# GIM INTERNATIONAL

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## Sentinel-2A in Orbit

### An Overview of the Features of the European Sentinel Family

**PIONEERING LOCATION** Esri's Startup Programme

**COMPARING DIM AND TLS** Capturing an Archaeological Site in Oman

**UAS-BORNE LIDAR** for Mapping Complex Terrain and Vegetation Structure

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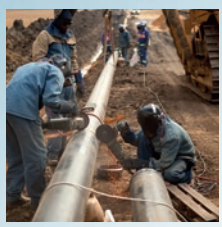


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No 2820

**On this month's front cover: Lift-off of the Vega rocket that carried the Sentinel-2A satellite from Europe's Spaceport in Kourou, French Guiana. An extensive article on this ESA-developed satellite programme can be found in this magazine on page 22 (Image courtesy: ESA).**



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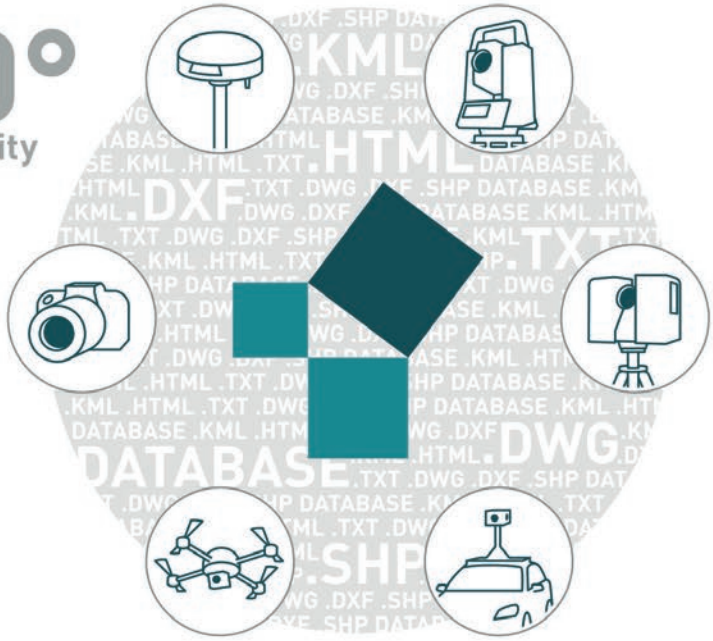


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BPA WORLDWIDE BUSINESS



# Urbanisation

Urbanisation is one of the most pressing issues of modern times. Wikipedia defines urbanisation as "a gradual increase in the proportion of people living in urban areas". That gradual increase has accelerated in recent decades and as of 2007, according to the United Nations, more than half of the world population live in an urban area. That statistical fact is placing an enormous strain on modern society and its citizens. While the majority of the biggest urban agglomerations are to be found in the developing world, there are some in the developed world too. Cities like Karachi (Pakistan), Jakarta (Indonesia), Mumbai (India) and Manila (The Philippines) are each home to more than 20 million people, and Delhi (India) and the Pearl River Delta (encompassing Hong Kong, Guangzhou and Shenzhen in China) are approaching – or already exceed – 40 million.

I myself grew up in a village with a mere 1,000 inhabitants. As a student, I never lived in a city with a population of more than 100,000, and for the past 10-plus years I've been living in a small town (population: 10,000) on the shores of Lake IJssel – just 20 kilometres away from that little village where I was born and raised. The urbanisation statistics are beyond my imagination and, to be honest, so too are the associated social, economic and health-related problems.

I recently visited the International Federation for Housing and Planning (IFHP) in Copenhagen, Denmark. (By the way, Copenhagen is a very well-organised, relatively small capital city in the north of Europe, where good governance and decision-making put it at the forefront of tackling possible problems of urbanisation). The IFHP, which was founded more than 100 years ago, stems from the first wave of urbanisation in the late 19th/early 20th century, when ideas started to emerge about moving away from the dwellings that came with industrialisation and giving citizens a better place to live – such as the 'garden city'. The IFHP's main priority has always been to improve the quality of life for people in cities. Of course, that task has become increasingly complex over the years, with scarcity of resources and lack of space now posing a tremendous problem. IFHP strives to create and promote understanding of human settlement issues in a changing world, and challenges decision-makers across the globe to develop smart cities for the betterment of the their citizens.

I believe that geomatics has an ever-more important role to play in helping to identify and solve the problems of urbanisation, along with the correlating challenges of climate change, public health and socioeconomic issues. I invited the IFHP to become a partner of the GIM International Summit, an event aimed at creating opportunities for networking and learning from each other – for thinking, discussing and exploring ways in which the geomatics sector can help the decision-makers who are trying to optimally channel urbanisation in their own regions. I'm very happy to announce that the IFHP has agreed to partner with our summit, because it is perfectly aligned with the underlying objective: to build bridges between real-world problems and the solutions geomatics can offer.


Photography: Arie Bruinsma

▲ *Durk Haarsma, publishing director*

# GI/EO for Sustainable Environment

In 2007, Kevin Wall and former US vice-president Al Gore founded the Live Earth concerts to raise environmental awareness. In January 2015, at the World Economic Forum in Davos, they announced the Live Earth 2015 global festival on 18 June on all continents with the goal of gathering one billion voices to take climate action, urging world leaders to adopt a new climate accord at the UN Climate Change Conference in Paris in November 2015.

The call to action (www.liveearth.org) is supported by many countries. President János Áder of Hungary announced in January 2015 the new Directorate of Sustainable Environment, with Csaba Körösi as director. The former Hungarian ambassador to the UN was co-chair with the Kenyan Eskinder Debebe of the Working Group that elaborated the 17 UN Sustainable Development Goals for 2016-2030. The Hungarian president joined the Live Earth initiative on 5 May by launching an awareness campaign (www.elobolygonk.hu) involving the Association of Cities with County Rank, the mayor of Budapest and civil societies.

The call to action was disseminated on the blog of HUNAGI, the Hungarian GI (Geographic Information) Association, on 26 May (http://hunagi8.blogspot.com). Al Gore's 1998 Digital Earth Vision is now embraced by the International Society for Digital Earth (www.digitalearth-isde.org), with which HUNAGI has been formally linked since 2003. The vision has been re-evaluated by an expert ISDE group and published in the Proceedings of the National Academy of Sciences and in the International Journal of Digital Earth as the 'Next-generation Digital Earth Vision to 2020'.

HUNAGI participated in the ISDE's Big Data track of the ICSU Codata Conference on 'Open Data and Information for a Changing Planet' in Taipei, Taiwan, in 2012 and at the UNESCO Conference on Education for Sustainable Development in Nagoya, Japan, 2014. In July 2015 the kick-off meeting of the ISDE European Chapter is taking place in Italy, at the EC's DG Joint Research Centre.

Sustainable development needs spatial data infrastructures from local to global, in which GI and related technologies and services, including Earth observation (EO), play a vital role. The Global Spatial Data Infrastructure (GSDI) Association supports the inter-governmental Group on Earth Observations (GEO) in contributing to the implementation of GEOSS – the Global Earth Observation System of Systems – and was involved in the recent GEOSS Science and Technology Stakeholder Workshops and the EU BYTE Project brainstorming on 'Big Data in Environment'. GSDI also contributed to the 39th CEOS WGISS Meeting hosted by Jaxa in Japan, sharing information on recent GSDI activities in marine/coastal spatial data infrastructure (SDI) best practice in support of the IHO Marine SDI Working Group. At the WGISS meeting, Geoscience Australia and NASA introduced the Australian and Kenyan Data Cube projects. The GSDI/HUNAGI representative proposed an ESA pilot in a selected part of the Danube region focused on multi-country environment with exploitation of historical EO and other GI allowing retrospective analysis to support future decision-making. The initiative, which was received with interest at HUNAGI and EUROGI board meetings, and the expert of Danube-Net of the DG JRC Danube Reference Data Service project will be drafted for presentation to ESA ESRIN.

HUNAGI's membership in EUROGI provides opportunities for insight into sustainable development-related actions on global and regional levels, such as the NASA World Wind Europa Challenge Award at the FOSS4G Europe conference in Como, Italy, in July. The best apps from students, professionals and SMEs will be highlighted. As NASA project manager Patrick Hogan wrote: "The world dearly needs a common platform for sharing data about our world, a world that is increasingly under threat from lack of sustainability." (see http://eurochallenge.como.polimi.it/projects2015)

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

1. Sentinel-2A Environmental Satellite Safely in Orbit - http://bit.ly/1LDuvoR
2. Ordnance Survey Maps Undergo Major Innovation - http://bit.ly/1LDuNMj
3. Centimetre-accurate GNSS Solution for UAVs - http://bit.ly/1LDuYaq
4. Airbus Defence and Space Enters the Field of Precision Farming - http://bit.ly/1LDv5CX
5. Celebration of Maps during International Map Year - http://bit.ly/1LDv81J

## SITECO RoadScanner4 for ASCO Japan

Over 120 kilometres of roadway infrastructure on the Japanese island of Okinawa were captured in February 2015 in high-accuracy 3D detail using SITECO's RoadScanner4 mobile mapping system equipped with Zoller & Frölich Profiler 9012 scanners, an iXBlue Landins inertial navigation system and complemented with spherical colour imagery from Point Grey's LadyBug5 camera.

▸ http://bit.ly/1Rf6aEf

*SITECO's RoadScanner 4 mobile mapper.*

## Support for Transition of Google Earth Enterprise Users

In coordination with Google, Esri is providing replacement software and training to customers and partners using Google's enterprise geospatial technology. NT Concepts, an experienced Google integrator, is working in partnership with Esri to help customers who have implemented Google Earth Enterprise and Google Maps Engine make the transition to the ArcGIS platform with minimal interruptions to their operations.

▸ http://bit.ly/1Rf7il7

## Wearable Reality Capture with Leica Pegasus: Backpack

Leica Geosystems announced a wearable reality-capture technology with the Pegasus:Backpack at HxGN LIVE, which was held from 1-4 June in Las Vegas, USA. This mobile mapping solution combines five high-dynamic cameras, which work in a variety of light conditions, and a Lidar profiler with an ultra-light and ergonomic carbon-fibre chassis. The result is a 3D view indoors or outdoors for engineering or professional documentation creation at the highest level of authority.

▸ http://bit.ly/1Rf9rDx

*Leica Pegasus:Backpack.*

# Grow with Your Needs


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No 2832

# Spectra Precision Equipment for Kenya Land Survey Efforts

The Kenya Department of Surveys has acquired eight Focus 30 total stations and an additional eight Epoch 50 GNSS receivers as part of an ongoing major effort to adjudicate land and prepare deeds. According to the Lands Cabinet Ministry, until recently 67 percent of Kenya had yet to be adjudicated, even though the work was supposed to be completed within 20 years of being commissioned in 1957 by the British colonial government.

▸ http://bit.ly/1Rf9C1w

*Focus 30 total station and Epoch 50 GNSS receiver.*

# Focus on the Future at Intergeo Conference in Stuttgart

The agenda for the Intergeo conference in Stuttgart – to be held from 15-17 September 2015 – is packed with exciting topics that are the focus of ongoing political debate on the digital world and will play a key role in shaping the way we work in future. With keynote speeches and plenary talks delivered in English and simultaneous interpreting provided for one strand of the conference on the second day, it is clear that Intergeo is also becoming increasingly significant on an international scale.

▸ http://bit.ly/1RfaJhY

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## Thought-provoking Conference Programme to Cause a Stir

The inaugural GIM International Summit – taking place on 10-12 February 2016 in Amsterdam, The Netherlands – is an initiative of *GIM International*, one of the leading international magazines for the geospatial industry. The GIM International Summit will draw thought leaders and key decision-makers from the global geomatics sector.

With the inspiring programme of the GIM International Summit we aim to cause a stir in the geomatics world and create a truly different experience for attendees. Several inspiring keynote speakers are already confirmed and more high-profile names are still to be announced. The out-of-the-box character of the conference will also be reflected in the workshops and masterclasses. In addition to the daytime programme we are organising a number of lively social events that will enable you to experience Amsterdam to its fullest.

## First Keynote Speakers Confirmed

Morten Jerven

Pier Vellinga

Morten Jerven and Pier Vellinga are the first two keynote speakers to be confirmed for the GIM International Summit. Jerven is an economic historian who works at the School for International Studies at Simon Fraser University in Vancouver, Canada. Vellinga is a professor of climate change at Wageningen University and at the VU University Amsterdam, The Netherlands.

Morten Jerven is the author of *Poor Numbers: How We Are Misled by African Development Statistics and What to Do about It*, and has published widely on African economic development, especially on patterns of economic growth and economic development statistics. *Poor Numbers* was picked by Bill Gates, Foreign Affairs and the ONE Campaign as one of the most important books of 2013.

Pier Vellinga is an advisor to the European Union on 'greening the EU economy'. He is scientific director of the national programme 'Knowledge for Climate' (2007-2015), in which role he has initiated the Climate Adaptation Services Foundation (CAS). Vellinga was instrumental in setting up the Intergovernmental Panel on Climate Change (IPCC) as vice-chairman of IPCC from 1989 until 1994. He was the first author on proposing the 2-degree climate change target in 1989. For his role in IPCC he shared in receiving the Nobel Peace Prize in 2007.

## FIG Becomes Endorsing Partner of GIM International Summit

The GIM International Summit is proud to announce that FIG has become an endorsing partner of the event. The International Federation of Surveyors (FIG) is a United Nations and the World Bank Group-recognised non-governmental organisation representing more than 120 countries worldwide. By bringing together the national member associations, FIG represents the interests of surveyors across the world.

## MORE about the Summit

- The conference programme of the GIM International Summit is increasingly taking shape. Visit www.gimsummit.com/programme to find out what awaits you in Amsterdam in February 2016.
- Are you interested in learning more about the organisers of this brand-new event? Take a look at the conference committee here: www.gimsummit.com/conference-committee.

## Sign up here

Do you want to be part of the geomatics innovation? Sign up to attend the GIM International Summit at **www.gimsummit.com**.

# Dutch Ministry and Kadaster Join Forces for Worldwide Land Registration

The Dutch Ministry of Foreign Affairs and Kadaster, the Dutch bureau of land management, have joined forces to advocate the worldwide registration of land use and property rights in the short term. This cooperation was officially announced as the Partnership Land Administration for National Development (LAND) in The Hague, The Netherlands, on 11 June 2015.

▸ http://bit.ly/1Rf8WJx

*Kees de Zeeuw, Kadaster International, and Minister Ploumen.*



# Hi-Target Launches New GNSS RTK Receiver

Hi-Target, a Chinese manufacturer of high-precision geographic instruments, recently announced the release of the V90 Plus, the company's next-generation GNSS RTK. The V90 Plus is equipped with the advanced Trimble BD970 OEM and delivers centimetre accuracy for a variety of applications. The full-wave RTK antenna based on air dielectric technology supports the whole constellation and makes it much lighter and more stable.

▸ http://bit.ly/1Rfecgd

*The V90 Plus.*

# Proteus to Distribute the ZEB1 Handheld Laser Scanner

Proteus, established in UAE and UK, has signed a distribution agreement for the Middle East region with Geoslam for the ZEB1 handheld laser scanning technology. Proteus will also provide laser scanning services globally with a focus on providing a complete package, including scanning and modelling. The ZEB1 is a handheld 3D laser scanner suitable for indoor, outdoor and underground use. It is lightweight and compact, providing the flexibility to capture detail wherever and whenever an accurate laser survey is required.

▸ http://bit.ly/1RfdOtw

*ZEB1 handheld laser scanner.*

# Heroes of the 21st Century

The term 'superhero', to which the copyright is owned jointly by the two biggest comic-book firms in the United States – Marvel and DC Comics – generally refers to people who have superhuman powers and who use those talents for the benefit of the community.

The concept of superheroes first emerged during the Great Depression (1929-1940), a period of severe economic decline and an unemployment crisis. The USA suffered most from the distressing results of the global collapse. In those days, people very much needed something encouraging and hopeful, whether imaginative or real. Superman appeared on the scene in the late 1930s, as the USA started to overcome the crisis. Superman's enemies were harming the Earth and its people. The number of superheroes, who fought against these public enemies called 'supervillains', gradually increased and they have become outstandingly popular. During the Second World War, the USA's supervillains were the countries who fought against the allies. Later on, a new generation of superheroes emerged whose superpowers originated from technological assets. Batman was amongst them. He had no superpowers at all, but rather technological opportunities and equipment that he used for the benefit of the public and to fight the enemies.

Who is the supervillain of the 21st century? Without any hesitation, I would say 'global climate change'. The Secretary General of the United Nations, Ban Ki-moon, declares climate change as the most important priority of the century. Increasing numbers of natural disasters, global famine, drought, food and energy demands and a ruined planet…now the supervillains have turned into superthreats. As children have no chance to select their parents and homelands at birth, some live in abundance while others face death. At least one third of all children born each day will have to manage with just USD2 daily to meet their basic needs for their entire lives. One fifth of them will never use electricity. One in eight of them will suffer from hunger and at least 1 percent, i.e. ten million children, will die of hunger or hunger-related diseases before the age of 5. One in eight of them will survive without reliable clean-water resources and one in ten of them will never have access to health services. In the 21st century, we badly need numerous real superheroes to fight these enemies for the benefit of the communities. Those superheroes will probably be ones without superpowers but with supertechnologies to use: geographical information systems (GIS).

Geographical information technologies enable us to understand the layers of Earth and to make sound decisions. It is possible to create and sustain healthy living conditions in our towns, cities and regions with geographical information systems, as they help us deal with our environment from different perspectives and levels. GIS provides significant tools for determination of land for development, efficient and effective use of renewable energy resources, protection of natural systems, tackling pollution, etc. In a world where the opportunities that geographical information technologies offer are well understood and adopted, it is possible to make environmentally friendly plans. Hence, the 21st-century heroes' most important weapons against the superthreats of the era should be geographical information technologies.

In fact, the message I would like to convey is quite clear: we do not have to be superheroes to fight the enemies/threats and make things better for people. Actually, anyone can achieve this. Technology can change everything, if properly used. We can make better and more efficient analyses with geographical information technologies – they can show us the past, help us understand today and guide us during our journey into the future.

5....4....3....2....1....

One person has just died of either hunger or hunger-related disease.

5....4....3....2....1....

Another person has just died of either hunger or hunger-related disease. And so on, every five seconds. Don't you agree that we need superheroes?

Prof Dr Alper Çabuk has a BSc in landscape architecture, two MScs (in environmental management and landscape planning) and a PhD in environmental economics. He is currently manager of the Earth and Space Sciences Institute of Anadolu University, Turkey.

# Less Is More

The book *Geographic Information Science and Systems*, released in 2015, is a fully revamped version of the third edition published in 2011 but written by the same four authors, one from the US and three from the UK. The result is a solid volume which weighs no less than 1.1kg according to the dispatch note. The authors are each notable figures in the industry. Michael Goodchild is retired professor of geography at the University of California; Paul Longley is professor of Geographic Information Science at University College London; David Maguire is vice-chancellor at the University of Greenwich and formerly with Esri; and David Rhind was CEO of Ordnance Survey and serves as member of the Editorial Advisory Board of *GIM International*. The 19 chapters, distributed over nearly 500 pages, provide a vista on the latest advances in the rapidly evolving GI science and the allied digital tools and techniques used to collect, store, process, analyse, visualise and distribute geodata and information. After the Introduction (Chapter 1) the book has been divided into four parts. These are (1) Principles; (2) Techniques; (3) Analysis; and (4) Policy, Management and Action. Each part consists of four or five chapters. The arraying of the broad spectrum of topics based on this ordering seems sound but has an inconvenient consequence; from time to time one does not find a topic where one would expect to find it. For example, GNSS is treated as GPS in the georeferencing chapter (Chapter 4) as a useful tool for measuring the 3D coordinates of ground control points. One would also expect a fully dressed coverage in Chapter 8, which deals with data collection, but here GNSS is absent. Some of the topics are scattered throughout the book, such as mobile GIS systems which are handhelds for capturing geodata in the field. These are covered in Chapter 6 (GI system software) and in Chapter 10, which covers the Geoweb. The same is true for virtual globes, including Google Earth and Microsoft's Bing Maps. They are branded as GIS software but the topic is also touched upon in Chapter 10 (geoweb) while one would expect to come across the topic – first and foremost – in Chapter 12, which is on geovisualisation. Chapter 4 is insightful as it not only touches upon metric reference systems, which are essential to the making of maps, but also upon postal codes, IP addresses and cadastral parcel numbers as useful sources for georeferencing manmade objects. The section on surveying in Chapter 8 only includes total stations by showing – for a large part – a photo of a surveyor and a total station mounted on a tripod at a road construction site. The authors state: "Two people are usually required to perform a survey, one to operate the total station and the other to hold a reflective prism". This account ignores the advances in robotic total stations in the last decade. Added to this, it is not clear why some data collection techniques are covered and others are left out. For example, a light is shone on airborne Lidar but ground-based laser scanners and mobile mappers, i.e. cars, vans, locos, boats and other vehicles equipped with laser scanners, digital cameras and positioning sensors remain absent. Data acquisition techniques are arranged based on whether they capture data in the form of rasters or vectors, with the odd outcome that airborne Lidar is touched upon in the vector data section. Of course Lidar acquires points, which is a vector feature as are lines and polygons, but the only physical meaning of these points is that they are samples lying on a curved surface, the envelope of an object or group of objects. Lidar points are blindly sampled and soon after collection they are usually transferred to raster format through interpolation, TINs or point clouds. What is the benefit of categorising data acquisition techniques in accordance with the way geodata is modelled in geographic information systems?

A general omission confronting any reader who wants to deepen his or her knowledge is that the bibliographical paragraphs at the end of each chapter are very short. Books on land surveying, photogrammetry, laser scanning or any other major geodata acquisition technology are not mentioned at all. The many colour photos and graphics are appealing to today's visually oriented students; most of the images and maps reflect the origin of the authors. The book is well-written but suffers from the flaw of aiming at a holistic coverage of topics. Every chapter appears as a synopsis – no more than that – providing glimpses of the abundance of topics treated. It is too little about too much. The book is probably useful as part of an introductory course for undergraduate geography students all over the world. When it comes to geomatics programmes, I would prefer the classic written by Burrough and McDonnell which provides a strong theoretical basis for GIS, which is relatively timeless. For the fifth edition, which might be published around the year 2020, I would recommend the authors to keep in mind the maxim: 'Less is more'.

*Geographic Information Science and Systems*, Fourth Edition.
Authors: Paul A. Longley, Michael F. Goodchild,
David J. Maguire, David W. Rhind, published by Wiley,
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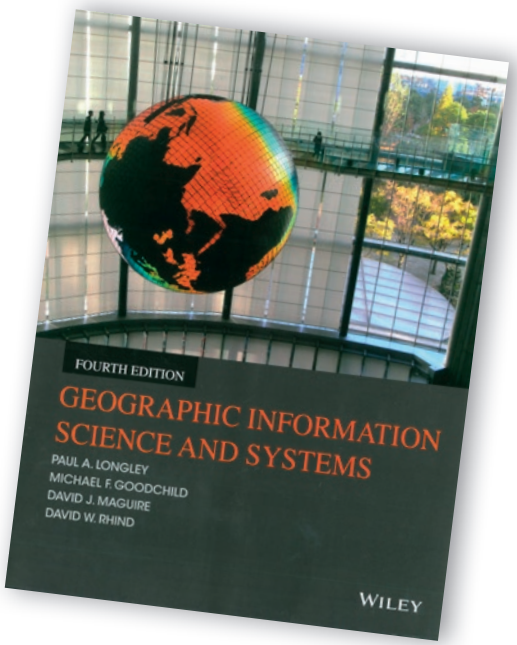


# Topcon Announces Increased 3D Scanning Integration with Autodesk Solutions

As a result of the strategic business relationship with Autodesk, Topcon Positioning Group has announced improved workflow compatibility for the GLS-2000 3D laser scanner and ScanMaster software with Autodesk solutions via the latest version of Autodesk ReCap. The GLS-2000 pairs with Topcon ScanMaster software to collect, process, edit and deliver 3D point cloud data from a laser scanner for a variety of applications. Autodesk ReCap allows users to perform tasks such as scan conversion, editing and viewing point cloud data, and provides integration with Autodesk's broader portfolio of design software.

▸ **http://bit.ly/1Rfahjy**

*Topcon GLS-2000 3D laser scanner.*

# EuroGeographics Welcomes New Member from Turkey

The General Directorate of Land Registry and Cadastre of Turkey is the latest organisation to become a full member of EuroGeographics. EuroGeographics' members approved the application at their Extraordinary General Assembly held recently in Belgium, which was attended by delegates from more than 23 countries. As a result, the membership association for the European National Mapping, Land Registry and Cadastral Authorities now represents 61 organisations from 46 countries – the whole of geographical Europe.

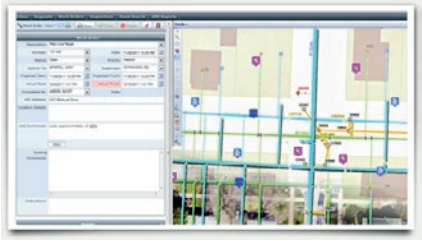
▸ **http://bit.ly/1Rfa28f**

# Inspiring GISTAM 2015 Conference Connects Researchers and Practitioners

GISTAM 2015, the 1st International Conference on Geographical Information Systems Theory, Applications and Management, took place in Barcelona, Spain, from 28-30 April. GISTAM 2015 was held in conjunction with ICEIS 2015 and ENASE 2015, covering a broad range of related fields including all aspects of geographical information.

▸ **http://bit.ly/1RfbBDb**


*GISTAM started with a panel session.*



*Cityworks.*

## Application Integration Offers Public Works Professionals Remote Inspection Capabilities

Cityworks, the GIS-centric public asset management platform, was demonstrated live on the main stage at the 2015 Cityworks User Conference working seamlessly with CycloMedia's Street Smart Application. The integration illustrates the power of leveraging Esri's ArcGIS cloud-based solutions with visualisation and management tools to create an innovative use of technologies for remote asset management.

▸ **http://bit.ly/1RfbMOG**

# Precise but Slow, or Quick but Dirty?

Many indigenous poor in less-developed countries have rights to land but those rights are not formally registered. The lack of tenure security creates instabilities and threats of forced eviction, and blocks an escape from the helix of poverty. A new weapon in the battle against poverty, as advocated by FIG and the World Bank, is to speed up registration of rights for the poor and the vulnerable by deploying a broad spectrum of geodata acquisition techniques for delineating parcel boundaries depending on need (see FIG Publication 60 and the January 2015 issue of *GIM International*). The traditional techniques are precise but costly and labour-intensive, while their operation requires well-trained professionals. The result of such archaic approaches is progress at a snail's pace. It could take decades – or even centuries – before all the rights of the 75% of the world population still lacking access to formal registration have been recorded with top-end tools in precision surveys. The fit-for-purpose approach offers a fast track to securing land rights and ensuring effective land use in countries where land administration is immature or in decay. The basic underlying thinking of the concept is: Why should it be a case of one size fits all? Why should property boundaries in predominantly agricultural areas be measured with the same high-precision equipment operated by highly qualified professionals as in rapidly growing urban conglomerates, where land is scarce and expensive? Today an abundance of geodata acquisition techniques are available, ranging from precision GNSS to unmanned airborne systems (UASs) and high-resolution Earth observation imagery. There are cheap mobile GIS handhelds and there are smartphones in the hands of billions. Some tools provide highly accurate parcel boundaries but require time-consuming, highly skilled labour. Other tools are quick and dirty but may support the goal at hand, namely to safeguard subsistence farmers' rights to land by enabling delineation of general boundaries. As the nearby city encroaches ever closer and the threat of expropriation or even expulsion looms, the general boundaries may be incrementally upgraded to fixed boundaries. The fit-for-purpose concept recognises that aerial and high-resolution satellite images are suitable alternatives, and they also cost three to five times less than field surveys.

Recently, the European Space Agency (ESA) has put the Sentinel-2A into orbit on 23 June 2015 (see page 22). Four of the 13 spectral bands captured by Sentinel-2A are similar to the satellites equipped with optical sensors suited to topographic and cadastral mapping. The same is true for its forthcoming twin. Extensive research on the early SPOT 1, 2 and 3, the payload of which – like Sentinel-2 – consisted of push-broom scanners, has shown that images with a GSD of 10m which capture the visible and near-infrared parts of the electromagnetic spectrum are suited for mapping at scale 1:50,000. As Sentinel-2 has the same GSD as the early SPOTs, the images could be used for filling gaps in the topographic maps of the world or for updating outdated 1:50,000 maps. Added to this, the Sentinel-2 pair has the potential to operate as an alternative fit-for-purpose technology for capturing general boundaries. A distinctive advantage is that the images can be obtained free of charge, which makes them affordable for covering the rural territories of developing countries. Of course, objects in satellite images are only identifiable if they are covered by at least five to six pixels, depending on the shape. Hence plots and agricultural fields with an area upwards of 500 square metres can be outlined as general boundaries. It would be worthwhile to conduct pilots to assess the potential of Sentinel-2 in the fit-for-purpose concept. ◂

*GIM INTERNATIONAL INTERVIEWS KURT DARADICS, ESRI*

# Pioneering Location with an **Out-of-the-box Approach**

Esri recently exhibited at The Next Web Europe, a conference focused on entrepreneurship, technology and startups in Amsterdam, The Netherlands. But why was Esri involved? Is it looking for new frontiers for spatial analysis? Is the developer market the group that will bring a fresh contribution to Esri's startup and developer programme? *GIM International* spoke to Kurt Daradics, global leader of Esri's Emerging Business Group, to find out.

***Kurt, we last met in April at The Next Web conference in Amsterdam. What were you doing there?***

Esri has been sponsoring The Next Web for a few years now. Boris Veldhuijzen van Zanten at The Next Web has built up a wonderful community of 'good people', and they produce some of the best 'tech' events from a production and curated-community point of view. Plus, their media brand is doing very well. We'll be back next year again for sure.

***There was a sizable Esri delegation: Nicholas Furness, developer evangelist, Lars Schmitz, Esri Germany, and Frank Holsmuller, regional marketing manager from Esri Europe. You seem to take The Next Web and similar events very seriously. What were your goals at the event?***

Esri attends tech conferences like The Next Web to educate attendees on advancements in our platform and meet novel new startups. Esri has been in a public beta of esri.com/startups for a little while now, and attending events like The Next Web helps us find the best geo and mapping-related startups. At Esri, we have also created a startup programme that helps software startups on the path to global success by giving them free three-year access to ArcGIS cloud services, software development tools, ready-to-use content, training, technical support, global partnership opportunities and co-marketing. This enables entrepreneurs to build mapping and location analytics capabilities into their products. Esri has innovated massively in the cloud and we're helping a wide array of companies across 60-plus industries solve an even wider array of problems.

***TomTom, what3words and Esri were all present at The Next Web. Do you think events like The Next Web deserve more interest from the geomatics industry as a whole?***

Now more than ever, it's about location, location, location. Today, even more so than when Gerardus Mercator helped us to capture the 3D world in 2D maps, we need to find ways to rationalise our multidimensional experience. Having a location strategy is critical – especially in the context of scalable, global commercial enterprises. The implications for geomatics and GIS are unprecedented. How exciting!

***Lots of these events are also attended by 'geeks' who are 'ahead of the masses' when it comes to technology. Why are geeks so passionate about contributing to the world?***

This is both a fun question and an important one. In my experience, geeks tend to be passionate and curious. They are driven by what moves them. I think many of the folks that are drawn to the tech industry also have a fascination for progress. We need more geeks, and we've been having fun with the #GeoGeeks hashtag.

***You seem to be particularly interested in developers rather than traditional GIS professionals and enterprises. Why?***

The command line is one of the most powerful inventions ever. Compound this with broadband infrastructure, stack maturation and mainstream mobile supercomputing – this all sets the stage for unprecedented opportunities for geo-related cloud apps in both established enterprises and emerging markets. Esri has invested heavily in R&D to support the 'product-market fit' for developer tools. Resources, like the ones we offer at developers.arcgis.com, enable developers and startups to get going quickly with self-service account creation, solid documentation and robust code samples (e.g. esri.github.io). All of our efforts set the stage for startups to become highly scalable, and build broad awareness about Esri's commitment to this market.

***With ArcGIS Esri has created a platform for mapping for the masses. What do you foresee as the ultimate impact of this?***

Another important question, especially in the context of the 'masses' inside enterprise organisations. To highlight my point, Microsoft has embedded Esri Maps for Office. Now

▲ *Kurt Daradics.*


▼ *Exhibition floor at The Next Web Europe Conference.*

everyone that has Excel can make maps on the fly. Plus, Esri has developed lightweight apps like Collector that do not require formal GIS training to get into the GIS game, so there is an explosion in the enterprise market for location-based apps and having a 'location strategy.' Couple this with other tech trends like Big Data, the Internet of Things (IoT) and form factor innovation. Fast forward 10 years from now and we'll be more connected than ever imagined. Having said all that and to get to the heart of your question, I think that mapping technologies will play a vital role in helping humans rationalise this Big Data explosion. There is a principle called 'see, feel, change'. Humans are emotional and visual creatures. When we 'see' data on a map it triggers intuitive 'feelings' which drive action and 'change'. Imagine trying to gain those same insights looking at the same data presented in a .csv table – it's not going to happen, right?

***Information and communication technologies are enabling cities to tackle many of their challenges, leading to the emergence of 'smart cities'. What is Esri's role in this development?***

Esri's smart communities efforts, including our hub programme, are key examples of the innovation that Esri is delivering to this market. Esri works side by side with governments, big and small, to build smart communities – places where people feel safer, healthier and happier. Cities around the world are working with Esri to gain access to the entire ArcGIS platform, whether for just one department or across their organisation.

## *I THINK THAT MAPPING TECHNOLOGIES WILL PLAY A VITAL ROLE IN HELPING HUMANS RATIONALISE THIS BIG DATA EXPLOSION*

Esri has 40-plus years of expertise and offers more than 150 apps that solve real-world problems for the economy, infrastructure, health and public safety (not to mention our partner ecosystem of ArcGIS Marketplace apps). These cities and communities have become part of our supportive user and partner community, and there is an emerging startup component to this work.

***You are co-founder and director of business development at CitySourced. Can you tell us more about that?***

I co-founded CitySourced in 2009 and it was my last startup prior to joining Esri. The basic idea of CitySourced is very simple. It started as a free mobile app where a citizen could download the app, and take photos of civic issues that needed to be fixed (e.g. vandalism, overgrown vegetation, road hazards, etc.). The report was delivered electronically to the city hall, along with the photo, latitude/longitude location of the issue and other metadata. The city could notify the mobile clients with status updates (e.g. issue resolved). The solution has evolved into a civic engagement platform, with other features like trash-pickup reminder notifications, city knowledge base and more. CitySourced achieved profitability quickly and already has over 250 clients globally. In 2012 I left to join Esri to build the startup programme, which Esri prototyped with companies like CitySourced.

***It's part of Esri's vision to connect governments, industry leaders, academics and non-governmental organisations with the analytical knowledge they need to make the critical decisions that shape the planet. How is the evolving GIS technology changing those needs?***

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The obvious line to draw here relates to Moore's Law, and form factors are getting smaller and more powerful. In fact, there's a new 'invisible' map. Esri has a geofencing solution called Esri GeoTrigger Service that triggers events like real-time location-based messaging and intelligence to iPhone and Android apps. For example, we have cities that are embedding this technology via our mobile SDKs (software development kits) into their mobile apps to push customer surveys on mobile devices to collect citizen feedback after visiting a physical city department. Other examples of GIS delivering insights include the data from fitness-tracker mobile apps. Cities are starting to partner with these sorts of companies to aggregate route data to help optimise public bike lanes, for example. It's one thing for an urban planner to make an educated guess (or even use GIS tools to model and predict traffic flows), but another dimension to layer on historical route data collected by these apps to better plan bike lanes.

Expanding on data visualisation and the 'see, feel, change' concept mentioned above, the innovation that Esri is delivering around 3D visualisations is novel, including 3D in the cloud, as well as virtual reality. We're working with a startup called InsiteVR that won the TechCrunch Hackathon last year using Esri's 3D tech with Oculus Rift to deliver virtual-reality visualisations of maximum building heights in urban environments. Another one of our startups, SmarterBetterCities, just announced USD1M financing to expand its 3D CloudCities libraries. These libraries further the vision of Esri founder Jack Dangermond on geodesign, which is a design framework and supporting technology for urban planning professionals to leverage geographic information, resulting in designs that more closely follow natural systems. My prediction is that geodesign will be Jack's legacy and gift to the world.

***Is there anything else you would like to share with our readers?***

We have about 200 startups in our programme currently. We're seeing rapid product and client development with the startups that engage with Esri. If any *GIM International* readers have a product-focused idea that they want to develop please feel free to check out esri.com/startups and apply. Email us at startups@esri.com or engage with us via @esristartups. ◂


## KURT DARADICS

Kurt Daradics leads Esri's Emerging Business Group (startup programme) globally. Prior to joining Esri, he co-founded CitySourced, a mobile app for governments. Kurt is a mentor with Code for America, serves on the board of Social Media Week LA, and produces annual events for the Los Angeles tech community such as 'Social 25' and 'Digital Family Reunion'.

✉ kurt_daradics@esri.com, Twitter: @KurtyD

*AN OVERVIEW OF THE FEATURES OF THE EUROPEAN SENTINEL FAMILY*

# Sentinel-2A in Orbit

The launch of Sentinel-2A on 23 June 2015 signals the start of the era of the Sentinel-2 twin constellation. The satellite has been constructed by Airbus Defence and Space for the European Space Agency (ESA). The Sentinels are a new family of missions in progress and a major asset within the European Copernicus programme, which is dedicated to providing a comprehensive picture of the 'health' of the Earth. To mark the occasion of the launch, the author provides an overview of the mission, the features of the sensors on board and applications of the images.

Although rarely used in common speech, the English word 'sentinel', which is of French and Italian origin, means 'gatekeeper'. The Sentinel space missions aim to acquire a wealth of geodata needed to safeguard the 'health' of our planet.

## SENTINEL FAMILY

Once completed, Sentinel will comprise a family of six constellations, each with two Earth observation (EO) satellites, to fulfil revisit and coverage demands. Since the launch of Sentinel-2A, which weighed 1,140kg including fuel, the second Sentinel satellite is now in orbit. Figure 1 illustrates the dimensions of the satellite. The polar-orbiting Sentinel-1A, which was launched on 3 April 2014, carries a C-band synthetic aperture radar (SAR) specially designed for environmental tasks related to both land and the maritime environment. The applications include mapping changes in land cover; monitoring landslides and floods; detecting and tracking oil spills; and monitoring sea ice movements. From interferograms, derived from comparing SAR images of the same area but captured at different times, deformations can be determined with an accuracy of a few millimetres which enables monitoring of earthquakes and volcanic activity. Sentinel-1B, the twin of 1A, will be launched in early 2016 and will halve the revisit time from 12 to six days. Sentinel-2B, the twin of 2A, will be launched in mid-2016. Sentinel-3 will carry a radiometer to measure global sea-surface temperatures with an accuracy better than 0.3K. The twins will also have on board a 21-band imaging spectrometer to measure ocean and land colour and a SAR altimeter to measure sea-surface topography. Launch of the Sentinel-3A spacecraft is scheduled to take place in Q4 of 2015. Sentinel-4 and -5, which are scheduled for lift-off in 2015, will be carried on meteorological satellites operated by Eumetsat and will observe the Earth from a geostationary orbit aimed at monitoring the composition of the atmosphere. The main payload of Sentinel-6, which should be ready for launch in 2020, will be a radar altimeter for high-precision measuring of the topography of the global ocean. The Sentinel family has been specifically developed to support the massive data needs of the Copernicus programme by providing robust EO imagery and derived datasets.


▲ *Figure 1, Testing of Sentinel-2A under construction. (Courtesy: ESA).*

## COPERNICUS PROGRAMME

Copernicus was a European mathematician and astronomer who banished the Earth from the centre of the universe by postulating a heliocentric model. He also developed the quantity theory of money. To honour the influential Renaissance man, the European Commission named a comprehensive space programme after him. The European Copernicus programme collects and provides data for monitoring land, sea and atmosphere. The data is captured by EO satellites, in situ sensors, and airborne and sea-borne sensors. The space component, of which the Sentinels form part, is guided by the ESA and the in situ component by the European Environment Agency and the Member States. Services and data are provided free of charge. The Copernicus programme, previously known as Global Monitoring for Environment and Security (GMES), does not only rely on data collected by its own missions since European and international operators contribute data captured by altimetry systems, optical sensors, radiometers, spectrometers and SAR. Copernicus is vital to scientists for studying climate and changes in climate over time. The programme is invaluable to emergency managers for responding to earthquakes, floods, forest fires and other natural disasters, and for monitoring technological accidents or humanitarian crises. It also contributes to security-related issues such as maritime surveillance and border control, and enforces EU policies on, for example, fishing quotas. Practitioners use the data for a wide range of applications including agriculture, fisheries, forestry, health, management of urban areas, regional and local planning, transport and tourism. Copernicus enables central planners to prepare national, European and international legislation on the emission of particulate matter and carbon and on many other environmental issues, and to examine the effectiveness of the execution of the relevant measures.

*Figure 2, After completion Sentinel-2A and 2B will operate in the same sun-synchronous orbit 180° apart (Courtesy: ESA).*

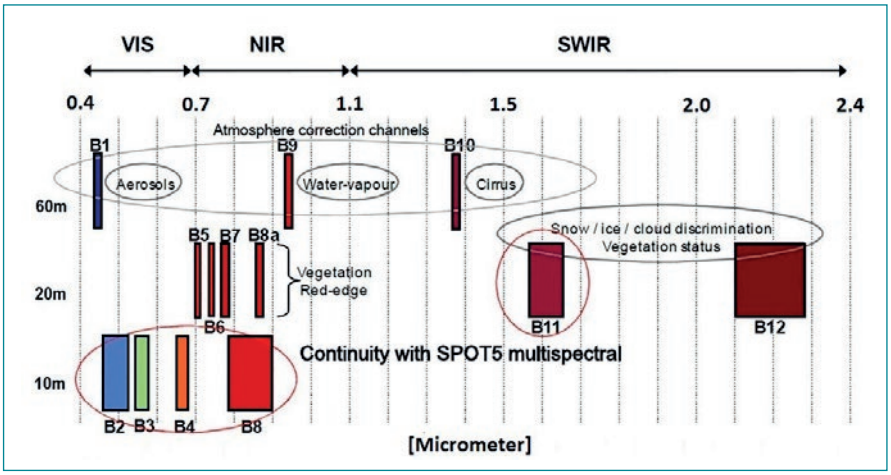



*Figure 3, The 13 spectral bands are recorded at spatial resolutions of 10m, 20m and 60m (Courtesy: ESA, modified).*

## SENTINEL-2

The two Sentinel-2 satellites have been designed and built by a consortium of companies including the French space agency (CNES) and German Aerospace Center (DLR). The endeavour is led by Airbus Defence and Space. The constellation will consist of two identical polar-orbiting satellites which, once completed, will operate on opposite sides of the same sun-synchronous orbit (inclination 98.5°), 180° apart (Figure 2). This configuration optimises coverage and global revisit times. The single multi-spectral instrument on board, weighing 275kg, is a push-broom imager capturing 13 spectral bands simultaneously with an intensity range of 12 bits (Table 1). The ground sample distance (GSD) of three visible (VIS) and one near-infrared (NIR) band is 10m; for four NIR bands and two shortwave infrared (SWIR) bands the GSD is 20m, while the instrument captures three bands with a GSD of 60m (Figure 3). The latter bands will be mainly deployed for atmospheric corrections and cloud screening: 0.443 micron for aerosol retrieval, 0.945 micron for water vapour retrieval and 1.375 micron for cirrus cloud detection. The reference attitude is 786km, which allows 14.3 rotations per day. The equator will be crossed at 10:30, a time chosen to ensure minimal cloud cover and sufficient solar illumination. It also enables long-term time series to be built in combination with Landsat and SPOT historical data as these satellites also cross the equator at similar points in time.

| GSD [m] | Wavelength [micron] | Bandwidth [nm] |
|---|---|---|
| 10 | 0.490 | 65 |
| | 0.560 | 35 |
| | 0.665 | 30 |
| | 0.842 | 115 |
| 20 | 0.705 | 15 |
| | 0.740 | 15 |
| | 0.783 | 20 |
| | 0.865 | 20 |
| | 1.610 | 90 |
| | 2.190 | 180 |
| 60 | 0.443 | 20 |
| | 0.945 | 20 |
| | 1.380 | 20 |

*Table 1, Sentinel-2 sensor characteristics.*

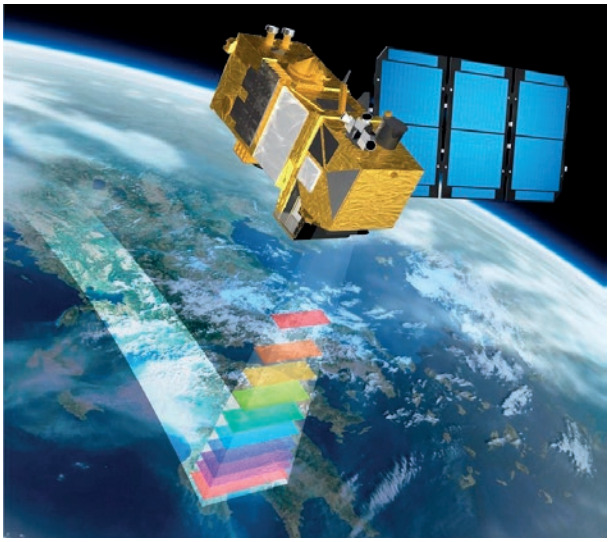
## COVERAGE

The two satellites will systematically cover all continental land surfaces between latitudes 56° south and 83° north; all coastal waters up to 20km from the shore; all EU islands and all islands exceeding 100km$^2$ on the rest of the planet; the Mediterranean Sea; and the Caspian Sea and all other enclosed seas (Figure 4). The field of view is 290km and the repeat cycle is 10 days. Once the Sentinel-2 twins are operational, the same spot over the equator will be captured every five days and even more frequently at higher latitudes. The revisit time over the equator can be augmented to three days owing to collaboration between ESA and NASA that allows images of Landsat-8, which was launched on 11 February 2013, to be combined with the Sentinel-2 images. Landsat-8 images have GSDs of 15m, 30m and 100m and capture the panchromatic, multispectral and thermal infrared parts of the EM spectrum. They can be downloaded free of charge within 24 hours of acquisition. The Sentinel-2 twins have a pointing capability of ±20.6° across track, which enables the capture of strips of around 6,400km in length – a beneficial property for emergency response. Table 2 compares features of Sentinel-2A with SPOT and Landsat while Figure 5 shows the differences in area coverage.

## PRODUCTS

As usual with satellite imagery, products are delivered in diverse stages of post-processing. Scientists may prefer data which is as close to the raw data as possible and they may use own software to keep all the processing steps in their own hands. Level-1B will be most suitable for them; only radiometric corrections have been applied while an enhanced physical geometric model is provided, but the georeferencing

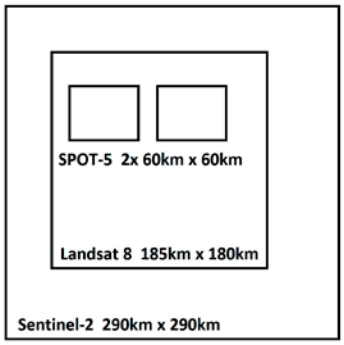

*Figure 4, Land and coastal zone coverage (Courtesy: ESA, modified).*



▲ *Artist's impression of Sentinel-2A in orbit (Courtesy: ESA).*

▼ *After encapsulation in the Vega rocket fairing (left) Sentinel-2A is transported to the launch zone (Courtesy: ESA).*

itself is left to the user. Level-1B is the first stage available for the public; Level-0 and Level-1A are system products. Practitioners may prefer data in a more advanced stage of processing. For them, Level-1C will be most appropriate. The original data is processed into orthoimagery using a digital elevation model (DEM). The pixel values refer to top-of-atmosphere (TOA) reflectance. The datasets are accompanied by all parameters for transforming the TOA values into Earth surface radiances. The images are resampled to the nominal GSDs of 10m, 20m and 60m and delivered as tiles covering 100 km by 100 km in UTM/WGS84 projection, one tile per spectral band. This level is also complemented by quality indicators on radiometry and image content.




▲ *Figure 5, Scene coverage of Landsat, SPOT and Sentinel-2 imagery (Courtesy: M. Lemmens).*

## APPLICATIONS

The multispectral images will serve multiple users and a wide range of applications involving land and coastal zones. A non-limitative list includes:

- detecting land cover changes
- increasing food security through observing the seasonal growth stadia of crops worldwide
- estimating chlorophyll concentrations and carbon mass over massive land areas
- studying changes in health conditions of inland waters
- inspecting rising and falling water levels in the marine environment, lakes and rivers
- examining changes in ice extent in mountainous and arctic areas
- emergency response in the aftermath of floods and earthquakes.

## FINAL REMARKS

All public, commercial and scientific users all over the world have full and open access to Sentinel data. After registration and acceptance of the terms and conditions, users obtain licences free of charge and gain online access to the data as long as security restrictions do not apply. Additional access and specialised products will be provided through tailored conditions. ◀

| | Landsat | SPOT | Sentinel-2 |
|---|---|---|---|
| Mission lifetime | 1972 - present | 1986 - present | 2015 – 2023*) |
| Origin | USA | France | EU |
| Spectral bands | 7 | 4 | 13 |
| GSD [m] | 15, 30, 60, 100 | 2.5, 5, 10, 20 | 10, 20, 60 |
| Swath width [km] | 185 | 2 x 60 | 290 |
| Repeat days | 16 | 26 | 5**) |

▲ *Table 2, Comparison of Sentinel-2 with SPOT and Landsat; *) designed for a minimum lifetime of seven years, but the expectation is many more years; **) at the Equator in twin configuration and in cloud-free conditions.*

**More information**

www.esa.int/Our_Activities/Observing_the_Earth/Copernicus
https://sentinel.esa.int/web/sentinel/toolboxes/sentinel-2

***MATHIAS LEMMENS***

Mathias Lemmens gained a PhD degree from Delft University of Technology, The Netherlands, where he presently lectures on geodata acquisition technologies and geodata quality. He has been involved with *GIM International* since 1997, presently as senior editor. He is an international consultant and is the author of the book *Geo-information: Technologies, Applications and the Environment* published by Springer in 2011.

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*CAPTURING AN ARCHAEOLOGICAL SITE IN OMAN*

# Comparing DIM and TLS

Photogrammetry and terrestrial laser scanning (TLS) are both proven technologies for archaeological documentation. Dense image matching (DIM) has evolved rapidly since 2010 and enables the highly automatic creation of detailed point clouds from overlapping imagery. How well does DIM perform for archaeological applications compared to TLS? The authors go in search of an answer.

The necropolis of Al-Ayn in Oman (Figure 1) comprises 19 well-preserved tombs of between 2m and 4m in height which extend over 130m. Since 1988 the tombs have been a UNESCO World Heritage site. The exterior diameters of the slightly conical tombs range from 3m to 6m, and the interior diameters from 1.5m to 2.5m. The building material consists of quarry blocks of varying sizes. The photogrammetric and terrestrial laser scanning (TLS) surveys, carried out in February 2014, were aimed at documenting the necropolis and enabled a comparison between dense image matching (DIM) and TLS. Such a comparison is interesting as today's cameras are light and thus more easily portable than TLS equipment, and because the processing of imagery and creation of point clouds has become cheaper in recent years as a result of open-source packages. Furthermore, images can capture pottery shards, bone fragments and other small objects in great detail.

## CONVENTIONAL TOOLS AND ACCURACY

Photogrammetry and TLS have been used for archaeological documentation for many years. Nevertheless, conventional tools such as measuring tapes, folding rules, levels and simple theodolites and total stations are still commonplace. The data captured by conventional tools is mainly used for creating orthogonal views, vertical sections and maps. No unified accuracy requirements have been defined by archaeologists. The authors' co-workers, specialised in archaeology, derived accuracy measurements from a project in which object points were measured with a total station and subsequently georeferenced. The coordinates were mapped at scale 1:100. Vertical sections, drawn in the field and manually digitised, were mapped at scale 1:50. This exercise, which contains several intermediate steps, resulted in an accuracy of 3.6cm. Both TLS and DIM enable digital processing without intermediate steps

*Figure 1, View of the necropolis of Al-Ayn in Oman.*


*Figure 2, TLS with reference spheres, two mounted on the legs of the tripod, the third on top of a tripod at the right.*

which may reduce accuracy. Additionally, their accuracies have proven to be significantly higher compared to conventional tools. In consultation with the archaeologists, the accuracy standard was set to 2cm.

### TLS

TLS point clouds were acquired using a Zoller and Fröhlich Imager 5010. The capturing of the 19 tombs both on the outside and inside was done from 91 TLS positions. The exterior of each tomb was captured in seven scans with an average resolution of 6mm and the interior in one or two scans with a resolution of 4mm. The maximum range was 25m to the exterior of the tombs, and 2.5m for the interior. The point clouds were coloured from images taken using a Canon EOS 500D DSLR camera with a 10mm fisheye lens and mounted on a panoramic tripod head.

### PHOTOGRAMMETRY

The interiors and exteriors of the tombs were recorded using a remote-controlled Canon D60 SLR camera, focal length 24mm, mounted on a tripod to ensure stability. With a minimum overlap of 80% in all directions every point in the scene was captured in at least four images. The exterior of each tomb was captured by an average of 56 images taken from a distance of 5m. The interior required 93 images per tomb taken from a distance of 2m above the tomb. In total 4,222 images were taken, which were processed using PhotoScan from Agisoft LLC. Compared to similar freeware, such as VisualSFM, Photoscan produces denser point clouds and is easier to handle. The calibration parameters, determined using a test field, differed by at most 1mm at selected object points from the parameters calculated in the simultaneous calibration of the bundle block adjustment. Therefore, the latter was used. On average, the image scale was 1:200. The image measurement accuracy of signalled tie points was 1.8 microns and the internal object accuracy was 0.3mm. After 3D similarity transformation (7 parameters: scale, 3 translations and 3 rotations) the two point clouds showed a maximum deviation of 2.3mm at the control points, which far exceeds the accuracy standard of 2cm.

**THE MAXIMUM DEVIATION OF 2.3MM AT THE CONTROL POINTS FAR EXCEEDS THE ACCURACY STANDARD OF 2CM**

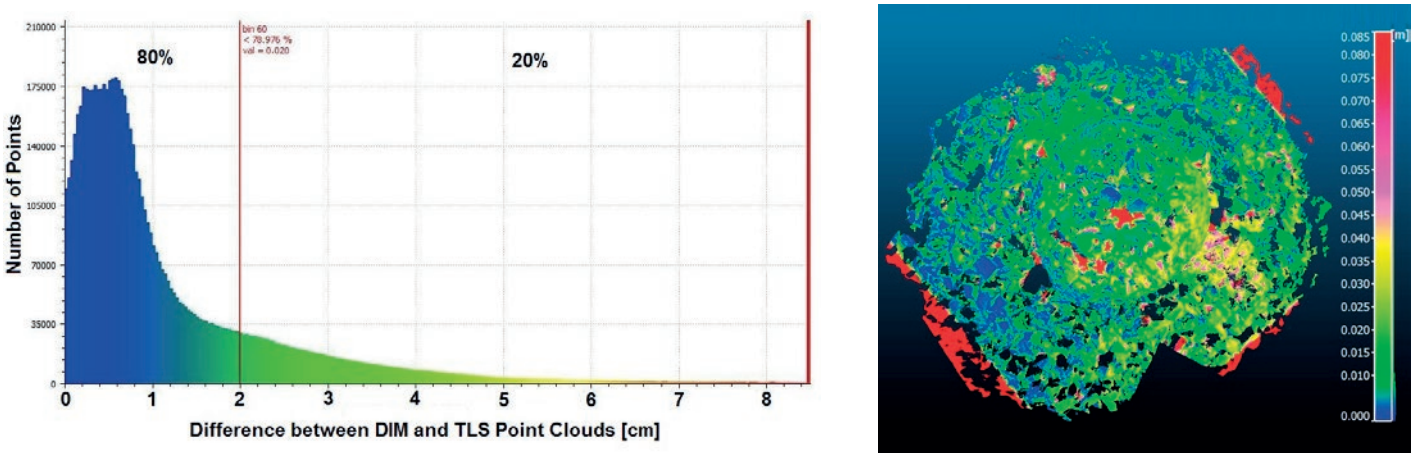
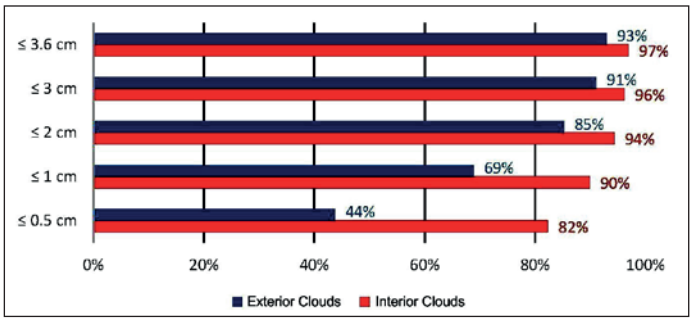
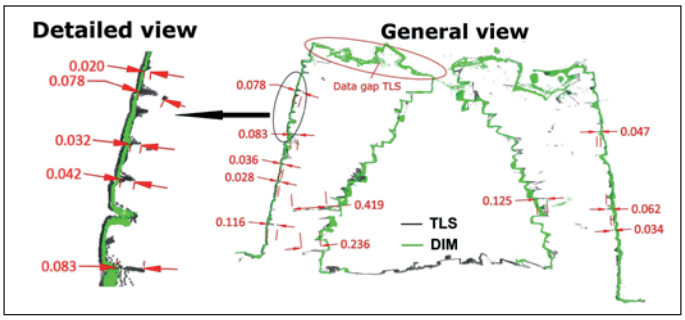



*Figure 3, Differences between DIM and TLS point clouds of a tomb shown as histogram (left) and from above; note the circular form in the centre representing the interior of the tomb.*




▲ *Figure 4, Deviations grouped in five classes.*




▲ *Figure 5, Vertical section of a tomb (differences are in metres).*

## GEOREFERENCING

To enable the comparison of DIM and TLS point clouds and derived products, a network of 10 points was created around the tombs using a total station. The local 3D coordinates were transformed to a geodetic reference system using four GNSS control points. The coordinates of the TLS stations and control points were connected to this geodetic reference system through a total station resulting in a planar accuracy (1 sigma) of 5mm and a height accuracy of 2mm. The positions of the TLS stations were also determined using a referencing set by Laserscanning Europe GmbH (Figure 2). The spheres with integrated prisms have been designed for quick and flexible scanning without targets. The centres of the spheres were determined with a total station. Two spheres – diameter 6cm – were mounted on the legs of the tripod and a third one with a diameter of 10cm was positioned at a distance of 10m-15m from the scanner. The workload of referencing with spheres is 50% less than when using signalised targets, without significant loss of accuracy. Since the set of spheres could not be used inside the tombs due to space limitations, the positions of the TLS were measured there using a total station and the coordinates of at least three reference points were determined additionally.

## COMPARISON

Five tombs with differing features and spread over the area were selected for comparing the DIM and TLS point clouds using the open-source software CloudCompare. TLS point density becomes coarser towards the edges of the scan, an effect images suffer less from. TLS point clouds show data gaps in regions of scan shadows; the DIM point cloud is more complete because of the 80% overlap. Due to shadows present in the joints of the quarry blocks, DIM could only detect a few points feasible for matching. In contrast, TLS is not affected by lighting conditions.

Nearly 80% of the differences are less than 2cm and the number of major deviations tends asymptotically to zero (Figure 3). Large deviations are due to TLS scan shadows (red in Figure 3). Differences larger than 8.5cm, a threshold found empirically, were indicated as data gaps. There are large differences in the joints between quarry blocks. To assess the deviations they were grouped in classes (Figure 4). About 90% of the points inside the tombs differ by less than 1cm as the scanner and camera could capture the inside of tombs at very close range. The differences of the top part are less than 1cm for 69% of the points and less than 3cm for 90% of the points. Differences larger than 2cm occur only in areas of data gaps and when the surfaces of blocks and joints are poorly illuminated. One remedy would be to improve the planning of the survey. Vertical sections show the origins of the differences between the TLS and DIM point clouds (Figure 5). In the DIM, point cloud surfaces are smoothed. The time spent on field work and data processing workload are similar. DIM requires one tenth of the financial investment of TLS and needs only basic photogrammetric knowledge, whereas proper planning and execution of complex TLS projects require at least six months' training.

## EVALUATION OF FIELD WORK

The field work took 10 man-days. The most time was taken up by determining control points and imaging the top part of the tombs. An experiment with a camera mounted on a 4m-long pole produced poor results. Building scaffolding would have taken up too much time and exceeded the financial budget. A feasible alternative would have been to use a multicopter UAS as this technology produces fast and highly accurate results. However, the law restricted its use.

## ACKNOWLEDGEMENT

Thanks are due to the Institute for Ancient Near Eastern Studies (IANES) at Eberhard Karls University Tubingen for its cooperation. ◀

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*NEW LIGHTWEIGHT LASER SCANNERS FOR VERY-HIGH-RESOLUTION POINT CLOUDS*

# **UAS-borne Lidar** for Mapping Complex Terrain and Vegetation Structure

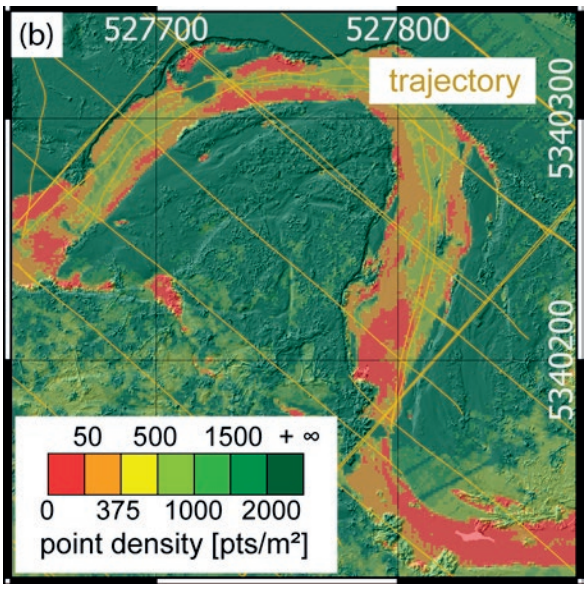
The development of lightweight, survey-grade Lidar sensors has made it possible to equip unmanned aerial systems (UASs) with very precise laser scanners, thus opening up new possibilities in the domain of close-range 3D mapping. To test the capabilities of UAS-borne laser scanning, a flight experiment was conducted using the RIEGL VUX full-waveform scanner mounted on a RIEGL RiCOPTER UAS platform. In the experiment, both the topography and the vegetation structure of an alluvial forest along the River Pielach in Lower Austria were captured. The resulting point cloud has a density of more than 1,500 points/m² and an accuracy of better than 2cm.

The Neubacher Au is a Natura2000 conservation area near the confluence of the Pielach and Danube rivers (Figure 1). It is a highly dynamic landscape due to periodical inundation during flood peaks. The fluvial topography includes pristine channels, side channels and oxbow lakes. This topography is perpetually changing, as is the vegetation structure. As a retreat area for aquatic and terrestrial habitats, alluvial forests are of high ecological value. Mapping these sensitive areas with traditional terrestrial or airborne techniques is challenging due to the high complexity of the terrain and the vegetation.

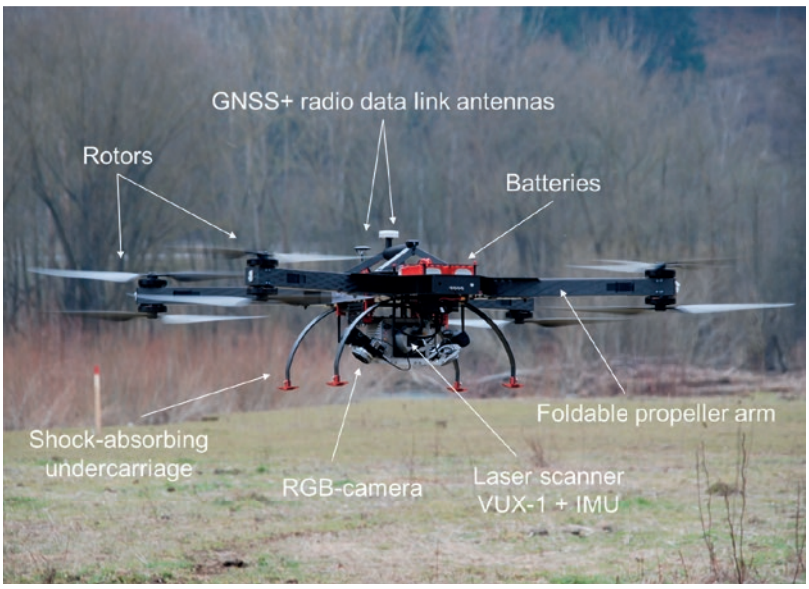
The recent advance of survey-grade Lidar sensors with a weight of less than 10kg offers new perspectives for 3D mapping of complex natural landscapes in high resolution. To test the potential of UAS-borne laser scanning, a flight experiment was conducted using the RIEGL VUX sensor mounted on a RIEGL RiCOPTER UAS.

## SENSOR SYSTEM

The carrier platform is a RIEGL RiCOPTER, which is an X-8 array octocopter. Four




▲ *Figure 1, The study area of Neubacher Au: DEM shading superimposed with point density map and flight trajectories.*




▲ *Figure 2, Photograph of RiCOPTER UAS platform and VUX sensor system during take-off in front of alluvial forest.*

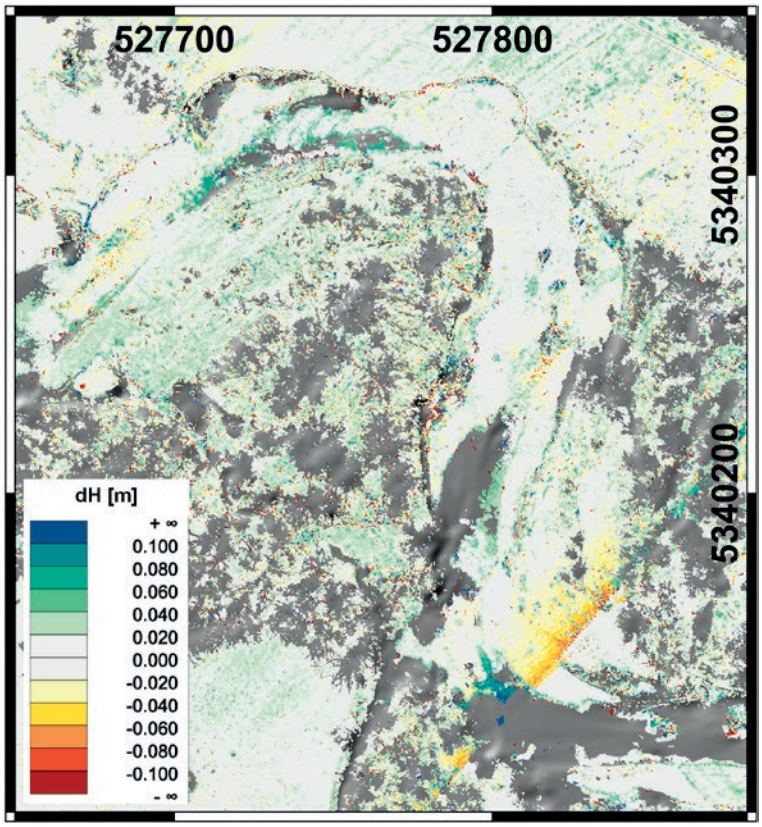



*Figure 3, Colour-coded height differences within smooth strip overlap areas. Background: DTM shading.*

foldable carrier arms, each carrying a coaxial array of two propellers, are attached to the carbon-fibre main frame. A shock-absorbing undercarriage enables safe landings. The maximum payload including batteries and all sensor components is 16kg. At the maximum take-off mass (MTOM) of 25kg, the RiCOPTER achieves a flying time of 30 minutes. The maximum flight altitude is 150m, but nationally regulated limits for civil unmanned aircraft need to be considered.

The VUX sensor system is mechanically and electrically integrated into the RiCOPTER aircraft fuselage. It consists of a global navigation satellite system (GNSS), an inertial measurement unit (IMU) for capturing the flight trajectory, the VUX-1 time-of-flight laser scanner, a control unit and a camera for video downstream. Furthermore, two Sony Alpha 6000 RGB cameras can be mounted on the UAS. The scanner features an effective measurement rate of 350kHz with a total field of view (FOV) of 230°. The large FOV is beneficial for vegetation mapping as trees can be captured from both above the canopy and from the side. The ranging accuracy is 10mm according to the vendor's datasheet. Figure 2 shows a photograph of the UAS and the sensor system just after take-off, with the alluvial forest visible in the background.

## DATA ACQUISITION

Data was captured on 26 February 2015 under leaf-off conditions. The flight crew consisted of the pilot remotely controlling the UAS and the sensor based on either a line-of-sight view or video images. An additional operator was present at the ground-station computer for flight mission guidance. The acquisition of the area of interest was based on a standard airborne laser scanning (ALS) flight plan with longitudinal and cross strips. The regular strip distance was 40m and the flying altitude was 50m above ground level, which was about 15m above the highest trees. Depending on the sensor-to-target range, the resulting laser footprint diameter was between 1 and 2.5cm enabling detection of small vegetation objects. Take-off and initialisation of the navigation system were performed manually. The GNSS/IMU system was initially aligned on the ground and after take-off by backward movements of the UAS. After finishing the initialisation procedure the autopilot took over control and the RiCOPTER subsequently flew the programmed path autonomously at a speed of 8m/s. The mission parameters and the large scanner FOV resulted in a mean laser pulse density of 1,500 points/m$^2$ and in multiple strip overlaps so that the vegetation was captured from all sides.

The high strip overlap was additionally used for a thorough calibration of the entire sensor system in post processing by a strip adjustment. This was done by simultaneously minimising the point-to-plane distances of more than 100,000 correspondences. Within the strip adjustment, the acquisition system was fully recalibrated. This includes the estimation of scanner calibration parameters (e.g. rangefinder scale error), mounting calibration parameters (i.e. misalignment and lever arm), and strip-dependent trajectory errors (i.e. GNSS and IMU errors). The adjustment led to a substantial quality improvement of the acquired point clouds, resulting in a final relative accuracy of 1.7cm (Figure 3).

## RESULTS AND APPLICATIONS

While thorough processing of the flight data is still work in progress, the first preliminary results are presented in Figure 4. A perspective view of the dense 3D point cloud coloured by reflectance is illustrated in Figure 4a, whereby the trunk, stem and thicker branches appear in red colour tones indicating high target reflectance and lower values (green to blue) are observed for the thinner twigs and their tips. Figure 4b shows a small section of the near-ground 5cm-resolution digital elevation model (DEM), which demonstrates that topographic features and dead wood can be mapped

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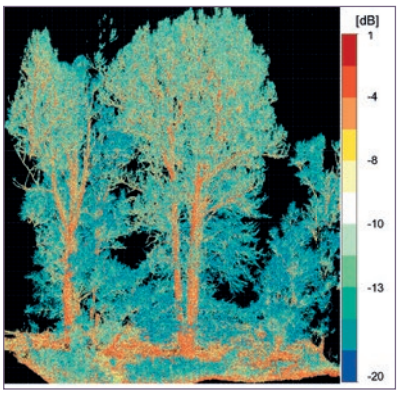



▲ *Figure 4a, Perspective view of 3D point cloud coloured by target reflectance.*

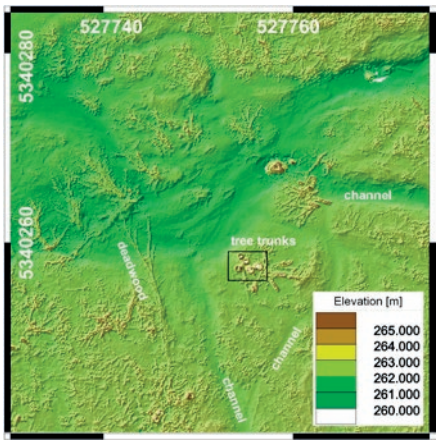
with remarkable sharpness. Furthermore, the density and spatial coherence of the point clouds fuel hopes that these point clouds can also be used for characterisation of terrain roughness with an accuracy better than 10cm. A potential field of application is flood modelling where, besides geometry, roughness (flow resistance) is an important input parameter.

Figures 4a and 4b both show the potential of the ultra-high-density 3D point cloud for detailed single-tree modelling. Whereas complete coverage of individual trees with points on all sides and from the trunk to the canopy is hard to achieve with terrestrial laser scanning (TLS), unmanned laser scanning (ULS) makes it possible thanks to the flexible flight path. ULS point clouds thus combine the advantages of TLS (short sensor-to-target range) and ALS (regular planimetric point spacing, bird's-eye perspective). Compared to TLS, there is less scan shadow in ULS as the laser beam first traverses the rather sparse canopy area before hitting the thicker branches and tree trunks near the ground. Due to the high scan rate and the resulting ultra-high point density, many last echoes hit the ground surface. This enables the derivation of a very-high-resolution digital terrain model (DTM) with grid spacing in the 10cm range.

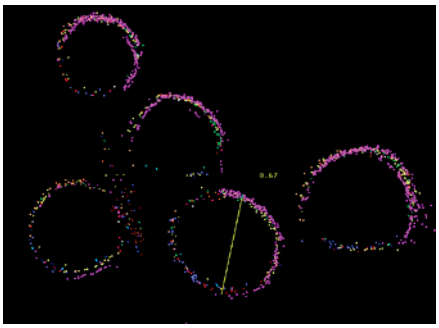
The diameter at breast height (DBH) is an important parameter in forestry since, in combination with the tree height, it allows the estimation of biomass. Whereas obtaining tree heights from ALS is already state-of-the-art, DBH estimation based on Lidar remote sensing is currently only feasible via TLS, which is both time-consuming and labour-intensive in forest environments. Figure 4c shows a horizontal section of the ULS point cloud including all points 1.20-1.40m above the terrain. In this dataset the stem diameters can directly be measured with centimetre precision. Individual colours are used in Figure 4c for the points of each flight strip, underlining the remarkable georeferencing quality.

## CONCLUDING REMARKS

The field experiment employing the RIEGL VUX sensor system mounted on the RiCOPTER UAS provided a homogeneous, ultra-high-resolution 3D point cloud of a complex alluvial area comprising both topography and vegetation. With a point density of more than 1,500 points/m$^2$, a vertical strip-fitting precision of less than 2cm and a comprehensive 3D capturing of the terrain shape and vegetation structure, the experiment demonstrated the high potential of UAS-borne laser scanning for different environmental sciences and applications. ◀




◀ *Figure 4b, Very-high-resolution near-ground DEM: 5cm grid, hill shading superimposed with colour coding.*



◀ *Figure 4c, Horizontal section of 3D point cloud at 1.30m above ground level used for measuring stem diameters. Individual colours are used for each strip.*


### GOTTFRIED MANDLBURGER

Gottfried Mandlburger studied geodesy at the Vienna University of Technology (TU Wien), where he also obtained his PhD (with honours) in 2006. He is currently working as senior researcher in the photogrammetry research group within the Department of Geodesy and Geoinformation at TU Wien. His research areas are topographic and bathymetric Lidar, DTM modelling, topographic data management and scientific software development. He is working together closely with experts in the field of hydraulic engineering emphasising on flood and habitat modelling. Gottfried Mandlburger has published several articles in the above field and is a board member of the DWA (German Association for Water, Wastewater and Waste) working group 'Multi-dimensional numeric models'. He is a member of the editorial advisory board of the ISPRS journal and coordinator of the Lidar software suite OPALS developed at TU Wien.

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Norbert Pfeifer is professor of photogrammetry within the Department of Geodesy and Geoinformation at TU Wien, Austria. He studied surveying and obtained his PhD in 3D terrain modelling. He moved to TU Delft, The Netherlands, to work in the Photogrammetry and Remote Sensing Department, concentrating on terrestrial laser scanning. He later became senior researcher at alp-S Centre for Natural Hazard Management and a lecturer in the Department of Geography, both based in Innsbruck. In 2006 he took the professor position at TU Wien. His research interests are photogrammetry and laser scanning, both from the side of measurement science, calibration, orientation, feature extraction and modelling, and from the application side, especially in the environmental sciences.

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*FIG WORKING WEEK, SOFIA, BULGARIA, MAY 2015*

# Creating a New Generation of **Global Surveyors**

The recent FIG Working Week, held at the National Congress Centre in Sofia, Bulgaria, from 17-21 May, was the first major FIG event for Prof Chryssy Potsiou in her new capacity as FIG president, but she rose to the occasion successfully. Her ambitions are clear: FIG has a long-term commitment to the global agenda. She underlined that FIG will work with its Member Associations to support the implementation of UN FAO's Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security and UN-Habitat's Continuum of Land Rights at the country level. FIG will work with UN-GGIM in its mandate to include land administration activities in the domain of global information management.

Scalability of security of tenure solutions will involve the use of a network of grass-roots surveyors from the communities. FIG will embrace and manage the change to encourage the use of innovative, scalable approaches to recording and securing land rights, including informal and customary rights. This will include fit-for-purpose land administration and property valuation solutions. FIG also supports the development of a new generation of global surveyors working at the local level – surveyors who are aware of the global issues and contribute solutions to the global agenda, while also being able to identify, initiate and foster research and to develop a clear professional and scientific vision.

### FIG HONORARY AMBASSADOR

Clarissa Augustinus, founder and lead of the Global Land Tool Network (GLTN), has worked closely with FIG for many years both since the establishment of the GLTN and through her position at UN-Habitat. The FIG Council acknowledged its long-standing cooperation with her by awarding her the title of FIG honorary ambassador. Clarissa Augustinus is standing down from UN-Habitat in June 2015.

### HIGHLIGHTS

The theme 'From Wisdom of the Ages to Challenges of the Modern World' provided the framework for discussion of the latest innovations and developments. The Working Week took place just a short time after the dramatic earthquake in Nepal. This truly brought home the potential impact of an earthquake and put the challenges for surveyors involved in measuring our planet into sharp focus. In situ scanners are achieving greater precision. Vertical and horizontal reference frames are developing to a global level as a foundation for global data infrastructures. At the local level, crowdsourcing and public involvement are subjects of debate: how will the role of the professional change in the future as easy-to-use and handheld measurement devices become increasingly available? There is no doubt that participation will rise and will significantly contribute to the advancement of land administration worldwide – including in the marine environment. 3D modelling for cadastre is under development. The topic of ethics in relation to our profession is also under continuous scrutiny.


*At the opening ceremony participants received a captivating insight into traditional Bulgarian dancing.*

> 'FIG has a long-term commitment to support the global campaign for security of tenure for all and will endeavour to solve these land issues through partnerships. FIG, as a recognised NGO, will work closely with the global family of UN organisations to support solutions to the 21st-century global challenges of climate change, food security, social justice and urbanisation.' - Chryssy Potsiou, FIG president

### NEPAL

The FIG Young Surveyors Network organised a 'Mapping Response – Contributions for Nepal' initiative. Participants used their laptops to join the existing Open Street Map (OSM) project to map for Nepal. The young surveyors organised hands-on sessions on the Social Tenure Domain Model – software which has previously been used in a disaster environment during the Ebola crisis. Disaster recovery is one of the key areas of attention within FIG.

▲ *During the plenary session, Clarissa Augustinus was officially awarded special status as FIG honorary ambassador by FIG president Chryssy Potsiou.*

### BITCOINS

It became apparent that the young surveyors take a somewhat different and more natural view of the crowdsourcing developments than their older colleagues. The Young Surveyors Network organised its own event and some interesting workshops during the Working Week, including a debate on the use of blockchains (Bitcoin technology) for land administration: a completely transparent approach in which everyone can see all transactions. Just after the Working Week in Sofia, the cadastre of Honduras announced it would become the first country to make use of this technology.

### APPEALING PROGRAMME

The colleagues from the Chamber of Graduated Surveyors in Bulgaria together with the FIG Council, ten FIG Commissions and the FIG Office organised an appealing programme with more than 350 presentations throughout the three conference days. The plenary sessions concentrated on 'The Surveyors' Response to Changing the City Management, to Pro-Growth Land Management and to Global and Regional Professional and Institutional Reforms'. Around 900 participants from 70 countries joined the Working Week 2015, which was supported by FIG sponsors Esri, Trimble and Leica.

### EXHIBITION

A lively exhibition was held alongside the conference as part of the Working Week, featuring the FIG sponsors Esri, Trimble and Leica as well many others, such as the Chinese companies ComNav and CHC. At lunchtime and during coffee breaks, the exhibition floor was bustling with delegates who seized the opportunity to gain updates on the latest techniques through short demos and discussions at the booths. Outside, on the square in front of the National Congress Centre, the organisers had designated a small area where companies could demonstrate their products in action in the open air. For many delegates, the exhibition perfectly bridged the gap between theory and practice, enabling them to see ideas such as crowdsourcing or 3D modelling, for example, put into practice. ◀

*A REVIEW OF GEO BUSINESS 2015*

# Underlining the Importan



Attendance at this year's GEO Business, held on 27 and 28 May in London, UK, was up 25% on last year's figures, with the 2015 event attracting more than 2,000 people from 47 countries over the course of the two days. It provided geospatial professionals with a comprehensive insight into what is an exciting and progressive industry that is positioning itself at the very forefront of new technology and practice.

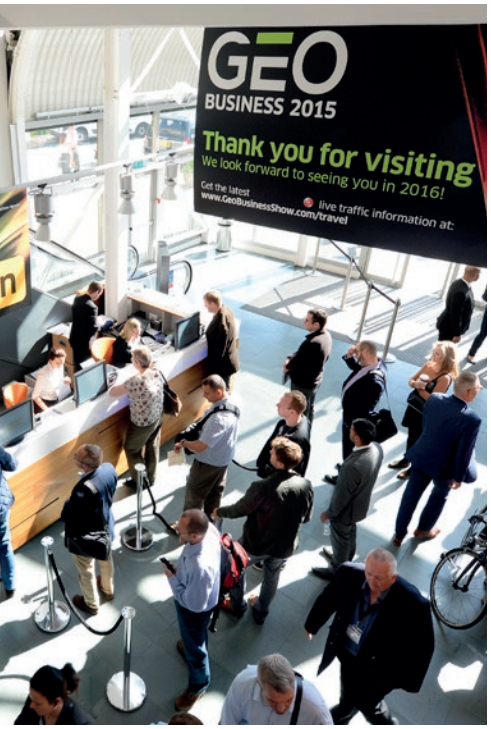
The conference featured 24 guest speakers who covered topics ranging from the latest GIS technology to aquatics, from data infrastructure to bridges and from boats to lasers. All of the speakers were leaders in their fields. Whether theorists or practitioners, each spoke positively about the industry while also encouraging debate. Attendees were often forced to consider how they could improve their role as an essential part of the built environment programme.

On day one Kate Hall, director for the built environment at HS2, presented the opening keynote address on the controversial issue of the planned HS2 high-speed railway, championing the impact it will have on the UK economy. She explored its value and outlined advantages, not only for the UK but also for the surveying industry as a whole due to the amount of surveys and engineering that will be required throughout the project lifecycle. The audience responded well to such a strong and positive opening speech, which demonstrated in the clearest terms the geospatial industry's importance to the progress and development of a nation's infrastructure and growth.

### GEOSPATIAL SURVEYING AND BIM

Another highlight on day one was the 'BIM Meets Geospatial' session with Paul Hill, senior consultant from Arup, Morten Hertz Knudsen, specialist and market manager from COWI, and Jana Siebenbrodt, product manager from FARO 3D Software. Each of

# ce of the Geospatial Sector




the three speakers focused on a different aspect of how geospatial surveying interacts with – and is becoming part of – the BIM process.

They were not the only ones to examine the role of BIM within the industry. Coverage of BIM was rife during the event, underlining the importance of geospatial expertise in development and construction projects. It was fascinating to learn more about the capabilities of the software, and to hear about how manufacturers are developing it to make the surveyor's role in BIM easier.

## MEASURABLE RESULTS

While many of the speakers delved into the theory and explored ideas in considerable depth, there were also valuable insights into live projects, including the true practicalities of activity, real outputs and measurable results. For example, Yung Loo, tunnel engineer at Arup, presented a seminar on locating CERN's next-generation particle accelerator, 'The 100km Future Circular Collider'. Darren Cunningham, scheme project manager at Network Rail, discussed how to use BIM to improve 100 million annual journeys at London Waterloo Station, and Ben Scott-Robinson, head of interactive experience at Ordnance Survey, introduced OS Locate, declaring: "Simplicity is everything." The projects were diverse, showing the breadth of the survey industry and its related professions. Combinations of theory and examples of practicalities were particularly successful in encouraging debate and generating a sense of realism – and in revealing to the audience that theory and practice can sometimes differ.

## THE CASE FOR A UK CADASTRE

At the other end of the spectrum, legal issues were also addressed. Martin Penney, Adam Harwood, and Julia Stolle from Technics delivered an insightful argument into boundary demarcation in the UK and Europe and whether there is a case for a UK cadastre. This raised the interesting question of the role of the survey in neighbourhood disputes, repositioning and boundary demarcation. The Technics team argued how a UK cadastre – digital country-wide mapping – would benefit the legal profession and property transactions. That topic sparked debate, which is unquestionably important, and GEO Business 2015 was a suitable forum for such debate to take place.

Out on the exhibition floor a range of suppliers, including instrument and equipment manufacturers, associations, surveyors and software developers, had designed their stands for maximum impact and engaged the constant stream of visitors. This year's event attracted a notable number of industry entrants keen to learn more about what the industry – and the companies who are active within it – can offer. Similarly, industry clients and partners seemed well represented. The atmosphere was one of exploration – together with peers, with the industry's next generation and with potential customers and partners alike.

As if echoing the industry's evolution, this year's exhibition floor was home to a single stand for all the collaborators of the event: The Survey Association (TSA), Chartered Institute of Civil Engineers (ICES), Royal Institute of Chartered Surveyors (RICS), Institute of Civil Engineers (ICE) (involved for the first time this year) and Association of Geographical Information (AGI). That they all came together as one demonstrates the breadth of industry support. The GEO Business conference is still growing and appeals to those outside of the surveying industry as well as within it, which only serves to underline the importance of the geospatial sector.

# 3D Visualisations Generated by Underwater Laser Scanning

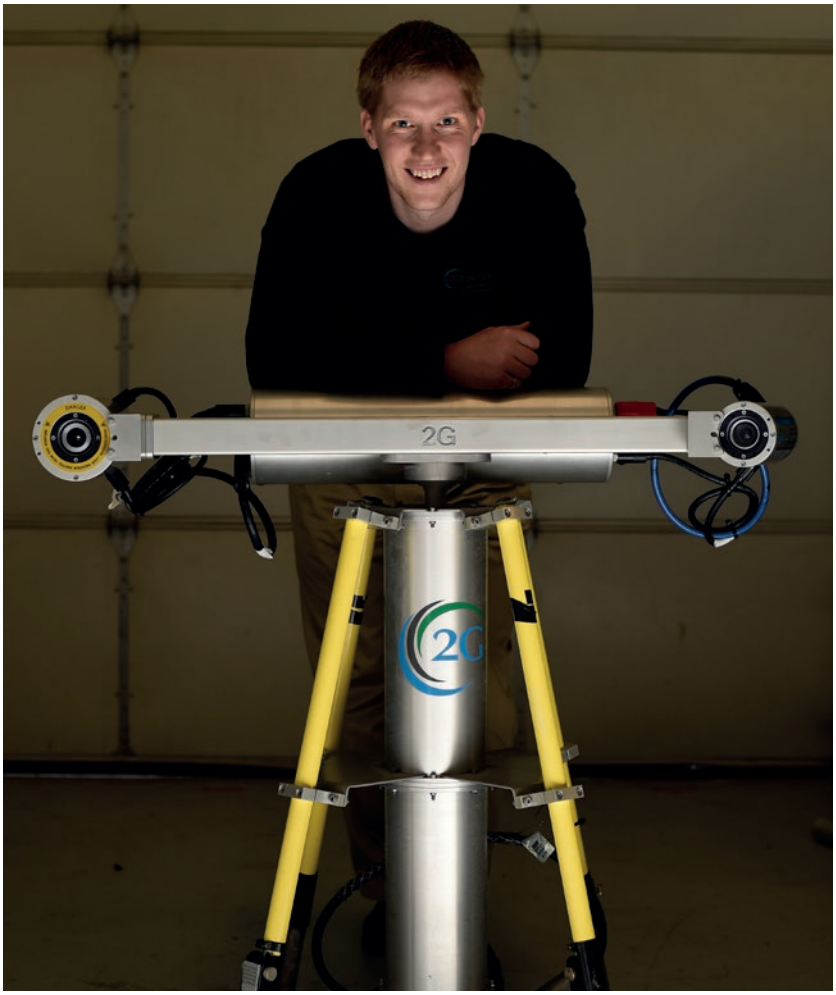
2G Robotics is located in Waterloo, Ontario, Canada. The company's underwater laser scanners generate real-time 3D models of subsea assets and environments from which submillimetre measurements can instantaneously and repeatedly be captured. These models provide the precision and accuracy needed for detecting and assessing damage, developing design and repair plans, and performing maintenance and installations.

Jason Gillham, founder and CEO, has always had a passion for marine technology. He founded 2G Robotics in 2007 after completing his studies in Mechanical Engineering at the University of Waterloo. Gillham possesses over ten years of experience in the development of marine technology, the operation of marine robotics, and the processing and analysis of data from marine systems. Driven by the desire to improve subsea imaging and measurement technology, Gillham and the team at 2G Robotics developed the ULS line of underwater laser scanners. The company has continued to expand since 2007 and is nearing a total of 50 systems built and deployed worldwide.

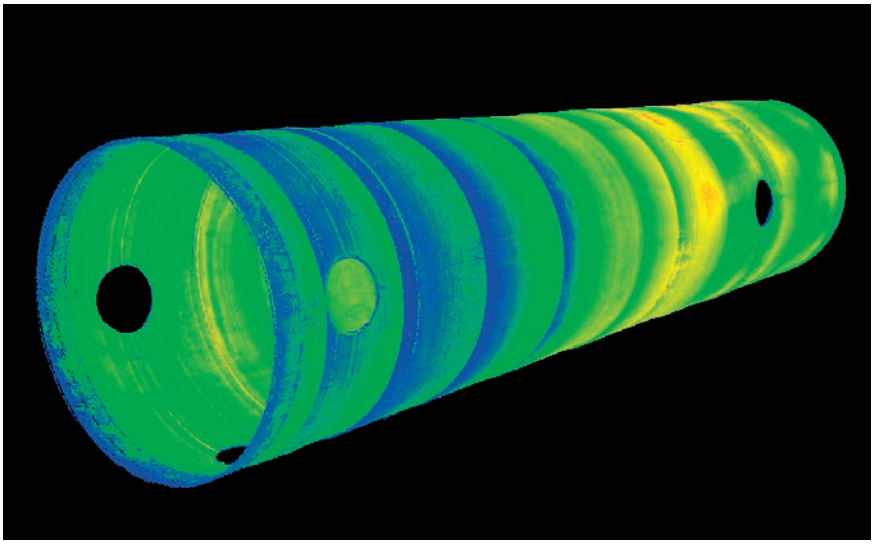
### CURRENT PROFILE

The mission of 2G Robotics is to provide the best subsea imaging and measurement technology. 2G Robotics is dedicated to using advanced research, development and engineering for the production of truly

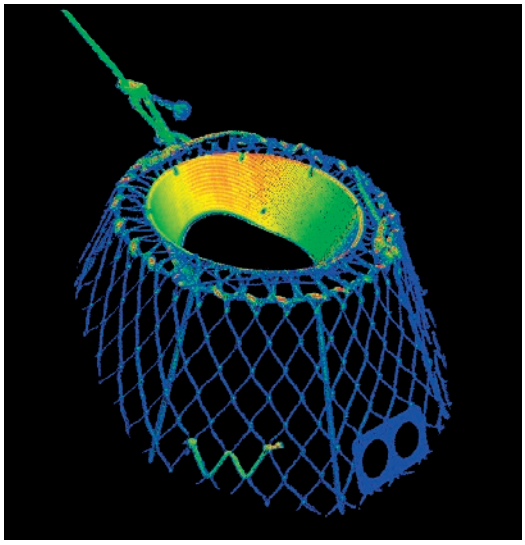
Every month ***GIM International*** invites a company to introduce itself in these pages. The resulting article, entitled Company's View, is subject to the usual copy editing procedures, but the publisher takes no responsibility for the content and the views expressed are not necessarily those of the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




▲ *CEO and founder Jason Gillham.*



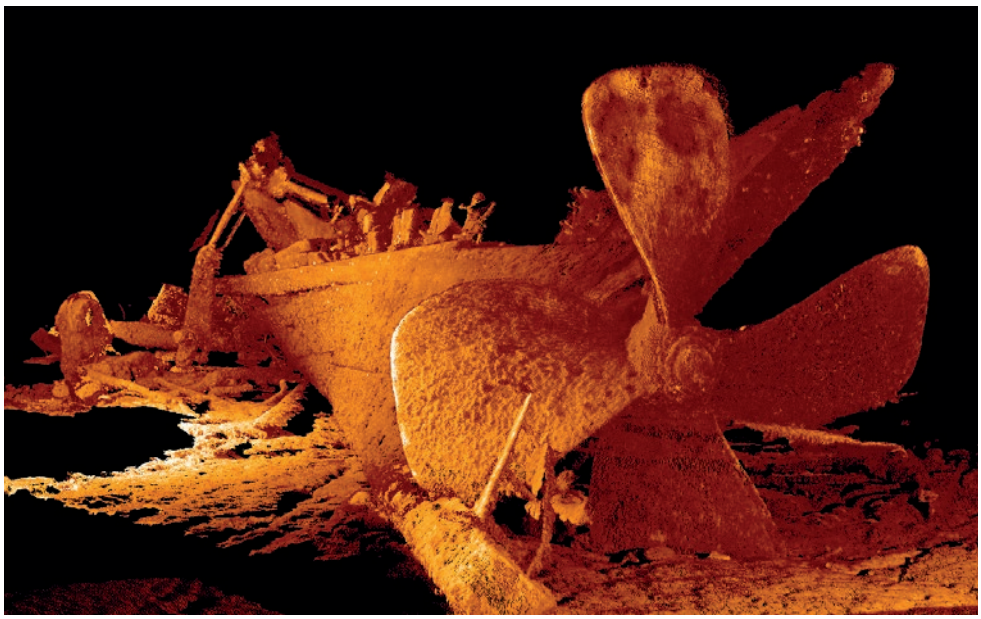
▲ *A laser scan of an I-Tube during a project in Angola.*



▲ *Fisheries and Marine Institute demo of a crab pot net.*

cutting edge solutions. The foundation of 2G Robotics is its wealth of engineering expertise in the development of innovative and reliable systems, which has led to the success of its underwater laser scanners. The 2G Robotics ULS line currently consists of three models which operate at varying distances, the ULS-100 (short-range), ULS-200 (mid-range), and ULS-500 (long-range). These systems can easily be deployed by ROV, AUV or diver.

"When customers are confronted with more challenging requirements or deployment constraints, we are keen to work with them to develop innovative and optimal solutions," says Gillham. Collaborating with customers is intrinsic to 2G Robotics' culture. The company has collaborated with customers, including ADUS DeepOcean and C&C Technologies, to develop deployment solutions tailored to their specific needs to best facilitate their projects.



▲ *Wreck of The Monohansett.*

## INTERNATIONAL AND GLOBAL SCOPE

2G Robotics' underwater laser scanners have been deployed on all seven continents. The scanners have been used to inspect pipelines, mooring chains, jacket nodes, water-supply tunnels, water wells, and coastal retaining walls, and have also been used to perform spool metrologies, monitor ice scallop formations, assess fishing gear performance, and provide 3D archaeological records of underwater historical sites.

2G Robotics targets seven markets with its underwater laser scanners. These seven markets are: civil infrastructure, hydroelectricity, marine archaeology, nuclear, offshore oil and gas, research and education, and water distribution. The offshore industry is the company's primary market and, within that market, the company focuses on pipeline survey and inspection, helping to ensure safe offshore operation by providing the detailed information needed to mitigate the likelihood of ruptures that would cause devastating environmental damage.

Earlier this year, 2G Robotics solidified its global presence with the formation of a global sales and distribution partnership with Seatronics, an Acteon company. This partnership facilitates global access to 2G Robotics' high-resolution underwater laser scanners and provides the benefit of Seatronics' expertise and global technical support.

## VIEW OF THE FUTURE

"2G Robotics remains focused on its vision to improve subsea metrology. We continually strive to advance and better our technology in order to deliver the best results," states Gillham. The ULS-500 will soon be available with an increased scan range, increased sample rate, and an integrated and synchronised stills camera. Looking to the future, 2G Robotics will continue to innovate to enhance its existing product line and provide new products and solutions to ensure efficient and reliable subsea surveys and inspections. ◀

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No 2827

# FIG General Assembly 2015 – Close-run Decision between Vietnam and Switzerland

The FIG 38th General Assembly was held on 17 and 21 May 2015 in Sofia, Bulgaria, in connection with FIG Working Week 2015. The General Assembly was very well attended. On 17 May, 51 member associations out of 102 were represented while 56 out of 103 were present on 21 May. The sessions were attended by affiliate, academic and corporate members as well as observers.

The only election was the decision on the venue for the Working Week 2019. Four strong candidates were included in the first round, and FIG was grateful for such substantial interest in hosting a future FIG Conference. The competition was very tight, and all bidders showed great creativity in their presentations throughout the Working Week. Since no bidding association secured a total majority in the first round, a second round of voting took place between geosuisse, Switzerland, and VCGR, Vietnam. This produced 35 votes for Switzerland and 40 for Vietnam, which means that the FIG Working Week 2019 will be held in Hanoi, Vietnam.

Two member associations were admitted as new members: Distinctive Engineering Group, Rwanda, and Licensed Surveyors Association of Ghana (LISAG). Since the last General Assembly, FIG Council has admitted 5 new affiliate members, 5 new corporate members and 6 new academic members.

The General Assembly appointed Teo CheeHai as FIG honorary president, especially in recognition of the exceptional job he has done for FIG in the past four years as president of the Federation. Meanwhile Christiaan Lemmen was appointed honorary member for his outstanding work for FIG for many years, not only as chair of the Permanent Institution, OICRF, but also in assisting the development and promotion of the surveying profession at an international level, his contributions to several FIG publications and his work in FIG Commission 7. The adoption of both appointments was accompanied by a standing ovation.


*Angel Yanakiev, president of Bulgarian Chamber of Surveyors, hands over the FIG flag to Jeff Needham, president of New Zealand Institution of Surveyors which will be organising the FIG Working Week 2016.*

Dr Clarissa Augustinus, UN-Habitat, has worked closely with FIG for many years through her position in UN-Habitat and since the establishment of the Global Land Tool Network (GLTN). FIG Council wanted to acknowledge the long-standing cooperation with her that has outlasted many councils and FIG presidents. Therefore, at the General Assembly, FIG Council announced its decision to recognise Clarissa Augustinus as honorary ambassador as a special consideration.

FIG president, Chryssy Potsiou, revealed the ideas behind the Work Plan 2015-18 and the planned activities including a new FIG Regional Capacity Development Network based on the Africa Task Force 2009-2014. Four Task Forces were endorsed by the General Assembly: Real Property Markets, Commission Structure, Corporate Members, and Scientific Journal.

It was pleasant to see an active General Assembly commenting and asking questions to the Commission Work Plans of which many related to communication, education, mutual recognition and how national delegates can be more involved in the work of the commissions. Unfortunately the chair of Commission 9, Dr Liao Junping, had to make the sad decision to step down as chair. FIG Council decided to appoint Mr Steven Nystrom, NCSP, US, as chair of Commission 9 for the rest of the term 2015-2018.

**More information**
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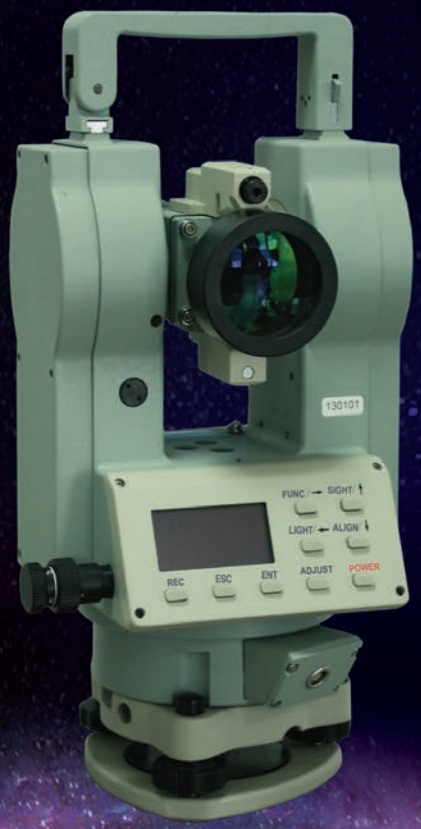


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No 2750

# Regional SDI Developments in Europe Highlighted at the INSPIRE Conference

The INSPIRE GWF 2015 Conference in Lisbon, Portugal, from 24-29 May provided a good opportunity for both the European and global audience to learn more about the activities of several GSDI Organisational Members who presented at the conference and/or exhibited. This annual SDI conference provides the European Commission with the opportunity to inform the whole of Europe on developments relating to implementation of the pan-European SDI driven by the 2007 INSPIRE Directive – Infrastructure for Spatial Information in the European Community. It is also an excellent meeting place for networking among colleagues who are implementing their national SDIs. In all, more than 40 workshops were held over the five days of the conference, which also featured four well-attended plenary sessions and more than 400 paper presentations, all delivered under the theme of 'Convergence: Policies, Practices and Processes through Public Private Partnership'.

At this year's conference, GSDI member EUROGI – the European Umbrella Organisation for Geographic Information – ran two workshops seeking feedback from participants about various EUROGI Position Papers that the organisation is developing for presentation to the European Commission later this year. The workshop themes were 'Internet of Things, Big/Linked Data and Open Data' and 'Promoting SME Growth, Promoting Sustainable Urban and Regional Development'. Various members of EUROGI and its member organisations were also well represented across the spectrum of the presentations in the nine parallel sessions that ran each day.

The Open Geospatial Consortium was represented in various sessions, including workshops on 'OGC/W3C Spatial Data on the Web' and 'Web Mapping with OGC Services and GeoServer: An Introduction'. OGC European services director, Athina Trakas, was a lead speaker in the Urban & Climate Resilience & Sustainability session. Mark Reichardt, OGC president and CEO, and Kevin Pomfret, executive director of the Centre for Spatial Law & Policy and chair of the OGC Spatial Law & Policy Committee, spoke at the Geospatial Leadership Business Summit. Mark also moderated the session on Standards & Interoperability and spoke at the session on Digital Single Market, and Kevin moderated the session on Geospatial Policies.

▲ *Delegates at the Standards and Interoperability session.*

Of the North American members, Ivan DeLoatch, executive director of FGDC at USGS and a long-time GSDI member, was moderator for one of the key SDI sessions. Natural Resources Canada was represented by Cindy Mitchell, presenting 'Platforms, Policies and the Public – Integration of Canada's Geospatial Data and the Open Government Portal'.

Various Eurogeographics members were represented in the stream of papers presented at the conference, and the National Land Survey of Finland (member of both GSDI and Eurogeographics) offered a workshop on 'Leveraging INSPIRE SDI in e-government services: The Oskari Platform'.

KU Leuven was represented by Joep Crompvoets, current project leader of the GSDI GLIM project – Geoinformation Legal Interoperability Map of the World, who presented a paper on 'INSPIRE in the EU Member States: Analysing the 2013 Country Monitoring Reports' and 'Geospatial Convergence in Kosovo'. The GSDI secretariat was on hand with secretary-general Roger Longhorn's presentation on 'Survey of National Coastal and Marine SDI Geoportals'.

GSDI members present on the exhibition floor included open-source GIS specialists Boundless, educational GIS training association UNIGIS and Esri, Inc. Esri staff also led workshops including 'INSPIRE – From compliance to maximising use in an open innovation ecosystem'. GSDI member GeoCat was also present at the conference.

In all, 11 GSDI member organisations were represented at INSPIRE GWF 2015 this year, a record turnout. ◀

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# The Joint Board of Geospatial Information Societies (JBGIS)

The JBGIS is a coalition of international organisations involved in the collection, coordination, development, management, standardisation or regulation of geospatial information and related matters. The purpose of the JBGIS is to provide, where possible, a collective and unified voice at the international level regarding geospatial affairs, especially to the United Nations and other global geospatial information stakeholders. The current members of the JBGIS are:

- Global Spatial Data Infrastructure Association (GSDI)
- IEEE Geoscience and Remote Sensing Society (IEEE-GRSS)
- International Association of Geodesy (IAG)
- International Cartographic Association (ICA)
- International Federation of Surveyors (FIG)
- International Geographic Union (IGU)
- International Hydrographic Organisation (IHO)
- International Map Industry Association (IMIA)
- International Society for Photogrammetry and Remote Sensing (ISPRS)
- International Steering Committee for Global Mapping (ISCGM)

The JBGIS typically meets once a year at a location linked either to one of the conferences of the member organisations or to meetings conducted by the UN initiative on Global Geospatial Information Management (UN-GGIM). With the launch of the UN-GGIM initiative the JBGIS has found a significant focus for its activities. It now provides support to the UN-GGIM secretariat, helping to plan meetings of the UN-GGIM Committee of Experts or of the High Level Forums (HLF) or special workshops. One of the first significant outcomes was the adoption of the UN General Assembly resolution on a 'Global Geodetic Reference Frame for Sustainable Development' (see *GIM International*, May 2015). This was championed by the IAG and strongly supported by all JBGIS member organisations.


▲ *Third High Level Forum on UN-GGIM.*

Several representatives of the JBGIS made presentations at the 3rd HLF of the UN-GGIM, held in Beijing, China, from 22-24 October 2014:

- Mark Cygan (IMIA) spoke on behalf of the JBGIS during the Opening Ceremony
- Teo Chee Hai (FIG) moderated the session 'Sustainable Cities and Human Settlements'
- Abbas Rajabifard (GSDI) gave the keynote address in the session 'Climate Change and Disaster Mitigation'
- Mark Cygan (IMIA) was member of the panel on 'Leveraging the Technology Revolution'
- Chen Jun (ISPRS) gave the keynote address in the session 'Working Together Across Borders and Regions'
- Robert Ward (IHO) was member of the panel on 'Working Together Across Borders and Regions'.

This close alignment of JBGIS interests with those of the UN-GGIM continues in 2015. For example, the 22nd meeting of ISCGM will be held just prior the 5th session of the UN-GGIM Committee of Experts in New York from 5-7 August 2015. This meeting will address two critical issues: the role of geospatial information for supporting decision-making in the framework of disaster management, and the future development of global mapping. The 2015 annual meeting of the JBGIS will also be held in conjunction with the aforementioned UN-GGIM Committee of Experts meeting. ◀

Chris Rizos
Chair of the JBGIS

**More information**
www.iag-aig.org
www.fig.net/jbgis/

*The mission of the Association is the advancement of geodesy.*

IAG implements its mission by:

- advancing geodetic theory through research and teaching,
- collecting, analysing and modelling observational data,
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No 2826

# It's International Map Year: All Systems Go!

The International Map Year (IMY) has started well and further success is anticipated as various national IMY committees will be organising national and local Map Days. More and more countries have registered to take part, including several who are not yet ICA members; many conferences are also including IMY in their programmes; cartographic journals and national cartographic societies are including news on IMY in their outreach. There are moves to establish links with important national and political bodies (e.g. the US Department of Education) which may be able to implement changed agendas using IMY ideas and concepts in broader societal activities. The progress can be followed at the IMY website [1], which is an excellent resource for IMY advice and information. The website is managed by Manuela Schmidt from the Department of Cartography at TU Wien, Vienna, Austria, who is also webmaster of the ICA homepage. ICA is thankful to her for taking on this task in her usual efficient manner, and also recognises the important groundwork laid in the previous year by two PhD students: Domonkos Hillier and Ádám Bérces, from Eötvös Lorand University in Budapest, Hungary. We are grateful for their assistance in developing ideas initially agreed by the IMY Working Group which met in March 2014.

The book, *The World of Maps*, has been translated to French and Spanish, and can be freely downloaded from the IMY homepage. The French version has also been printed as a special issue of the journal of the Comité Français de Cartographie (Cartes & Géomatique no. 221), and is available from the CFC website [2]. Recently, work has also been started on translation of the book into Arabic and Chinese.

WE MAPS

INTERNATIONAL MAP YEAR 2015–2016

IMY will be officially inaugurated at the Opening Ceremony of the main International Cartographic Conference in Rio de Janeiro, Brazil, in August 2015. The activities taking place since the start of 2015 will be reported to the ICA General Assembly being held at that event. Furthermore, all attendees at the ICC and the General Assembly will have the opportunity to learn more about what IMY can involve in terms of activities at a national and local level, by visiting the dedicated IMY information desk in the ICC exhibit area. As IMY is scheduled to last into 2016, there is considerable scope to engage in activities such as Map Days and also map exhibitions, visits to official or commercial mapping establishments and lecture programmes on cartography, all organised in possible collaboration with national mapping organisations, universities that offer cartography courses or libraries with map collections. Suggestions for such activities are given on the IMY website along with the downloadable logos, leaflets and online book.

It is important to note that IMY is directed towards four main audiences: schoolchildren, politicians and government decision-makers, professionals in related fields, and the general public. This is a significant opportunity for ICA, and for the individual cartographers, cartographic institutions and enterprises it unites, to reach out from internal business to show the rest of society the power of geographic information and maps. ◂

**More information**

1. http://mapyear.org
2. www.lecfc.fr/index.php?page=publication

www.icaci.org

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No 2824

# The 36th International Symposium on Remote Sensing of Environment

Biodiversity, agriculture, atmosphere, disaster management, polar regions, marine applications, urban monitoring and new Earth observation and sensors were among the 12 general themes of the 36th International Symposium on Remote Sensing of Environment (ISRSE), which took place from 11-15 May 2015 at the Berlin Conference Center (BCC) in Germany. ISRSE is a biannual international event dating back to 1962, when the first ISRSE was convened in Ann Arbor, Michigan, USA.

The 36th ISRSE was hosted by the German Aerospace Centre (DLR). During the 5-day symposium, 743 participants from 66 countries attended 415 oral presentations in 81 technical sessions, and 167 posters were on display. Each morning featured plenary sessions, with a total of 29 keynotes giving an overview of Earth observation and science programmes as well as technological trends. 14 companies and agencies exhibited their products and services. The European Space Agency and the European Commission were platinum sponsors of this event. Further sponsors included EUMETSAT, NASA and Airbus.

The symposium was opened with a welcome address by Dr Wolfgang Scheremet, director general of industrial policy, Federal Ministry for Economic Affairs and Energy of Germany, and Prof Johann Dietrich Wörner, chairman of the Executive Board of DLR. The symposium platinum sponsors, the European Commission and the European Space Agency, contributed to the opening with an address by Dr Rudolf Strohmeier, deputy director general of research and innovation and by Prof Volker Liebig, director of Earth observation.


▲ *Group photo after the opening session (from left to right): Gunter Schreier, DLR; Volker Liebig, ESA; Johann Dietrich Wörner, DLR; Wolfgang Scheremet, Ministry for Economic Affairs and Energy; Rudolf Strohmeier, European Commission; Helmut Staudenrausch, DLR.*

Prof Charles Hutchinson welcomed the participants on behalf of the International Centre for Remote Sensing of Environment, the managing organisers of the ISRSE conference series. Prof Christian Heipke, secretary general of ISPRS, highlighted in his welcome address the relation between the conference and ISPRS. Through the ISPRS Committee on Remote Sensing of Environment (ICORSE), the ISRSE is a symposium in the ISPRS series of conferences. In his presentation during the closing ceremony the new chair of ICORSE, Lawrence Friedl from NASA, stressed that the relationship between this biannual symposium, ISPRS and the Earth observation user communities will be strengthened. The latter – amongst others – were presented at the symposium by Barbara Ryan, director of the Group on Earth Observation (GEO). The keynote presentations are available at the symposium website [1].

All full conference papers have been published in the ISPRS Archives: 36th International Symposium on Remote Sensing of Environment (Volume XL-7/W3), 11-15 May 2015, Berlin, Germany. Selected papers will be invited for a full peer-review publication in a special edition of the *ISPRS Journal of Photogrammetry and Remote Sensing*.
The next ISRSE will be hosted in 2017 by the South African Space Agency (SANSA) in Tshwane, South Africa. ◀

Gunter Schreier and Helmut Staudenrausch, DLR

**More information**
1. www.isrse36.org
www.isprs.org

## JULY

**FOSS4G-EUROPE CONFERENCE**
Como, Italy
from 14-17 July
For more information:
E: contact-foss4ge@osgeo.org
W: http://europe.foss4g.org/2015/

**ESRI INTERNATIONAL USER CONFERENCE**
San Diego, CA, USA
from 20-24 July
For more information:
E: uc@esri.com
W: www.esri.com/events/user-conference

**13TH SOUTH EAST ASIAN SURVEY CONGRESS (SEASC 2015)**
Marina Bay Sands, Singapore
from 28-31 July
For more information:
E: pat@eventspeople.com
W: www.seasc2015.org.sg/index.html

## AUGUST

**27TH INTERNATIONAL CARTOGRAPHIC CONFERENCE**
Rio de Janeiro, Brazil
from 23-28 August
For more information:
E: christina@congrex.com.br
W: www.icc2015.org

**ISPRS GEOSPATIAL WEEK**
La Grande Motte, FR
from 28 August-02 September
For more information:
E: info@isprs-geospatialweek2015.org
W: www.isprs-geospatialweek2015.org

**UAV-G CONFERENCE 2015**
Toronto, Canada
from 30 August-02 September
For more information:
W: www.uav-g-2015.ca

## SEPTEMBER

**PHOTOGRAMMETIC WEEK 2015**
Stuttgart, Germany
from 7-11 September
For more information:
W: www.ifp.uni-stuttgart.de/phowo

**INTERDRONE 2015**
Las Vegas, NV, USA
from 09-11 September
For more information:
W: www.interdrone.com

**INTERGEO 2015**
Stuttgart, Germany
from 15 -17 September
For more information:
W: www.intergeo.de

**SUMMIT ON EARTH OBSERVATION BUSINESS (PART OF THE WORLD SATELLITE BUSINESS WEEK)**
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For more information:
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# KCS TraceME



## LoRa ™ Internet of Things

KCS has extended their successful TraceME product line with an advanced module, targeted for worldwide mobility in the Internet of Things era. The latest development of the TraceME GPS/GPRS Track and Trace module will combine the RF location based positioning solution with the LoRa™ technology. This combination offers 'smart objects' being even smarter, since LoRa™ enables long range, battery friendly communication in a wide variety of (M2M) applications. Supporting GPRS/SMS and optional 3G, Wi-Fi, Bluetooth LE, ANT/ANT+ and iBeacon™ provides easy integration with existing wireless networks and mobile apps. Other variants in the high/mid-range and budget-line will follow soon.

## ANTI-THEFT module based on RF

KCS TraceME product line offers an intelligent location based positioning solution for indoor and anti-theft applications.The solution is based on RF with an intelligent algorithm of measuring the propagation time of transmitted (proprietary protocol) signals. Unique features are: minimum size (46x21x6.5mm), weight (7 grams for fully equipped PCB) and a standby battery lifespan of more than 10 years.'Listen before talk' algorithm makes it practically impossible to locate the module, which secures the valuable vehicle or asset. Supporting GPRS/SMS and optional 3G, Wi-Fi, Bluetooth LE, ANT/ANT+ and iBeacon provide easy integration with existing wireless networks and mobile apps.

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