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Digital Oblique Aerial Cameras (1)

A Survey of Features and Systems

GIM International Interviews

Burak Keser

Guiding Museum Visitors

Young Geo in Focus

Visibility Maps of Turin

Including Atmospheric Conditions

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BPA WORLDWIDE BUSINESS

Tipping Point

It's time to start benefiting from the open data policy that has become institutionalised over the past decade or so. When laying down rules – such as the INSPIRE Directive in Europe – forcing tax-funded institutes and organisations to open up and share the geospatial data they have gathered, one intention of the policymakers was to stimulate commercial growth (in addition to more ideological reasons in line with the belief that 'data paid for by taxpayers should be freely available to taxpayers'). In an interview with *GIM International* in May 2012, European Commissioner Neelie Kroes, who is responsible for e-issues in Europe through the Digital Agenda, came out in support of open data since she believed open data would lead to new business opportunities. In this issue of *GIM International* Professor David Rhind, member of our Editorial Advisory Board and retired vice-chancellor of the City University in London, United Kingdom, calls open data one of the biggest happenings in the field of geoinformation in recent years – bigger than the deployment of unmanned aerial systems for instance. Rhind states in his Insider's View column (page 6) that the open data policy has a positive influence on transparency and a government's accountability to its electorate, and that it improves public services and evidence-based decision-making. Last but not least, it enhances a country's competitiveness in the global information sector. He regards the signing of the Open Data Charter by Canada, France, Germany, Italy, Japan, Russia, the United Kingdom and the United States during the G8 meeting last June, later followed by the World Bank and UN Economic Statistics Directorate, as a tipping point. In the meantime, tens of thousands of datasets have been opened up and linked to each other in portals like INSPIRE. Success stories of IT companies such as Data Publica in France, Husetsweb in Denmark or Climate Corporation in the USA, who have built their business model on analysing, linking and consulting on parts or combinations of these datasets, can serve as examples of SMEs looking for paths to growth. This is exactly what Neelie Kroes envisioned when advocating the reuse of geoinformation data by reintegrating it into new products and services in order to enter new, previously inaccessible markets. It's always difficult to name just one tipping point, of course. The road to open data has already been a long and winding one, and the final destination has not yet been reached. However, the positive news about a recovery of the world economy, albeit fragile, could bolster the efforts of new and existing entrepreneurs to seize the chances offered by open geospatial data and hence create a new tipping point.

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Photography: Arie Bruinsma

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No 2555

The front cover shows hot-air balloons over Cappadocia, Turkey, a region famous for its unique geological features. This issue contains an interview with Burak Keser, head of the Cadastral Department in Turkey. Turkey is also hosting Intergeo Eurasia later this month (28-29 April in Istanbul).

(PHOTO: HTTP://TRAVELWELLFLYSAFE.COM)

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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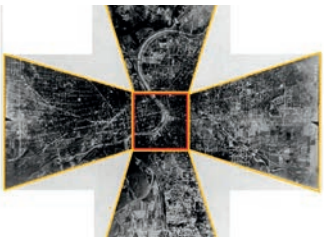

Change and the GIS World

So what have been the recent big happenings in the world of geographic information systems and science? A fair case can be made for the coming of age of unmanned aerial vehicles (UAVs). Civilian lineal descendants of military drones now range from devices measuring just a few centimetres across that take photos or videos, to fully functional mini-aircraft or helicopters for collecting survey-accuracy Lidar. These have proved capable of flying through volcanic ash to measure particle sizes, track wild animals and map large areas, sometimes autonomously.

But my vote goes elsewhere: to the rapid expansion of the open data concept. Some of this is not new. However the signing of the Open Data Charter by the leaders of Canada, France, Germany, Italy, Japan, Russia, the United Kingdom and the United States at the G8 meeting in June 2013 was a tipping point. It commits those nations to a set of principles ('open by default', 'usable by all for any purpose', available at zero or marginal cost, etc), to a set of best practices, including metadata provision, and national action plans with progress to be reported publicly and annually. Other global bodies – notably the World Bank and the UN Economic Statistics Directorate plus some US states and cities around the world – have also signed up.

PROF DAVID RHIND
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Predicted benefits of open data – and prime drivers for top-level political action – have included enhanced transparency and government accountability to the electorate, improved public services, better decision-making based on sound evidence and enhanced national competitiveness in the global information business. Most importantly for us, the common finding worldwide is that GI is the cornerstone of success in making government information widely useful.

Of course there is much hype. But behind it all there are some important developments. Some 50,000 open datasets are now available in the US, and 10,000 in the UK. The most innovative development is the Climate Corporation. This is a US start-up founded in 2006 by two former Google data scientists. It has combined 30 years of weather data, 60 years of crop yield data and 14 terabytes of soil data – all free from US government agencies. The services offered include yield forecasting to help farmers make decisions such as where and when to plant crops in order to boost productivity, plus weather forecasting and crop insurance to help manage risk. The 'precision agriculture' firm was acquired by Monsanto, the world's largest seed company, for US930 million last October. In principle, could this be replicated in Europe? Interestingly, the success of Climate Corporation seems to owe much to 'first mover' advantage rather than guarding intellectual property rights – a contrast to many other information traders (including some government bodies).

MICROSOFT ANNOUNCES VERSION 2 OF ULTRACAM OSPREY ++ ORDNANCE SURVEY BECOMES PRINCIPAL MEMBER OF OGC ++ COWI MAPS GREENLAND GLACIER WITH UAV ++ EXACT 3D SCAN OF MONT BLANC ICE CAP ++ ESA TO CERTIFY FIRST GALILEO POSITION FIXES WORLDWIDE ++ DEBUT FOR GPS-LESS UAV LIDAR SURVEYING AND MAPPING SYSTEM ++ PHASE ONE

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No 2525

Microsoft Announces Version 2 of UltraCam Osprey

At the ASPRS conference in Louisville, Kentucky, USA, in March this year, Microsoft's UltraCam business unit introduced an updated version of the UltraCam Osprey, a digital aerial system that combines a high-performing photogrammetric nadir camera with oblique image-capture capabilities.

http://bit.ly/1l0Usz5

UltraCam Osprey.

Ordnance Survey Becomes Principal Member of OGC

Ordnance Survey, UK, has announced that it has raised its Open Geospatial Consortium (OGC) membership level from Technical Committee level to Principal level. As a Principal Member, Ordnance Survey will participate in OGC's Planning Committee to explore market and technology trends relevant to OGC's mission to assure that OGC's policies and procedures remain effective and agile in a changing technology environment. Ordnance Survey will also be involved in final-approval decisions for all OGC standards.

http://bit.ly/1l0UBT8

FOSS4G-Europe Welcomes Contributions

Independent software developers, scientists, industry experts and agency representatives will come together at FOSS4G-Europe held in Bremen, Germany from 15 to 17 July. Contributions can be submitted on the conference website until 15 April. Under this year's motto, 'Independent Innovation for INSPIRE, Big Data and Citizen Participation', the conference series FOSS4G-Europe is uniting the GIS community from a broad spectrum of fields including geodesy, geoinformation, land management and remote sensing.

http://bit.ly/QbTAO8

Most Shared

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

1. Debut for GPS-less UAV Lidar Surveying and Mapping System - **http://bit.ly/QbOCRv**
2. Three-dimensional Measurement Techniques in Focus - **http://bit.ly/1ewct2i**
3. Image Sensors Bring Computer Vision to Google's Project Tango - **http://bit.ly/1mxUpxM**
4. Malaysia Remote Sensing Agency Signs RADARSAT-2 Deal - **http://bit.ly/1mxUNfx**
5. Apple's Lessons for the Geospatial World - **http://bit.ly/1mxV3uZ**

Debut for GPS-less UAV Lidar Surveying and Mapping System

Lidar technology, photogrammetry and other sensors continue to revolutionise the surveying and mapping industries, and the world is now buzzing about how the future of those industries may lie with UAVs and unmanned vehicles. However, it is only in the last few years that the sensor technology has been sufficiently reduced in terms of size and weight to be considered for UAV platforms. It is now possible to capture point cloud data from a Lidar-equipped UAV and produce 3D environment results, processed without the need for GPS and other sensors.

http://bit.ly/QbOCRv

XactMaps' UAV.

LAUNCHES IXU 150 AERIAL CAMERA ++ CHARLES TOTH ELECTED AS ASPRS VICE PRESIDENT ++ GEOMAAT AND TNO DEVELOP SOFTWARE FOR 3D POINT CLO MAPPING
AND MODELLING SOLUTION FOR MANNED AIRCRAFT ++ AFGHANISTAN MAPPED WITH HYPERSPECTRAL IMAGING DATA ++ TOPCON TECHNOLOGY ROADSHOW NORTH

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No 2505

Exact 3D Scan of Mont Blanc Ice Cap

Chartered land surveyors located in France, as well as two surveyors from Leica Geosystems France, have reached the top of the Mont Blanc. For their seventh expedition, they decided to make the first ever 3D laser scan of the shape and volume of the legendary peak using the Leica Nova MS50 MultiStation. ◂

▸ **http://bit.ly/1l0VLOp**

Leica Nova MS50 scans Mont Blanc ice cap.

Charles Toth Elected as ASPRS Vice President

ASPRS, the Imaging and Geospatial Information Society, has announced the results of its 2014 elections for National Officers. The Tellers Committee reported that Charles Toth, of Ohio State University (OSU), won the election to become ASPRS vice president for 2014. With the installation of officers at the ASPRS Annual Conference in March, Stewart Walker moved into the position of president, Lynn Usery became president-elect and Stephen DeGloria became immediate past president. ◂

▸ **http://bit.ly/QbP4Py**

ESA to Certify First Galileo Position Fixes Worldwide

To mark the first anniversary of Galileo's historic satnav positioning measurement, ESA plans to award certificates to groups who have picked up signals from the four satellites in orbit to perform their own fixes. 2011 and 2012 saw the launch of the first four satellites – the minimum number needed for navigation fixes. ◂

▸ **http://bit.ly/QbOnWx**

Phase One Launches iXU 150 Aerial Camera

Phase One has unveiled its new integrated digital medium-format aerial camera. The iXU 150 is built with a 50MP CMOS sensor offering 8,280 pixel cross-track coverage. The sensor offers 68 percent more capture area than the sensor in any full-frame 35mm DSLR. Quality captures are now possible across its full range from ISO 100 to 6400, at a capture rate of 0.8 seconds per frame. Its light weight and small footprint make it very suitable for UAV integration, mapping and multiple camera configurations for oblique or wide coverage with synchronised shutter release. ◂

▸ **http://bit.ly/QbOLEz**

Phase One iXU 150.

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No 2504

Velodyne Lidar Claims Major Improvement in Mobile Mapping

Velodyne's Lidar division, a manufacturer and supplier of real-time Lidar sensor technology used in a variety of commercial applications, has announced a quantity order for HDL-32E sensors for a mobile mapping application that leverages the advantages of 'Calibrated Reflectivities'.

http://bit.ly/QbRei6

Calibrated Reflectivities.

COWI Maps Greenland Glacier with UAV

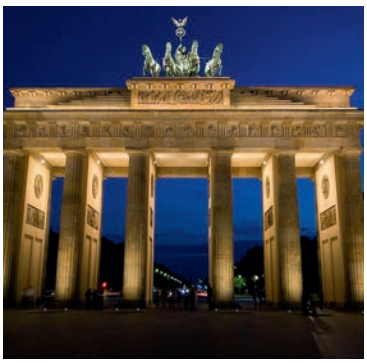
COWI has used its UAV to map a glacier 150km northeast of Nuuk, Greenland, in order to test whether UAVs can be used as an alternative to satellites and aircraft when mapping glaciers. The test mapping was carried out for DTU SPACE to enable daily mapping of the glacier edge geometry, with the purpose of studying the applicability of the UAV technology in monitoring glaciers.

http://bit.ly/1l0VzyM

Intergeo 2014 Draws Geomatics Industry to Berlin

Intergeo, the leading conference and trade fair for geodesy, geo-information and land management, is to return to the German capital for its 20th anniversary. Surrounded by the heady mix of politics, organisations and media in the city of Berlin, the geomatics platform will be turning its attention first and foremost to the questions arising from the increasing digitisation of modern infrastructures. Both urban and rural areas can benefit from intelligent geoinformation solutions.

http://bit.ly/QbRDBe



Brandenburg Gate, Berlin.

Topcon Technology Roadshow Travels through North America

Topcon Positioning Systems (TPS) has announced the Topcon Technology Roadshow 2014, launching in April. This 'hands-on' educational programme focused on advanced positioning technologies will feature a 465-square-metre mobile classroom and theatre housed in a custom-designed 18-wheeler.

http://bit.ly/QbPLbz

Topcon Technology Roadshow.

AMERICA ++ VELODYNE LIDAR CLAIMS MAJOR IMPROVEMENT IN MOBILE MAPPING ++ INTERGEO 2014 DRAWS GEOMATICS INDUSTRY TO BERLIN ++ 3D MO
CHRISTCHURCH CITY ++ GEO BUSINESS 2014 LAUNCHES INAUGURAL CONFERENCE PROGRAMME ++ FOSS4G-EUROPE WELCOMES CONTRIBUTIONS ++ MI S VERSION

3D Models Released for Christchurch City

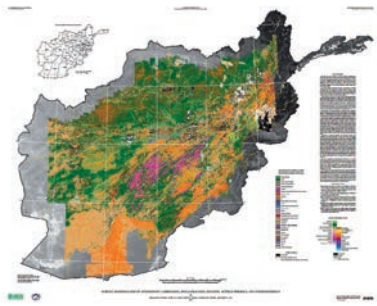
The release of a new set of 3D models of central Christchurch in March – as part of the Canterbury Spatial Data Infrastructure (SDI) programme led by Land Information New Zealand (LINZ) – means it will now be much easier to visualise the inner city as it was before the earthquake in September 2010. The release is facilitated by 3D Enabled Cities – one of eight projects in the Canterbury SDI Programme that began in 2013 to support the recovery effort by enabling improved sharing of location-based information between government agencies and the private sector.

http://bit.ly/QbSIcm

Afghanistan Mapped with Hyperspectral Imaging Data

A coalition of scientists from the United States and Afghanistan has released 60 high-tech maps that will help Afghanistan chart a course for future economic development. These maps represent a milestone as Afghanistan is the first country to be almost completely mapped using hyperspectral imaging data.

http://bit.ly/QbPvta



Hyperspectral resource map of Afghanistan.

Geomaat and TNO Develop Software for 3D Point Clouds

Geomaat, supplier of professional surveying services tailored to the needs of the design and construction industries, has worked together with Dutch research institute TNO to develop software for the automatic detection of objects from a 3D point cloud. Geomaat is using the software for various projects, especially in road-building.

http://bit.ly/QbP9Tx

OF ULTRACAM OSPREY ++ ORDNANCE SURVEY BECOMES

++ DEBUT FOR GPS-LESS UAV LIDAR SURVEYING AND MAP

Integrated Mapping and Modelling Solution for Manned Aircraft

WaldoAir, USA, and Pix4D, Switzerland, have announced the launch of an integrated camera system for use on single-engine aircrafts bundled with aerial image-processing software. This complete system offers the manned aircraft industry the same technological advantages of fast and cost-effective mapping and modelling that the UAV industry has been introducing over the last two years.

http://bit.ly/QbPlC4

GEO Business 2014 Launches Inaugural Conference Programme

Diversified Communications UK, the organiser of GEO Business, has recently announced that the final, vital component for its inaugural event is now in place following the launch of a wide-ranging conference programme. The conference committee has compiled a pioneering programme which covers the breadth of the geospatial industry. The event is scheduled to be held in London, UK, at the Business Design Centre from 28-29 May 2014. The exhibition is combined with an extensive commercial workshop programme.

http://bit.ly/QbSWA2

GEO Business website.

Going Oblique

The camera is the most essential part of any photogrammetric workflow as its features define the type and quality of the imagery – the ultimate resource. Since 2000, the film in the focal plane has been gradually replaced by chips, not only in cameras on the consumer market but also in highly specialised aerial cameras. The number of pixels of today's aerial cameras are counted in tens or even hundreds of megapixels (MP). The benefits of digital aerial cameras over film-based ones are well-documented; these include better radiometric resolution – commonly 16 bits per colour – and elimination of film-processing and scanning costs. Availability of digital image content supports a highly automated workflow enabling the creation of digital elevation models/digital surface models (DEM/DSM), orthomosaics and virtual 3D city and landscape models with little delay between capture and delivery. This not only allows for rapid response in the aftermath of a disaster but is also increasingly demanded by urban planners and managers who want up-to-date 2D, and increasingly 3D, data of buildings, facilities and other objects. Important camera features include the geometric and radiometric quality of lenses, focal length, the number and size of pixels, the radiometric resolution of pixels counted in number of bits, and spectral bands recorded, including panchromatic (PAN), red, green and blue (RGB), near-infrared (NIR), or green, red and near-infrared known as colour-infrared (CIR). In addition, the viewing angle, i.e. the orientation of the optical axis in space, is key. When the optical axis intentionally points in the vertical, aerial surveys result in nadir images which are circa parallel to the terrain. The orientation of the optical axis of oblique images purposefully deviates from nadir. The size of the tilt angle determines whether the horizon is visible or not.

MATHIAS LEMMENS
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The *Manual of Photogrammetry* (4th edition, p. 279) lists three advantages of vertical over oblique:

- Less complicated relationships in geometry
- Detection and recognition of objects is aided by the nearly normal shapes of images
- Less hidden ground (occlusion) because of less obliquity

As a result, extracting accurate geometry from aerial images on a production scale has long been limited to vertical images. Today's sensors can be calibrated accurately, georeferencing can be done through GNSS/IMU alone while today's computers can swiftly conduct the complex calculations needed for extraction of real-world coordinates from imagery. Hence, extraction of accurate geometry from oblique images, acquired by off-the-shelf products, has now become a reality. As a contribution to the series on oblique airborne imagery, I present in this issue of *GIM International* the first part of a survey on features and systems (see page 20). A follow-up article will be published in the May issue.

PRINCIPAL MEMBER OF OGC ++ COWI MAPS GREENLAND GLACIER WITH UAV ++ EXACT 3D SCAN OF MONT BLANC ICE CAP ++ ESA TO CERTIFY FIRST GALI WORLDWI
PPING SYSTEM ++ PHASE ONE LAUNCHES IXU 150 AERIAL CAMERA ++ CHARLES TOTH ELECTED AS ASPRS VICE PRESIDENT ++ GEOMAAT AND TNO DEVELOP POINT CLO

GIM INTERNATIONAL INTERVIEWS BURAK KESER, HEAD OF CADASTRAL DEVELOPMENT IN TURKEY

Bridge Together

The Turkish Cadastre is currently in the midst of a process of renovation. A comprehensive updating of its data is needed in relation to capacity building, the introduction of modern services and e-government. Here, Burak Keser provides an overview of this huge project and insight into its impact on the country's economic development.

Could you give a brief introduction to the history of land administration in Turkey?
As in many countries, the history of our land registry spans more than one and a half centuries. The first regulation on title deed transactions dates back to 1847, under the Ottoman Empire. We regard this year as the year our modern land registry was established. The directorate of ownership was founded in 1924. When the Directorate of Cadastre was affiliated to the organisation, it received its current name as the General Directorate of Land Registry and Cadastre. Today our institution carries out its legally founded activities as an affiliate to the Ministry of Environment and Urbanisation. As you see, we have a long history; there is a lot of knowledge and experience within our organisation.

What is your mission and how does the organisation look today?
According to the Civil Code, one's right of ownership to a real property is only legally confirmed upon its entry into the land registry. The land registry and cadastre are the sources of information that forms the legal and technical basis for all kinds of land-related activities. Our mission is to ensure that a reliable land records are available, and we have 18,000 professional staff members helping us to do so. Our teams in land registry and cadastre provide services from 970 land registry directorates and 81 cadastral directorates all over the country, supported by 22 regional directorates. The senior management consists of a general director plus deputies and the board of land registry and cadastre. There are a number of consultation and control units under the general director in the headquarters in Ankara.

With regard to cadastre, what are the main responsibilities?
Our 81 cadastral directorates conduct cadastral transactions all across Turkey. Furthermore, we have responsibilities related to forest cadastre, zoning practice, land unification, expropriation and of course control and archiving cadastral maps and plans.

And what about the land registry, which is related to cadastre?
For as long as we have existed, we have been providing a quality service in every single area of our country with a large transaction volume. Our 970 land registry directorates find solutions to property sale, donation, distribution, mortgaging and in establishment of servitude. Property transactions may concern partition or unification of property. Our activities transferred the equivalent of USD948 million in fee income to the budget in 2008 and that figure rose to USD3.1 billion in 2013.

What is the status of cadastral establishment and modernisation? I'm sure it is relevant for the development of the country, isn't it?
Yes it is! Turkey has experienced strong economic growth at an average rate of 7.5% per annum since 2001. The housing and construction sector has been very active and is growing at a rate of 7%. Residential, industrial and commercial construction is taking place at a rapid pace in the major cities, and all support services, including property surveys and subdivision, are stretched to keep up with increasing demand. Most secondary city areas have grown in size too, some encroaching by as much as 50% into previously rural areas during the last decade.

The nationwide establishment of the cadastre with its 55 million parcels and 13 million owners was a huge effort but is now complete. Since property transactions are registered within the space of one day in many offices, the Turkish cadastre and registration system is considered one of the most effective in the region. However, there are still many shortcomings that must be addressed to modernise the system and bring it up to the same standards of service as in European countries. The cadastre and land registry software, called TAKBIS, currently runs nationwide.

Is that a big challenge?
The most challenging aspect is that cadastral maps continue to be in paper format, that they vary in accuracy and consistency, and that they are not linked to the national network. Coordinates are central to digital spatial information systems but several different geographical coordinate systems have been

Burak Keser

Burak Keser was born in Erzincan, Turkey, in 1975. He received a BSc in survey engineering from Selçuk University. Over the past 17 years, Mr Keser has worked in various positions within the General Directorate of Land Registry and Cadastre of Turkey, including as an engineer, chief engineer, supervisor and deputy director general. He is currently head of the Cadastre Department there.

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used in Turkey over the years and at present there is no standard system in use for the country's cadastre. This lack of a consistent coordinate system is a critical shortcoming for developers, spatial analysts and users alike, and it will take several years to rectify the situation.

How is the modernisation being organised?

To first give you a general idea of our activities: the Turkish active global positioning system and new rectified orthophoto maps are used to plan, manage, supervise and carry out quality control, with a minimal amount of field work undertaken. The orthophotography is available to other public agencies, including municipalities, as part of our responsibility for the national spatial data infrastructure.

The land registry and cadastre modernisation project has five components. Firstly renovation and updating. There have been several interruptions to development of the cadastre over the last 90 years; it has been subjected to several restarts under different laws and regulations, each bringing the use of new technologies. The cadastral renovation will be put out to tender among qualified private-sector survey firms in line with national procurement procedures. The second component is the implementation of improved service delivery from a modern and integrated cadastral and land registry service. In the third component, the development of human resources and the institutional development is very important to ensure that our personnel skills match our organisation's strategic needs. Training will be phased and sustainable, and it will include management, leadership, technical, administrative and legal training. In the fourth component policies and institutional options will be developed for the introduction of the property valuation function in Turkey. Finally, appropriate project management is the key to success, and this is organised within the fifth component.

Are you using sophisticated tools in this modernisation process?

Yes indeed. Our TAKBIS system is one of the basic systems allowing people to upload all relevant ownership information in an electronic environment and to facilitate all kinds of online transactions. Our spatial property system, called MEGSIS, is an open-source application, an in-house development. It enables cadastral data to be collected digitally by the central system from local users in the cadastral offices and to be harmonised with land registry data in order to be submitted to stakeholders through e-government links. The archive of information dating from the Ottoman Empire will be uploaded into the electronic environment as a part of the title-deed information system, called TARBIS. Finally our permanent GNSS network, TUSAGA Active, provides map and location information about any place at any time in a project area within just a few seconds, with centimetre accuracy. The TUSAGA

Active system comprises 146 permanent GNSS stations in Turkey and in the Turkish Republic of North Cyprus.

You mentioned e-government?
Yes, the e-government initiative, of which the cadastre and registration is a central part, is one of the government's key priorities. The digital cadastre information provides the base maps and related information for many e-government functions such as municipal services, emergency management, land use planning and development control, postal services, real-estate monitoring, utilities management and property taxation.

A huge development with huge volumes and impact. How can this be financed?
Apart from domestic sources, the World Bank is contributing to the financial and technical aspects of the project. In Turkey the basic prerequisites for land administration are in place – a viable and strong single agency and a comprehensive and coherent legal framework. The government of Turkey approached the World Bank for support in modernising the cadastre and registration system and integrating it into the e-government initiative. The World Bank is currently financing several similar projects in the region and will bring to Turkey its broad regional and global experience in land policy and administration reforms.

What have been the lessons learnt so far?
As the general directorate of land registry and cadastre, we are critical to our country's economic development. We have learnt that the focus should continuously be on improving government services. While most project investments are oriented towards renovation of the cadastre, the ultimate objective of the proposed operation is to improve government services with regard to registering property rights and providing land and real-estate information to the public and private sectors. A baseline survey was conducted before the start of the project, and customer satisfaction surveys will be conducted halfway through the project and again at the end.

We are using private-sector surveyors. The number of cadastre parcels that require renovation is about 10 million, of which 6 million parcels already are renovated using the project funds. The public sector has insufficient capacity to undertake this massive task. Experience has shown that the private sector in Turkey is fully mature and capable of providing the services within this task. In fact, in 2006 and 2007 about 100 contracts for cadastre surveys/renovations, each around USD1 million in value, were issued to private-sector surveyors.

Cadastral information is used as base data for many local government functions. Therefore cadastral renovation is very important for local governments and it is crucial that the agency reaches out to local authorities to seek their support. The project will incorporate, where possible, European best practices in land registration and cadastre systems. Finally, as I said, new technologies are speeding up cadastral surveys, map digitisation, data entry and transformation, and minimising the chance of errors.

What would you recommend to other countries in similar situations?
Strong political willingness and support is needed. In Turkey, the land registry and cadastral activities take place under one roof. This structure brings benefits in modernisation: the process can be carried out very quickly while utilising the latest technology. We are keen to share our experience openly with other institutions around the world. We have even coined a slogan for this: 'Bridge Together'.

What is your message to the profession?
We should strive to be at the forefront of new technology, and society already expects this of us. However, new knowledge needs to be generated at the same pace as technological change. It is therefore our responsibility to maintain knowledge of cutting-edge developments and to maintain our high standards. To do this, professional development is essential. Production of high-quality, comprehensive and accurate data is essential for land management activities. ◂

◂ Regional office of the General Directorate of Land Registry and Cadastre in Istanbul, Turkey.

A SURVEY OF FEATURES AND SYSTEMS

Digital Oblique Aerial Cameras (1)

It has become customary for me to provide a survey article on digital aerial cameras in the April issue of *GIM International* every three years. The previous survey (April 2011; vol. 25:4) addressed small, medium and large-format cameras, while in April 2008 (vol. 22:4) the focus was on sensor architecture. This article and a follow-up one will centre on oblique aerial camera systems, the use of which is steadily growing for (3D) capture of urban areas and roads, railways and other corridors.

After providing an introduction to oblique aerial imagery and the diverse camera configurations which allow oblique image capture, this article addresses the following systems: Pictometry, Leica's RCD30 Oblique, UltraCam Osprey, Midas from Track'Air and the Trimble AOS.

Mathias Lemmens gained a PhD degree from Delft University of Technology, The Netherlands, where he presently lectures on geodata acquisition technologies and geodata quality on a part-time basis within the recently renewed MSc in Geomatics programme. He is the author of the book *Geo-information: Technologies, Applications and the Environment* published by Springer in 2011. He was editor-in-chief of *GIM International* for ten years and now contributes as senior editor.

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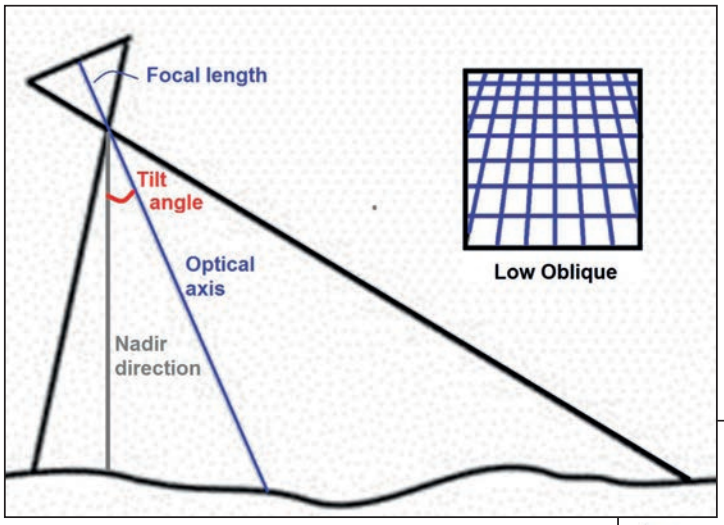
Added to this, Phase One sensors will be covered as their medium-format cameras are increasingly mounted as modules on arrays for customised use. The follow-up article (i.e. part 2) will cover the oblique systems of Digicam, Dimac, Icaros, VisionMap and Wehrli. The initial sources used to compile this survey include conference papers, brochures, factsheets, whitepapers and Geomatching.com, the product comparison website for hardware and software. In a subsequent stage, the manufacturers themselves were individually approached for feedback.

OBLIQUE

Most of the 3D city models and digital maps in car navigation systems or route planners originate from aerial or spaceborne imagery as their source. The images have been captured by high-definition cameras which are manufactured by a dozen or so firms. Starting around 1990, R&D efforts were focused on the move from film to digital, leading to the rapid launch of digital (oblique) camera systems from 2000 onwards. Oblique images are taken such that the orientation of the optical axis deviates with intent from the vertical, i.e. nadir direction. If the horizon is visible, the image is called 'high oblique' or otherwise 'low oblique' (Figure 1). Oblique images are usually captured by multiple lens systems. These consists of two or more lenses mounted in the same camera body or two or more cameras mounted in an array so as to keep the angles between their optical axes fixed. The shutters are usually synchronised to obtain exposures at the same instant. The accuracy largely hinges on how well the optical axes can be calibrated and retained. A good description of the characteristics of oblique aerial images can be found in Pictometry's patent (side bar, page 23) and in my Endpoint column (see page 15).

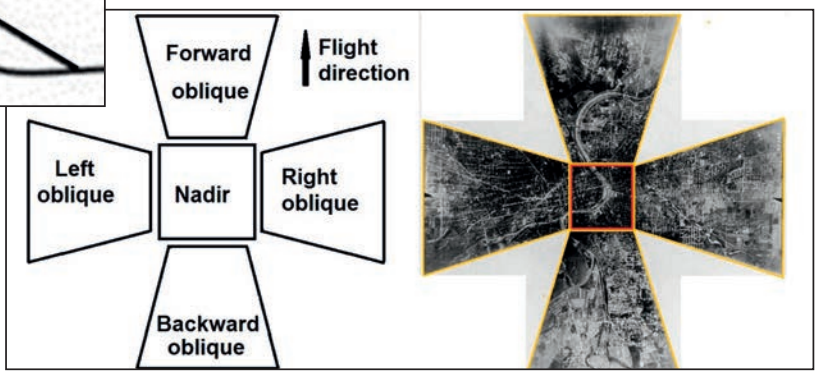
CONFIGURATIONS

There is nothing new about taking oblique images – they have already



▲ *Figure 1, Low oblique view. Inset: the scale becomes gradually smaller from bottom to top of the image, that is from foreground to background in the scene.*

▼ *Figure 2, Maltese cross concept: principle (left) and a rectified mosaic of Fairchild T3A images.*



been in use for over a century for military survey and large-scale mapping projects. Around the year 1900, Scheimflug developed a multiple-lens camera viewing oblique in 8 directions. During World War 1, the US developed a tri-lens camera. In the interwar period, engineers employed by Sherman Fairchild extended this multiple lens system to the five-lens T3A, which remained the precision-mapping camera of the US Army until 1940. The T3A can be considered as the forerunner of today's Maltese cross digital oblique cameras as it acquired five negatives sized 5.5 by 6 inches simultaneously (Figure 2). The central lens pointed vertically, i.e. in nadir direction, and the other four, which were spaced at 90 degrees intervals around the central lens, were tilted 43 degrees away from the vertical. During a mapping conference held in Washington in 1940, the military use of the T3A was abandoned in favour of the tri-metrogon, a cluster of three K-17 wide-angle reconnaissance cameras; one pointing in the vertical and the other two at a tilt angle of 60 degrees on each side to provide horizon-to-horizon coverage. The digital variant of the tri-camera configuration has also become popular in recent years. Figure 3 shows the so-called Fan configuration when one camera is looking into the nadir, the second to the left and the third to the right. In general, the Fan consists of two or more digital cameras which have been assembled such that their optical axes are in the same vertical plane, but each camera views at a different angle resulting in a panoramic view across track. Multiple camera heads can also be mounted in a block such that they allow extensive ground coverage – equal in all directions – during one exposure. Another method to obtain oblique views is by sweeping one or more cameras across track. The scan motion allows a large field of view across the flight direction and provides oblique views. Vision Map's A3 dual-camera system operates according to this sweeping principle.

SERIES ON OBLIQUE PHOTOGRAMMETRY

The fourth contribution of this series on oblique airborne imagery focuses on oblique camera systems. The previous ones, published in January, February and March, covered properties of oblique airborne imagery, automated processing and automatic building detection, respectively. The fifth article, to be published in the May issue of *GIM International*, will continue the survey on digital oblique aerial camera of systems which are not covered here. The series is 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 and configurations available on the market. You are cordially invited to contribute. To do so, please feel free to contact the editorial manager at wim.van.wegen@geomares.nl or the senior editor at m.j.p.m.lemmens@tudelft.nl.

PICTOMETRY

The first company to revitalise the Maltese cross concept in the digital era was Pictometry with its PentaView capture system. However, Chris Barrow – who has been CEO of EagleView, the parent company of Pictometry Int. Corp, since 2008 ▶

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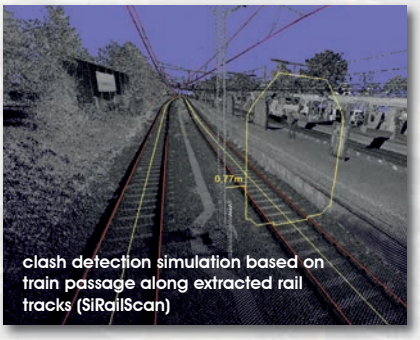

clash detection simulation based on train passage along extracted rail tracks (SiRailScan)

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PICTOMETRY: SELECTED QUOTES FROM PATENT US 20040105090

Conventional photogrammetry involves the capture and / or acquisition of orthogonal images… although orthogonal and ortho-rectified images are useful in photogrammetry, they lack information as to the height of features depicted therein and require highly-trained analysts… Oblique images are considered to be of little or no use in photogrammetry. To […] warp the image onto a coordinate system dramatically distorts the oblique image and thereby renders identification of objects and the taking of measurements. Correcting for terrain displacement within an oblique image by using an elevation model further distorts the images thereby increasing the difficulty with which measurements can be made and reducing the accuracy of any such measurements. The present invention comprises … a computerised system for displaying, geolocating, and taking measurements from captured oblique images. Image display and analysis software is executed by the system… The software retrieves the positional data for one or more user-selected points on the displayed image, and calculates a separation distance between any two or more selected points. The separation distance calculation is user-selectable to determine various parameters including linear distance between, area encompassed within, relative elevation of, and height difference between selected points. Oblique images, unlike orthogonal images, display the sides of terrestrial features, such as houses, buildings and/or mountains, as well as the tops thereof. Thus, viewing an oblique image is more natural and intuitive than viewing an orthogonal or ortho-rectified image, and even casual observers are able to recognise and interpret terrestrial features and other objects… Oblique images capture a generally trapezoidal area or view of the subject surface or object, with the foreground of the trapezoid having a substantially smaller ground sample distance (i.e., a higher resolution) than the background of the trapezoid.

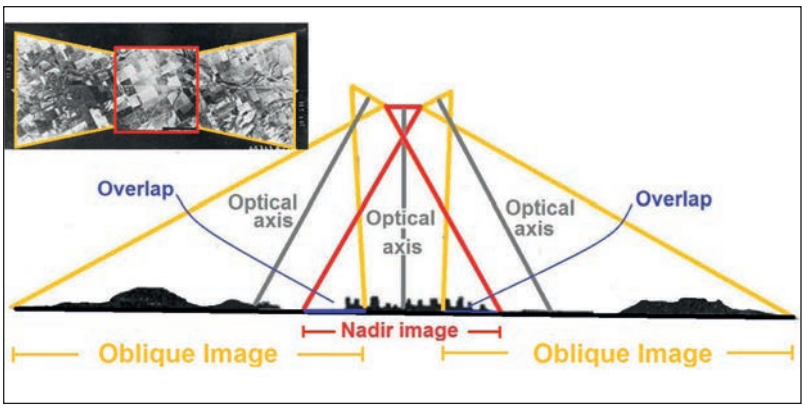
– stated in an interview in the March 2014 edition of *GIM International* that the PentaView capture system is not precisely a Maltese cross configuration like the Fairchild system, since the cameras have a higher oblique angle resulting in five distinct image captures as opposed to the single Maltese cross appearance on the ground. Pictometry, headquartered in Rochester, New York, USA, employs the PentaView system mainly for visual inspection purposes aimed at public safety and planning. In 1993 the company was awarded a patent on a cluster of five medium-format digital cameras on a mount and production started five years later. Each CCD of the five cameras of the patented system consists of 4,900 by 3,200 pixels and each pixel has a size of 9 micron and a radiometric resolution (RR) of 12 bit. The chips capture colour (RGB) images. Part of the system is a display and measurement software package called Electronic Field Study (EFS). Measuring length, height and area depends on the use of an accurate DEM. Pictometry got a strong boost in September 2005 when Blom Group entered into an exclusive licensing agreement with the company for 23 European countries to capture cities with a population of 50,000 or more.

LEICA RCD30

The Leica RCD30 Oblique camera system, introduced in 2011, is available in two configurations: trio and penta. The trio configuration consists of one nadir camera with a focal length (f) of 50mm and two oblique cameras (f = 80mm), one forward-looking and the other viewing backward; the tilt angle of both cameras is 45 degrees. The penta configuration consists of 5 cameras arranged in the form of a Maltese cross; f is 50mm for nadir and 80mm for oblique and the tilt angle of the 4 oblique cameras is 35 degrees. The 80MP CCD contains 10,320 by 7,752 pixels of size 5.2 micron and the RR is 14 bit. The spectral range for all 5 camera heads is either RGB or multispectral, i.e. RGB plus near infrared (NIR: 780-880nm). The weight of the system including camera heads, controller, mount and integrated GNSS / IMU is 30kg. The trio configuration is aimed at 3D corridor mapping while the penta is suited for 3D urban mapping in particular.

ULTRACAM OSPREY

Microsoft has given its product line of third-generation UltraCam aerial cameras the names of birds of prey: Hawk, Falcon, Eagle and Osprey. The latter is a nadir / oblique system, introduced in spring 2013, of which the cameras are arranged in a Maltese cross (Figure 4). The nadir camera is the same as the UltraCam Hawk, a 90MP mapping camera introduced in 2013. The nadir camera (f = 51mm) collects five bands: PAN, RGB and NIR. The image size of the PAN band is 11,674 by 7,514 pixels; each pixel has a size of 6.0 micron, resulting in a CCD format of 70.04mm by 45.08mm. At a flying height of



▲ *Figure 3, Fan concept using a three-camera arrangement.*

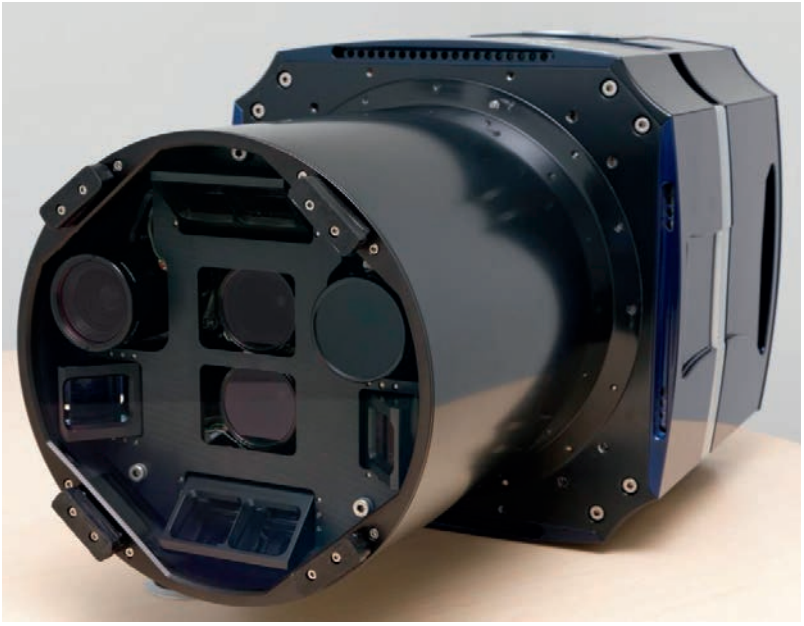


Figure 4, View of the UltraCam Osprey clearly showing the nadir and oblique-looking heads.

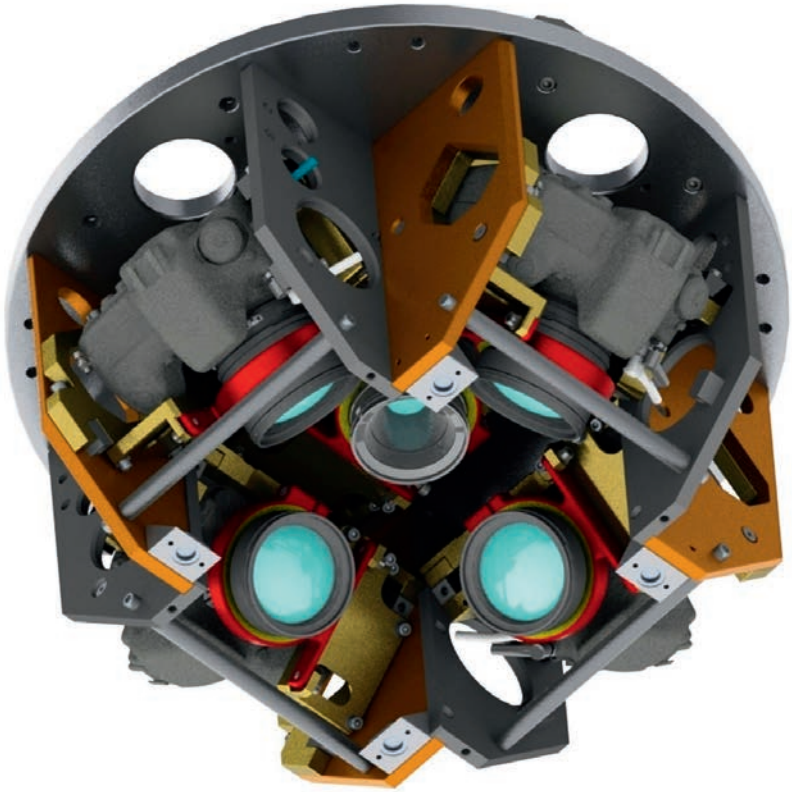


Figure 5, Midas: mounting of individual medium-format cameras to a Maltese cross configuration.

850m, the GSD is 10cm. The oblique cameras are tilted by 45 degrees, have a focal length of 80mm and a pixel size of 5.2 micron. The across track pointing cameras contain CCDs consisting of 6,870 by 4,520 pixels while the forward and backward cameras each contain two such CCDs, paired along the short edge (4,520 pixels) of the CCD, resulting in a stitched image of 13,450 by 4,520 pixels.

TRIMBLE AOS

The Maltese cross coverage can also be realised by just three cameras, one pointing nadir and the other two viewing oblique. One such system is the Aerial Oblique System (AOS) initially constructed by RolleiMetric for Alpha Luftbild, a German aerial survey company, but now part of the Trimble stable. AOS comprises three Rollei AIC medium-format digital camera units, each of which is equipped with a 39MP CCD which consists of 7,228 by 5,428 pixels each having a size of 6.8 micron. The shutters of the three cameras are synchronised to simultaneously capture the vertical image and the two oblique images pointing in opposite directions across track. The complete three-camera unit can then be rotated rapidly by 90 degrees to obtain the second pair of oblique images pointing in the along-track direction. The three-camera unit can be lowered down through the port in the aircraft floor to operate outside the aircraft, and can be retracted when it is not in operation and during take-off and landing. RR is16 bit per colour and the focal length is 47mm. In combination with the CCD size of 49.1 mm by 36.9 mm, this results in a field of view of 55 by 41 degrees.

MIDAS

Large and medium-format metric cameras are often too expensive for projects which do not require high accuracy. A flexible solution is to mount small and medium-format cameras in an array in varying layouts. This is what Track'Air, founded in The Netherlands, did. They provide customised layouts consisting of an assembly of one to ten off-the-shelf RGB cameras, Lidar or multispectral sensors. The sensor packages include three cameras viewing nadir, forward and backward, or five cameras arranged in a Maltese cross of which the oblique cameras are tilted 45 degrees with respect to nadir (Figure 5). When introduced as Midas (Multi-camera Integrated Digital Acquisition System) in 2006, the system consisted of Canon EOS 1Ds Mk2 cameras equipped with Zeiss lenses, focused to infinity and

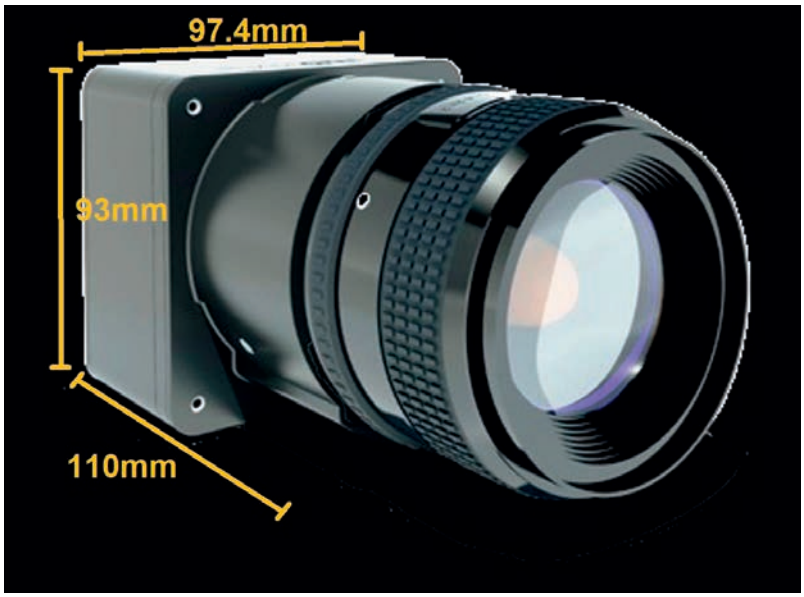


Figure 6, Phase One iUX 150 and the camera body dimensions.

focal lengths of 28mm or 50mm. The CCD size is 5,616 by 3,744 pixels and the size of each pixel is 6.4 micron. The current Midas model uses either the Canon 1Ds Mk3 or Nikon D800e cameras (7,360 by 4,912 pixels). The Zeiss lenses are focused to infinity and the focal lengths range from 50mm to 135mm. In March 2014, eight years after the launch of MIDAS of which over 100 systems have been supplied to customers all around the world, the Chimera consisting of five Phase One iXA cameras (size of the chip: 7,752 by 10,320 pixels and a pixel size of 5.2 micron) was presented at the 2014 ASPRS conference. The Schneider lenses are focused to infinity and one may choose from a range of focal lengths, including: 28mm, 55mm, 80mm, 110mm, 150mm and 240mm. At a height of 1.5km, GSD is 5cm.

A flexible solution is to mount small and medium-format cameras in an array in varying layouts

MODULAR

The arrangement of individual small or medium-format cameras in a mount ensures multiple patterns which may be configured according to customer needs. Denmark-based COWI, for example, operates oblique camera systems based on the Midas concept. The types of camera have been adjusted to customer needs so that the nadir-looking camera is a Hasselblad with a Phase One back piece. The Phase One medium-format cameras are increasingly being assembled in arrays to configure oblique camera systems. Phase One is headquartered in Denmark too, and in mid-February 2014 it was announced that UK-based private equity firm Silverfleet Capital would acquire a 60% majority stake in the company. Phase One specialises in high-end digital photography equipment and software. Since 2012 the company has been extending its consumer base, which primarily consisted of professional photographers, to aerial photography by offering the iXA which has no viewfinder and very few mechanical moving parts. Since early spring 2014 the aerial survey market has been further served by the introduction of a lightweight medium-format camera: the iXU 150. The sensor, sized 43.8mm by 32.9mm, contains 8,280 by 6,208 pixels with a pixel size of 5.3 micron. 'Lightweight' has been the *leitmotiv* during the design as the camera body weighs just 750 grams (1.25kg with an 80mm lens). The weight reduction has been enabled through a magnesium chassis which is more expensive but is 30% lighter than the use of conventional materials. Figure 6 shows the camera and depicts the dimensions of the camera body.

CONCLUDING REMARKS

Part 2 of this diptych on oblique aerial camera systems will cover the oblique aerial camera systems of Digicam, Dimac, Icaros, VisionMap and Wehrli. If a camera system is not highlighted in this survey but should be, please feel free to contact me.

ACKNOWLEDGEMENTS

Thanks are due to all listed manufacturers of oblique digital aerial cameras for their feedback on the final draft.

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INCLUDING ATMOSPHERIC CONDITIONS IN DSM VIEWSHED ANALYSIS

Visibility Maps of Turin

High-rise buildings affect the skyline of a city and thus the human perception of urban spaces. From which points can a building, or parts of the building, be seen? The answer requires viewshed analysis of raster or vector 3D city models. Visibility is not just a geometric exercise in which lines of sight are calculated using standard GIS tools. Visibility and perception of space are also determined by atmospheric conditions, contrast between foregrounds and backgrounds including the sky, visual acuity and psychological aspects. Here, the authors present a simple but accurate method for generating visibility maps based on the above criteria and demonstrate its effectiveness for a newly erected skyscraper in Turin, Italy.

A viewshed represents the visibility of a building or another object from a fixed vantage point and this can be computed from a digital surface model (DSM) using standard GIS functions. The result may be either 'yes' – the building is visible from the viewpoint – or 'no' – it is not visible. The results of n viewpoints within an area end up in a cumulative viewshed: n – m, with m being the number of points from which the building is not visible. This simple addition of the binary values 1 and 0 does not do justice to partial visibility and for this the visual magnitude has been introduced, resulting in a range of values between 0 and 1. This measure has been widely used in the analysis of rural and forest landscapes. Visual acuity is determined by the eye's visual angle and means that a building with a diameter of 20m can be seen from a maximum distance of 69km assuming crisp air, i.e. haze, dust or other diffusing particles are absent.

METHOD

However, diffusing particles will be often present in the atmosphere and they will obstruct a clear view of the building when observed from long distances. Perfectly clear air is the best-case scenario but leads to unrealistic values as atmospheric conditions affect visibility more than visual acuity. Visibility can be indicated from parameters that describe the atmospheric conditions, but it is more feasible to use sight distances registered over time by weather stations. The sight distances should preferably be collected hourly, and such high-frequency observations can be obtained from international databases.

Gabriele Garnero is a professor of geomatics at the University of Turin and of planning sciences at the Polytechnic of Turin, Italy. His research interests include applications of GNSS, photogrammetry and remote sensing, architectural surveys, digital cartography, GIS and cadastral applications.

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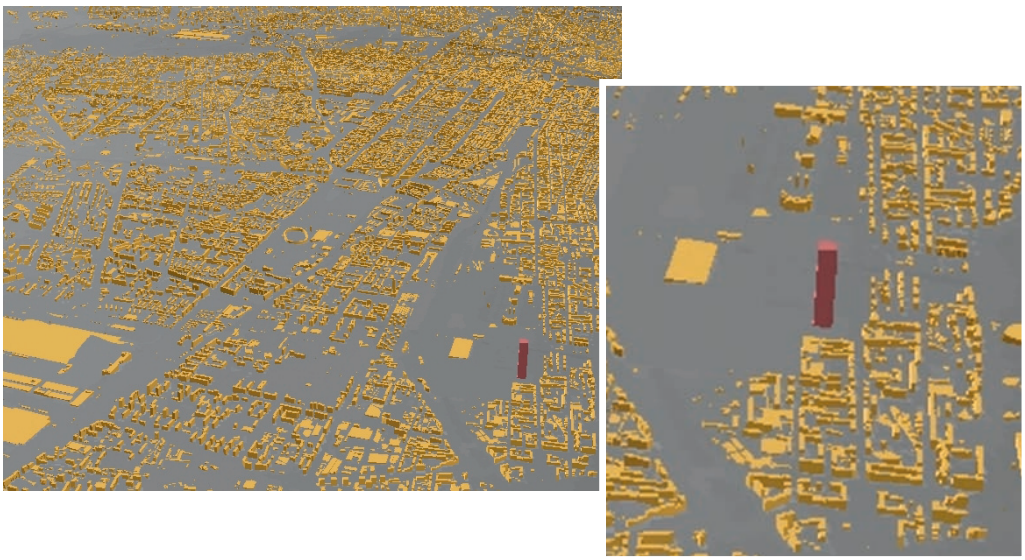

Figure 1, 3D raster block model of Turin (left) and skyscraper and vicinity.

Real-time weather observations can also be used. Depending on the frequency of sight changes, the sight distances can be averaged over a certain time span, e.g. a week, month or year. The city of Turin, which has a lot of heavy industry, has lowest visibility in September and October, and highest in August and January; the difference may be up to 7km. This method does not simply perform averaging but instead selects the most dominant visibility distance in a certain time span.

Perfectly clear air is the best-case scenario but atmospheric conditions affect visibility more than visual acuity

DATA AND RESULTS

The test area lies in Turin, northwest Italy. The bare ground heights were derived from a recent digital elevation model (DEM) of the Piedmont region, captured by airborne Lidar with an average density of 1 point per $5m^2$ and interpolated to a grid of 10 x 10m. A map, scaled at 1:1,000 and containing eave outlines of buildings and their heights above street level, was transferred into a raster layer with a

Figure 2, Visibility maps: green indicates visible areas from a distance of 20km (left) and 1.6km.

cell size of 0.5 x 0.5m using ArcGIS tools. Also the DEM was resampled to a grid size of 0.5 x 0.5m. Merging both datasets created a raster including the buildings and their heights, which are shown as simple blocks (Figure 1). The skyscraper has a square footprint of 45 x 45m. Its height is 210m, the foot lies at 234.50m above reference level and the top lies at 444.50m for all four corner points. If one of the four corner points is visible, then the building is indicated as visible. Using geometric computations and visual acuity, the length of the line of sight appeared to be 218km. Subsequently, visibility constraints were introduced based on atmospheric conditions. Figure 2 shows two maps, each computed within 30 minutes, using the visibility distances of 20km and 1.6km.

CONCLUDING REMARKS

The method allows it to be determined at design stage how the (psychological) perception of places in an urban landscape will change when new buildings are erected or existing buildings are demolished. This provides valuable information for architects and city planners. The use of colour contrast between a building and its surroundings allows refinement of the method. ◂

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A SPATIALLY ENABLED ONLINE TOOL FOR MONITORING WORKPLACE SAFETY

Indoor Risk Management

Risk management of power plants, dry docks and many other workplaces is aimed at ensuring the health and safety of workers as well as the people living in the vicinity. A spatially enabled risk management system supports staff safety by reducing or even eliminating incidents. Here, the author describes an online tool which has been developed in the Philippines and has been filed for a patent.

In the workplace, faulty wiring may cause a fire, slippery floors may cause workers to fall, and poorly shielded equipment may result in injured limbs. National labour and employment organisations all over the world have the statutory duty to protect workers, to promote and advocate injury prevention, and to enforce regulations. Therefore, the focus should be on the avoidance of incidents; this requires regular inspections to detect deficiencies of facilities, equipment and machinery. A management information system is a valuable tool in helping to avoid incidents, to act adequately if they do occur and to lessen the risk of them recurring. But such a tool also requires locational data about workplace facilities, equipment and machinery since georeferenced data enables the right measures and actions to be taken. The Environment, Health, Safety, and Security (EHSS) intelligent solution developed in the Philippines is such a spatially enabled risk management tool.

A floor plan should be complemented by maps of the environment up to the municipal or national level

EHSS

Any spatially enabled risk management tool relies on storage and processing of locational data on facilities, equipment and machinery in the form of 2D or 3D coordinates. This can be done in a local database system, but a national reference system is preferable. EHSS stores locational and attribute data in a relational database management system (RDBMS). The locational data is input interactively on a pre-loaded map. Developed as a web application, it uses the RDBMS MySQL in concert with PHP, a server-side HTML embedded scripting language designed for web development. It allows the identification, notification, recording, investigation, analysis, assessment, correction and control of risks and hazards in ▸

Rowena B. Quiambao holds a postgraduate diploma and an MSc from ITC, The Netherlands. She is the country manager of Rethink Safety Limited, a subsidiary of the Safety Center Group in the Philippines. Prior to this, she was with the Philippine Institute of Volcanology and Seismology working on hazard and risk assessment.

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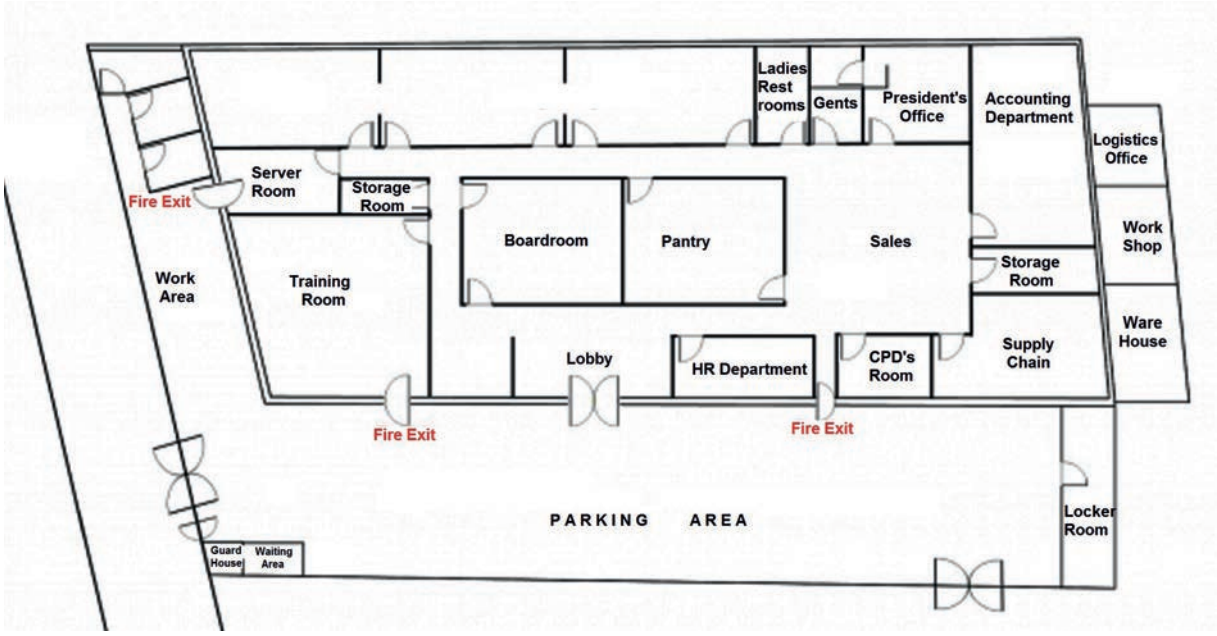

Figure 1, Floor plan map of a workplace used as base map.

the mapped workplace. To keep the data up to date, continuous auditing and measuring through workplace surveys are required. On the resulting base map (see Figure 1) the locations of incidents and hazards can be mapped allowing analysis of the cause and providing insight into how to avoid future events.

A floor plan of the workplace should be complemented by maps of the environment

ENVIRONMENT

A chemical plant, dry dock or metal workshop may be surrounded by residential or commercial properties, schools, hospitals and suchlike. Toxic gases may escape, fuel oil may stream into the water or a high-pressure boiler may explode. Such an incident may injure people, demolish houses or cause other damage to the surrounding area. A company's reputation can be severely harmed by workplace accident, even if it just affects a few people living nearby. Therefore, a floor plan of the workplace alone is insufficient and should be complemented by maps of the environment, possibly up to the municipal or even national level (Figure 2). These maps must include locational data on both natural and man-made features including individual objects, land cover and land use.

RISK ASSESSMENT

The tool allows the probability of an hazardous event, such as an explosion of a tank filled with

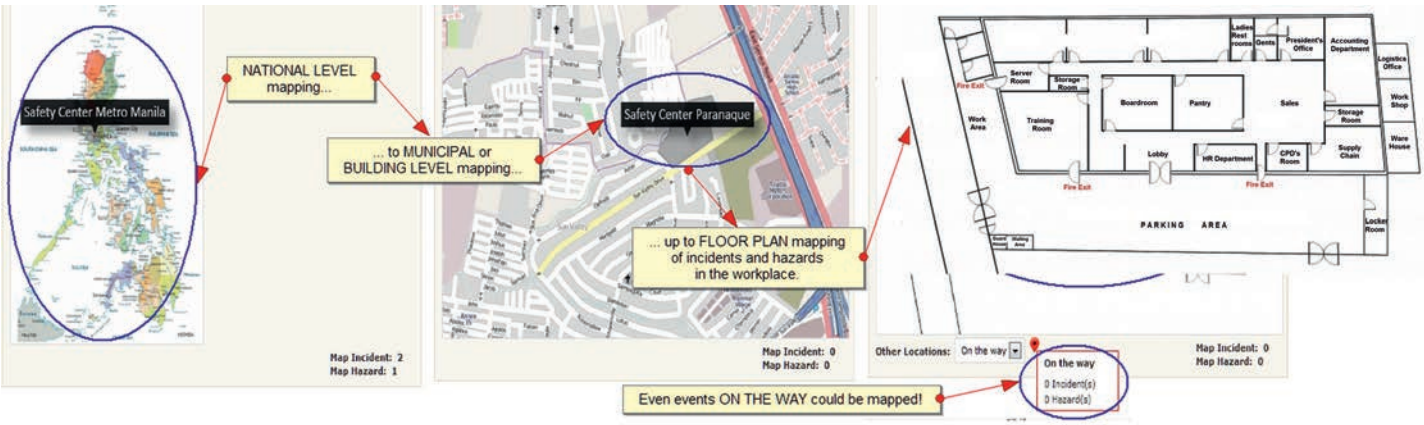

Figure 2, Hierarchy of map data, from national level (left) to individual floor plan.

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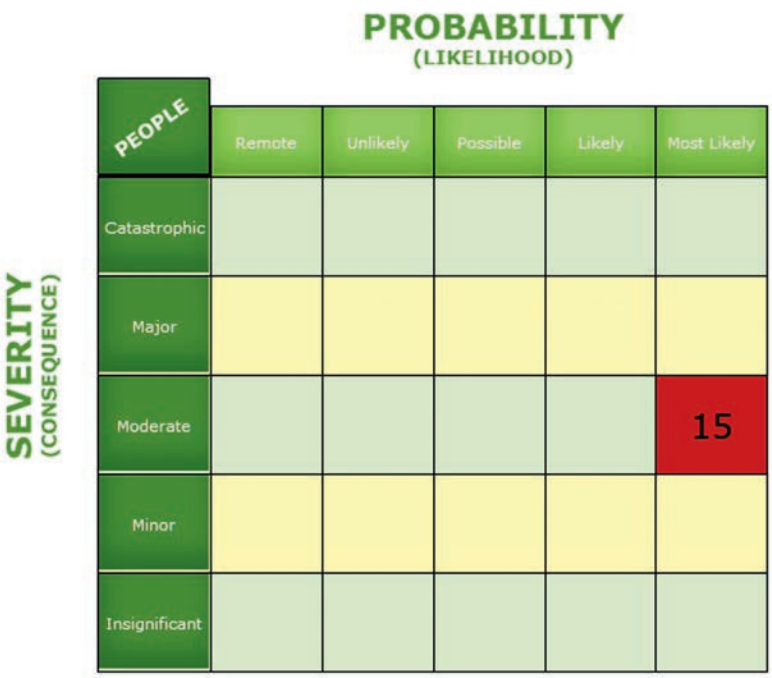

▲ *Figure 3, Sample of a risk matrix report.*

liquid gas, to be assessed and its impact on both the workplace and the vicinity to be determined. The results are presented in both graphical and tabular form. When probability is high and impact moderate, the risk score should be high which is indicated in a risk matrix (Figure 3). The maps of the workplace and the surrounding area are also useful for assessing the extent of the area at risk and the type of damage an incident in the workplace may cause to nearby buildings, other objects and to people living in the vicinity.

CONCLUDING REMARKS

Legislation, regulations and standards on workplace safety are not yet fully in place or implemented in many parts of the world. A spatially enabled risk management system, such as EHSS, can help remedy this deficiency. The author intends to make this tool widely available and to further improve its functionality and ease of operation in close collaboration with users.

ACKNOWLEDGEMENTS

Thanks are due to Ben Tan, Gina Quiambao, Chrit Lemmen, Rohan Bennett and Walter de Vries. ◀

BIOGRAPHY

The authors are presently 2nd-year students on the MSc in Geomatics of the Built Environment at Delft University of Technology, The Netherlands. The curriculum was renewed in 2012 and now focuses on advanced technology for capturing, storing, analysing and disseminating geoinformation. The MSc attracts students from all over the world, including from Lithuania, Greece and China.

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Indoor Navigation at the Hubei Museum, Wuhan, China

Guiding Museum Visitors

Some museums have been guiding visitors through their exhibitions electronically using audio tours for decades. The audio content is triggered automatically when the visitor enters a room or stands in front of a display. Now that smartphones are ubiquitous, why not employ the latest technology for museum guidance? They are cheaper and more user friendly for visitors and museum management alike, and they can be more informative too. Challenged by this question, seven MSc students from the Delft University of Technology went to Wuhan, China, in early Autumn 2013.

Since 2000 various indoor navigation systems have been proposed, all of them able to locate the user inside a building, to communicate with him or her, to display a 2D or 3D map of the building interior and to plan a path towards a desired location. In our research, we focused on path planning and localisation/orientation. The methods for the latter can be grouped into: (1) odometry using accelerometers, magnetometers, compasses and gyroscopes, (2) direct sensing using radio frequency identification (RFID), barcodes or other tags installed in the inside, (3) trilateration, and (4) signal strength analysis using pattern recognition techniques. For use in determining the location of museum visitors, we looked at Wi-Fi signal strength.

WI-FI SIGNALS

Wi-Fi enables PCs, laptops, smartphones, tablets and other electronic devices to exchange data with the internet using microwaves in the 2.4GHz and 5GHz bands through access points (AP) or hotspots, which have an indoor range of 20 to 50 metres. The strength of the signals emitted by a smartphone and its media access control (MAC) address, which is a unique identifier assigned to network interfaces, can be determined by Libelium Meshlium Xtreme monitors, which is called 'Wi-Fi monitoring'. In turn, the smartphones themselves can measure the strength of the AP signals in range and compare that with the strengths measured at sample points in an earlier training stage, which is called 'fingerprinting'. Both methods allow the Wi-Fi AP infrastructure already present inside the building to be exploited. As the renowned Hubei Museum has a Wi-Fi network and most visitors carry a smartphone, we investigated both Wi-Fi monitoring and fingerprinting. After comparing both methods, fingerprinting was found to be most suitable for the functionality of the application.

Young Geo in Focus
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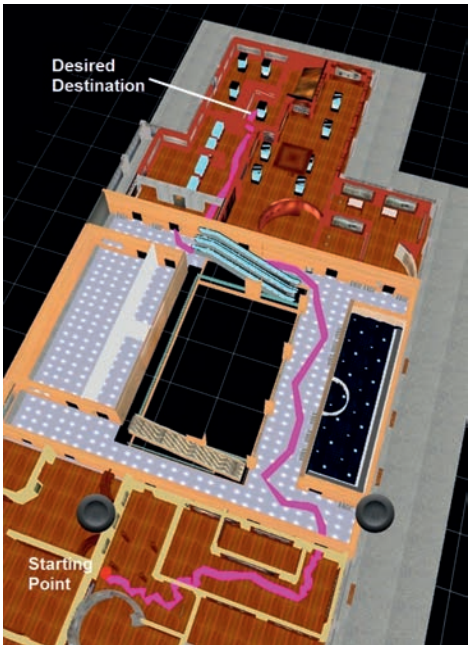

Figure 1, Path (pink line) from starting point (red dot) to the desired destination.

Group photo: The seven MSc geomatics students from Delft in front of the Hubei Museum, Wuhan. From left to right: Benny Onrust, Marija Kruminaite, Eva van der Laan, Haicheng Liu, Antigoni Makri, Karl van Winden and Weilin Xu.

REQUIREMENTS AND RESULTS

Comprising 51,000m^2, the Hubei Museum welcomes between 1,000 and 5,000 visitors a day to view its objects of historical and cultural value. The indoor navigation systems should be able to determine the starting point of each visitor and provide relevant information on the exhibits the visitor can currently see, i.e. the visitor's location should be continuously tracked. Furthermore, it should help the visitor to follow the shortest path from the present location to desired locations. On top of these visitor needs, the museum management wants to gain insight into the amount of time visitors spend looking at each display, how many people are in the building at any one time, how long they stay in the museum, and other information.

Wi-Fi monitoring requires the instalment of monitors which increases the costs. A key criterion is 'localisation granularity' (i.e. the frequency of localisation update). In the case of Wi-Fi monitoring, this is done every few minutes which is sufficient for guidance through a museum as visitors usually spend more than a few minutes in a particular room. Fingerprinting allows the exploitation of the Wi-Fi AP infrastructure already available without the need to install additional provisions. This results in lower implementation costs, while its accuracy is at the level of a few metres which is sufficient for museum guidance purposes. Its location granularity can be adjusted in line with the particular needs. In a museum there is no need to determine the exact coordinates of the visitor, but it is important to identify which room the visitor is in. Usually, both methods tested correctly determine which room the visitor is in. Our 3D path planning method made it possible to determine the route from the present location to a desired location within five seconds using the A* shortest path algorithm, which is a modified Dijkstra algorithm (Figure 1).

LOOKING FORWARDS AND BACK

This research was conducted within the framework of the Synthesis Project which is a part (seven weeks/10 ECTS) of the MSc in Geomatics at Delft University of Technology, The Netherlands. The project is aimed at integrating knowledge and skills gained during the first year by tackling a real-world problem as a team of students. The project gave us broad experience in working in a team as each student had to cover a predefined part of the research. This allowed us to develop our interpersonal skills while operating in a group. On top of that, we learned to manage a project, including approaching sponsors, budget planning, communicating with third parties and much more. The project resulted in two conference papers which also improved our writing skills, and we are proud to have contributed to research into indoor navigation. Our trip was rewarding and impressive as for most of us it was our first visit to China. We were inspired by the support from, and the hospitality of, the researchers at Wuhan University. It was truly a great experience!

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FOIF

Focusing on High-Quality Surveying Instruments

FOIF (Suzhou FOIF Co., Ltd.) is located in Suzhou Industrial Park in China, near Shanghai. The company has integrated the disciplines of R&D, manufacturing, sales, logistics and after-sales service to address the measurement needs of the construction and surveying industries by providing high-quality instruments including gyroscopes, GNSS receivers, total stations, theodolites, levels, laser plummets, etc. The company has evolved into the leading manufacturer of its kind in China.

The origins of FOIF date back nearly 50 years, with the founding of Suzhou First Optical Instrument Factory in 1958. Over the past almost half a century, FOIF has achieved many 'firsts' in the domestic surveying and mapping market. As early as 1966, the company launched China's first EDM 5B, for instance. Many other innovations followed, including the country's first laser theodolite J2-JD in 1975, first rotating laser JP1 in 1986, first total station DQZ2 in 1996, first reflectorless OTS total station in 2002, first auto gyroscope station GTA1300 in 2010, and most recently China's first high-precision digital level (+/-0.3mm) in 2013.

Today, FOIF is a joint-stock company with an annual turnover of more than USD35 million. The company continues to focus on high-quality surveying instruments and industrial measuring instruments, and its main products are surveying instruments, construction instruments, laser instruments and tools. FOIF currently has 8 product series and approximately 100 product models including GNSS receivers, GIS HW & SW solutions, total stations, electronic theodolites, optical theodolites, automatic levels, laser plummets, laser levels and measuring instruments for indoors.
The company is led by the board of directors, and general managers are responsible for the supporting the organisational structure which includes a marketing centre, a management centre, research & development centres, manufacturing centres and a subsidiary for the production of accessories.

COMPANY PHILOSOPHY

FOIF is guided by the philosophy of creating value for its customers and is committed to innovating through continuous improvement and refinement. The firm attaches great importance to technological advancement. Just some examples of its innovative achievements include the DS03 precision level which has the highest accuracy in the industry, the automatic gyroscope station using the very latest technology and the most advanced reflectorless total station with a measuring distance of up to 500m.

In terms of product quality, the company has established several

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.

▲ *FOIF's assembly workshop for total stations and theodolites.*

▼ *FOIF booth at Intergeo 2013 in Essen, Germany.*

working groups for surveying. It has successfully presided over and participated in groups to draft near 20 different national standards, including for total stations, electronic theodolites, optical theodolites and levels.

It is a high-tech enterprise and has been awarded a Grade AAA certificate from the Chinese government in the Jiangsu province for honouring contracts and keeping promises. FOIF's quality management system attained ISO9001:1994 certification from DNV (Det Norske Veritas) in 1996, and attained ISO9001:2000 certification in 2002.

INTERNATIONAL PARTNERS

FOIF's products are recognised both domestically and internationally in the surveying, engineering, construction markets and industrial measurement, and are currently sold all over the world. The company also actively provides ODM services for well-known clients at home and abroad. Today, the company is seeking exclusive distributors for cooperative business relationships in certain regions. Within long-term partnerships, agents are required to handle marketing, provide customers with pre-sales information and advice, and to offer local service as well as providing feedback to FOIF.

High-precision solutions based on product quality, service and an innovative spirit

In 2014, FOIF plans to increase its focus on the overseas market and intends to generate up to 25% of its turnover through export. This growth will come from stabilising its activities in the South American market and expanding sales in the African and North American markets.

In response to the ongoing economic challenges both at domestically and internationally, the company is committed to further improving the performance and quality of its products, improving service quality, stabilising the market share of its existing products and tailoring its high-performance surveying instruments more closely to customer needs. Over the next five years, FOIF aims to become a truly international provider of high-quality R&D and high-precision surveying instruments and industrial measuring systems solutions based on stable and reliable product quality, warm and thoughtful service and an unremittingly innovative spirit. ◀

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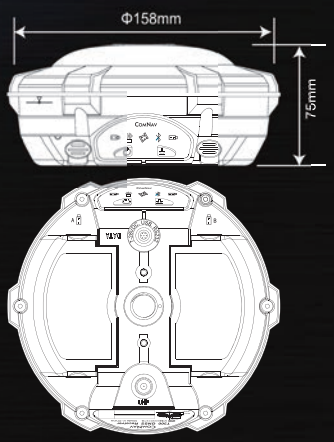

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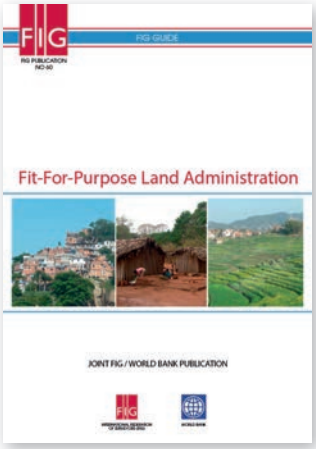
Engaging the Challenges, Enhancing the Relevance

Keynotes during the FIG XXV Congress in Kuala Lumpur, Malaysia, 16-21 June 2014

Humanity faces a series of challenges including that of undernourishment, shelter and climate change. The profession must tackle these challenges with its sciences, technologies and practices. This will be the general focus of the first plenary session during the XXV FIG Congress to be held in Kuala Lumpur, Malaysia, 16-21 June 2014. One of the three keynote speakers during this session will be Mr Gregory Scott, GGIM advisor, Statistics Division, United Nations Department of Economic and Social Affairs, United States, who will be introducing 'Global Geospatial Information Management for the "World We Want"'. Additionally, a prominent Malaysian Minister will address this issue from a Malaysian perspective.

The second plenary will focus on the profession, which can play a key role in the betterment of society, the environment and the economy and needs to attend to emerging issues and trends. Mr Paul Munro-Faure, deputy Director, Climate, Energy and Tenure Division, Natural Resources Management and Environment Department, Food and Agriculture Organization of the United Nations will present a keynote on 'Appraisal and Valuation Standards for the Responsible Governance of Tenure of Land, Fisheries and Forestry'. In this session there will be further keynotes on 'Towards Better Compatibility, Interoperability and Affordability with Multi-system GNSS for the Benefit of Humanity' and 'Fit-for-purpose Land Administration and Management: A Joint World Bank and FIG Declaration'. This keynote is related to a new FIG publication on this issue.

During the third plenary session the keynote speakers will elaborate on: 'Place-based Information for National Development and Regional Collaboration'; 'Better Investor Confidence and Increased Property-market Stability with International Property Measurement Standards'; and 'Sustaining the Profession and Enhancing its Significance and Relevance'. The Post-2015 Development Agenda, the successor to the Millennium Development Goals, is on the horizon. In 2013, the United Nations' High-Level Panel of Eminent Persons on the Post-2015 Development Agenda submitted its report entitled 'The World We Want' with a vision for a new global partnership to eradicate poverty and transform economies through sustainable development. The session will consider how information management, the land and the seas will lead humanity towards the 'World We Want'. From this focus, keynotes will be given in the fourth plenary on 'Population Growth, Climate Variability and Environmental Vulnerabilities in Asia and the Pacific and the "World We Want"', and 'Charts, Marine Spatial Information Infrastructure and Blue Economy for the "World We Want"'. This latter keynote will be given by Mr Mustafa Iptes, director, International Hydrographic Organization. Additionally during the fourth plenary session, the source code of the Social Tenure Domain Model (STDM) will be launched during a keynote from UN Habitat: 'People to Land Relationships, Land Indicators and Land Tools for the "World We Want"' by Dr Clarissa Augustinus, Global Land Tool Network, UN-Habitat.



The cover of FIG Publication No. 60.

To supplement the themes of the plenary sessions there will be an extensive technical session programme with more than 600 papers/abstracts in over 150 sessions covering a broad range of subjects specially composed by the 10 FIG Commissions, Task Forces and Networks. There will furthermore be a number of sessions held together with various FIG partners and also other forums and seminars.

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SDI and the Oscars: Giving Thanks for All the Support

The winners' acceptance speeches given at this year's Academy Awards ceremony once again included recognition of the many people who stood behind an individual, a film or a studio. If the international geospatial community was to come together to hold its own awards ceremony, you would hear members of five different groups being acknowledged over and over again for their contributions and support.

First, our thanks go to the pioneering leaders of the early national SDI initiatives in North America, Europe and Australasia. They provided the leadership and examples of best practices (and possibly ones to be avoided…), and encouraged the early discussions and critical comparisons so important to creating our SDI community.

Second, to companies like Esri, the Hexagon group, DigitalGlobe, Google, Trimble, Microsoft, PCI, Caris and so, so many others. They continue to offer the technology, data, services, advice and user support that fire the imagination, expand the marketplace and raise our expectations for quality and performance. Through their people and philanthropy – and often without any fanfare – they also provide the talent, treasure and time so critical to the success of SDI implementation and education worldwide.

Third, our thanks go to organisations like OpenGeo and OpenStreetMap for the creation and ongoing improvement of open-source software and freely available geospatial data. They also provide the online forums and face-to-face meetings that help sustain

David Coleman.

communities and – again – raise our expectations of the products and services we use.

Fourth, learned societies like Digital Earth and the 10 member organisations of the Joint Board of Geospatial Information Societies (JBGIS, 1). These organisations have been instrumental for many years in promoting the geospatial community through commissions and conferences, as well as externally through their professional and educational outreach efforts. I am proud that our own GSDI Association is a member of JBGIS.

Fifth and finally, transnational and international initiatives and organisations like INSPIRE and Eurogeographics, EUROGI, EIS Africa, the Group on Earth Observations (GEO) and United Nations Initiative on Global Geospatial Information Management (UN-GGIM). Through their membership of strong public-sector leaders, they have kept our community visible and maintained conversations between national mapping organisations. In particular, I would like to recognise the important work undertaken by the International Standards Organization (ISO) and the Open Geospatial Consortium (OGC). Standards are the glue that holds together data exchange and interoperability efforts, and their use in whole or in part is essential to the success of any spatial data infrastructure. OGC is celebrating its 20th anniversary this year and I wish our colleagues there every success for the next 20 years.

Speeches of thanks and acknowledgement often attract more attention due to the names inadvertently left out rather than those mentioned. I'm sure I will be reminded that I have omitted some important contributors in this column, and I look forward to finding ways to acknowledge them in future columns. ◂

Dr David Coleman is president of the GSDI Association, a professor of geomatics engineering and Dean of the Faculty of Engineering at the University of New Brunswick in Canada.

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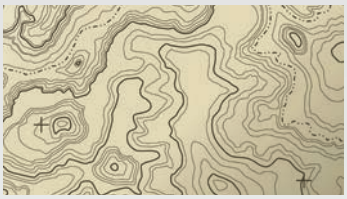

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- collecting, analysing and modelling observational data,
- stimulating technological development, and
- providing a consistent representation of the figure, rotation and gravity field of the Earth and planets, and their temporal variations.

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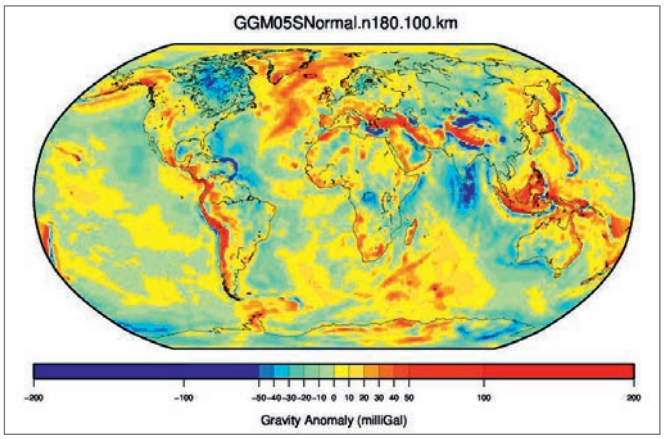
Commission 2 was established in order to promote, support, and stimulate the advancement of knowledge, technology, and international cooperation in the geodetic domain associated with the determination and interpretation of the Earth's gravity field.

Commission 2: Steady Progress in Gravity Field Studies

Details of the structure and goals of IAG's Commission 2 'Gravity Field' can be found in *GIM International* (04/2013) and *The Geodesist's Handbook*. The two most important conferences of the Commission namely the symposium 'Gravity, Geoid and Height Systems' (9-12 October 2012 in Venice, Italy) and the IAG Scientific Assembly (1-6 September 2013 in Potsdam, Germany), have also been covered in *GIM International* (02/2013 and 11/2013).



Gravity anomalies from the GRACE-only model GGM05S up to degree and order 180 using data from 2002 to 2013 (Image courtesy: The University of Texas Center for Space Research).

Many of the investigations in the gravity field community over the last few years have been closely related to the GRACE and GOCE space missions. Many new global models were generated by various institutions using data collected by these missions and have since been made publically available. In particular, the long time series of GRACE gravity field models has supported many studies in the fields of oceanography, hydrology, atmospheric sciences, solid Earth modelling and mass transport. The recent GOCE models are used in many local applications for validation of, and combination with, terrestrial gravity data and GPS/levelling measurements for the improvement of regional and local geoid models. These models allow for the practical realisation of a World Height System, which seems to be possible in the very near future.

Despite the GOCE mission coming to an end in November 2013, the complete dataset is still being analysed, and the results will be integrated into new high-resolution combined global models. The GRACE mission will still deliver data at least until 2016, which is much longer than expected at the start of the mission. However a follow-on mission is necessary in order to ensure the continuation of monitoring of temporal changes in the gravity field. An agreement between European and US space agencies has been signed and the GRACE follow-on mission is scheduled for launch in 2017.

With respect to terrestrial gravimetry, one main goal is the establishment of a new Global Gravity Reference System based on measurements made by modern absolute gravimeters and permanently installed superconducting gravimeters. The future of the international comparison campaigns of absolute gravimeters is assured at least until 2017 with the assistance of the metrology community. The last such comparison campaign was held in Walferdange (Luxembourg) in November 2013 with the participation of 27 instruments. The next one is scheduled for 2017 in China. A special workshop on terrestrial gravity (TGSMM2013) was held in September 2013 in St. Petersburg (Russia) where the focus was on new developments in instrumentation and the applications of static and mobile (mainly airborne and shipborne) gravity measurements. The first results of the newly developed cold-atom gravimeters were presented at that conference.

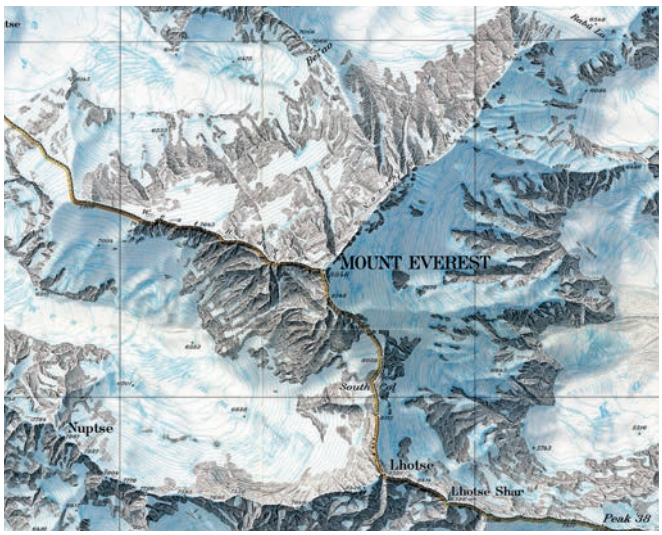
A major satellite altimetry activity over the past two years has been the development of new 'retrackers' and experiments to improve altimeter range accuracies globally and over shallow waters. Another result was the publication of an improved Global Marine Gravity Field from altimetric geodetic missions. Future activities will include the establishment of a permanent altimetry service.

The next major conference for the gravity field community will be the 3rd General Assembly of the International Gravity Field Service, to be held in Shanghai (China) from 30 June to 6 July 2014.

MORE INFORMATION
www.iag-commission2.ch
www.iag-aig.org

Maps – *Cartes* – Design – *Dessiner*

Good design and better mapping are core to effective cartography. Information in a well-designed map will be rapidly recovered, unambiguous, easily recalled and ultimately inspire confidence in both the product and the action that results from the map's use. The ICA Commission on Map Design acts as a forum for discussion, exchange of ideas and the development and spread of the principles and practice of high-quality, effective cartographic design.



Extract from National Geographic Society map of Mount Everest by Bradford Washburn.

One of the Commission's objectives for the 2011-2015 period has been to "develop a map design website as a focal resource for researchers in map design and map-makers of all kinds". It is clear that this Commission uses the web effectively as a means of presenting and commenting on examples of good design. The ambitious manifestation of that commitment is evident at 1 which is a website dedicated to presenting one example of good and interesting cartographic design for each day of 2014. At the end of the year a portfolio of 365 maps, with commentary, will have been created – an excellent resource for those who want to learn about and appreciate what makes a good map. This compendium will cover the breadth of cartographic practice to illustrate and emphasise the importance of map design in classic and contemporary cartography. Both traditional printed maps and the best of internet cartography are represented.

The series started with a predictable nod to the classic London Underground map/diagram developed by Beck in the 1930s. There are further classics in the examples which follow: Map 3 is a work of fine art by Jasper Johns, currently hanging in the Museum of Modern Art, New York City, showing the impact of geography on the work of a modern artist; Map 6 is an example of the groundbreaking work of Charles Minard in the 19th century – not the masterful Napoleonic Army graphic, but a similar flowline map showing coal exports. However, there is ample representation for 21st century cartography also: Map 8 including video to show the dynamic nature of ship traffic in the Baltic Sea presents innovative design and uses the map to tell a story and speculate on the future; Map 24 is a fascinatingly simple, and simply fascinating, map of the racial geography of the USA from the 2010 census. Map 42 is a timeless representation of Everest illustrating the creativity of topographic cartographers, while Map 16 shows how cartographic skills can be effective in the most constrained circumstances. Ruslan Enikeev's 2012 map of the internet (Map 40) stands alongside educational products (e.g. Map 19), propaganda documents (e.g. Map 38), historical works (e.g. Map 43), novel media for mapping (e.g. Map 37), personal attempts to describe the environment (e.g. Map 14), and a host of other types of cartographic design. This website merits repeat visits as the number of maps increases daily.

The intention of this repository is to be a barometer for modern map-making, to supply inspiration for those who seek ideas for how to map their data, and also to improve the public's appreciation of, and demand for, quality in maps.

MORE INFORMATION
1. http://mapdesign.icaci.org/category/mapcarte/
www.icaci.org

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Sustaining Land Imaging: UAVs to Satellites

The ISPRS Technical Commission I Symposium, in conjunction with the Pecora 19 ASPRS Fall Meeting and IAG Commission 4 Symposium, will take place from 17-20 November 2014 in Denver, USA. The three-day event will include technical programmes, plenary sessions with keynote and invited papers, and parallel sessions with oral and poster presentations. In addition, the symposium exhibition will feature the latest developments in commercial geospatial technologies.

The main focus of ISPRS Technical Commission I is primary data acquisition and processes which include remote sensing technologies, sensor platforms, geometric and radiometric sensor calibration, georeferencing and sensor orientation, image and data standards, low-level sensor integration, and system design. The ISPRS Technical Commission I Working Groups play a vital role in organising meetings which foster multidisciplinary research and developments, and international cooperation.

The Mid-Term Symposium, the most important event organised by ISPRS Technical Commission I, provides a unique forum for all geospatial sensing and data-acquisition professionals. Scientists, researchers, practitioners and decision-makers will present their latest research, discuss state-of-the-art sensing technologies, share research ideas and encourage international collaboration.

The main topics of the Symposium are:

- Data acquisition and pre-processing, and integration of various imaging sensors with other relevant systems on remote sensing platforms
- Design, construction, characterisation, and installation of imaging and non-optical imaging sensors (IR, SAR, IfSAR, Lidar, RF, etc.) for aerial and spaceborne missions for Earth observation
- Testing, calibration and evaluation of imaging and non-optical imaging sensors, including laboratory, in-flight/in-situ, inter-calibration and test fields
- Image technologies and data transfer protocols, standardisation of definitions and measurements of active and passive imaging sensor parameters, geometric and radiometric properties, quality standards and factors affecting data quality
- Integrated platform guidance, navigation, direct georeferencing and integrated sensor orientation
- Mobile mapping, UAV/UAS and autonomous system applications

You are encouraged to submit a paper or abstract for oral or poster presentation. All accepted papers will be published in either the *International Annals* (double-blind full paper review) or the *International Archives* (abstract review) of the Photogrammetry and Remote Sensing and Special Information Sciences.

We hope you will take advantage of this opportunity to join fellow researchers, scientists and practitioners from mapping and remote sensing at this important event. Attend general and technical sessions, exhibits and educational workshops on the very latest remote sensing research, modelling, applications, analysis techniques and technologies. Reconnect with old friends or make new ones at the ISPRS Technical Commission I Symposium. ◂

UAVs are among the main topic of the Symposium.

See you in Denver!

Charles Toth, president
The ISPRS Technical Commission I

MORE INFORMATION
www.commissions1.isprs.org
www2.isprs.org/commissions/comm1.html
www.isprs.org

Future events

APRIL

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

AAG Annual Meeting 2014
Tampa, FL, USA
from **08-12 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

IGRSM2014
Kuala Lumpur, Malaysia
from **22-23 April**
For more information:
E: igrsmalaysia@gmail.com
W: www.igrsm.com/igrsm2014/

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

AUVSI Unmanned Systems 2014
Orlando, FL, USA
from **12-15 May**
For more information:
W: www.auvsishow.org/auvsi2014/public/enter.aspx

GeoDATA 2014
Dublin, Ireland
On **14 May**
For more information:
E: geodata@geoaware.info
W: www.geoaware.info

ISPRS TCIV Symposium on Geospatial Databases and Location-based Services
Suzhou, China
from **14-16 May**
For more information:
W: www2.isprs.org/2014tc4symposium/index.html

ILA Berlin Air Show
Berlin, Germany
from **20-25 May**
For more information:
W: www.ila-berlin.de/ila2014/home/index_e.cfm

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

For extended information on the shows mentioned on this page, see our website: www.gim-international.com.

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