Compared to vertical images, oblique images give a deeper and more complete description of urban areas, allowing the extraction of denser point clouds and more information in the 'smart city' domain, with façades and buildings completely reconstructed (Figure 4). Mismatches or wrong reconstructions can still be present because of: (1) buildings, roads or other objects having been captured with different scales, (2) presence of occluded areas, (3) depth and image GSD changing more suddenly than for vertical images, and (4) the smaller intersection angles and baseline between images making point cloud generation sensitive to noise. Higher overlaps may overcome some of these issues, although they increase the size of datasets and the number of point clouds.

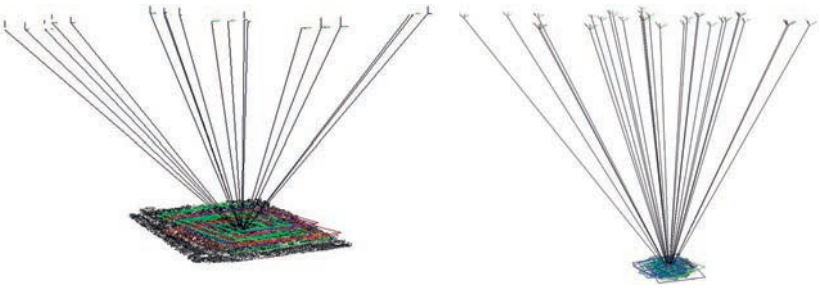

Figure 3, Redundancy in the observations of Maltese-cross configuration (left) and fan.

Figure 4, Colour-coded dense point cloud of an urban area.

CONCLUDING REMARKS

Traditional processing procedures are being challenged. Because oblique systems are still rather new, however, many questions remain open including: When should oblique imagery be used? What are its strengths and weaknesses? What is the optimal acquisition pattern for metric mapping? How can illumination and scale changes be dealt with? Which processing software is reliable and efficient? Methodologies need to be fine-tuned in order to improve automated processing, feature extraction and scene interpretation, and for other mapping purposes.

ACKNOWLEDGEMENTS

Thanks are due to Blom-CGR S.p.A. (Parma, Italy) and VisionMap (Israel) for providing the oblique imagery. ◂

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DEVELOPMENTS FROM HUNGARY

Multispectral Aerial Cameras

Today's spatial applications increasingly require very high-resolution multispectral images with photogrammetric accuracy. The Hungarian Interspect Research Group recognised this trend in 2006 and developed a series of cameras to satisfy the exacting GIS users. Here, the authors provide an overview of the cameras' history and features, and claim that the imagery reveals unparalleled detail, thus allowing large areas to be captured at very high aircraft speed.

In Hungary, the use of multispectral images started back in the seventies; initially for water management and environmental applications, followed by forestry, archaeology and other uses. Satellite images gradually became available, enabling the exploration of remote sensing technology which focuses on determining land uses, tree species and much more from multispectral imagery. In contrast, photogrammetry has always focused on geometric accuracy for renewing topographic and cadastral maps and creating orthophotos and digital elevation models (DEM) from overlapping B/W and RGB images.

SUB-CENTIMETRE GSD

To monitor environmental problems, manage water networks and handle other issues, GIS users are increasingly demanding multispectral images which have the rich detail and geometric fidelity of photogrammetric imagery. The present large-format digital aerial cameras have a maximum ground sample distance (GSD) of 2.5-3cm when they compensate for motion blur, but the duration of exposure may heavily limit the overlaps between images. For example, the GSD of two of the highest-quality calibrated cameras – Leica's ADS80 and RCD30 – is 3cm ▸

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Zsolt Molnár (1981) is one of the founding members of Interspect Research Group where he has been technical director since 2009. He is co-designer of the IS aerial camera series and also of an NDVI camera.

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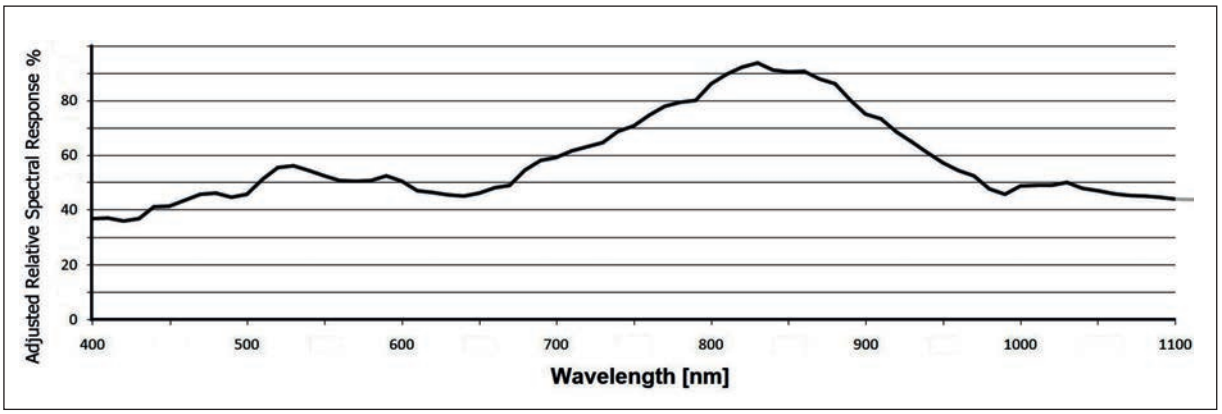

Figure 1, Sensitivity of the applied CMOS sensors can be varied within the 325-1,200nm range; the diagram shows 400nm-1,100nm.

if ground speed is above 160km/h. To avoid changes in environmental conditions and illumination when surveying large areas, however, higher speeds may be required in order to shorten the duration of flight. The cameras developed by Interspect Research Group (IRG) from Hungary achieve a resolution of 0.5cm with 65% overlap even when the aircraft flies faster than 160km/h.

SENSITIVITY

Rising to the above challenges, IRG has been working on developing high-resolution multispectral cameras which have photogrammetric accuracy. In addition, flooding of large areas and other natural incidents require quick response and hence recording from the air, often in poor weather conditions. Therefore, the cameras should not only allow capturing of ultraviolet, RGB, and near-infrared (NIR) bands but should also be sensitive enough to cope with cloudy and hazy weather. However, the lower the amount of light the larger the shutter time has to be and long exposure times introduce the major problem of image blur due to the movement of the aircraft. To enable high-speed flights at low altitudes, IRG started focusing on avoiding blur without using forward motion compensation (FMC). This is possible when the shutter time is extremely short; this requires very sensitive sensors together with low noise levels, which is important during image analysis. Most of today's CCD sensors capture the EM range between 370nm and 1,100nm. In contrast, the NIR sensors in IRG's cameras cover the spectral range of 356nm to 1,150nm and are most sensitive from 800nm to 900nm (Figure 1). This range can be subdivided into more narrow bands depending on the task. Even when the shutter time is less than 1/1,000sec, the sensors are still sensitive enough to capture NIR up to 1,150nm at acceptable noise levels.

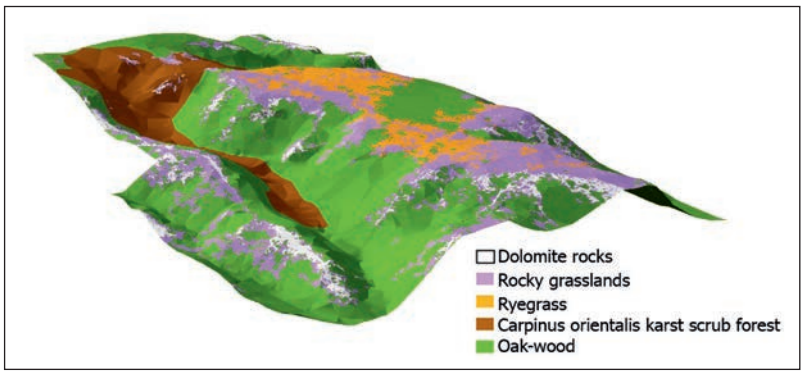

Figure 2, Vegetation map of Haraszt-hegy (Vértes, Hungary) derived from IS 2 images superimposed on a DEM.

FROM IS 1 TO IS 4

The development of cameras able to capture multiple electromagnetic

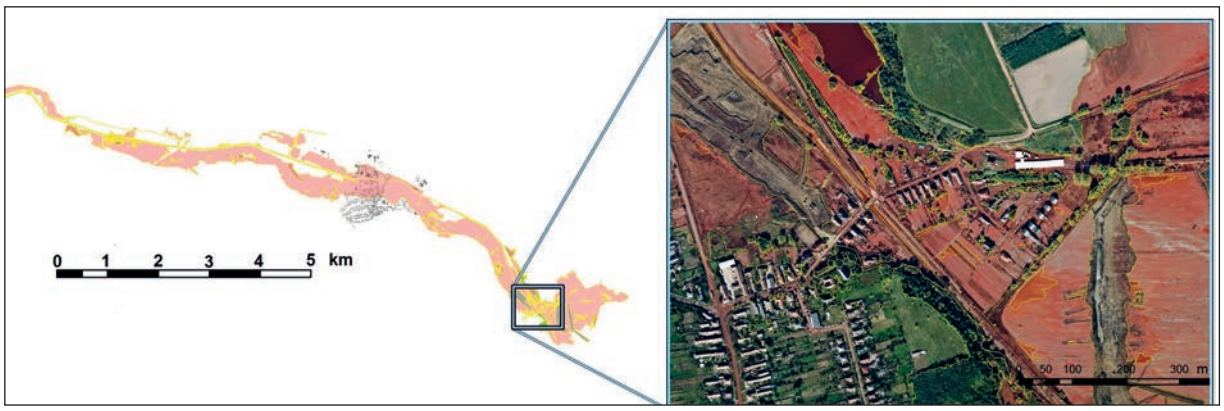

Figure 3, Extension of inundation area of the red sludge flooding (left) and orthoimage map.

Figure 4, Part of multispectral orthophoto map – GSD 0.5cm – generated from IS 3 imagery shown as an RGB composite (left) and colour-infrared composite.

(EM) bands – and which can operate under harsh light conditions and at low altitudes or high speed to guarantee high resolution without introducing blur – went through several stages: from IS 1 to IS 4. The use of sensitive RGB sensors resulted in the single-lens IS 1. The system was tested above Budapest Zoo & Botanical Garden on 9 September 2009, in the late afternoon in weak light conditions. The 272 images recorded enabled the creation of a seamless image mosaic with uniform brightness and contrast with a GSD of 1.8cm: a world record. This success encouraged IRG to develop IS 2 aimed at reducing size and weight and ensuring a broad dynamic range for highly detailed mapping. After its completion in 2010, over 40 large areas were captured. The resulting orthoimage maps were used successfully for water-quality estimation, mapping of inland water, forest and vegetation (Figure 2), and also for monitoring the floods of October 2010 which caused red sludge deposits (Figure 3). Next, the spectral bands were extended from RGB to NIR resulting in IS 3, allowing the creation of multispectral orthoimagery (Figure 4). The system has also been equipped with GNSS and an inertial navigation system (INS) allowing direct georeferencing.

With a GSD of 0.5cm no other camera parallels the resolution it obtains during high-speed/ low-altitude flights

The development continued with the extension of the spectral bands to ultraviolet accompanied by an increase of spatial resolution. IS 4 can record 16 bands, of which 12 have variable sensitivity. Furthermore, with a GSD of 0.5cm, no other camera parallels the resolution it obtains during high-speed/low-altitude flights. Its operating principle differs from the CCD-based high-resolution or modular systems as it has only one CCD sensor for recording RGB, while the multispectral sensors are based on complementary metal-oxide semiconductors. IS 4 has been used for wild counting and surveys in bird colonies, and such applications require sub-centimetre GSD (Figure 5).

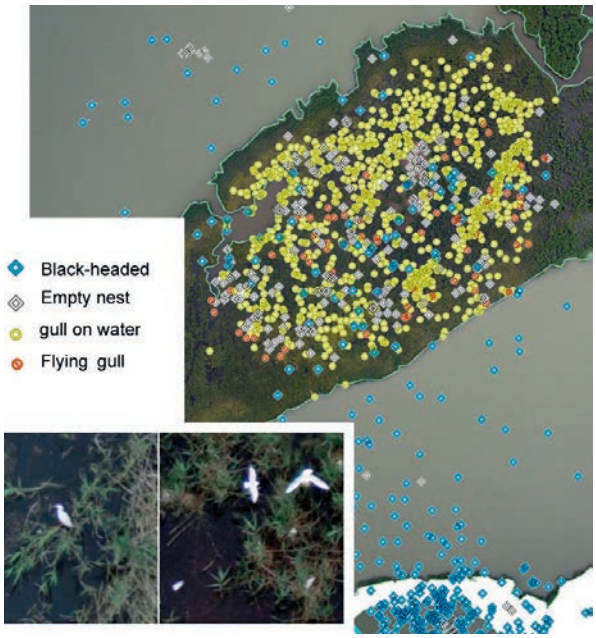

Figure 5, Map of distribution of great egrets and black-headed gulls near Lake Velencei derived from IS 4 imagery captured at heights of 500m and 800m.

FUTURE RESEARCH

The authors calculated that sharp images with 65% overlap can be captured at a height of 500m and with a speed of no less than 800km/h, which is jet-aircraft velocity. The main challenge is to convert a jet aircraft in such a way that it can be used for high-quality image capture. Furthermore, IRG aims to improve spectral characteristics for easier detection of various pollutants and invasive plant species.

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RAPID REDUCTION OF PIXEL VOLUMES

Wavelet Compression

Earth observation satellites and (un)manned airborne surveys continue to produce imagery and full motion video at increasing rates. Managing, processing and disseminating such massive volumes of data requires specialised image compression. Here, the author discusses how compression based on Intergraph's Enhanced Compression Wavelet (ECW) raster technology can meet these needs.

Today dozens of orbiting satellites capture multispectral images of large areas at high spatial and temporal resolutions using a variety of sensors of which the intensity value per spectral band frequently exceeds 8 bits per pixel. Expanding manned or unmanned aerial surveys are also contributing to the abundance of pixels present on geodata providers' servers. Furthermore, end users expect both historical and current imagery in near real time, and so demand instantaneous access to ready-to-use data through web services. Data storage and processing costs have fallen significantly, but that rate has not kept pace with the rapid growth of the collection of geodata. As a consequence, managing images remains a challenge for organisations. Data optimisation techniques such as compression are employed not only to greatly reduce storage and transfer costs, but also to reduce time to market and provide visually lossless image quality ready for rapid display.

Robert Widz, a graduate from University of Science and Technology, Poland, has been with Intergraph for nearly 20 years, presently as EMEA geospatial executive director. He has supported key projects in Poland and other countries in Europe and participated in many conferences on geoinformatics.

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BIG DATA

The abundance of raster-based sensor sources and increased capture rates is driving more and more organisations to carefully consider an effective storage format and data management system on a scale with this growth. According to International Data Corporation (IDC), the volume of digital data created in 2010 exceeded one zettabyte (10^{21} bytes). By 2020, it is predicted that online business transactions will reach 450 billion per day. The U.S. Library of Congress alone collects 35 terabytes of data each month. In the same manner, organisations working with space and airborne images are confronted with the challenge of 'big data'.

WAVELET TECHNOLOGY

The Enhanced Compression Wavelet (ECW) format has been available for over 15 years. In contrast to other wavelet-based methods, the patented ECW has been specially developed for geodata. It is based on Discrete Wavelet Transformation (DWT) and is relatively simple and very fast. For geodata, wavelet compression offers a significant advantage over standard JPEG or LZW by using region-of-interest decoding. This allows files to be reduced to terabyte size and requires no additional pyramid or overview files in order to rapidly extract regions from the files. Figure 1 shows a common deconstruction of the wavelet filter used in JPEG2000. The original image (top left) is deconstructed to two levels, with each image

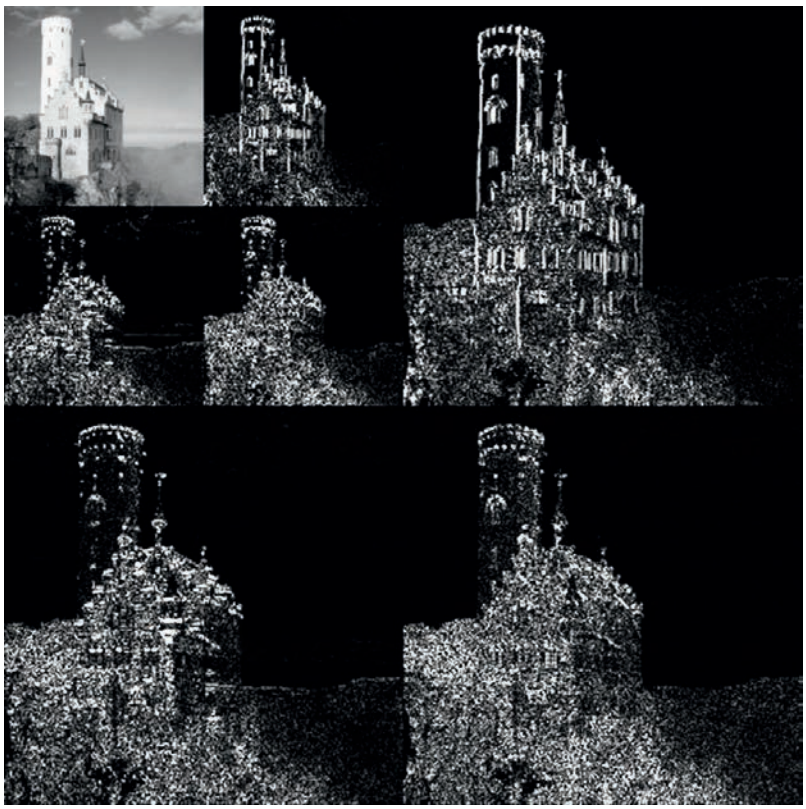

Figure 1, JPEG2000 wavelet transform deconstruction. (source: wiki http://en.wikipedia.org/wiki/Discrete_wavelet_transform)

representing the frequency image applied after the DWT. This visualisation is equivalent to ECW but on a much larger scale as it is applied to large geoimagery.

PERFORMANCE CRITERIA

Irrespective of the raster storage format, critical qualities include (1) encoding speed, (2) decoding speed, (3) storage requirements, and (4) preservation of image quality. All formats must sacrifice one or more of these qualities to some degree in order to meet or optimise one of the others. For example, maintaining numerically lossless compression preserves 100% of the image quality but increases storage requirements as well as encoding and decoding time. On the other hand, optimising for storage requirements or compression rate increases the speed of encoding and decoding but sacrifices image quality. The degree to which a raster format implements these qualities varies, but ECW aims at achieving a good balance between the four criteria. When image quality and storage requirements are equivalent, ECW encoding and decoding is faster compared to JPEG2000 and other formats. It preserves visually lossless image quality while still achieving compression rates of 95% and increases encoding speed. The quality of the output image is better compared to standard JPEG or LZW compressed GeoTIFF while requiring less storage, plus encoding and decoding is faster.

Null blocks save 95% compression time while the file is 30% smaller without compromising image quality

RECENT IMPROVEMENTS

ECW continues to be improved to keep pace with hardware optimisation and increasing size of geodata sets. In early 2013 a new revision was introduced (ECW v3). Earlier versions would peak at around 25MB per second irrespective of hardware improvements. ECW v3 is a parallel, multi-threaded method working with tiles which removes the bottleneck of single-threaded encoding working with lines. The output format itself remains unchanged and is comparable bit-wise. However, compression time and speed have been improved by 400%, although actual results

Size of input (pixels)	Method	Time	Speed
50,000 x 50,000	Line	245s	29.2MB/s
	Tile	58s	121.8MB/s
100,000 x 100,000	Line	1,014s	28.3MB/s
	Tile	254s	112.0MB/sec

Table 1, Processing time and speed of Line and Tile method on a 24 core, Xeon E5-2620 with 32GB.

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▲ *Figure 2, Mosaic containing a road but dominated by no-data area.*

may vary as they depend on input format and hardware (Table 1).

CORRIDORS

To further optimise speed and storage of imagery of railways, rivers, coastlines, power transmission lines, highways or other corridors, null blocks have been introduced. Optimal capturing of linear features would be by elongated rectangular image patches which follow the feature. However most sensors will capture square-like frames or use broad swath widths, thus collecting useless data. Two possible solutions are storing and compressing broad swaths which for the majority contain useless data, or splitting, slicing or tiling the imagery into hundreds or thousands of smaller images to minimise empty spaces. Both approaches are far from optimal. The use of null blocks combines both options. Figure 2 shows a mosaic (2.5 million x 1 million pixels) of a road corridor, which is dominated by no-data area. Compressing without null blocks would require almost nine days. By passing over a site, non-road parts can be defined as null blocks which do not need compression, saving 95% compression time – nine hours instead of nine days – while the file is 30% smaller without compromising image quality. ◀

BIOGRAPHY

The authors, **Reinier Oost** and **Dieuwertje Wesselink**, are presently 2nd-year students on the MSc track in geoscience & remote sensing at Delft University of Technology, The Netherlands. The curriculum focuses on advanced observation technology in combination with innovative data processing and modelling techniques. The resulting information and its interpretation is needed for a wide variety of geo-related decision-making.

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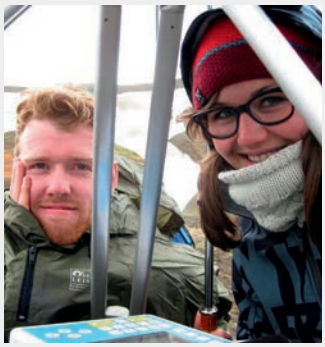

By **Reinier Oost** and **Dieuwertje Wesselink**,
Delft University of Technology,
The Netherlands

Fieldwork in Iceland: Putting Theory into Practice

Under the Volcano

A two-week field trip to Iceland – that was all they were told beforehand. After one year of studying at Delft University of Technology, MSc students headed towards this geodetically very interesting island in June 2013. Here the authors, two of the students, describe the background to the fieldwork, the activities performed and their impressions.

In the Krafla volcano region, located in the very north of Iceland, a blend of natural geophysical processes and human-induced deformations are causing vertical and horizontal movements of the Earth's surface, while groundwater circulation and volcanic processes cause mass displacements. A major source of human-induced vertical deformations is the injection and extraction of groundwater by the geothermal power plant at the Krafla volcano. In view of a plan to build a new power plant in the vicinity of the existing one, societal demand for monitoring these deformations is rising. For this purpose the Krafla power plant established a GPS campaign network in the region five years back with a density of one point every few kilometres. Each point of the network has to be re-surveyed once every year or few years aimed at establishing long time series. The Krafla volcano is well known due to the fires that lasted from 1975 until 1984 and is rather active, which complicates the separation of human-induced deformation from the ones caused by natural processes such as plate spreading, post-glacial rebound and volcanic processes.

GPS FIELDWORK

Our fieldwork, which lasted two weeks on site, was aimed at quantifying the magnitude of the different causes of deformation through measurements. GPS receivers and total stations had to be transported to the off-road benchmarks by car or on our backs, sometimes in snow-covered conditions. The surface deformations are a matter of several millimetres to a few centimetres per year and GPS is accurate enough to measure these small changes provided that the equipment is set up very precisely, exactly levelled and positioned above the marker in the ground. Not only

▲ *Taking GPS measurements at a benchmark.*

Students, professors and supervisors.

do the measurements in the field have to be carried out carefully but also a lot of post-processing is required to obtain the high levels of accuracy necessary to quantify horizontal and vertical surface movements over time.

MASS CHANGES

The determination of mass changes in the subsurface is done through gravimetric measurements, using a very precise relative gravimeter. As the change in gravity due to subsurface mass flow is very small, the gravimeter must be not only very accurate but also sensitive. The required high sensitivity makes the instrument very fragile, meaning that it may easily become disrupted during transport. Therefore, great care has to be taken when driving over unpaved roads or walking on uneven terrain. The gravimeter will not only measure the acceleration caused by the gravity field but also acceleration caused by motion or vibration in the vicinity of the instrument. Hence, the great challenge of measuring gravity lies not in operating the instrument itself but rather in carefully avoiding disturbing signals. Nevertheless, complete avoidance of influences caused by motion or vibration is impossible and therefore careful post-processing using least squares adjustment and sophisticated statistical testing is definitely a necessity to detect and remove outliers.

LOOKING FORWARDS AND BACK

The study goal of the fieldwork was to gain experience in performing geodetic and atmospheric measurements, data processing and analysis. In collaboration with the Institute of Earth Sciences of the University of Iceland we set up our base camp in Reykjahlid. On the first day we had a tour in the Krafla area; walking through lava fields was amazing. We were told what was expected of us: within two weeks we had to plan and carry out a GPS and gravimetric measurement campaign. We had to arrange the fieldwork ourselves, just getting advice from our supervisors. All the knowledge gained during one year of studying in Delft came in handy, but we also extended our knowledge. By choosing the techniques and measurement points ourselves, we were forced to think about what we wanted to measure and how to do that, keeping in mind both the daily and the long-term planning. We discovered that taking measurements has to be done with great caution and very precisely, which we had not realised beforehand, and that it is essential to apply proper adjustment and statistical testing on the presence of errors in the data or in the models. There's no better way to learn your lesson than finding outliers in your own data! During several courses we had learned a lot about GPS but getting hands-on experience was very useful, as was being responsible for the full cycle from analysis of the expected results, planning of the measurement requirements, data collection and post-processing. The fieldwork made what we had learned over the past year tangible and was ultimately very rewarding.

Young Geo in Focus

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SECON Private Limited is an ISO 9001:2008, CMMI Level 3 and NAB-accredited firm which was established in 1981. Headquartered at Bangalore, India, it is a financially sound and zero-debt multidisciplinary engineering consulting firm. SECON is the oldest and largest commercial mapping and investigation firm in India and is also one of the country's leading companies for civil engineering consulting.

Initially, SECON was involved in land surveys for infrastructure projects and focused particularly on pipeline and irrigation mapping. It later moved into geotechnical investigations and water resource engineering, and in 2000 SECON diversified into highway engineering and construction supervision. SECON has evolved from using a 1902 Vernier theodolite to total stations, DGPS and now into terrestrial laser scanners. The company was among the first in India to adopt CAD in the late 1980s and GIS and digital mapping technologies in the mid-1990s.

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.

SECON currently specialises in and targets projects relating to water resources, highways, public health, electrical and geotechnical engineering, pipeline mapping, land information systems, airborne and ground geophysical surveys, and the entire spectrum of geomatics – from land surveying to airborne, satellite, and Lidar mapping with a sound background in GIS-based asset management and CAD-based software development. The services are completed with divisions for project management consulting and independent engineering services. Company director Mr Dhyan Appachu explains: "SECON is one of the few companies in India to offer services for the entire lifecycle of an infrastructure project. There is a growing demand from clients for a firm to provide a total solution from a single window, and SECON is well positioned to fulfil these requirements, both in India and internationally."

COMPANY VALUES

The SECON board of directors is headed by chairman and managing director (CMD) Major BM Appachu. Executive director Col BN Devaiah is the CEO, and international operations are headed by Dhyan Appachu. Each of the various verticals has a different head, and most of the key management staff are senior ex-army engineering officials. The company has business development offices spread all across India.

SECON strives to be a trusted employer, vendor and partner and believes in long-term relationships. The board of directors believes that the company's main asset is its competent staff, and is therefore committed to keeping them happy and motivated, as well as up to date on the latest technologies and ensuring that they follow documented quality standards.

INTERNATIONAL CLIENT BASE

In India itself, most of SECON's clients are government organisations who value the company's expertise in the core development sectors such as roads, water supply, sanitation and irrigation, flood control and water resources. However, SECON's digital mapping and GIS division provides services to private-sector clients right around the globe. SECON gained valuable international exposure by

SECON staff and activities.

Founder Major BM Appachu with his first instrument, a 1902 Vernier theodolite.

carrying out a multimillion dollar project for the design of the complete infrastructure for 101 townships in Libya, for example. The company has also achieved preferred outsourcing vendor status for geomatics for clients worldwide. This has helped to protect SECON's export division from the vagaries of the global economy.

ONSHORE/OFFSHORE MODEL

The advent of better satellite images, cloud computing, web conferencing and other technologies have made the world a smaller place, allowing for better interaction between professionals, partners and clients. SECON has both export and import-based relationships with its clients. It exports offshore outsourced and on-site services for engineering design for public health, highways, structures, water resources and electrical engineering. Other services include offshore and on-site placement for digital mapping, photogrammetry, Lidar, remote sensing and GIS-based software development. Meanwhile, SECON has established partnerships with internationally recognised firms for airborne mapping for photo, Lidar, hyperspectral and geophysical surveys and imports their services for projects in India for continual improvement. On an 'as-needed' basis, SECON also partners with international firms on engineering consulting projects, both in India and internationally.

SECON is particularly keen to promote the onshore/offshore design model that it successfully executed in Libya in 2010. This involves deploying key staff on site in the client's country for client management, field data collection and investigation purposes. The data collected is then used to prepare the complete design and relevant reports back at SECON's offices in India.

FUTURE OUTLOOK

SECON has a separate R&D wing for evaluating and introducing new technologies and improvements in current practices. The R&D wing also develops software to improve the productivity of SECON's in-house requirements. After continuous improvement, SECON actually developed one of these software tools – the Pipeline Alignment Sheet Generator which was originally introduced in 1996 as a tool to help SECON with its pipeline mapping projects – into a commercial product. It has already been sold successfully in Europe and the Middle East to companies with oil, gas and water pipeline projects. SECON is on target to generate a revenue of USD18 million for 2013-2014, with an annual growth of 10-15% forecast for the next five years.

On a domestic level, despite the fact that the Indian economy is currently experiencing a downturn, the Indian government continues to invest in much-needed improvements to the country's infrastructure. There are great opportunities both for updating the land records and asset inventorisation for the entire country, which has not been done for over 50 years. Furthermore, there is great potential both in India and other developing countries for SECON to provide its services in support of establishing basic infrastructure like highways, public health systems, irrigation, flood control and water resources. ◂

MORE INFORMATION
www.secon.in

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Website: www.fig.net

New FIG Publication

The new FIG Publication No. 59, *International Boundary Making*, elaborates on the boundary-making process. Its purpose is to propose a comprehensive methodology for establishing a boundary-making process between two states that wish to constructively and fairly settle their international boundary together. It begins with preparations for a boundary agreement and continues with the boundary delimitation, the boundary demarcation, boundary documentation and boundary maintenance, including considerations regarding long-term boundary maintenance and administration.

This publication provides comprehensive documentation and guidance on a specialist topic of surveying that has been lacking up until now. It is a very good reference publication for all those involved or interested in international boundaries and fills a gap both in surveying and international boundary literature.

The methodological part includes a model for initiating a boundary-making process, an order of precedence of boundary delimitations, and a model for the boundary chapter in a peace/boundary agreement.

Practical cases of delimitation of international boundaries are then presented. Many lessons can be learned from these diverse cases regarding disputes and regarding the models and mechanisms used for dealing with the issues. The publication focuses on land boundaries between states. The presented practical cases refer to such boundaries, including the following international boundaries: the Israel-Jordan boundary; the Iraq-Kuwait boundary; the Ethiopia-Eritrea boundary; the Cameroon-Nigeria boundary; the Sudan-Abeyei (today South Sudan) boundary; and the Nepal-China and Nepal-India boundaries. From the presented problems, one can also learn about the various considerations that should be taken when preparing an international boundary for long-term maintenance and administration, in order to achieve stability along the boundary line.

This FIG publication may serve as a guide to decision-makers, legal advisors and geospatial experts dealing with international boundaries. It may help geopolitical experts and anyone who wants to learn more about the subject of international boundary making.

This FIG publication has been prepared by senior practical professionals with expertise in boundary delimitation. Three of them served as director generals of national surveying and mapping organisations (William Robertson in New Zealand, Dr Haim Srebro in Israel and Buddhi Shrestha in Nepal) and one served as head of the UN Cartographic Section (Miklos Pinther).

FIG extends its gratitude to the United Nations Cartographic Section for its contribution to this publication, in particular the peer review carried out by Ms Ayako Kagawa, Mr Ghassan Mkhaimer and Mr Kyoung-Soo Eom, and to the New Zealand Institution of Surveyors for its valuable assistance, including among other things supporting the printing of the publication. It is hoped that this publication will enhance information and the sharing of methodological knowledge and practices regarding the delimitation of international boundaries and will help to promote peace throughout the world.

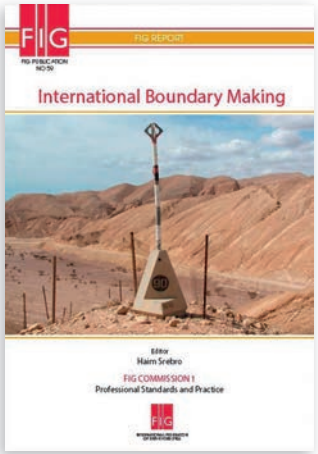

FIG Publication No. 59, International Boundary Making.

FIG Congress 2014 – still possible to register at early-bird rate
Do not miss the FIG Congress 2014 from 16-21 June 2014 in Malaysia. Register now for this outstanding event and please note that the early-bird registration closes on 27 February. For more information visit the FIG website.

MORE INFORMATION
www.fig.net/pub/figpub/pub59/figpub59.htm
www.fig.net/fig2014

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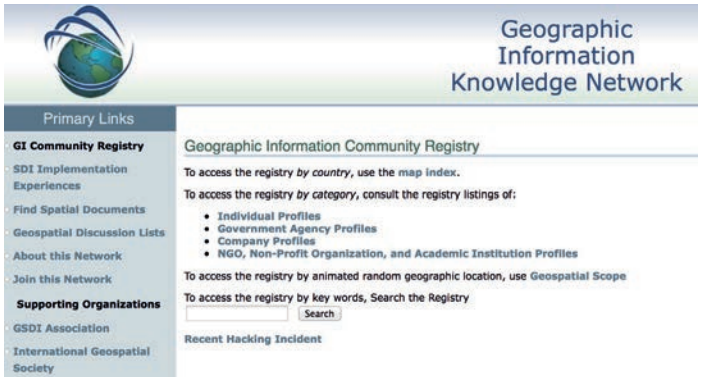
No 2510

GSDI's Geographic Information Knowledge Network

The GSDI Association's Geographic Information Knowledge Network (GIKNet) was established almost four years ago as a means of sharing information on SDI implementation lessons learned, best practices, source materials, assessments and follow-up surveys. It is a collaborative effort that relies on regular contributions of documents from the GSDI Association's member organisations and, in some cases, by the International Geospatial Society's individual members. Each community member acts responsibly and makes his or her own decisions on what and how much to contribute.



Screenshot of the Geographic Information Knowledge Network (GIKNet) website.

Information on the website is accessible at no charge, but users are required to register before they can search the information it contains. The website includes three major components:

(1) The GI Community Registry [1] is a collection of profiles of individuals and organisations provided voluntarily by community members. Geospatial professionals and students may enter and maintain their own professional profile in a format similar to that found on other social networking sites. Individuals affiliated with a geospatial agency or organisation are also encouraged to enter basic information about that organisation using a prescribed template. Over the years, profiles have been created of over 120 organisations.

(2) The SDI Implementation Experiences section [2] deals with basic information from respondents concerning SDI experiences within their own organisation. Some of this information is only provided when the project is initially undertaken, and needs to be supplemented by information and reports found in the next section.

(3) The Spatial Documents Depot [3] currently contains over 50 reports, papers and even academic postgraduate theses summarising plans, experiences and lessons learned by member organisations and colleagues related to spatial data infrastructure development. Recent additions to the Depot include a report from the United Nations Economic and Social Council ('Establishment and implementation of standards for the global geospatial information community: report of the Secretariat'), a manual from the Permanent Committee for Geospatial Data Infrastructure of the Americas ('SDI Manual for the Americas') and a graduate thesis ('The Role of Canadian Municipal Open Data Initiatives: A Multi-city Evaluation', by Liam Currie from Queens University in Canada).

Indeed, most of the documents found in the Spatial Documents Depot are also available online elsewhere. However, the advantage here is that their presence and accessibility in one location enables users to easily find and compare relevant experiences from different organisations and countries.

Naturally, the value of such a document repository and the profile information is sustained only when the information and links are kept up to date. This is where the GSDI Association relies on volunteer reviewers to assess information for relevance and, where possible, to urge members to keep their information up to date.

If you have not already done so, please consider registering on GIKNet, reviewing the information there and adding documents and/or links to relevant information you have found. As it says on the GIKNet website, "None of us knows as much as all of us".

Prof David J. Coleman
President, Global Spatial Data Infrastructure Association

MORE INFORMATION
1. www.giknet.org/registry
2. www.giknet.org/survey/sdisurvey.php
3. www.giknet.org/depot
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.

IAG EXECUTIVE COMMITTEE 2011 - 2015

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Since the predecessor of the IAG, the 'Mitteleuropäische Gradmessung', was established back in 1862, IAG celebrated its 150th anniversary in 2012. Celebrations climaxed 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.

Some Observations on Modern Geodesy

In 1862, the Prussian General Johann Jacob Baeyer initiated the Central European Arc Measurement (*Mitteleuropäische Gradmessung*) project. This is considered the forerunner of today's International Association of Geodesy (IAG), which celebrated its 150th anniversary with a Scientific Assembly in Potsdam, Germany, from 2-6 September 2013. Following on from the report in the November 2013 edition of *GIM International* magazine, we present some highlights of the Scientific Assembly here.

IAG presidents: Back row Ivan Mueller (1987-1991), Chris Rizos (2011-2015); front row Gerhard Beutler (2003-2007, Michael Sideris (2007-2011).

The breadth of topics covered in the programme of 241 presentations and 234 posters within the six main themes underlined the contributions of modern geodesy to science and society, and a number of observations can be made:

- The most popular theme was Gravity Field Determination & Applications. The recent gravity field mapping satellites (first CHAMP, then the GRACE and GOCE missions) continue to produce exciting results in support of a wide range of geoscience applications, including geoid determination, physical oceanography, hydrology, geophysical and atmospheric sciences. The gravimetric community waits eagerly for the GRACE follow-on mission.

- On the other hand, the value of reference frames to the broader navigation, geospatial and global change communities continues to rise. The International Terrestrial Reference Frame (ITRF) is a highly valued 'product' of modern geodesy. The ITRF is increasingly recognised as the fundamental datum for national and regional mapping, as well as global change studies. The current ITRF2008 will soon be superseded by ITRF2013.

- GNSS continues to be the workhorse of geodesy, not only as the quintessential 3D (and also 4D) geodetic positioning technology, but also providing invaluable measurement data for the determination and maintenance of the ITRF, easy 'connection' to the ITRF, and supporting precise orbit determination for many Earth Observation satellite missions. High-precision GNSS is by far the most advanced, and accessible, geodetic tool ever developed.

- Modern geodesy is very dependent on the satellite missions launched by a handful of space agencies. In addition to GNSS and gravity field mapping missions, there are many Earth Observation satellites including those for magnetic field mapping, topographic, sea and ice surface mapping, timing, relativity probes and Earth imaging. The challenge is to 'operationalise' what are often one-off science missions so as to ensure long-term series of observations of many Earth system parameters.

- IAG is fortunate enough to have launched a range of services in the 1990s, and is now reaping the rewards in terms of increased accuracy and resolution in the geometric and gravimetric mapping of the dynamic Earth. The challenge for IAG in the coming decade is the realisation of an integrated Global Geodetic Observing System (GGOS). Such a synoptic observing system will contribute to unified measurement modelling and analysis. That will deliver a quantum increase in accuracy and stability for the time, gravitational and spatial reference frames underpinning today's geodetic enterprises.

- The International GNSS Service (IGS) is the most visible of the IAG services because its products and expertise support the ever-growing range of GNSS applications in science and engineering. In 2014 the IGS will be celebrating the 20th anniversary of its founding.

In summary, after 150 years we can proudly claim that geodesy matters, now more than ever!

MORE INFORMATION
www.iag-aig.org

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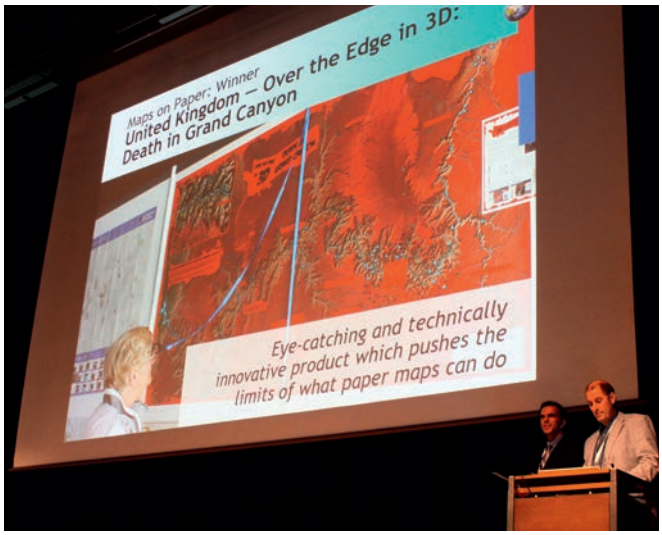
No 2505

Embracing the Spirit of 'Maptember'

The scope of ICA's interests covers all aspects involved in creating, using, studying and recording maps and spatial databases – the disciplines of cartography. In his summary of the year 2013, presented on the association's website, ICA president Georg Gartner highlights "a most successful year for cartography" with activities on offer addressing all of these aspects. One period of last year which demonstrated such activity, in production, application and research in maps and spatial data handling, was the month of September. This was promoted, in the UK, as 'Maptember' and it encompassed a host of conferences and meetings of interest to map enthusiasts. 17 events were promoted through the www.maptember.org website, and the most dedicated cartographer could 'bookend' this rich period of mapping-oriented indulgence with two additional dates – the International Cartographic Conference in Dresden (25-30 August, as reported on in December's *GIM International*) and the meeting of the North American Cartographic Information Society held in Greenville, South Carolina (9-11 October).

Despite living in the distant west of the USA, Ken Field, the editor of *The Cartographic Journal* (an official ICA affiliate journal), was by far the most resolute attendee at this range of events. One of the results of this dedicated commitment is a thoughtful and highly recommended editorial in the journal's final edition for 2013, discussing the nature of the meetings which constituted Maptember as well as broader issues of the future of cartography. From his unique position, Field was able to present insightful and valuable comments about the organisation of meetings, publicity and attracting attendees, the content of – and presentation methods for – conferences, the nature of related events and mechanisms (including awards competitions, map displays, Twitter feeds and social media engagement), the role of newcomers and 'old hands', the value of face-to-face contact, and the sheer number of events and publications. Useful from a generic perspective, his comments should be considered by all those who have organising the best future for cartography at heart.



An example of forward-looking cartography: Ken Field's winning entry in the overall paper map awards ceremony at the Dresden ICC, August 2013 (Dirk Burghardt and Corné van Elzakker, jury chairs, officiating).

On a wider note, we move into 2014 noting that this is the 25th anniversary year of some of the most momentous events of the 20th century: the period (1989 and into 1990) during which political change came, with varying degrees of disorder and outcome, to Budapest, Gdansk, Beijing, Berlin, Prague, Bucharest, Cape Town and Moscow. John Simpson, the BBC's distinguished foreign correspondent, was present in each of these cities during those heady times, probably the only such person in the world. His perspective, from this unique standpoint, was presented in an excellent volume of remembrances of the events, *Despatches from the Barricades*.

The lesson, both from Simpson's book and Field's editorial, is that the most valuable perspectives come from those who engage with a topic in the widest possible way – in content, and geographically. The future of cartography relies on a successful integration of communities which held their separate events during Maptember, but which have so much in common. ICA will continue to look forward to embrace the breadth of all aspects of our discipline.

MORE INFORMATION
www.icaci.org

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No 2503

Joint ISPRS/IGU Conference on Geospatial Theory, Processing, Modelling and Applications

ISPRS Technical Commission II aims to advance the research, technology and applications of spatial information science, focusing on a number of aspects in particular. The first focus is on the development of efficient representation and modelling for multiscale, multidimensional and multi-temporal data. The second focus is on the design of methods, tools and algorithms for integrating, managing, mining and visualising existing and newly created multi-resolution spatio-temporal sensor data for use in spatial decision-support systems. The third focus is on the development of server, web and mobile frameworks to enable high-performance computing (e.g. grid and cloud computing) for big geospatial data processing and geospatial modelling and simulation. The fourth focus is on the quality-control assessment of spatial data and analysis at multiple scales using existing and new approaches to spatial uncertainty modelling including multivariate statistics, crowdsourcing and citizen science.

Theme: 'Building Connections in GISciences for Future'.

The ISPRS Technical Commission II Midterm Symposium will be held together with the 16th IGU Spatial Data Handling Conference from 6 to 8 October 2014 in Toronto Marriott Downtown Eaton Centre, Toronto, Canada. This joint event – the Joint International Conference on Geospatial Theory, Processing, Modelling and Applications – will be hosted by the Canadian Institute of Geomatics (CIG) and co-organised by the International Society for Photogrammetry and Remote Sensing (ISPRS) Technical Commission II on Theory and Concepts of Spatial Information Science, International Geographical Union (IGU) Commission on Geographical Information Science and Commission on Modelling Geographical Systems.

Themed 'Building Connections in GISciences for Future', the joint conference intends to present and disseminate the research, development and innovative applications of geographical information theory and technologies in broad areas. The main topics of the joint conference are as follows, but papers on other topics relevant to the conference theme are also welcome:

- Spatio-temporal modelling and dynamics
- Multiscale n-dimensional spatial data representations, data structures and algorithms
- Spatial analysis, data mining and spatial statistics
- Data quality and uncertainty modelling
- Geospatial computation, geodesign and geospatial simulation
- Geographical visualisation and virtual reality
- Geographical decision-support systems and decision theory
- GIS systems analysis, design and implementation
- Spatial knowledge discovery and data mining
- Mobility: tracking, analysis and communication
- Semantic interoperability and ontology for geospatial information
- Web-based methods and systems for spatial information dissemination
- Effective, efficient and responsible use of geographical information in society
- Geomatics data acquisition for GIS (e.g. GNSS, remote sensing, mobile mapping, etc.)
- GIScience and technology education and training

Abstract submissions should be made according to the following categories by the deadline of 15 February 2014. For detailed full-paper submission instructions and deadlines, please visit 1.

The joint conference also welcomes proposals for pre-conference workshops or seminars. For more information, please visit 2.

MORE INFORMATION
1. www2.isprs.org/paper-submission.html
2. www2.isprs.org/call-for-workshops.html
www.isprs.org

Future events

MARCH

Geospatial Conference in Tunis (GCT)
Tunis-Gammarth, Tunisia
from **17-21 March**
For more information:
E: GCT@3g-consult.de
W: www.gct-tunisia.com

ICRS 2014: International Conference on Remote Sensing
Dubai, United Arab Emirates
from **19-20 March**
For more information:
W: www.waset.org/conference/2014/03/dubai/ICRS

4th edition of the Specialised Salon GeoExpo
Sofia, Bulgaria
from **19-22 March**
For more information:
E: buildingweek@iec.bg
W: www.buildingweek.bg

ASPRS 2014
Louisville, KY, USA
from **23-28 March**
For more information:
E: hstaverman@asprs.org
W: www.asprs.org

World Bank Conference on Land and Poverty
Washington, DC, USA
from **31 March-03 April**
For more information:
E: landconference@worldbank.org
W: http://go.worldbank.org/522XXPNXS0

APRIL

Bristol International UAV Systems Conference
Bristol, UK
from **07-08 April**
For more information:
E: admin@bristolusconference.co.uk
W: www.bristolusconference.co.uk

AAG Annual Meeting 2014
Tampa, FL, USA
from **8-12 April**
For more information:
W: www.aag.org/annualmeeting

ENC-GNSS 2014
Rotterdam, The Netherlands
from **14-17 April**
For more information:
W: www.enc-gnss2014.com

10th Annual GEOINT Symposium
Tampa, FL, USA
from **14-17 April**
For more information:
W: http://geoint2013.com

SPAR International 3D Measurement & Imaging Conference
Colorado Springs, CO, USA
from **14-17 April**
For more information:
E: ldehaan@divcom.com
W: www.SPARPointGroup.com/international

Interexpo GEO-SIBERIA-2014
Novosibirsk, Russia
from **16-18 April**
For more information:
E: argina.novitskaya@gmail.com
W: http://bit.ly/1a328gN

Intergeo Eurasia 2014
Istanbul, Turkey
from **28-29 April**
For more information:
E: ofreier@hinte-messe.de
W: www.intergeo-eurasia.com

MAY

Geospatial World Forum 2014
Geneva, Switzerland
from **05-09 May**
For more information:
E: info@geospatialworldforum.org
W: www.geospatialworldforum.org

Esri Africa User Conference 2014
Cape Town, South Africa
from **06-08 May**
For more information:
E: auc@esri.com
W: www.esri.com/events/auc

MundoGEO#Connect Latin America 2014
Sao Paulo, Brazil
from **07-09 May**
For more information:
E: connect@mundogeo.com
W: http://mundogeoconnect.com/2014/en

GEOBIA 2014
Thessaloniki, Greece
from **21-23 May**
For more information:
E: igitas@for.auth.gr
W: geobia2014.web.auth.gr

GEO Business Show 2014
London, UK
from **28-29 May**
For more information:
E: info@geobusinessshow.com
W: http://geobusinessshow.com

JUNE

GEOSummit 2014
Bern, Switzerland
from **03-05 June**
For more information:
E: dkatzer@geosummit.ch
W: www.geosummit.ch/de/index.html

5th International Conference on Cartography & GIS
Riviera, Bulgaria
from **15-21 June**
For more information:
E: bgcartography@gmail.com
W: http://iccgis2014.cartography-gis.com/home.html

XXV FIG International Congress 2014
Kuala Lumpur, Malaysia
from **16-21 June**
For more information:
E: fig@fig.net
W: www.fig.net/fig2014

JULY

AfricaGEO 2014
Cape Town, South Africa
from **01-03 July**
For more information:
E: aparker@ruraldevelopment.gov.za
W: www.africageo.org

OCTOBER

Intergeo 2014
Berlin, Germany
from **07-09 October**
For more information:
E: dkatzer@hinte-messe.de
W: www.intergeo.de

Calendar Notices
Please send notices at least 3 months before the event date to:
Trea Fledderus, marketing assistant, email: trea.fledderus@geomares.nl

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