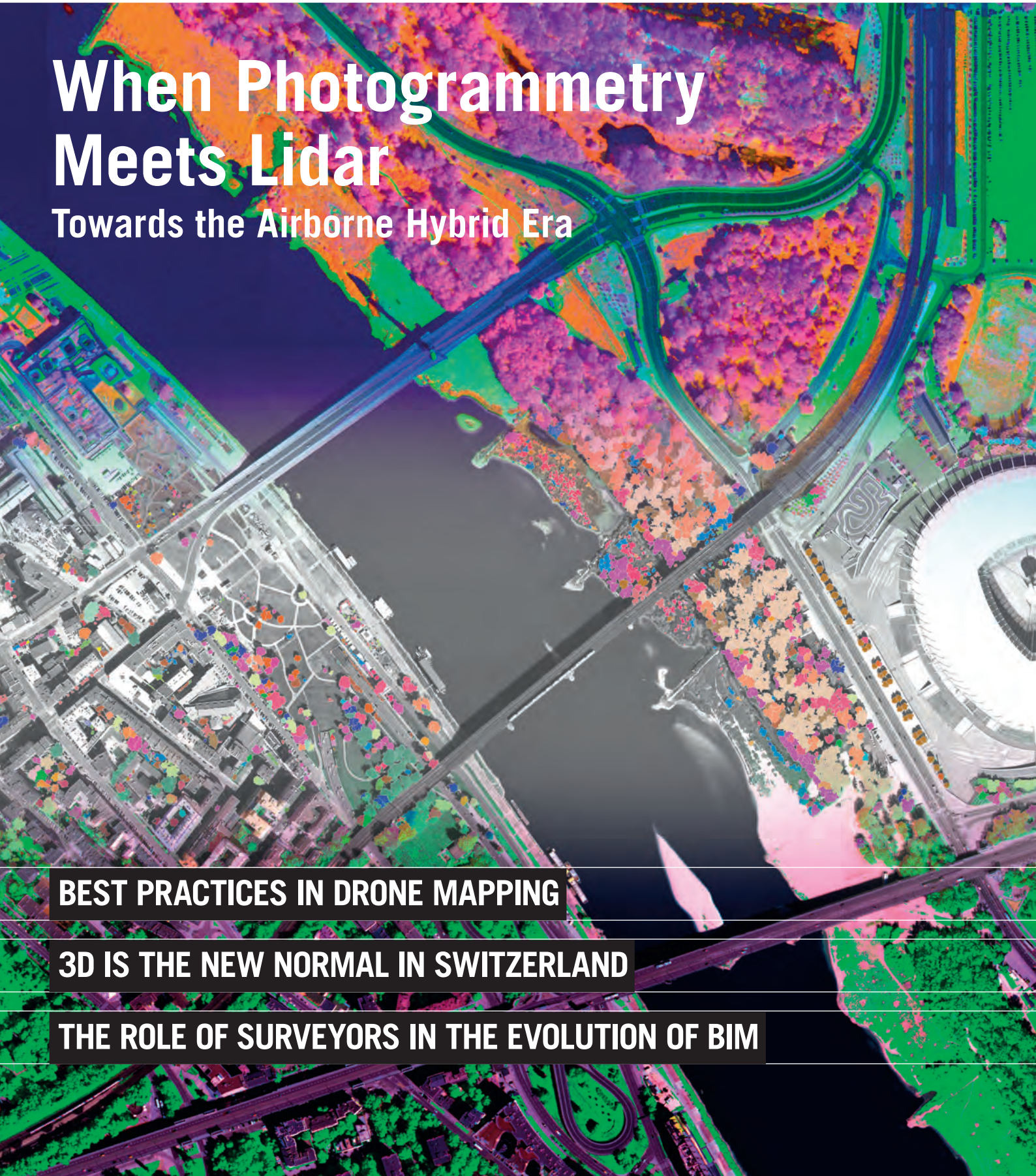
GIM INTERNATIONAL

THE GLOBAL MAGAZINE FOR GEOMATICS
WWW.GIM-INTERNATIONAL.COM

geomares

ISSUE 5 • VOLUME 33 • SEPTEMBER/OCTOBER 2019



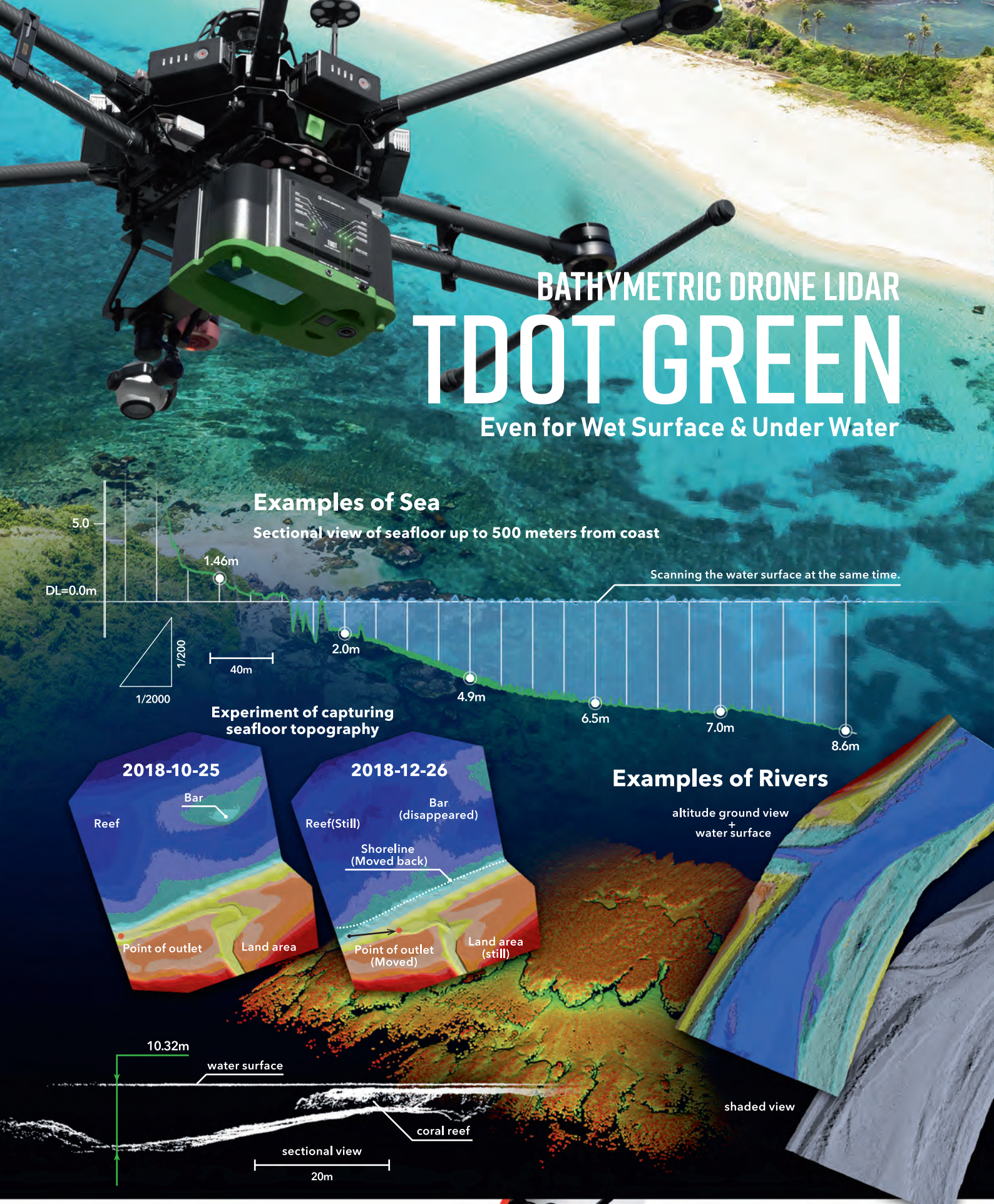
When Photogrammetry Meets Lidar

Towards the Airborne Hybrid Era

BEST PRACTICES IN DRONE MAPPING

3D IS THE NEW NORMAL IN SWITZERLAND

THE ROLE OF SURVEYORS IN THE EVOLUTION OF BIM



AMUSE ONESELF INC.
1-1-14 3F Kitahama 1 Chome Heiwa Bldg.
Kitahama, Chuo-ku, Osaka-City 541-0041, Japan
https://amuse-oneself.com/en/
info@amuse-oneself.com

TDOT Series Work Flow
on YouTube
https://youtu.be/kcxmcCrlZLo

TDOT Series Promotion
on YouTube
https://youtu.be/-NH6CREa06o

STUTTGART 2019
17 – 19 SEPTEMBER

INTERGEO®
KNOWLEDGE AND ACTION FOR PLANET EARTH

Hall : 1 Booth : L1.033

SOUTH
Target your success

- 3D Laser Scanning
- UAV
- Location-based Services
- Hologrammetry & VR

- Optical-electrical Instruments
- Survey Accessories
- GNSS Positioning
- Railway Engineering

- Marine Survey
- Indoor Mobile Mapping
- Desktop & Tablet Mapping
- GIS

STUTTGART 2019
17-19 SEPTEMBER
INTERGEO®
Hall 1 A1.046

E-mail: mail@southsurvey.com
www.southinstrument.com www.southsurvey.com

GIM INTERNATIONAL

DIRECTOR STRATEGY & BUSINESS DEVELOPMENT Durk Haarsma
FINANCIAL DIRECTOR Meine van der Bijl
SENIOR EDITOR Dr Ir. Mathias Lemmens
CONTRIBUTING EDITORS Dr Rohan Bennett, Huibert-Jan Lekkerkerk, Frédérique Coumans, Ian Dowman
CONTENT MANAGER Wim van Wegen
COPY-EDITORS Lynn Radford and Claire Koers
MARKETING ADVISOR Sybout Wijma
PRODUCTION MANAGER Myrthe van der Schuit
CIRCULATION MANAGER Adrian Holland
DESIGN ZeeDesign, Witmarsum, www.zeedesign.nl

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

SUBSCRIPTIONS
GIM International is available bimonthly on a subscription basis. Geospatial professionals can subscribe at any time via https://www.gim-international.com/subscribe/print. Subscriptions will be automatically renewed upon expiry, unless Geomares receives written notification of cancellation at least 60 days before expiry date.

ADVERTISEMENTS
Information about advertising and deadlines are available in the Media Planner. For more information please contact our marketing advisor: sybout.wijma@geomares.nl.

EDITORIAL CONTRIBUTIONS
All material submitted to Geomares and relating to *GIM International* will be treated as unconditionally assigned for publication under copyright subject to the editor's unrestricted right to edit and offer editorial comment. Geomares assumes no responsibility for unsolicited material or for the accuracy of information thus received. Geomares assumes, in addition, no obligation to return material if not explicitly requested. Contributions must be sent for the attention of the content manager: wim.van.wegen@geomares.nl.

COVER STORY

On the front cover of this year's bumper Intergeo issue: Millions of trees in an area spanning 500 square kilometres are being monitored in an unprecedented mapping project of the urban green environment in Warsaw, the capital city of Poland. The project, which is based on a unique multisensor photogrammetric platform, will result in the Tree Crown Map. (Image courtesy: MGGP Aero)

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

PENTAX

Focusing on true performance

NEW
Upgraded Advanced Total Station

G6Ti and G6Ni
GNSS Receivers

Powerful GNSS engine in compact and robust housing which provides stable precision measurement outcome in harsh outdoor environment.

R-2500NS Series
Total Station

A full-featured reflectorless total station with enhanced functionality. Providing exceptional performance and cost effective solutions to modern professional surveying works.

TI Asahi Co., Ltd.
International Sales Department
4-3-4 Ueno Iwatsuki-Ku, Saitama-Shi
Saitama, 339-0073 Japan

www.pentaxsurveying.com/en/
Tel.: +81-48-793-0118
Fax: +81-48-793-0128
E-mail: International@tiasahi.com

Fit for the Future

Changes are occurring all around us at an ever-faster pace, making the world we live in today completely different from the one we have been used to. Even just a decade ago, daily life was nowhere near as digitalized as it is now; our everyday work has evolved and so has society as a whole. Anyone who pauses for thought at Intergeo 2019 in Stuttgart can't fail to be astonished at how far our profession has come in the last few years – taking advantage of the recent technical advancements on the one hand, and helping to shape them on the other. And we haven't seen the end of it; technologies such as artificial intelligence and blockchain will certainly play a role in the years to come – the only thing we're still debating is how and when. So whether you're in a company, an educational institute or a governmental organization, it is always good to think about the future and how it will influence your business, research or governing activities.

If that holds true for all of us, it most certainly also applies to learned societies – including the ones in our field. President Rudolf Staiger of the International Federation of Land Surveyors (FIG) has acknowledged that and come up with a Work Plan 2019-2022, titled 'Volunteering for the Future'. The FIG Council Work Plan formulates actions that should support the number-one priority during his current period of office: making FIG 'fit for the future'. Two such actions are the installation of a task force on governance and the establishment of a working group that will develop a strategy for the future. It is indeed a challenging task that Staiger and his council members have taken upon themselves, but a very necessary and inevitable one.

The outcome is uncertain, so it is necessary to be prepared for every possible conclusion. In these changing times, we need to be ready for anything, including unexpected and maybe even unwanted results… that is what being 'fit for the future' really means. Conferences and trade shows are an excellent opportunity to get a sense of what lies ahead, and Intergeo is one of our industry's leading events. In other words, now is the perfect time to be thinking about what the future might bring for you and your company, and how best to prepare for that. If you would like to discuss the future of our profession or industry developments, please feel free to stop by our booth (#A3.052) at Intergeo. We hope to see you there!

Durk Haarsma, director strategy & business development

durk.haarsma@geomares.nl

A Decade of Geospatial Advancements

This year's edition in Stuttgart marks the 25th anniversary of Intergeo. My own personal Intergeo debut was back in 2010, in the city of Cologne, so this is an anniversary year for me too: it will my 10th time attending the event. In our review in 2010, we wrote: "Many exhibitors offered solutions for mapping and gathering information without annoying pedestrians or causing traffic jams by blocking the road. The number of mobile mapping systems on offer is still increasing, and the combination of systems mounted on a roof rack becoming more and more flexible." Since then, we have seen those systems evolve into today's much more sophisticated solutions. For example, the development of algorithms enabling simultaneous localization and mapping (SLAM) has led to mobile laser scanning solutions that are able to provide 3D data from GNSS-denied environments.

But the advancement of mobile mapping has not been limited to the ground only. We have seen unmanned aerial vehicles (UAVs or 'drones') take off – both literally and figuratively speaking – as one of the key devices for mapping and surveying. At my debut in 2010, there were just a handful of exhibitors cautiously showcasing their UAVs on a very limited scale. UAVs were a novelty at that year's event. I recall that the number of exhibiting UAV manufacturers increased only slightly in the first few years following my debut in Cologne, and around 2013/2014 some well-respected geospatial experts described UAVs as nothing but a hype. It was just a matter of waiting until the storm blows over, they said. Well, I have been waiting and working in the geospatial business ever since… and in the meantime we have all safely emerged from our storm shelters, only to discover that UAVs are still around.

Last but definitely not least, it is worth keeping an eye on the surveyor's workhorse: the total station. At Intergeo 2010, Leica introduced the Viva TS 15, an imaging total station, and our roving reporters also spotted imaging total stations by Topcon and Trimble – hands-free surveying had become a reality at last! From then onwards, total stations featuring a built-in digital camera for capturing job-site images gradually became mainstream, advancing the work of surveyors drastically. Of course, we have also seen the rise of terrestrial laser scanners as a vital measuring device. Having arrived on the geospatial scene at around the same time that I myself did, total stations have continued to evolve and now – as scanning total stations – combine their conventional capabilities with those of a laser scanner in a unique device.

As I prepare to attend my tenth consecutive Intergeo, I regard all the developments I have observed over the past decade as a tangible reflection of the innovation that characterizes the geospatial industry. Intergeo 2019 will without any doubt give us an exciting glimpse of what we can expect in the decade to come!

Wim van Wegen, content manager

wim.van.wegen@geomares.nl

PART OF HEXAGON

Leica Geosystems AG
leica-geosystems.com

- when it has to be **right**

Leica Geosystems

Tell the World: We Are More than Scan-to-BIM

Building information modelling (BIM) will be a growing opportunity for the surveying and spatial industry, providing we focus more on adding value to BIM and concentrate on what we can offer to other industries rather than merely preparing it. Opportunities in digital twins, smart buildings, smart infrastructures and smart cities require more than just BIM as data. The surveying and spatial industry will not benefit from this growing market without fully realizing the BIM market opportunity and providing advocacy, leadership and education in BIM.

EVEN MORE LIES BEYOND

With the increasing availability of laser scanning technologies, scan-to-BIM has become the major pathway for the surveying and spatial professional to contribute to the digital engineering of buildings and infrastructure. While there is a growing demand for the scan-to-BIM service within the architecture engineering and construction (AEC) industry, it is essential to note that this service – which effectively is a 3D surveying and mapping service – is a small part of the broader BIM economy. Analysis of the various facets of surveying and geospatial market reveals that the growth in surveying and mapping services and survey equipment is marginal. The message from the analysis is clear: the cost of collecting geospatial data will continue to decline and there will be limited growth in services related to surveying and mapping. In contrast, a fast-growing area is GIS and what we can do with the spatial data. We can draw some similarities between BIM and GIS. BIM will be no different to surveying and mapping if we only focus on preparing data and information. If we go beyond modelling building information, however, we can discover a continuum of opportunities.

ADOPT THE SDI PHILOSOPHY

As surveying and spatial professionals, our immediate contribution lies in modelling buildings and infrastructure and this is already being done with considerable success in the AEC industry. However, BIM is about more than merely representing buildings and infrastructure using spatial information; it is also about collaborative data environments (CDEs) and a solution for the fragmented AEC business model. Based on the spatial data infrastructure (SDI) philosophy and our expertise in spatial data management, standards can be adopted in developing CDEs to facilitate the operation of buildings and infrastructure. We have longstanding expertise in generalizing large-scale spatial data to create a small-scale map. BIM provides opportunities to evolve GIS technologies that are focused primarily on outdoor environments into technologies that can be used for indoor spatial analysis. One single building presents all these opportunities for creating BIM, creating CDEs, maintaining and analysing the BIM data and converting it to city models. However, the AEC industry is not yet fully aware of these capacities in the surveying and spatial industry.

ADVOCATE, LEAD, RESEARCH AND EDUCATE

There are endless opportunities for adding value to BIM and we need to find the niche for the spatial industry. The essential points in the BIM value-add are the need for data integration and information sharing, and for complete digital information about buildings. Our expertise in integrating, sharing and managing spatial information opens a new door and is an opportunity to gain more prominence in AEC. Moreover, we cannot play a more significant role in society and develop business opportunities unless we define and highlight what we can do by advocating BIM to stakeholders of the built environment. Plenty of questions are still unanswered: from integrating BIM with surveying and the spatial coordination of BIM, to translating data between BIM to GIS for our research and development community. Lastly and perhaps most importantly, we need to rethink the surveying and spatial engineering curriculum and to upskill the profession. There is an urgent need to update surveying and spatial training and education so that BIM becomes integrated into our knowledge and its prominence is highlighted to our students and the broader profession. ◀

▲ *Mohsen Kalantari.*

ABOUT THE AUTHOR

Dr Mohsen Kalantari is a senior lecturer in geomatics and associate director at the Centre for SDI and Land Administration in the Department of Infrastructure Engineering at the University of Melbourne, Australia. He teaches BIM, land administration systems and spatial analysis. He is also co-founder of Faramoon, a start-up focusing on the automatic generation of building models from point clouds.

✉ mohsen.kalantari@unimelb.edu.au

We are the #1 network for communication and cooperation among all relevant industry partners in Europe.
We invite you to grow your business by

- Increasing the influence of the European Aerial Surveying Industry on political and administrative decisions
- Promoting the benefits of aerial surveying data
- Harmonising standards through certification to ensure consistency and quality
- Working towards preferential airspace access for aerial survey
- Promoting the generation of new European-wide aerial survey initiatives and programmes that contribute to enriching European society
- Promoting collaboration and innovation amongst the community

EAASI
European Association of Aerial Surveying Industries

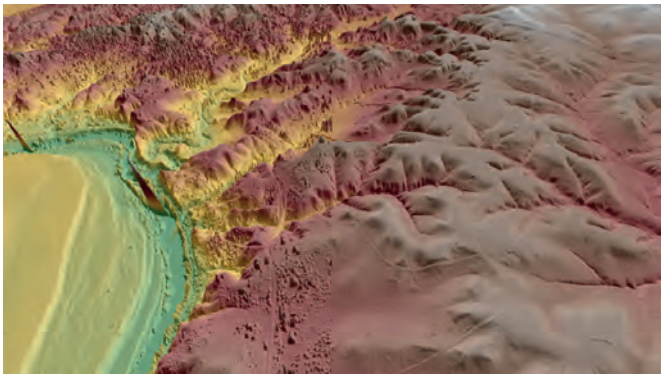
Join today and assure your seat at the Aerial Survey Summit in Brussels, 5 - 6 December 2019.

EAASI invites you to meet members and the Executive Board for Craftbeer and snacks at INTERGEO on Wednesday, 18 September 2019, 16:00 – 17:00. Hall 1, D1.007.

We are your voice to make Aerial Survey sustainable, make your voice heard by joining today. Visit:

www.eaasi.eu

Virtual Surveyor Enhances Lidar Elevation in UAV Mapping Software



▲ *Virtual Surveyor 6.4.*

Virtual Surveyor has enhanced the Lidar elevation data handling capabilities in Version 6.4 of its unmanned aerial vehicle (UAV or 'drone') surveying and mapping software. A new function enables Virtual Surveyor users to select specific feature classes from classified Lidar point clouds before converting the point cloud into a surface terrain. "The latest upgrades in Virtual Surveyor 6.4 are designed to meet the needs of UAV users who are increasingly equipping their drones with Lidar systems," said Tom Op 't Eyndt, CEO of the company in Belgium. Virtual Surveyor, which has doubled its user base in one year, is popular among surveyors because it bridges the gap between UAV photogrammetric processing applications and engineering design packages. The software generates an interactive onscreen environment with UAV orthophotos/DSMs and/or Lidar point clouds where the surveyor selects survey points and break lines to define the topography, creating highly accurate products up to five times faster than otherwise possible.

▸ **https://bit.ly/2MLIQ9w**

Ordnance Survey Demonstrates Pioneering BIM Project in Singapore

▲ *Marina Bay, Singapore.*

By combining building information modelling (BIM) with geospatial technologies, Ordnance Survey (OS) is breaking down barriers in Singapore. OS has spent two years in the Southeast-Asian nation championing the use of BIM data and its potential to transform urban planning. Britain's mapping agency lent its expertise to a project with the University of Singapore and the Singaporean government that aims to make Singapore a world leader in smart technology. OS's role was to develop data processing and 3D data modelling to help Singapore plan its future city more effectively. It contributed knowledge about the CityGML data model, an exchange compatible with BIM that stores digital 3D models and cities, so that data can be automated. Singapore's geospatial industry and urban planning departments are responsible for deciding what the city will look like in 20 to 30 years' time. Having more data, such as BIM, enables them to plan and design areas with specific groups in mind, such as the young, the elderly or community groups. Construction can take two or three years, so if urban planners can access information at the earliest stages, before a new high-rise building is built, it affords time to make changes and plan the outdoor environment around it.

▸ **https://bit.ly/2KvD2hD**

Lidar Technology for *Game of Thrones*

▲ *The* Game of Thrones *team generated 3D point clouds in Dubrovnik using Lidar.*

Lidar technology is more present in our lives than we realize – and sometimes even while we watch television, for instance. Imaging hardware and software from Teledyne Optech helped to enable 3D spatial data acquisition and visual effects for HBO's hit series, *Game of Thrones*. A team utilized Teledyne's Lidar technology to create a detailed 3D representation of the old city of Dubrovnik, Croatia, as the model for the fictional city of King's Landing. Lidar is becoming increasingly popular for creating realistic computer-generated imagery (CGI) and visual special effects. Traditionally, Lidar has been used for mapping and in construction, civil engineering, mining and transportation. The technology is now of particular interest to the film industry because of its ability to scan buildings – or even entire cities – in 3D, while maintaining a high level of detail and accuracy. Lidar's ability to generate exact replicas of locations reduces the time and cost for 3D modelling and helps create more realistic visual effects.

▸ **https://bit.ly/2YryP8m**

Atmos UAV Sets Foot in Southeast Asian Market

Atmos UAV, a Dutch manufacturer that develops high-end VTOL fixed-wing unmanned aerial vehicles (UAVs or 'drones') for surveying and mapping, has appointed Sonar Nusantara as its official distributor in Indonesia. Sonar, based in South Jakarta, offers solutions to a complete range of surveying needs through partnerships with global and well-known manufacturers in the geospatial industry. With this collaboration, Atmos UAV aims to meet the demand in the Southeast Asian region and provide local Marlyn operators with support and first-line maintenance. Marlyn is a fully autonomous hybrid (VTOL and fixed-wing) drone for mapping and surveying. With its patented design, Marlyn can take off vertically from anywhere, and map quickly and efficiently producing high-quality outputs for professional users.

▸ **https://bit.ly/2YWtg1m**

Hexagon Acquires Melown to Strengthen 3D Visualization Offering

▲ *A Melown Technologies 3D visualization of a digital urban model.*

Hexagon's Geosystems division has announced the acquisition of Melown Technologies, a Prague-based technology company, from Ivo Lukačovič's investment company, Helifreak Limited. Melown Technologies develops mass-scale computer vision and advanced visualization technology for interactive web-based rendering, enabling high-performing 3D visualization of digital urban and natural landscape models that are derived from aerial and terrestrial reality-capture sensors. "Melown Technologies has been the subject of takeover bids and offers of strategic cooperation for some time," says Lukačovič. "The bid from Hexagon was the most interesting as it offers us the best prospects for the future development of the company."

▸ **https://bit.ly/2ZEXSkX**

RIEGL Announces Investment in New Office and Production Facilities

RIEGL, a manufacturer of Lidar scanners for surveying applications, is investing heavily in the expansion of its production and office space. The continued, worldwide demand for high-performance sensors is allowing the company to grow and expand further. The company, which celebrated its 40th anniversary last year, is now meeting the rapidly increasing international demand for RIEGL laser scanners by expanding its office and production facilities. Recently, construction has started on a new office and production facility at the location of the company's headquarters in Horn, Austria. The new building will house the company's printed circuit board production and the software development team. The additional area comprises more than 2,200m² on three floors and will offer space for up to 80 employees. A state-of-the-art measuring tunnel system with a length of over 100 metres will also be built and used for testing and calibrating the RIEGL sensors. RIEGL is also continuing to grow in the USA. The company has been active and successful in this market for more than 25 years and is currently building a new North American office facility in Winter Garden, Orlando, Florida, offering 1,500m² of floor space. The building will offer trendy and modern workspaces for up to 50 employees. In addition to office space, the new RIEGL USA headquarters will also allow the company to expand in the areas of support, service and calibration for the complete RIEGL portfolio.

▸ **https://bit.ly/2ylYzxN**

▲ *New RIEGL production facility in Horn, Austria.*

UAV Maps New Zealand Beach to Create Detailed 3D Model

▲ *The Matrice 200 UAV coming in for a battery change.*

A landslide on Clifton Beach, New Zealand, earlier this year injured two Korean tourists when they were washed out to sea. Following this event, the beach was closed while Hastings District Council undertook a risk assessment. The Surveying Company was contracted to provide data collected by unmanned aerial vehicle (UAV or 'drone') to assist the council in making public safety decisions regarding access to the Cape. To map the cliff faces they used a combination of RTK GPS and a PPK GPS unit mounted to their UAV. Initially the surveyors concentrated on assessing the main rockfall where the tourists were injured, then proceeded with mapping the whole coastline from the Clifton Motor Camp to the Gannet Colony at the tip of the Cape to inform a quantitative risk assessment being undertaken by the council and the Department of Conservation. The reason for mapping the entire beach was to have a highly accurate 3D model to use as a baseline for future monitoring and rockfall event analysis. This data was necessary in order to determine whether the beach would be safe to access again.

▶ **https://bit.ly/2GRkdo4**

Airbus to Develop CO3D Earth Observation Programme for CNES

▲ *The Airbus-made CO3D constellation.*

The French Space Agency (CNES) has awarded the CO3D (Constellation Optique 3D) contract to Airbus. Under this agreement, Airbus will deliver a global high-resolution digital surface model (DSM). Following launch, which is expected in late 2022, the Airbus-made CO3D constellation, comprising four identical satellites, will deliver 50cm-resolution stereo imagery across the world on a daily basis. The data acquired will feed a cloud-based processing chain operated by Airbus and integrating CNES's algorithms to produce a cutting-edge 3D map of the Earth's landmass. Designed to weigh approximately 300kg, the CO3D satellites will join the Airbus fleet of optical and radar satellites, strengthening the company's ability to meet the growing needs of very demanding applications. Inaugurating a generation of highly innovative and all-electric platforms, these extremely agile satellites will instigate a new way of acquiring, processing and transferring images to the ground. Together with the four Pléiades Neo satellites, the CO3D constellation will offer impressive refresh rates for very-high-resolution imagery.

▶ **https://bit.ly/2yL07WI**

New Usage-based Service Plans for Trimble Catalyst Enable Precise Positioning on Demand

Trimble has announced that its Trimble Catalyst software-defined GNSS receiver for Android smartphones and tablets is now available with a usage-based service plan: Trimble Catalyst On Demand. The new service plan is focused on satisfying the requirements of a growing number of industries and organizations who recognize the benefits of using high-accuracy GNSS technology in the field, but need a more flexible payment model. Trimble Catalyst On Demand provides scalable access to RTK-quality GNSS positioning using an affordable pay-per-use hourly pricing model in addition to the current Catalyst monthly plans. The new service also enables automated domain-level email address access, which streamlines licence allocation for organizations with a large number of users.

▶ **https://bit.ly/2GPfB1t**

GeoDyn Launches High-speed Universal Aerial Film Scanner

▲ *GeoDyn's high-speed aerial film scanner.*

GeoDyn, known for innovative image conversion and processing technology, released and demonstrated PromptSCAN_2, a very-high-speed aerial film scanner, at the recent ISPRS Geospatial Week 2019 in Enschede, the Netherlands. PromptSCAN_2 accurately scans aerial film with resolution of 10, 15 or 20µm at two seconds per frame for panchromatic and three seconds per frame for colour. Thanks to its highly automated loading and exposure determination, it is possible to scan a complete film of 250 frames within 15 minutes – which is 50 times faster than any other aerial film scanner. This enables the very efficient conversion of valuable aerial film archives. During the ISPRS Geospatial Week 2019, PromptScan_2 was set up to continuously scan films. This highlighted GeoDyn's expertise at being able to bring PromptSCAN_2 to any aerial archive location and convert films in a fraction of the time and at a fraction of the cost that has previously been possible.

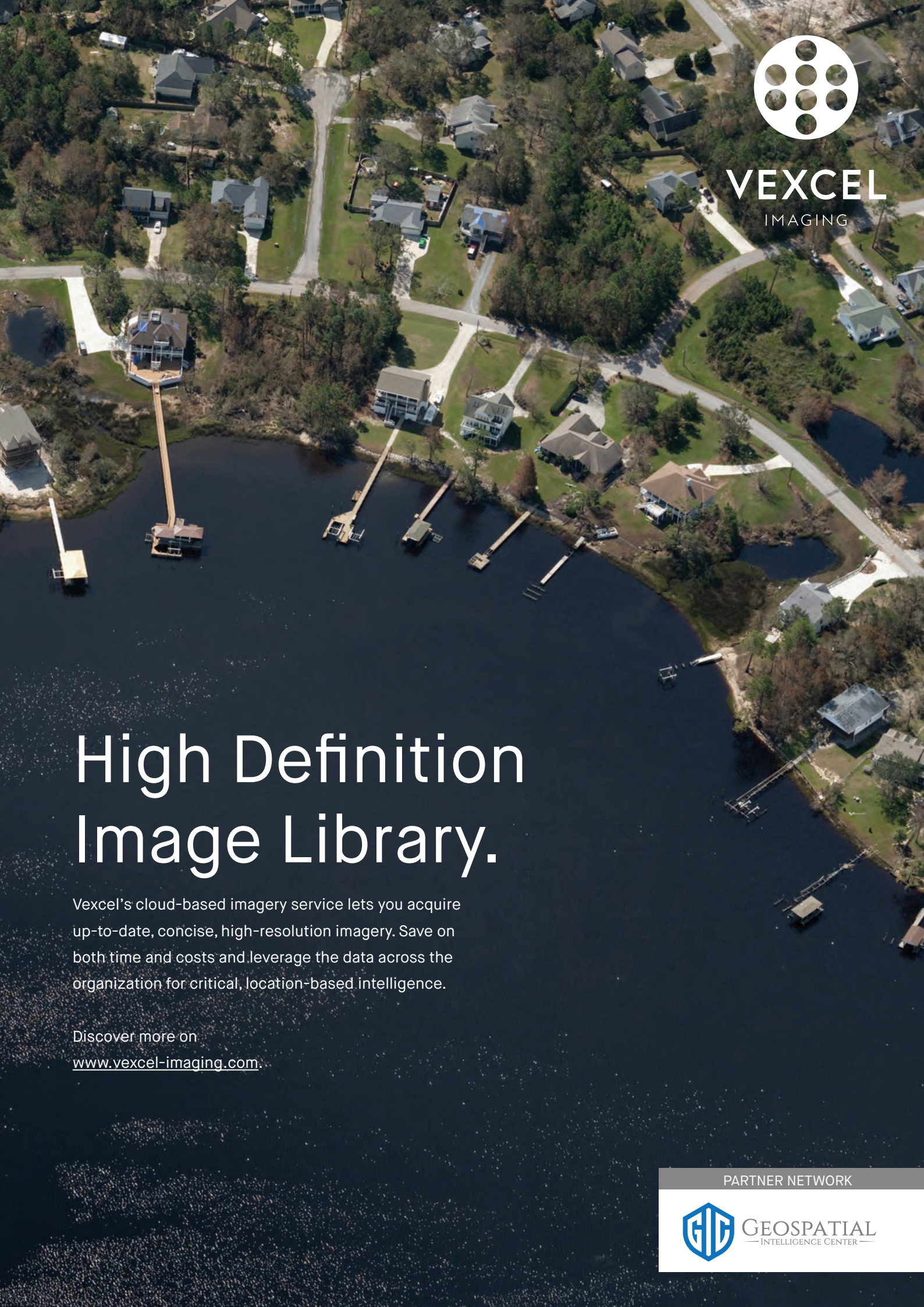
▶ **https://bit.ly/2TbMzON**

Arvizio Introduces Life-size Point Cloud Walk-through

▲ *A 350-million-point photogrammetry model of Melbourne, rendered in mixed reality.*

Arvizio has announced the introduction of new capabilities to its MR Studio enterprise mixed-reality platform. The new 4.0 release features hybrid rendering which allows GPU-accelerated resources to stream massive 3D models to multiple participants and simultaneously interact with point cloud and photogrammetry models utilizing Microsoft HoloLens and Magic Leap mixed-reality headset devices. Reality capture, using Lidar, 3D scanners or photogrammetry, is a powerful tool for capturing world-scale 3D scenes which have been typically visualized in 2D. The ability to stream enormous point clouds to immersive 3D devices opens up a whole new range of applications across industries including AEC, surveying and GIS, mining, energy and public safety initiatives. Point clouds bring with them a unique set of challenges due to the high number of points that must be rendered and the CPU and GPU limitations of headsets and mobile devices. Through a combination of dynamic level-of-detail processing and GPU-accelerated rendering, Arvizio can stream Lidar scans and photogrammetry models to untethered, standalone mixed-reality headsets.

▶ **https://bit.ly/2Yw3KjL**



High Definition Image Library.

Vexcel's cloud-based imagery service lets you acquire up-to-date, concise, high-resolution imagery. Save on both time and costs and leverage the data across the organization for critical, location-based intelligence.

Discover more on
www.vexcel-imaging.com.

PARTNER NETWORK

GEOSPATIAL
INTELLIGENCE CENTER

SENSORS TO ADVANCE THE MAPPING SECTOR

When Photogrammetry Meets Lidar: Towards the Airborne Hybrid Era

The airborne market for area-wide 3D data acquisition is experiencing a noticeable trend towards a hybrid mapping concept. In the near future, most airborne data collection will increasingly be performed by a combination of active and passive sensors. There are two main reasons for this. Firstly, collecting all relevant data while flying is an efficient and cost-effective solution, even more so when the flying restrictions and regulations are factored in. Secondly, exploiting the advantages of both light detection and ranging (Lidar) and dense image matching (DIM) point clouds will improve the quality of the final geospatial products. This article reports on the latest developments in the field of airborne hybrid systems, including both data acquisition and processing.

Almost all new generations of airborne Lidar systems integrate a Lidar unit and a passive imaging unit (in a single-camera or multi-camera fashion) in the same platform for concurrent acquisition of ranging and imagery data. Different combinations of the most recent technological trends in ranging and imaging are available, including (i) single-photon Lidar (SPL) or linear mode, multi-spectral and topo-bathymetric laser scanners, and (ii) nadir and oblique-looking cameras, equipped with RGB, NIR or hyperspectral sensors.

HYBRID SENSOR SYSTEMS

Table 1 provides an overview of the most recent hybrid sensor systems available on the market, including their main technical specifications as stated in the instrument datasheets. As far as the data collection is concerned, simultaneous multi-sensor acquisition from the same platform offers benefits in reducing the total flying time and costs, since all data of interest is collected in one go while already flying. However, there are still some challenges to tackle, such as the proper planning of the optimal conditions for concurrent acquisition of Lidar and images. Both flying-related parameters (e.g. height above ground and strip/image overlap) and environmental ones (e.g. time and season) should be carefully selected in order to find the best compromise for successful image matching and laser scanning.

HYBRID PROCESSING WORKFLOWS

The increased amount of data captured by these hybrid sensor systems requires the development of higher-performing workflows in order to efficiently scale the processing times to the user needs. Redundant processing steps should be eliminated, while extending the traditional processing chains for Lidar and airborne photogrammetry towards an integrated hybrid processing workflow. The game changer here is to consider it as a hybrid dataset rather than as separate Lidar and imagery data in order to jointly exploit their respective main strengths. Indeed, besides the clear advantage of enriching the monochromatic laser echoes with RGB information, and the possibility to generate true-orthophotos in one go, such a new hybrid processing workflow can integrate – and should ideally enhance – the most recent advances in both Lidar processing and photogrammetric/computer vision techniques. This represents a hot topic of research for both the scientific and the industrial communities. It involves two main aspects: (i) the simultaneous adjustment of Lidar strips and bundles of image rays, and (ii) the integration of Lidar and DIM points within augmented dense surface generation.

An integrated sensor orientation, in which image bundle block adjustment (BBA) and Lidar strip adjustment (SA) are performed concurrently, relies on searching for homologous features between Lidar and imagery, e.g. correspondences between Lidar points, image tie points and (when available) GNSS-measured control points. Such a hybrid adjustment solution is paramount to reduce the risk of bias between the generated Lidar and photogrammetric point clouds (i.e. to improve the relative orientation between them) and to increase the multi-sensor block stability under challenging configurations (e.g. corridor mapping). However, two issues should be properly dealt with. Firstly, correspondences should only be searched for in those areas where both Lidar and photogrammetry deliver consistent measurements of the Earth's surface; a deep understanding of the specific characteristics

Model	Manufacturer	Lidar unit					Camera unit			
		Laser wavelength [nm]	PRF(*) [kHz]	FOV [°]	Scan pattern	Vertical accuracy [cm](**)	# cameras	Spectral bands	Image resolution [MPx]	Focal length [mm]
CityMapper	Hexagon/ Leica	1064	700	40	circular	< 5	1 nadir + 4 oblique	RGB + NIR (nadir), RGB (oblique)	5 x 80	80 (nadir), 150 (oblique)
TerrainMapper	Hexagon/ Leica	1064	2000	20-40	circular	< 5	1	RGB+NIR	80	50, 80
SPL100	Hexagon/ Leica	532	6000	20-30-60	circular	< 10	1	RGB+NIR	80	50, 80, 150
Chiroptera 4X	Hexagon/ Leica	515/1064	500/140	28/40	elliptical	< 5 (topo)	1	RGB+NIR	80	50
HawkEye 4X	Hexagon/ Leica	515/1064	500/ 140/40	28/40	elliptical	< 5 (topo)	1	RGB+NIR	80	50
VQ-1560i-DW	RIEGL	532/1064	2 x 1000	58	cross lines btw channels	2	2	RGB+NIR	Up to 150	35, 50, 80
CP-780	RIEGL	1064	1000	60	parallel lines	2	2	RGB+NIR	Up to 150	35, 50, 80
VQ-880-GII	RIEGL	532/1064	700 /900	40	circular/ curved parallel lines	2.5	Up to 2	RGB and/or IR	100	50
VQ-840-G	RIEGL	532	100	40	elliptic	1.5	1	RGB	12	50
Galaxy T2000	Teledyne Optech	1064	2000	10-60	sawtooth	<5	1-4	RGB + NIR	150	50, 70
Eclipse	Teledyne Optech	1550	450	60	parallel lines	< 5	1	RGB	30	35
Titan	Teledyne Optech	532/1064/1550	900 (total)	60	lines	< 5	Up to two	RGB/NIR	29/80	-
CZMIL Nova	Teledyne Optech	532/1064	10-80	40	circular	15 (2σ)	2	RGB/ hyperspectr.	100	-
LiteMapper -7800VQ	IGI	1064	1000	60	parallel lines	2	Up to 5	RGB/NIR	150	40, 50
LiteMapper-4800VQ	IGI	1550	2000	75	parallel lines	2	Up to 5	RGB/NIR	150	32, 40, 50
LiteMapper -1560VQ	IGI	1064	2x1000	60	cross lines b/w channels	2	Up to 2	RGB/NIR	150	40, 50
LiteMapper -5800VQ	IGI	1064	2000	75	parallel lines	2	Up to 5	RGB/NIR	150	32, 40, 50

▲ *Table 1: Overview of the most recent airborne hybrid systems available on the market. (*)Max. pulse repetition frequency; (**)1σ value, under conditions specified in the instrument datasheets.*

of both measurement techniques is a fundamental prerequisite. Secondly, many Lidar-related, camera-related and trajectory-related parameters are involved within the integrated adjustment, and it is not easy to define their respective role (as unknowns, soft constraints or hard constraints) and weight. A rigorous hybrid adjustment is, for instance, implemented in the OPALS software by TU Wien.

3D reconstruction based on dense image matching, as facilitated by the SURE software by nFrames, is already a standard in the industry to produce dense 3D point clouds, digital surface models, true orthophotos and 3D meshes. It particularly benefits from the high availability of aerial image data, low acquisition costs, fine resolution of detail and availability of high-resolution multispectral information. If additional Lidar data is available and well co-registered, these results can be improved by the complementary sensor behaviour. Dense surface generation from imagery is particularly strong on detail and edges due to the high resolution defined by the pixel ground resolution. Meanwhile, Lidar technology is strong in its ability to retrieve low noise samples consistently with homogenous precision due to the reliable depth measurement of the active laser beam. This is particularly beneficial in the presence of poor texture, such as strong shadows or large white surfaces, where the passive texture matching is limited by the ability of the camera to resolve texture. Here, Lidar data can support the surface generation by additional depth measurements for better precision and completeness. Furthermore, polar measurements are helpful in case of small yards and very narrow streets, where the laser beam can occasionally reach the ground, while DIM reconstruction is often prevented by stereo-occlusions. Lastly, forestry applications additionally benefit from multiple returns and full waveform information of Lidar data. By integrating both data sources, this high completeness and reliability can support the high-resolution result from DIM, which delivers high fidelity along edges and other discontinuities, fine surface detail and particularly multispectral colour information.

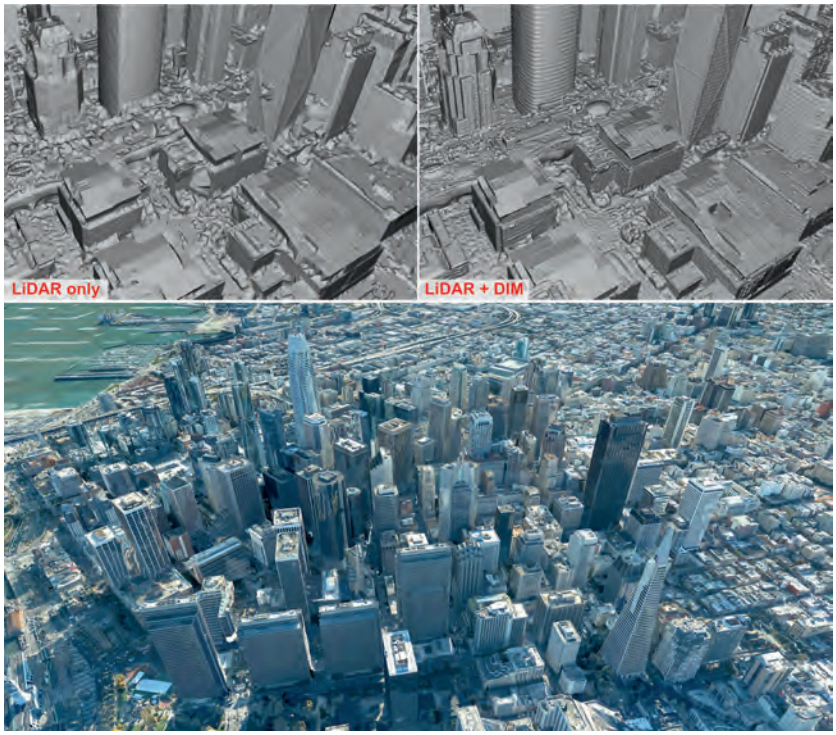
INTEGRATION CHALLENGE

The main challenge in integrating Lidar and DIM data consistently lies in proper consideration of their high variations in resolution and precision. In aerial applications, the dense image matching point cloud is typically of higher density and lower depth precision than the Lidar data when captured at high altitude, e.g. from fixed-wing aircraft. This is due to the resolution limitation of the Lidar beam divergence and repetition time on the one hand, and the availability of high-resolution large-frame cameras on the other. Furthermore, the variations of the local point-cloud precision for dense image matching can be high, particularly as the point precision depends not only on the ground resolution but also on the texture

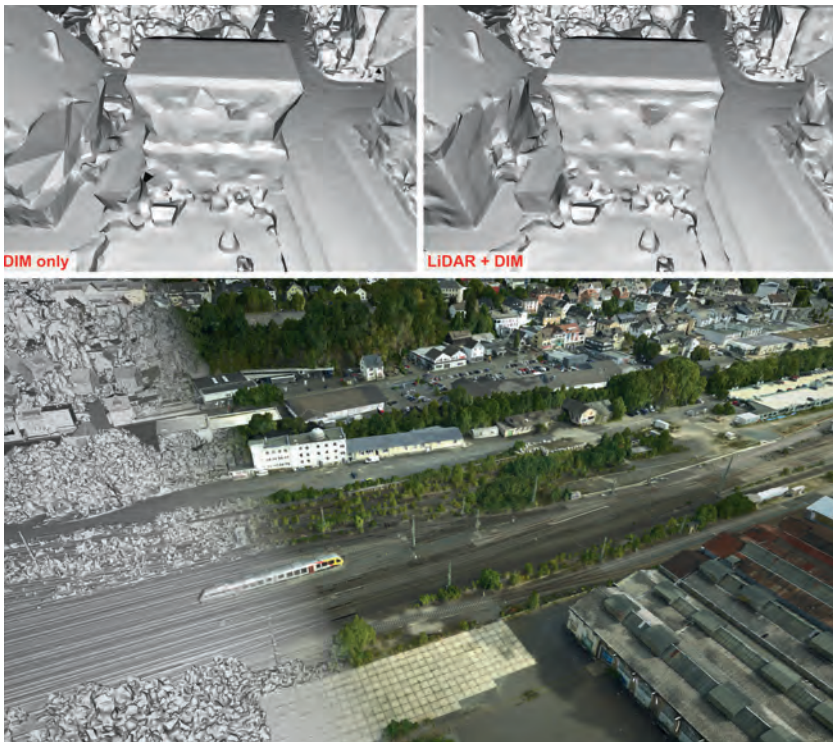
quality. Additionally, the intersection geometry of the stereo models has a strong impact as a quadratic function of the depth – which is particularly relevant for oblique imaging, where the depth variation is significant. Consequently, the depth fusion needs to be adapted to the precision of each point from both sensor systems. Within the nFrames SURE software, these photogrammetric precision values for each individual point are estimated and used during the fusion process.

HYBRID 3D GEOSPATIAL PRODUCTS

Two of the most prominent differences when comparing Lidar and DIM data as recorded by most hybrid sensor systems are the discrepancy in the achieved point density and the ability to retrieve points in narrow street canyons. This becomes especially obvious when looking at a dataset like San Francisco by Geomni (see Figure 1), which was captured with the Leica CityMapper airborne hybrid sensor. It combines tall buildings in the downtown area with a relatively low image overlap of 60% forward and 30% sideways, as well as a ground sampling distance of approximately 5cm in the imagery. When it comes to dense image matching, resolving points in San Francisco's narrow street canyons can be problematic, since tall buildings act as occluders in the aerial imagery, while image observations on the building tops can also be limited when the image overlap is low like in this dataset. In areas of the dataset where enough redundancy and a good geometric configuration of image rays are available (for example, on façades of buildings), dense image matching produces very detailed results due to the low ground sampling distance of the dataset and the oblique views of the buildings offered by Leica CityMapper's five camera heads. As an active polar measurement system, Lidar is capable of measuring points in street canyons where dense image matching lacks the required redundancy. At the same time, however, the spatial detail achieved by Lidar is relatively low (Figure 1, top left). By combining the data from both sensors, it is possible to produce a 3D mesh of San Francisco that features both the detail from dense image matching and the completeness and low noise levels from Lidar (Figure 1, top right). Figure 1, bottom, shows an overview of the 3D mesh produced



▲ *Figure 1: San Francisco – a 3D mesh extracted fully automatically from the Leica CityMapper sensor with an integrated Hyperion Lidar and multi-camera system, using the nFrames SURE software. Mesh geometry from Lidar only (top left), from both imagery and Lidar (top right), and overview of the 3D hybrid mesh (bottom). Data courtesy of George Halley, Geomni/Verisk.*



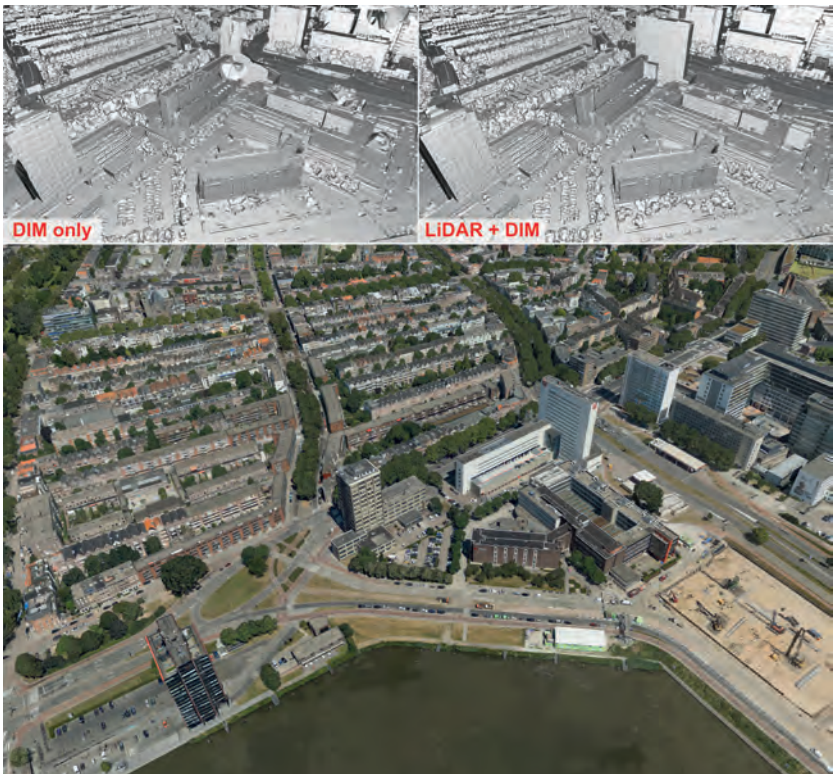
▲ *Figure 2: Betzdorf – a 3D mesh extracted fully automatically from the IGI LiteMapper-4800 sensor with an integrated RIEGL VQ-480i Lidar and nadir camera, using the nFrames SURE software. Mesh geometry from DIM only (top left), from both imagery and Lidar (top right) for an area with limited image coverage enabling higher completeness together with Lidar, and overview of the 3D hybrid mesh (bottom). Data courtesy of IGI.*

by a hybrid surface generation approach and supplemented with RGB texture from the multi-view imagery.

DETAILED RECONSTRUCTION

The hybrid dataset collected for Betzdorf, Germany, (see Figure 2) poses different challenges than San Francisco. It was captured by the airborne IGI LiteMapper-4800 which combines a RIEGL VQ480i with a 100MP nadir-looking camera, and includes imagery featuring a ground sampling distance of approximately 2cm and an overlap of 80% forward and 60% sideways. As visible in Figure 2 (top left), the missing oblique views can lead to data gaps in dense image matching, especially below overhanging structures of houses and close to the dataset boundaries where image redundancy is decreased. Thanks to the built-in Lidar scanner, however, this restriction can mostly be resolved in the integrated results (Figure 2, top right). An overview of the 3D mesh produced by combining Lidar and DIM data is given in Figure 2 (bottom). This also shows the level of detail with which the railway system is reconstructed. Here, Lidar and dense image matching data complement one another to allow reconstruction of both the railway itself and the poles alongside the railway.

Even though most datasets nowadays are captured at 80% forward overlap due to the significant resulting benefits of completeness and edge sharpness, the overlaps can still be limited for some applications, e.g. due to camera repetition rate or flying height. The Rotterdam dataset (see Figure 3) is an example of such a dataset. Captured using the Leica CityMapper flown at a relatively low altitude, it achieves an overlap of approximately 60% forward and 40% sideways and a very good ground sampling distance of approximately 3cm. As in San Francisco, such circumstances can result in data gaps arising during dense image matching – not only in street canyons, but also towards the top of tall structures (Figure 3, top left), where the image redundancy is further reduced due to the shorter distance between sensor and reconstructed object. As visible in Figure 3 (top right), integrating Lidar can greatly help to alleviate such issues while retaining the geometric detail of dense image matching throughout the rest of the dataset.



▲ *Figure 3: Rotterdam – a 3D mesh extracted fully automatically from the Leica CityMapper sensor using the nFrames SURE software. Mesh geometry from imagery with poor overlap of 60% forward and 40% sideways (top left), from both imagery and Lidar (top right), and overview of the 3D hybrid mesh (bottom). Data courtesy of Cyclomedia.*

CONCLUSION

This article has provided an update on the latest developments in the field of airborne hybrid systems, i.e. airborne mapping systems combining Lidar and camera (or multi-camera) sensors on the same airborne platform. Besides presenting the most recent hybrid solutions available on the market, it discussed the need for integrated processing of the concurrently acquired ranging and imaging data. It will be necessary to adopt a new perspective, one which looks beyond the traditional data processing chains and extends them towards a hybrid data processing concept. Integrated approaches for sensor orientation and surface generation are cornerstones for success in this context, both of which rely on a deep understanding

FURTHER READING

http://3dom.fbk.eu
www.nframes.com
Glira, P., Pfeifer, N., and Mandlburger, G., 2019. Hybrid orientation of airborne Lidar point clouds and aerial images. In: *ISPRS Ann. Photogram., Remote Sens. & Spatial Inf. Sci.*, Vol. IV-2/W5, pp. 567-574.
Mandlburger, G., Wenzel, K., Spitzer, A., Haala, N., Glira, P. and Pfeifer, N., 2017. Improved topographic models via concurrent airborne Lidar and dense image matching. In: *ISPRS Ann. Photogram., Remote Sens. & Spatial Inf. Sci.*, Vol. IV-2/W4, pp. 259-266.
Rothermel, M., Wenzel, K., Fritsch, D. and Haala, N., 2012. SURE: Photogrammetric surface reconstruction from imagery. In: *Proceedings LC3D Workshop*, Vol. 8, pp. 2-8.
Toschi, I., Remondino, F., Rothe, R. and Klimek, K., 2018. Combining airborne oblique and Lidar sensors: investigation and new perspectives. In: *ISPRS Int. Archives of Photogram., Remote Sens. & Spatial Inf. Sci.*, Vol. XLII-1, pp. 437-444.

ACKNOWLEDGEMENTS

Thanks to the contributing sensor vendors for their technical consulting and data sharing to support this research. A special thanks to George Halley from Geomni/Verisk, Jens Kremer from IGI and Bart Beers from Cyclomedia for providing publishing rights for the examples included in this article.

of the different properties of active and passive 3D imaging and of the uncertainty components in their measurements. The first solutions to address these issues are promising, as demonstrated by the 3D results achieved by combining Lidar and DIM data. They have clear potential to take the airborne mapping sector a step forward in terms of product completeness and geometric quality, object detection and processing efficiency. ◀

ABOUT THE AUTHORS

Isabella Toschi is a researcher in the 3D Optical Metrology (3DOM) research unit of the Bruno Kessler Foundation (FBK) in Trento, Italy. Since 2015, she has been investigating the potential of airborne oblique cameras and their combination with Lidar.
✉ toschi@fbk.eu

Fabio Remondino is the head of the 3D Optical Metrology (3DOM) research unit of the Bruno Kessler Foundation (FBK) in Trento, Italy. He received a PhD in photogrammetry from ETH Zurich in 2006. He is currently president of ISPRS Technical Commission II (Photogrammetry) and vice-president of EuroSDR.
✉ remondino@fbk.eu

Tobias Hauck is leading the research in the domain of integrating Lidar data into the nFrames SURE software. He graduated with a master's degree in electronic media and previously worked in software development for feature-film visual effects before joining nFrames in 2016.
✉ tobias.hauck@nframes.com

Konrad Wenzel is the CEO and founder of nFrames – a company developing photogrammetry software technology for large-scale mapping applications. In his role, he is responsible for strategic technology and business development. He graduated in geomatics and received a PhD degree in photogrammetry from the University of Stuttgart, Germany.
✉ konrad.wenzel@nframes.com

amsterdam
FIG WORKING WEEK 2020
10 - 14 MAY 2020 | RAI AMSTERDAM

SMART SURVEYORS FOR LAND AND WATER MANAGEMENT

The global challenges we are facing to create a sustainable planet need to be addressed in a smart way and require sustainable integrated approaches for sustainable land and water management. The FIG Working Week will facilitate the exchange of knowledge and technical expertise in Integrated Land and Water Management to address the impacts of climate change, mobility and rapid urban growth, unplanned development and environmental degradation.

The Netherlands has a long history of dealing with these challenges of building and managing a densely populated coastal country, with a land area of which nearly half is below sea level. The Dutch know how to do just this and have done so for centuries.

We put the Smart Surveyor at the centre stage and we are focusing on smart sensing technologies and new spatial data processing technologies

The digital transformation and new challenges affect our professional standards and practice. It also affects surveying education that needs continuous review, requires innovative teaching approaches and lifelong learning solutions. Therefore, your papers in these domains are more than welcome.

With only ten years to go, the FIG Working Week 2020 will be the platform for smart surveyors from all over the world to evaluate their actual and future role in achieving the UN Sustainable Development Goals.

REGISTER NOW AT:
FIG.NET/FIG2020

FIG
GIN Geo-Informatie Nederland
kadaster
ITC UNIVERSITY OF TWENTE.

SUBMIT YOUR ABSTRACT AND PAPER!
DEADLINE 1 NOVEMBER 2019

Seven Ways Cities Benefit from Digital Twins

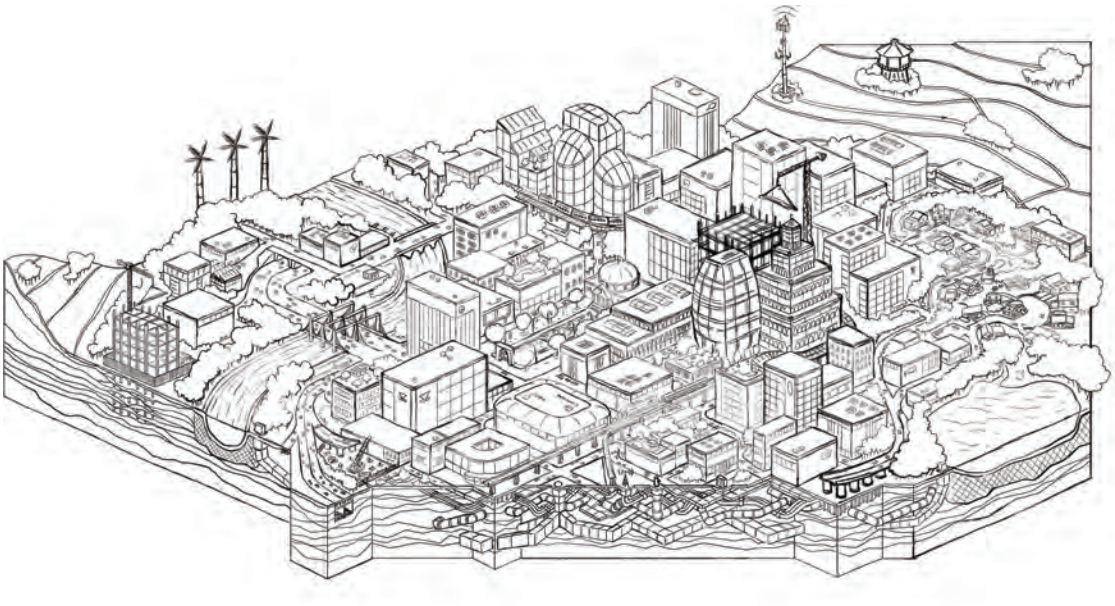
According to the World Economic Forum, the current 4.2 billion people living in urban areas will increase by 2.5 billion by 2050. This increase means that cities and supporting ecosystems must deliver on housing and infrastructure needs while also addressing quality of life, economic growth, safety and security, and resiliency. Assets are becoming increasingly vulnerable to climate-related forces: rising sea levels, drought, seismic activity, and violent storms. Cities seek solutions to help them both minimise chronic stress on current infrastructure and mitigate, respond to, and recover from the acute shocks of earthquakes, floods, and other catastrophic events.

To address these very real challenges, each city data owner needs to make accurate and relevant infrastructure information accessible across necessary departments, to the city ecosystem, and often to citizens.

It is important to trust that information used to support city infrastructure and services is complete and accurate. It is also important to have data help drive decision making when considering the effects of chronic stress on current infrastructure. And, it is important to have access to trusted data that can help to mitigate, respond to, and recover from acute shocks, such as those caused by weather-related events. City departments, its infrastructure, residents, and buildings are digitally advancing. With new technologies – such as Industry 4.0, the Industrial Internet of Things (IIoT), sensors, RFIDs, smart phones, and cloud services – cities can provide a range of new and enhanced services to residents. At the centre of this digital advancement in many industries are digital twins, a digital representation of a physical asset, process, or system, as well as the engineering information that allows us to understand and model their performance. Digital twins enable asset-centric organizations to converge their engineering, operational, and information technologies for immersive visualisation and analytics visibility. Made possible by advancing technology – such as the convergence of 3D/4D visualisation, reality modelling, mixed reality, and geotechnical engineering—digital twins provide an immersive and holistic view of infrastructure assets above ground and below ground.

"The power of a digital twin is in its ability to help decision makers derive new insights and inform better decisions, providing a holistic visualisation of infrastructure asset information and performance," said Robert Mankowski, vice president digital cities, Bentley Systems.

To gain a clearer understanding of digital twins, I offer seven ways in which city governments can benefit from advancing technology to improve efficiencies.



1. GATHER INSIGHTS THAT IMPROVE CITY INFRASTRUCTURE

While several cities have developed digital footprints using reality modelling, they are often no more than visually appealing 3D models. This is because different departments use different systems to manage data associated with their specific workflows and infrastructure assets. The data exists in a variety of formats – CAD, BIM, and GIS, engineering models, spreadsheets, databases, documents, real-time and historic IoT data streams, photos and point clouds. The data constantly changes, which makes it difficult to access and know that you have the right information at the right time.

By implementing an open, connected data environment (CDE), you can gain quick access to semantically rich models and know that they are accurate and up to date. "With Bentley iTwin® Services, an open-source framework for creating infrastructure digital twins, cities can federate data – whatever the engineering applications and BIM capabilities, repositories and file systems, or file formats and schemas might be," said Mankowski. "This federated approach enables an actionable digital twin of the city with data-driven analysis, modelling, and simulation, improving asset definition, configuration, geospatial location, and change management throughout asset lifecycles." Using these capabilities, city stakeholders can maximise operational budgets by extending the life of assets and equipment, making trusted information available whenever and wherever it is needed to support city infrastructure and services.

2. IMPROVE COLLABORATION ACROSS A VAST ECOSYSTEM OF CITY STAKEHOLDERS, CREATING ADDITIONAL VALUE FOR CITIES AND RESIDENTS

All stakeholders – from city departments, to the city ecosystem, to the city's residents – benefit from a collaborative approach to information. Highways, bridges and tunnels, rail, and other transit infrastructure are built, operated, and maintained within and between cities. So, it makes sense that these groups would benefit from effective collaboration. City operations, planning, and economic development, as well as emergency services and utility operators, all need to collaborate and share information with transportation agencies to improve decision making that results in the support of each group's initiatives. Thus, with a holistic approach to consuming and sharing information, infrastructure owners know that they have the latest information on existing conditions before projects begin. Moreover, by having the most accurate information, stakeholders can be more proactive when they plan for interruptions and communicate transportation and utility projects to the public, helping them avoid project areas. Additionally, this information enhances the city's ability to deliver on its promise of greater transparency, while communicating its vision for mobility and other infrastructure improvements.
Most cities experience a constant and simultaneous stream of projects at varying stages of completion, from transportation to utilities to buildings. For each project, the infrastructure owners and developers must consider the subsurface environment. The creation and curation of subsurface digital twins involves modelling the underground environment – geology, hydrology, chemistry, engineering properties – and the underground infrastructure – structures, tunnels, and utility networks. There are cautionary tales of the risk associated with this underground environment and the aftermath, where geotechnical teams are challenged to make right what is wrong, such as the sinking San Francisco Millennium Tower. Subsurface digital twins can be vital for assessing and managing risks throughout an infrastructure project, including through operations and maintenance.
"By its very nature, the physical underground environment is hard to visualise and comprehensively survey, so a digital twin that brings together the available data, makes it easily accessible for engineering analysis, and provides 4D visualisation capabilities can greatly improve understanding of the subsurface," said Mankowski.

3. IMPROVE MOBILITY AND SAFETY IN PUBLIC SPACES – EVEN WHEN HOSTING LARGE EVENTS

Digital twins help optimise how space is used to improve planning and designing of buildings, as well as to improve safety, efficiency, and revenue. They also provide users with the ability to simulate and analyse foot traffic on or in infrastructure assets, including rail and metro stations, stadiums, shopping malls, and airports. Using digital twins, engineers and designers can accurately test designs and operational and commercial plans to enhance footfall, wayfinding, crowd management, safety, and security.

4. IMPROVE URBAN PLANNING AND PROJECT VISUALISATION

With this technology, urban planners can stream large-scale digital twins online to visualise projects spanning entire cities down to the street level using a combination of terrain models, reality meshes, and semantic 3D city models. The technology allows urban planners to achieve a higher level of detail in their plans. Building owners also play a unique role in helping cities advance digitally. When intelligent models are associated with individual buildings, urban planners can merge these models into a citywide digital twin, making the information about the city even more intelligent. Using digital twins to engage developers and building owners during planning helps to influence the new

▲ *For the Helsinki 3D+ project, reality modelling plays a vital role, enabling the government to deliver the reality mesh and generate a 3D semantic information model in CityGML format to city stakeholders for developing projects, as well as to citizens, companies, universities, and researchers. (Image courtesy of City of Helsinki)*

or renovated space through incentives and zoning to ensure what is developed improves the residents' quality of life.

5. MAKE INFRASTRUCTURE RESILIENT: PREDICT, RESPOND, AND RECOVER FROM ACUTE SHOCKS

Extreme hydrometeorological events, combined with rapid urbanisation and inadequate draining substructures, trigger flooding and cause major damage to infrastructure, while impacting human safety and weakening the economy. To avoid flood risks and minimise the impact of a heavy rainfall, urban planners need to implement flood resilience technology that helps them comprehensively manage flood risks and rapidly recover from any disruptions caused by the event.

"When city departments have the systems in place to withstand the kinds of acute shocks caused by weather-related events, they effectively mitigate risk and shorten the recovery period," said Mankowski.

"Bentley's reality modelling solutions – along with our open applications – provide the ability to perform risk assessment at city scale, including what-if scenarios and post-event emergency triage."

With these systems, accurate and reliable risk and analysis data can be sent to agencies involved in flood preparedness, response, recovery, and mitigation. They also help resilience teams improve their decision making by using actionable insights to anticipate early warnings and promote response, increasing public safety and decreasing infrastructure damage. The systems help minimise service interruption, avoid additional mitigation cost, and improve response time. In addition, utilities can use information from the scenarios to define mitigation strategies, including cost/benefit analysis of changes to utility systems to mitigate future system issues.

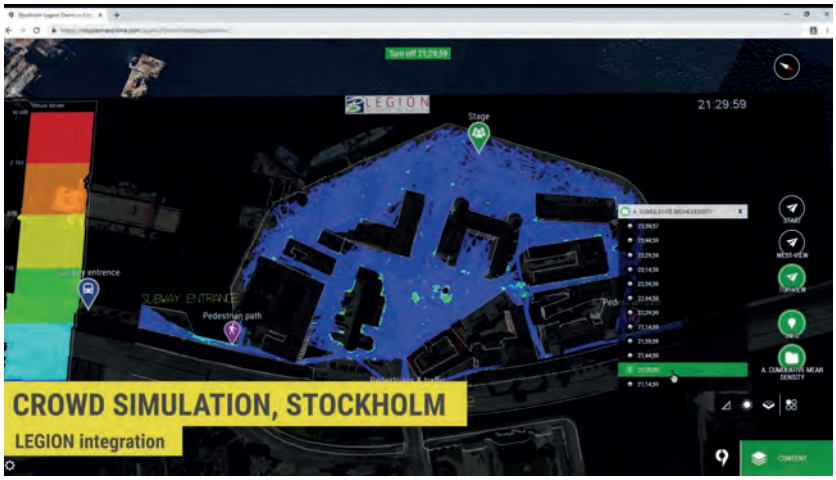
The effects of earthquakes are also significant and might include loss of life and damage to buildings and transportation infrastructure, as well as subsurfaces. Digital twins provide planning and response stakeholders with a platform to visualise, analyse, measure, and assess damages from a safe distance, while they identify what tactics they can use for recovery and appropriate egress routes.

6. ENGAGE THE PUBLIC AND CREATE A FEEDBACK LOOP

Digital twins also provide city planners with processes that help them get a quick buy-in on projects and for communicating plans in a comprehensive and visually aesthetic and compelling way. This communication helps residents understand how these plans impact their lives and provides information about ongoing projects to improve their safety and perhaps avoid commuting congestion near project sites. With digital twin technology, city planners can provide a fast, easy, and visual way to successfully communicate, promote, and share city projects in an interactive way to gain buy-in from residents and attract investors. This sharing includes delivering digital experiences (mixed reality and wearables), or visualisation and crowdsourcing through devices such as web, mobile, touchscreens, and digital billboards.

7. EMBRACE OPEN DATA INITIATIVES – ALLOWING OTHERS THE ABILITY TO CONCEIVE, DEVELOP, AND DELIVER SERVICES WITH TRUSTED CITY AND INFRASTRUCTURE INFORMATION

Many cities with digital city initiatives focus on open data environments. Also, many engage with universities, researchers, and other developers to offer apps and services to citizens via an open data initiative. ◀



▲ *Explore how pedestrians and crowds interact with infrastructure in preparation for large events to better understand ingress/egress or potential areas of congestion. With the use of LEGION to perform crowd simulation and OpenCities Planner which visualises a crowd gathering for an event in the city, points of interest are combined with the nearest subway entrance as well as ways out of the area. (Image courtesy of Stockholm, Sweden)*

▲ *With the help of a connected data environment, Águas do Porto, EM created a digital twin consisting of terrain information (GIS), real-time sensors, video surveillance of infrastructure, numerical modelling, remote data acquisition, and public reporting with the goal of using a digital twin to model and perform predictive analysis of the city's water supply, wastewater, stormwater, and bathing water systems to forecast flooding and water quality issues – improving city response and resilience. (Image courtesy of Águas do Porto, EM)*

DECADES OF INNOVATION
NOW FOR ANDROID™

MicroSurvey brings decades of innovation and expertise in survey field software creation to our next generation multi-platform FieldGenius application

Be among the first to join our MicroSurvey Technology Innovation Group and help mold our FieldGenius for Android™ software. Learn about all the advantages at microsurvey.com/FGA

EARLY ADOPTER
MICROSURVEY SOFTWARE

PART OF HEXAGON

Learn More
microsurvey.com/FGA

MicroSurvey FIELDGenius For Android™

NEW TASK-ORIENTED METHODS FOR DESIGNING CHOROPLETH MAPS

Against the 'How to Lie with Data' Classification

Choropleth maps are widely used for presenting population density, social index or other normalized statistical values related to spatial units. One of the 'white spots' on the research and development 'map' of cartography is that conventional methods for creating choropleth maps are data driven and may lose extreme values or small clusters of extreme values (hot spots) due to an unfavourable setting of class breaks. In this article, the author presents a new method and evaluation measures which enable better preservation of important spatial characteristics. The methods and software implementation result from the aChor project.

The choropleth map is a popular way to visualize thematic data, such as population density per spatial unit for example. The spatial units are coloured or shaded depending on value. The values are usually grouped into classes, and the classes with the lowest values are assigned less dominant colours or shades than classes with higher values. Spatial units may represent administrative areas such as municipalities, departments (e.g. in France), states (e.g. in the USA), counties (e.g. in Germany) or physical entities such as watersheds. Since each spatial unit receives one value, the number of values equals the number of spatial units. Choropleth maps give a quick and easy impression of how thematic data varies across a country or other geographic area. They are easy to interpret, but the simplification of the data introduces the risk of misinterpretation by the user or loss of essential information, such as extreme values. This affects visual perception, interpretation and decision-making, a topic which has been extensively covered by Monmonier (1991) in his book titled *How to Lie with Maps*.

EXISTING CLASSIFICATION METHODS

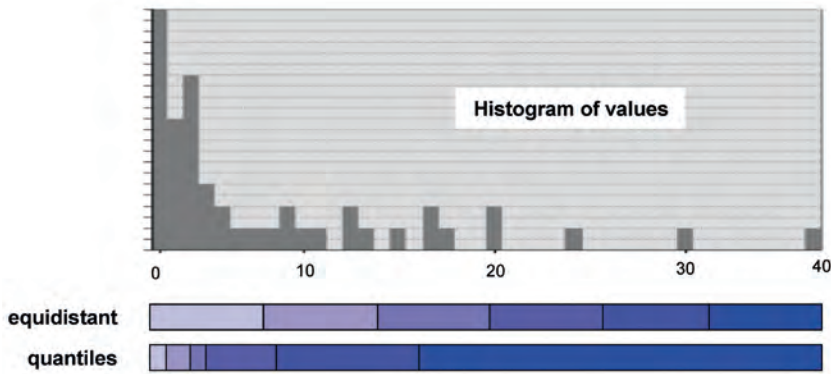
The transformation of the value range of thematic data to classes, called classification, requires the number of classes to be defined, the value range to be divided into the same number of intervals as the number of classes, and the colours or shades to be selected. The setting of the intervals is done by introducing thresholds, called class breaks. The setting of the class breaks in standard GIS and cartography software can be done in several ways, including:

- Dividing the value range into equal intervals (equidistant)
- Assigning the same number of values and thus spatial units to each class (quantiles)
- Detecting gaps in the value range and setting the class breaks at these gaps (natural breaks or Jenks optima)

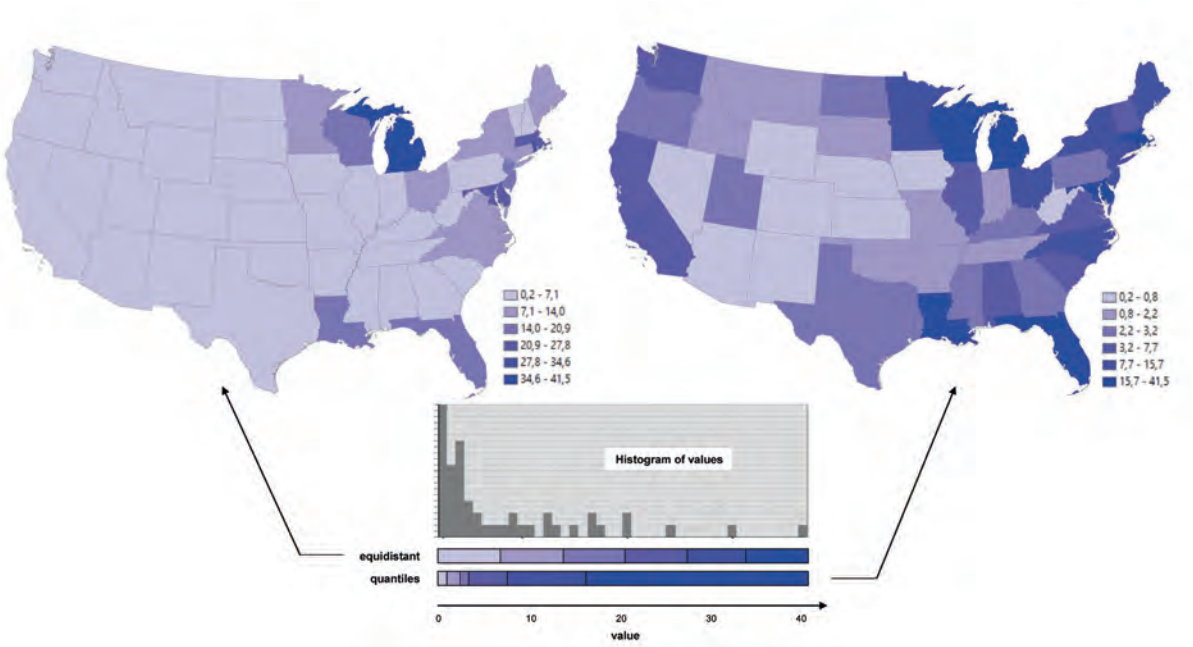
Figure 1 shows a histogram of the percentage of each state in the USA covered by water bodies. The histogram shows obvious gaps. This underlines that the choice of method, the setting of the number of classes, the many low values and the presence of isolated values significantly impact on the classification results. Although there is no one-size-fits-all classification method, it is possible to quantify the degree of uncertainty of the classification using measures. The aChor project developed and implemented measures for quantifying thematic uncertainty, spatial pattern and visual perception.

THEMATIC UNCERTAINTY

The variances of the values per class provide a measure for the thematic uncertainty. A low variance for each class is preferred since this guarantees that all values within the same class are similar or even identical, which reduces uncertainty. The within-class homogeneity describes the variation of values belonging to one class and is calculated as a variance measure, called Goodness of Variance Fit (GVF), which is the normalized squared differences of the values from the class mean. Normalized means that the GVF may vary between zero and one. In Figure 2, the equidistant method suggests uniform

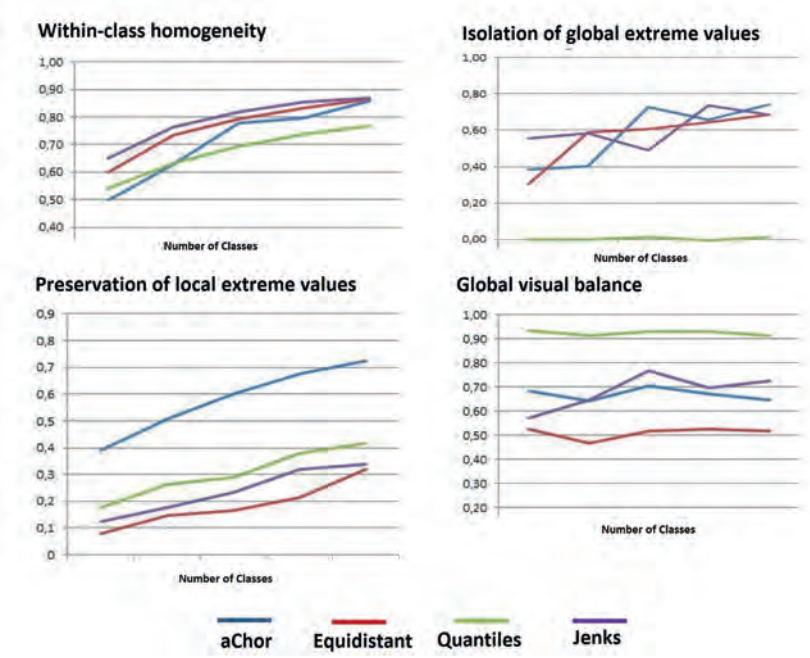


▲ *Figure 1: Histogram of data values used for generating the choropleth maps in Figure 2.*



▲ *Figure 2: Two choropleth maps showing percentages of area covered by water bodies per state in the USA using the equidistant method (left) and quantile method.*

behaviour with very few outliers resulting in a GVF of 0.77. This is better than the quantile method, which suggests more variety and higher values resulting in a GVF of 0.58. Alternatives are between-class heterogeneity or within-class matching values. Emphasis is often on the classes at both ends of the value range. One possible goal is the isolation of global extreme values. A measure, called GEX, can look for the – desirably small – number of elements in the two classes at the end of the value range and relate these to the number of elements that would appear in an equally distributed manner (GEX=0). A GEX value of +1 corresponds to one value in each of the two extreme classes. Applied to Figure 2, the quantile method has a nearly equal distribution (GEX=-0.04) while the equidistant method results in a GEX of -1.02 due to the many values in the class at the low end of the value range.



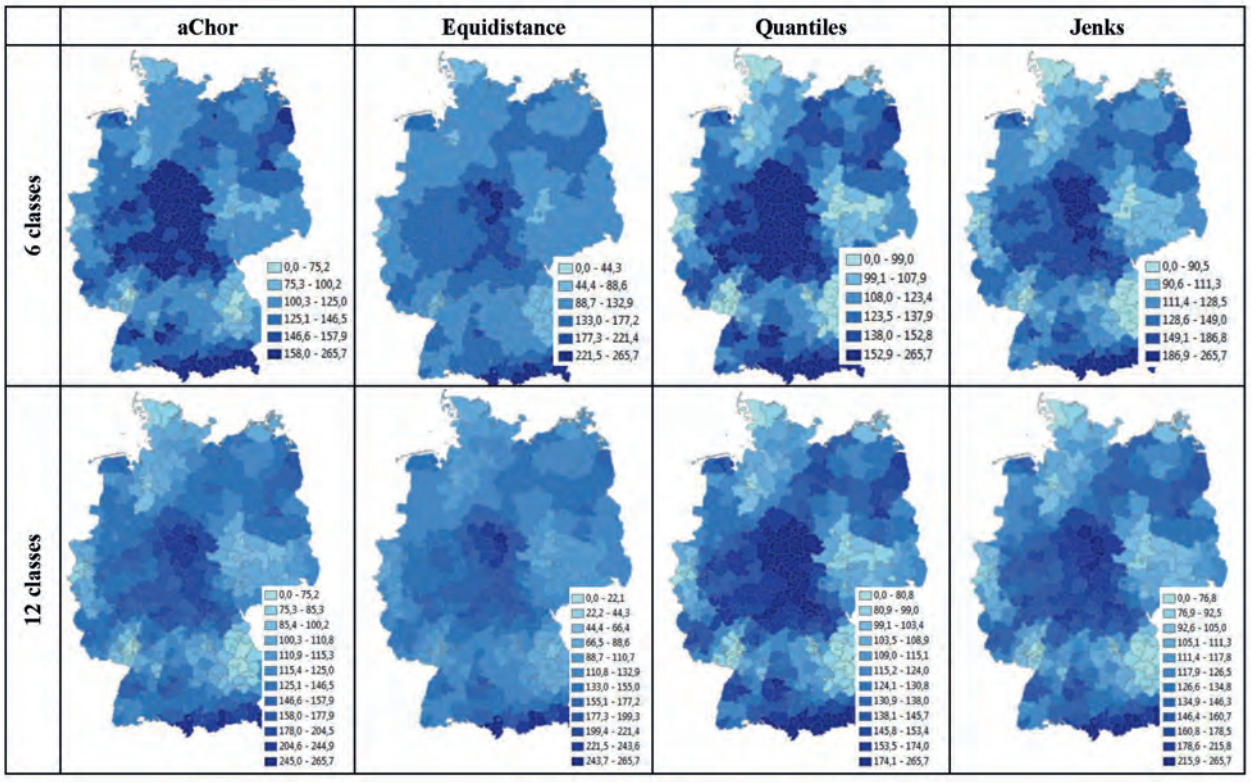
▲ *Figure 3: Performance of four methods applied to a rainfall dataset for Germany (July 2017) acquired from the German Climate Data Center. The vertical axis shows the uncertainty values on a scale from zero (worst) to one (best); the number of classes varies from four to 12 with an interval of two.*

SPATIAL UNCERTAINTY

Equidistant, quantiles, Jenks or other conventional methods are data driven and thus do not necessarily preserve spatial patterns. Extreme values, hot spots, edges or clusters might therefore get lost. Spatial uncertainty measures are rare. One of the measures is concerned with the preservation of local extreme values of spatial units. These spatial units show a larger (smaller) value compared to all neighbouring spatial units. Consequently, the data classification should not aggregate neighbouring spatial units into the same class assigned with the extreme value spatial unit. Of the 17 spatial units with an extreme value in Figure 2, the quantile method preserves 65% and the equidistant method 29%. To tackle the loss of spatial patterns by classification new task-oriented approaches are developed in the aChor research project (Chang & Schiewe, 2018), offering an alternative for GIS users and cartographers. For preserving extreme value spatial units, among all neighbours, the minimum of the absolute difference values is identified and stored together with the local extreme value. Later, at least one class break has to be placed within this interval. Class break setting is performed by applying a plane sweep algorithm.

PERCEPTUAL UNCERTAINTY

Dominant colours strongly affect visual perception, which is beneficial when spatial units with high values are rare. But large spatial units with high values are perceived more dominantly than smaller ones with the same high value, which is detrimental in many



▲ *Figure 4: Eight choropleth maps of the rainfall dataset evaluated in Figure 3 using four classification methods, and six and twelve classes.*

cases. A measure to quantify the proportion of the geographic area covered by one class is the ratio of the area covered by the class and the area of the entire geographic area divided by the number of classes. Applying this measure, called global visual balance, to the two choropleth maps in Figure 2 results in 0.77 for the quantile method and 0.22 for the equidistant method. The difference is caused by the area dominance of the class at the low end of the value range in the equidistant map. To detect huge area differences within the same class, the largest and smallest areas within the class may be considered, resulting in a measure called within-class visual imbalance.

EVALUATION

The performance of the measures was evaluated on various datasets. Figure 3 gives an example showing similar trends and values concerning within-class homogeneity for all methods – with Jenks being best and quantiles worst. Isolation of global extreme values shows strong variations. The quantile method shows weak values close to zero. In general, equidistance shows best results. Preservation of local extreme values shows monotonically increasing measures with an increasing number of classes for all methods. aChor always shows significantly better results. Global visual imbalance appears best with quantiles, resulting from the similar sizes of the spatial units. Equidistance always delivers the worst results. Figure 4 shows eight choropleth maps of a rainfall dataset for Germany using four classification methods and division of the rainfall data value range into six and twelve classes.

CONCLUDING REMARKS

Within the aChor project the methods have been implemented as a plug-in tool embedded in open-source QGIS, using open-source Python modules such as GDAL (Geospatial Data Abstraction Library), PySAL (Python Spatial Analysis Library), Fiona, Shapely and RTree. ◀

FURTHER READING

- Chang, J. & Schiewe, J. (2018) An open-source tool for preserving local extreme values and hot/cold spots in choropleth maps. *Kartographische Nachrichten*, 68(6): 307-309.
- Monmonier, M. (1991) *How to Lie with Maps*. University of Chicago Press.
- Schiewe, J. (2016) Preserving attribute value differences of neighboring regions in classified choropleth maps. *International Journal of Cartography*, 2 (1) 6-19.
- Schiewe, J. (2018) Development and comparison of uncertainty measures in the framework of a data classification. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*, XLII-4, 551-558.
- Lab for Geoinformatics and Geovisualization: www.g2lab.net
- GitLab account of project aChor: https://gitlab.com/g2lab/aChor/
- QGIS plug-in of aChor methods: https://plugins.qgis.org/plugins/aChor/

ABOUT THE AUTHOR

Jochen Schiewe is a professor of geoinformatics and geovisualization at HafenCity University Hamburg, Germany, vice-president of the German Cartographic Society (DGfK) and chair of the DGfK Commission on Cartography and Research. His research interests include cartographic algorithms, uncertainty modelling and visualization, and journalistic cartography.
✉ jochen.schiewe@hcu-hamburg.de

IGI UrbanMapper & DigiCAM

IGI UrbanMapper-2

2-IN-1 Large format & oblique
RGBI
30,460 x 14,100 px
Extended RGB
34,500 x 14,100 px
NIR, CIR, 4x RGB oblique
14,204 x 10,652 px

IGI DigiCAM-450

Large format camera system
RGBI
30,460 x 14,100 px

IGI Dual-DigiCAM-300

Large format camera system
RGBI
22,000 x 13,400 px

All systems are integrated with:
- » *IGIvisu* (Sensor Management)
- » *AEROcontrol* (GNSS/IMU System)
- » *IGIplan* with *CCNS-5* (Mission planing & flight guidance)

Visit us at PhoWo & INTERGEO 2019 in Stuttgart, Hall 1, Stand E1.067. For more information visit: www.igi-systems.com

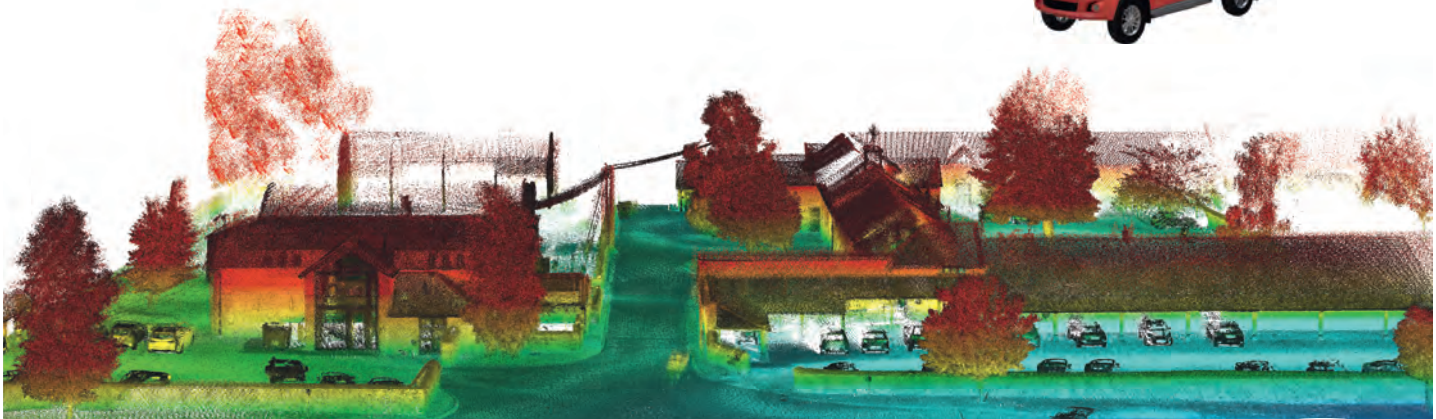
---

DIRECT GEOREFERENCING

OXTS Inertial+GNSS

INERTIAL NAVIGATION SYSTEMS

FOR UNMANNED & MANNED VEHICLES



BEST PRACTICES IN DRONE MAPPING

Can a UAV Fleet Help Your Business Take off?

Imagine flying to the most desolate and inaccessible regions, taking ultra-high-quality images and downloading them in real time, all from the comfort of your office. As *GIM International* has extensively covered in numerous case studies over the past years, this is no longer a pipe dream; nowadays, lightweight, high-performance unmanned aerial vehicles (UAVs or 'drones') can collect an extraordinary amount of data, offering greater accuracy and more precision than satellite imagery. UAVs are increasingly becoming the solution of choice and have indeed proven to be a disruptive force across a multitude of industries in the past decade, including the geospatial surveying profession. But will drones really provide all the answers to your mapping challenges? We interviewed five pioneers in the field to take us beyond the hype, explaining the lessons they have learned from the frontline and sharing their insights on the best ways to introduce UAVs into your business model.

WHAT TYPE OF WORK CAN UAVS BE USED FOR?

UAVs can serve mapping and surveying professionals in a broad variety of ways. They are useful to collect spatial data like volume numbers as well as for a suite of other end products such as orthophotos, detailed elevation models, contour lines, 3D PDFs or special plans with cut-and-fill areas. They can also be used for projects such as those involving land subdivision, terrain inspection for construction and signalling terrain borders. In the UK Andrew Griffiths, founder of Droneflight, uses "the senseFly eBee for survey work, and a variety of multi-rotor drones for survey and inspection including Aerialtronics' Zenith, Parrot Bluegrass, DJI M210 and the Flyability Elios". These devices have proven critical to the success of a number of large infrastructure and development projects including tunnelling, quarries, rail, highways and waste disposal. UAVs have been used to collect data, but also to provide clients with "a better understanding of project progress". At Lerch Weber SA in Switzerland, a seven-strong team uses drones for volume calculation and orthophoto purposes, whilst SRDP Consulting Inc, a Philippines-based enterprise, also uses drones for infrastructure inspection work as well as topographic mapping. Tom Wren, UAV manager at Plowman Craven, deploys drones for surveying, inspections and building information modelling (BIM), declaring that "UAVs are a real game-changer," offering more efficiency and a wider range of business opportunities.

WHY SHOULD YOU CONSIDER INCORPORATING UAVS INTO YOUR BUSINESS MODEL?

UAVs are ideal for projects that require a high degree of rigour and detail, since they have the capacity to map individual locations or macrostructures/terrains with great precision. Since UAVs can obtain high-resolution photographs, they make metric orthophotography, vectoral mapping schemes and detailed cartography including hydrographic and topographic maps possible. UAVs are relatively small-scale pieces of equipment and can fly very close to the ground in comparison with manned aircraft. They are nimble, agile and manoeuvrable, capable of hovering and of accessing spaces that are too difficult, hazardous or unsafe for people to reach, which enables observation and recording in previously inaccessible areas. In rail projects, for example, surveys are ideally "conducted with no personnel on the tracks and no need for track closures, and in as short a time as possible to minimize disruption", making drones the perfect solution for such projects at Plowman Craven. Using UAVs can significantly reduce danger to people and damage to equipment, as well as minimizing disruption in the target environment, thus keeping the overall risk to projects low.

UAVS: SAVING TIME AND MONEY

The cost-saving aspect of using drones is appealing to a lot of businesses, considering that even the most sophisticated drones cost significantly less than a helicopter or small aircraft. Whilst the initial outlay for a new UAV fleet and associated hardware, software and training might be significant, ultimately it could prove more cost effective, giving your company an advantage. Armin Weber of Lerch Weber SA found that conducting gravel pit surveys conventionally in the past was less economical and the business lost clients, whereas "with drones, we could be very competitive and we won back some of our clients; now, we have even more than before". All the experts interviewed agreed that investing in drones has been valuable, with Plowman Craven's Tom Wren stating

that his company wins "a lot of projects because of the breadth of deliverables and the timeframes we can deliver in. So from that point of view, [our] investment is constantly being paid back".

Weber explains some of the efficiencies enabled by drones: "In the past, our fieldwork flow included the setup of the ground control points. It was always very time-consuming. Today more and more drones are RTK/PPK capable, [which] reduces the need of ground control points dramatically". UAVs can be as steady as ground survey tools, saving time spent re-measuring due to human error. Drones can be deployed more quickly than organizing a helicopter or aeroplane flight, whether your own or contracting someone to do it, plus regularly flown routes can be automated. Hence, UAVs present a clear opportunity for surveying enterprises to save time and money.

STARTING CAN BE THE HARDEST PART

Weber cautions to "be aware that not everything works right away". It is important to be open to the idea of testing and refining, considering that the perfect setup might take time, but it is certainly worth pursuing. Griffiths agrees, suggesting that businesses start small, obtaining "a cost-effective drone that can be used for training and experimentation initially", and then using this process to increase knowledge and start to gain expertise.

When considering UAV fleet size, Weber suggests numerous factors that must be taken into consideration, including:

- Mission size: large or small? Is there a single point of interest?
- Could it be worth flying several drones simultaneously to reduce operation time?
- What about a spare drone in case of a failure?
- What meteorological occurrences need to be taken into account (e.g. like wind, rain or cold weather)?

Jakub Karas, director of UAS at UpVision, and Joel Ferrer Cruz, president of SRDP Consulting, both warn that having a backup drone is essential; purchasing at least two of each type will ensure the business is covered should there be complications. Cruz notes that "rotary drones are ideal for mapping areas that have limited space, while fixed wings are more suitable for larger areas". He recommends leaning towards reliable rotary drones to begin with, as they tend to cost less. Depending on the scope of planned work, Karas would establish a small fleet with a multicopter that has the possibility of changing sensors, a VTOL (vertical take-off or landing) and a smaller drone such as a Phantom 4 Pro. When selecting equipment, it makes sense to avoid drone systems that are unproven or not well reviewed within the industry.

Alternatively you could rent a drone to test it out first, or outsource some drone work to gain a better understanding of a drone before investing in it yourself. "Seeing a competent practitioner working with it, and being able to work with them, is an invaluable qualification tool," says Griffiths. The more practical and thorough your understanding is, the better your investment is likely to be:

▲ *Andrew Griffiths explained that his team at Droneflight undertook multiple evaluation exercises of real-world jobs to gain a complete understanding of the potential of the equipment, investing heavily in drone pilots.*

▲ *Jakub Karas with the UAV, just before take-off for a survey of the Erdenet Mine in the north of Mongolia.*

▲ *According to Joel Ferrer Cruz, once the business starts experiencing more demand, "local image processing software would be more efficient as it gives more capacity and flexibility to the image processing team".*

"Take small steps and validate the benefits" is his expert advice. The other experts agree, with Wren suggesting that commissioning an experienced consultant to set up your systems is beneficial.

HOW TO CHOOSE WHICH UAV TO INCORPORATE INTO YOUR BUSINESS MODEL

All five experts agree that it is absolutely critical to do a lot of your own research rather than accepting vendor promises at face value. Griffiths emphasizes that a vendor demonstration is never enough to gain true insight into the real-world limitations of a drone. Cruz says he talks to multiple manufacturers directly to get to know and compare their products, including by attending international expos which he sees as a way of staying updated on the latest trends and developments. Weber recommends relying upon established products and asking experienced users for their insights; drone user groups can help with feedback from their experience. Some UAV manufacturers offer webinars, which can be a useful way to collect a lot of intelligence about a range of different devices before committing to a major purchase, but it is even better to invite manufacturers or one of their users to engage with your team on a specific project. Griffiths found that this "enabled us to gain real practical working insight into the unit and the realities of operating it".

Questions you should be considering include:

- What is the intended use of the drone?
- What are the technical requirements?
- What are the real-world limitations of the drone?
- What are the regulatory requirements (such as aviation and other health & safety issues)?

It is critical to investigate your country's requirements in depth. In the Philippines, for example, the company, the personnel and each individual drone must be registered with and certified by the country's civil aviation authority. Complying with regulatory procedures is essential and comes at a cost, so a comprehensive budget that takes into account hardware, software, training, data processing and regulatory requirements is critical. Make sure you get things right before scaling up, too.

TO CLOUD OR NOT TO CLOUD? THAT IS THE QUESTION...

A drone can be described as 'just a device' – one that is being employed to acquire geospatial data. Then it all comes down to how to handle that data. Cloud-based processing for geospatial data has been around for a while. There are pros and cons that need to be weighed up. For example, the cloud is relatively straightforward to adopt for those new to UAV data processing, and can be an interesting option that pays off with a small number of orders. Griffiths considers cloud processing an "excellent entry point" since it simplifies the processing, and teams can obtain good illustrative results even without comprehensive training. However, Tom Wren (Plowman Craven) contends that jobs can be cheap to process in the cloud

IF UAVS ARE PLANNED TO BE PART OF YOUR LONGTERM BUSINESS MODEL, THE CLOUD WILL NOT OFFER ENOUGH SOPHISTICATION TO BE ABLE TO MEET ALL YOUR NEEDS

but take significant time, while turning work around rapidly is often key for clients.

Conversely, in-house processing demands major computing power and memory, and processing several thousand photos can easily take up days of staff time. This said, some clients prefer a comprehensive package with in-house processing included, enabling businesses to take control of the quality, timing and resolution of data collection and providing their own data rather than contracting a third party to do so. Joel Ferrer Cruz notes that once the business starts experiencing more demand, "local image processing software would be more efficient as it gives more capacity and flexibility to the image processing team". The experts also note that there are limitations to the cloud, with both Griffiths and Weber agreeing that, if UAVs are planned to be part of your long-term business model, the cloud will probably not offer enough sophistication to be able to meet all your needs. As Griffiths says: "Cloud-based solutions don't have the options to improve the quality of a photogrammetry model, use of GCPs is sketchy at best, and there is usually no ability to merge models together".

THE IMPORTANCE OF STAFF TRAINING

It is helpful for operators to have photogrammetry or field survey skills, and due to the expense of a drone fleet (and the accompanying hardware and software) it is important to invest significant time in staff training. Not all training is created equally, though, and some courses focus more on issues such as air law than on drone operation, so understanding the limitations of training is essential. Mishaps can occur, and it is worth investing considerable time to ensure adequate training is provided, drones are taken seriously as a data collection tool, rules are obeyed and the mission checklist is followed closely. As Tom Wren states, "drones make everything easier… as long as you know what you're doing".

UAVS EQUIPPED WITH REMOTE SENSORS CAN OFFER MAPPING AND SURVEYING COMPANIES UNPRECEDENTED CAPABILITIES TO ACHIEVE PRECISION AND ACCURACY

▲ *At Lerch Weber SA in Switzerland, a seven-strong team uses drones for volume calculation and orthophoto purposes.*

Andrew Griffiths suggests that skilling up dedicated staff to become drone specialists could be a wise decision for the business, and these experts could then "manage the equipment, suppliers and support the use of the drones in the wider organization".

All five experts emphasized how critical comprehensive training is, with Griffiths explaining that his team at Droneflight undertook multiple evaluation exercises of real-world jobs to gain a complete understanding of the potential of the equipment, investing heavily in their drone pilots. This approach of deploying and completing a task from beginning to end gives pilots responsibility for the quality of the project deliverables for clients, which works for the business. Jakub Karas has organized his team in a similar way, finding that it improves the process when pilots and operators have insight into the processing, planning and mapping components of the work. Other experts differ on this, with both Wren and Cruz preferring to maintain employee specializations. They keep the data collection and data processing teams separate but ensure that the data processing specialists are exposed to drone work in order to appreciate the spatial context of the image acquisition component.

THE LIMITATIONS OF UAVS

It is important to consider the limitations of drones. Most drones are small, which means a limited payload (i.e. carrying capacity) for critical components like cameras and sensors. Another limitation is that most drones rely on battery technology, meaning fairly short flight times. Whilst longer-lasting batteries can extend flight time, these tend to be heavy, adding to the payload, and data collection activities across large areas are therefore likely to require multiple flights or manned aircraft. Reliance on GPS technology, which is susceptible to interference from various wireless sources, is another challenge.

Cruz reminds us that UAVs are not the answer to every geospatial surveying

problem, stating that in his experience they cannot cover all his company's mapping needs: "For large and difficult areas, we still opt to use manned aircraft. Urban areas and high-wind areas such as mountains are more safely and efficiently mapped using manned aircraft". It is worth thinking about the ways in which drones could expand the range and increase the quality of the products and services offered by your business as a complementary method rather than seeking to completely replace traditional methods with drones.

CONCLUSION

Cruz reflects that "drones have become a real game-changer for us", noting the positive effect they have had on his business in terms of opening up new opportunities and enhancing the products and services delivered to clients. Griffiths notes that "when the use of drones becomes part of the 'business as usual' of an organization, the benefits of the technology can really be leveraged". Thanks to the use of UAVs for surveying projects, the results obtained are likely to be more up to date, detailed and indeed far superior than those obtained with traditional tools. UAVs equipped with remote sensors can offer mapping and surveying companies unprecedented capabilities to achieve precision and accuracy, resulting in cost savings at both the data collection and data analysis levels. The impact that UAV technology is having on the geospatial industry is certainly disruptive, but it is important to navigate regulatory issues, seek expert advice, do your research and consider the challenges as well as the opportunities for your own enterprise. ◀

▲ *Andrew Griffiths, founder of Droneflight.*

▲ *Armin Weber, survey engineer/co-owner at Lerch Weber SA.*

▲ *Joel Ferrer Cruz, president of SRDP Consulting.*

▲ *Jakub Karas, director of UAS at UpVision.*

▲ *Tom Wren, UAV manager at Plowman Craven.*

Analysis of a Galileo Outage: With or Without You?

It is Tuesday, 18 July 2019; technical weather is forecast as I get into my car on my way to an important GNSS verification test. Yesterday I had received a short e-mail from the local reseller, informing me that Galileo is off air. Should the verification go ahead or not?

Part of the purpose of the verification test was to validate the manufacturer's claims about the receiver by using the associated PPP correction service from a different supplier. Because most receivers come 'tied' to a PPP correction service supplier, we needed to test both at the same time, even though the client is not (yet) buying a new PPP correction signal. However, that is the way it is with proprietary PPP signals and licences for certain manufacturers for certain receivers only. If you want to switch your PPP provider, you have to buy a new GNSS receiver… (this is one of my personal bugbears; I have been in open standardization too long to willingly accept this behaviour).

Getting back to the point of this column: in this case the receiver/correction provider combination supports Galileo which, according to professional wisdom (or at least the EU's PR department), should greatly enhance the achievable accuracies. That is why we needed to discuss the issue of Galileo not being available. But the information in the e-mail was news to me. Normally I'm not slow to pick up on any GNSS news; after all, I make a living out of knowing a lot about GNSS. However, this was the first I (and the client) had heard about the outage situation. Further investigation revealed it was in fact old news. By the time I received the e-mail on 17 July, the problem had already been going on for a whole six days.

When I arrived at the verification site (a GNSS control point somewhere in the middle of the Netherlands), the reseller informed me that according to both the Galileo organization and the PPP provider, Galileo should be usable again, but we might "experience service instability". This quote is taken from the Notice Advisory to Galileo Users issued at 08:20 on 18 July (the advisory in which they declared the system was usable again).

Therefore, we decided to switch off Galileo completely for the test… and we found that the receiver made the grade without Galileo services giving us (after three hours of logging) an average and standard deviation in height of 2.7cm using the remaining GPS, Glonass and Beidou corrections. Could we have switched it back on and obtained better results? Who knows? All I can say is that it took until 22 July before Galileo control got the system back into a completely stable state.

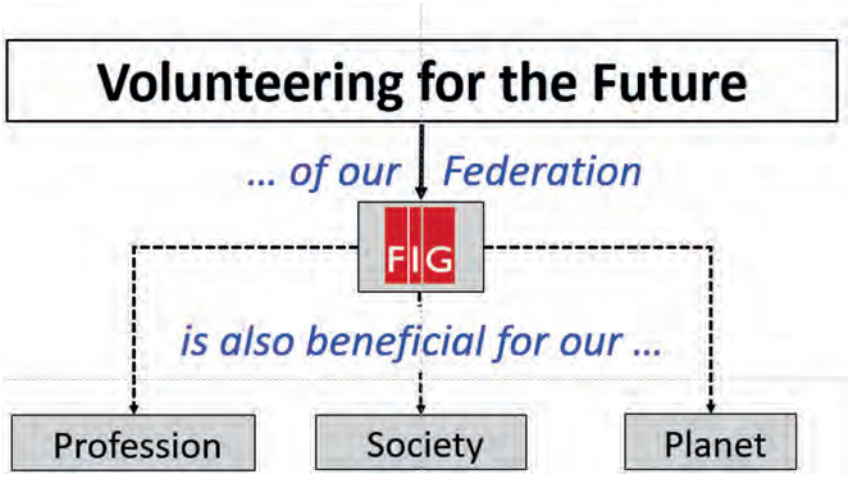
So, what can we learn from this situation? Two things. First of all, that we don't need Galileo. It may be useful, but the other systems do a great job without it. But the most important thing I have learned is the tremendous effect your PR department can have on your operations. Why do I say this? Well, the first news release is dated 14 July but was not picked up by any major news site or the 'in crowd', apart from a small item on the Novatel website. It wasn't until 18 July that the news was picked up more broadly, by which time the GSA declared the system to be usable again (except that it wasn't…!). It is still unclear what sort of instability could have been experienced, but the system was in a poor state for four days without anybody asking any questions. And when it was fully operational again, there were no headlines whatsoever. Four days and nobody noticed or nobody cared…

Kudos to the Galileo PR department!

Huibert-Jan Lekkerkerk is a contributing editor for *GIM International* and *Hydro International* and author of other various publications on GNSS and hydrography. He is a part-time senior lecturer in hydrography at the Maritime Institute Willem Barentsz (Cat A) and Skilltrade (Cat B) in the Netherlands. He also works as a consultant specialized in the specification and control of projects from an information management and hydrographic perspective.
✉ info@hydrografie.info

Volunteering for the Future

The International Federation of Surveyors (FIG) is a non-governmental organization representing the interests of all surveyors worldwide. Over the last 30 years, our profession has gone through a series of significant changes and innovations. The main technical advancements have been the introduction of GNSS, laser scanning and digital photogrammetry in conjunction with the use of unmanned aerial vehicles (UAVs or 'drones'). Thanks to new communication technology combined with GNSS technology, global localization of the place where we 'are' has become child's play.



Sociologists say that we are living today in one global world. In other words, there are more similarities between how we are all acting in our daily lives than ever before. We wear similar clothes and listen to the same music. But although our societies are becoming more and more aligned with each other, we can also observe a trend towards greater individualism. Over the past decades, it has become increasingly difficult to convince people to do volunteer work, whether for their local football club, a choir or a professional association.

The FIG Council's motto for the 2019 to 2022 term is 'Volunteering for the future'. Despite being very short and catchy, this slogan can – and should – be interpreted in several ways. This also prompts two main questions:

- Why is volunteering so important nowadays?
- Volunteering for what?

In answer to the first question, the topic of volunteering requires increased attention nowadays because the willingness to volunteer has declined significantly across a very broad base over the past decades. It is becoming more and more difficult to find volunteers for any kind of activity, and professional organizations such as FIG are no exception, whether at a local, regional, national or even international level. This is a mass phenomenon, which is observable on all continents of our planet. Many people identify the increasing individualism of our globalized society as the reason for the reduced interest in volunteering.

VOLUNTEERING FOR THE FUTURE OF OUR FEDERATION

The second question, 'Volunteering for what?', can be answered on two levels which are to some extent interlinked. The most important object (first level) of interest is our federation itself. Today, FIG is a truly global association representing and promoting the interests of our profession and of all surveyors worldwide. The FIG brand is well known, but this cannot be taken for granted. If we want to maintain our leading position as a professional organization, we need volunteers and ongoing support on all levels. Such commitment and personal involvement can be realized in many different ways.

Nowadays, surveying is seen as providing necessary and beneficial infrastructure for the well-being and further development of our society. When we are active on behalf of FIG, it means that we are at the same time (on the second level) also benefiting our profession, society and planet Earth. So hopefully this will convince you to become a volunteer very soon. ◂

Rudolf Staiger is president of the FIG for the term 2019-2022. In a recent interview with *GIM International*, he stated: "We are the biggest international society representing the geospatial and surveying profession on a very broad base. Nevertheless, except for our FIG office in Copenhagen, we are all volunteers. We have to strengthen our organization and prepare it for the near future. One of the major tasks will be to activate people who are willing to contribute to all FIG's commissions, networks and taskforces in the future."
✉ president@fig.net

GIM INTERNATIONAL INTERVIEWS BORKO DRAŠKOVIĆ

Geospatial Data as a Core Instrument to Transform a Country

After several turbulent decades, the Republic of Serbia is working towards a brighter future, including by radically transforming its geospatial information infrastructure. In fact, the country has received recognition for its reforms in the process of digitalization and economic development of the state. This confirms the role of geospatial data as a fundamental 21st-century resource with considerable potential for economic and social development of state and society. In this interview with Borko Drašković, general director of the Republic Geodetic Authority (RGA), *GIM International* takes a closer look at the achievements in Serbia, which can serve as an example for other countries in the Balkans and beyond.

A well-functioning land administration system is an important pillar for national stability and social welfare. What is the current cadastral situation in the Republic of Serbia, and how is that reflected in the country as a whole?

A country's land administration system reflects the conditions within that country. Over the past couple of decades, Serbia has transitioned through a very difficult period marked by great economic, political and social crises, which reflected upon on the land administration system itself. Until recently, the land administration system was admittedly the source of various problems, but also often used as a scapegoat for various malversations within the Republic of Serbia. Shortcomings in the cadastre made it difficult to realize infrastructure projects and to develop state administrative systems. But numerous real-estate intermediaries, business entities and even state authorities have disproportionately blamed weaknesses within the Republic Geodetic Authority (RGA) for their own inconsistencies, ineffectiveness or rising prices.

The strained land administration system even made it difficult to guarantee property ownership, resulting in more than 4.5 million objects still unregistered today, as well as approximately 3 million people without an address. Regulating this state of affairs and legalization of property allows for economic development of the country, legal certainty and the creation of an attractive investment environment. Today, in accordance with the national government's activities and with considerable help from the World Bank and other partners such as the Food and Agriculture Organization of the United Nations (UNFAO), RGA is solving the issues inherited from the past by making great strides, digitalizing data within business processes and introducing innovative solutions and technologies. We have completely changed the regular, inefficient property rights registration system following the passing of the Law on Registration in the Real Estate Cadastre and the Utility Cadastre in June 2018. We operate as a modern and pragmatic institution; it is no longer a traditional register of properties, but a digital public-sector platform that allows citizens to access geospatial data in a transparent, reliable and efficient manner. Our plans and activities are outlined in our 2021 Development Strategy. The vision and its implementation has invoked some strong and even judgmental reactions, but it is motivating other parts of the system to be proactive and participate in the reform of the entire country. The demand for geospatial data has multiplied, and geoinformation professionals are becoming a regular part of working teams.

In view of the millions of unregistered buildings and so many people without an official address, I guess it would be fair to say that the Republic of Serbia still faces some cadastral challenges. What is your main focus when it comes to tackling them?

That is correct, there are still some cadastral challenges to be faced. The major change

compared to the past is that we are now talking openly about these challenges and how best to solve them. Previously the problems were just brushed aside, and underwhelming legal solutions and inefficiencies of other institutions were blamed for the existing sad state of affairs. That led to such huge issues that we became an irrelevant and dysfunctional institution which housed inaccessible and imprecise analogue data that was of little real use. As a result of our inefficiency, other institutions created their own address registers and datasets, which led to new procedures and placed new burdens on citizens and the economy. We have now defined our challenges and embarked on a path less travelled – a less certain path, but one that will lead to our goal faster and more efficiently. This path requires a completely new way of thinking (digital), as well as the introduction of new and innovative technologies and business processes. By utilizing the Geosrbija geospatial platform, new methods of collecting data – such as crowdsourcing – can be integrated into a National Spatial Data Infrastructure (NSDI). We have managed to completely update the address registry in record time (two years to be exact), plus we are currently working together with municipalities to perform street name and number demarcation. Not only are we saving time by introducing these updating technologies, but we have also achieved tenfold financial savings. In addition, by utilizing satellite imagery and machine learning methods, we've successfully recorded all the objects in the Republic of Serbia and, in cooperation with other institutions within the country, we are working on their registration in the real-estate cadastre system. So as you can see, new technologies and a different mindset, together with a dedicated and professional team working within RGA, are allowing us to solve problems that spanned decades and to give our institution the central position it deserves in the 21st century. It is important that everyone in the system understands that digitalizing does not mean simply introducing IT systems and converting analogue processes. Instead, it involves digital business processes, digital legal frameworks and a digital mindset along with the relevant technical solutions for successful and operational digitalization. Otherwise, the door is open for misuse and a dysfunctional and unsustainable system. We are focused on this challenge, and are mostly working on the introduction of complementary digital processes, paying particular attention to simple solutions that are defined clearly and precisely.

In your country, you have been recognized as 'Reformer of the Year'. What were the main achievements that led up to this?

We made it possible for other state authorities to be visible. We offered all the institutions the opportunity to present their data on a national digital

platform free of charge and in a simple manner. Their data is spatially defined in the UTM system (*Universal Transverse Mercator coordinate system, Ed.*), with all the datasets overlapping, thus providing a plethora of information to users. We currently have 250 different datasets, and we are especially proud that we have mapped and digitalized the historical period that shaped the territory of Serbia, such as the Great War. It has been an achievement of the entire profession. The fact that the institution dealing with geospatial data has received recognition for reforms in the process of digitalization and economic development of the state only confirms what is often mentioned in the global discourse – that geospatial data is a 21st-century resource and that it has considerable potential for economic and social development of state and society. Up-to-date property registers represent secure ownership and a healthy economic environment. We have proved this in real life in Serbia. So far, these sorts of recognitions were mainly 'reserved' for other professions instead of the geoinformation profession. However, I am certain that we have entered the age of digital geospatial data, and that recognition of the geoinformation profession as a whole will be a regular occurrence from now on. Many key factors have led up to this achievement, including the new way of functioning for real-estate and utilities cadastres, new information systems, improvements in data quality, the Geosrbija digital geospatial platform, the new and efficient NDSI, and RGA's transparent and efficient work in cooperation with other institutions in the field of digitalization.

▲ *Receiving the 'Reformer of the Year' award from the National Alliance for Local Economic Development (NALED) in January 2019.*

How does RGA see its role in this age of digital transformation?

If we succeed in realizing the reform project, we will certainly be one of the leading and most important state institutions. Economic advancement crucially depends on high-quality land administration – Serbia cannot be successful unless RGA is successful. Geospatial data, and therefore our institution, is indispensable in the process of making smart decisions and creating legal certainty. Our goal is to establish a complete platform of public-sector geospatial data. The spatial georegister will play the central role in managing the workflow of different systems. In addition, our idea is to unify and host all the services and data in one central hub so that data can be processed and made available to the user in the most efficient manner possible. We are developing new services; today all of our data is available via API so it can be optimally utilized by public-sector organizations, businesses, citizens and educational institutions alike. They have access to the most up-to-date data at any time. Similarly, not only can we help the public sector to make genuine and high-quality decisions, but we can also help to develop business and the economy in the country as a whole for our citizens.
We have always emphasized strong cooperation, both regionally and internationally. In this time of rapid technological advancement, knowledge and experience are quickly exchanged and no one has the right nor the luxury to work alone and endanger the sustainable development of the planet. And in the upcoming period we see it as a necessity to continue to connect with other regional institutions, with institutions from Europe and with the rest of the world. Besides the World Bank, the United Nations and the European Commission, our friends from the Netherlands, Sweden, UK, Norway and others have also played an active part in our success. Also, we wish to provide assistance to other countries interested in achieving similar results.

What is the prevailing attitude towards the economic value of 3D geoinformation in Serbia right now?

Due to activities and results we achieved in the previous period, the government of the Republic of Serbia and the public have now come to understand the importance of spatial and 3D data in the economic development of state and society. As evidence of that, we only need to consider the improvement of the NSDI, the improvement of geosector and the adoption of strategic changes at the national level – such as the government's economic reform programme, Serbia's rise in the World Bank's 'Doing Business' index, Serbia's public-sector strategy and the government's Action Plan. Hence, geospatial data remains a key factor in developing state and society, all based on our results and that make us proud. I should also point out that RGA's new approach has also resulted in considerable advancement of the private sector. As RGA began to provide up-to-date and high-quality data in a contemporary manner, big and small private firms began to expand their businesses, to provide new services and also to employ geoinformation professionals. However, due to the country's geopolitical position and human nature in general, the prevailing thought still seems to be that although everything being done is probably good, it should be kept 'at arm's length' – which is the Serbian equivalent of saying 'not in my back yard'.

What role do you foresee for institutions such as the United Nations (UN-GGIM) and the World Bank, not only in Serbia but throughout the world?

In our experience, it is practically impossible to see the wider picture without the support of the UN and World Bank. The geosector and land administration are both complex systems, and geospatial information management is inconceivable without a global framework. The United Nations 2030 Sustainable Development Goals are a beacon for the development of missions, visions and goals to strive towards. So in our opinion, UN-GGIM and the World Bank will play a key

role in the further development of the geosector and institutions such as RGA at both a global and a local scale. Activities on integrated frameworks for geospatial data worked upon by both UN-GGIM and the World Bank will provide a basis for the further development of geospatial data infrastructures, taking into account the fact that different countries operate in different environments. Recommendations allow countries to create action plans in accordance with their priorities and circumstances. I think this 'global for local' approach is excellent, and the only feasible one.

How do you expect the Serbian land administration system to look in five to ten years' time?

I expect it to be a highly transparent and reliable system, with considerably improved efficiency and accessibility. In five years' time we will have achieved all of our projected goals, meaning that we will be one of the most successful land administrations in the world. We will certainly be within the top 20 in the Doing Business index, and we hope to reach the top 10. The system will also be fully functional, with all the inherited problems solved. In ten years' time, if we use the new technologies wisely for the common good, in line with the new user needs and in accordance with technological trends, we will be transformed and integrated into a uniform technological geospatial system of the highest order.

Lastly, Mr Drašković, you will be organizing a joint international conference in Serbia, together with the EU's Joint Research Centre (JRC), the World Bank, UNECE, UNFAO and UN-GGIM Europe this September. What is the topic of this event?

The main topic of the conference is the importance of digital transformation of state and society, including a focus on digital spatial data and the introduction of innovative services that relate to regional and spatial planning, smart cities and next-generation agriculture. The goal of the conference is to inform the different stakeholders (public sector, private sector, academic community, etc.) about the importance of applying ICT technologies and about the trends in Eastern Europe. RGA was chosen as host and organizing partner due to the results achieved previously relating to digitalization of its services, introduction of modern technical and technological solutions, and innovation in the field of managing geospatial information and real-estate cadastre. This is a special honour for the Republic of Serbia, RGA and our employees who work hard to provide our citizens with high-quality and efficient services. Thanks to our work, RGA is today an institution where colleagues and students from abroad (e.g. Kingdom of the Netherlands, Republic of Slovenia, Guyana, North Macedonia) arrive to exchange knowledge and experience and organize important international meetings. Hence RGA has shown, together with the government of Serbia and supported by the World Bank, that it is now on the right path to respond to all the challenges of the 21st century.

Borko Drašković has been director of the Republic Geodetic Authority (RGA) of Serbia since July 2015, during which time he has helped to improve transparency in the real-estate cadastre and work of RGA. As a result of the reforms he has undertaken, he was named 'Reformer of the Year' by the National Alliance for Local Economic Development (NALED) in January 2019. He is also a member of UN-GGIM and played a key role in laying down the foundations for Serbia's crowdSDI. The digital geospatial platform for Serbia's NSDI has been in operation for more than a year, during which time it has gathered over 240 datasets from many institutions in Serbia.

Mapping the world

Stay informed with *GIM International*

GIM International, the independent and high-quality information source for the geomatics industry.

- Topical overviews
- News and developments
- Expert opinions
- Technology

Sign up for your free subscription to the online magazine and weekly newsletter today!

www.gim-international.com

GIM INTERNATIONAL

BY **FRANK DE MORSIER**, **VERONICA ALONSO** AND **LINH NGUYEN**, PICTERRA, SWITZERLAND

AI-powered Object Detection as a Mapping-business Accelerator

Geospatial Imagery Analytics Market Expected to Reach US$8 Billion by 2025

UAV, aerial and satellite mapping service providers are competing for the global market – with a rising hunger – for geospatial insights. Automating the feature extraction process is key to accelerating, scaling up and diversifying a location intelligence service portfolio. Cloud-based platforms coupling cutting-edge machine learning research with a user-friendly implementation offer a powerful turnkey and cost-effective solution to those looking to gain competitivity by incorporating artificial intelligence (AI) automation into their workflows.

With more and more business relying on location data to optimize their planning and day-to-day work or to gain first-hand market insights, the geospatial imagery analytics market is poised to rise from around US$2 billion in 2018 to over US$8 billion by 2025, according to a 2019 Global Market Insights, Inc. report. This is a huge opportunity for unmanned aerial vehicle (UAV or 'drone'), aerial and satellite mapping service providers. The key to capturing a share of this growing market is to offer business solutions focused on specialized geospatial analytics.

▲ *There is a global market hungry for geospatial insights.*

Business and industries in need of geospatial analytics are increasingly diverse. For example:

- Farmers need to know how many of their plants are underproductive
- Ranchers need to know how many heads of cattle survived after a flood
- Insurance companies need to know how many roofs were damaged during a storm
- Electricity companies need to know how many solar panels are there in a city
- Oil companies need to detect oil spills
- Water companies need to know how many manhole covers are damaged or stolen

The applications and use cases are potentially endless. All of these businesses need the number, extent and location of each of the objects they are tracking.

THE CHALLENGES OF SCALING UP

Most of the UAV, aerial and satellite mapping service providers we speak with daily excel at producing digital mapping and surveying products. However, delivering geospatial insights derived from these products can be challenging and quickly become a bottleneck when scaling up the production pipeline. No one questions the potential value that these insight-rich geospatial products can add to their service portfolio, but so far they have proven hard to scale.

Manually extracting the features the clients are interested in is time-consuming and costly to scale up by engaging additional manpower. Automating this process by developing an in-house AI programme implies a huge investment. Hiring highly specialized professionals – machine learning experts, computer vision specialists and data scientists – and investing in infrastructure is not an option for small and medium-size drone service businesses. One cost-effective solution to automate the feature extraction process and increase the geospatial analysis production capacity is to use Picterra, a cloud-based AI object detection platform.

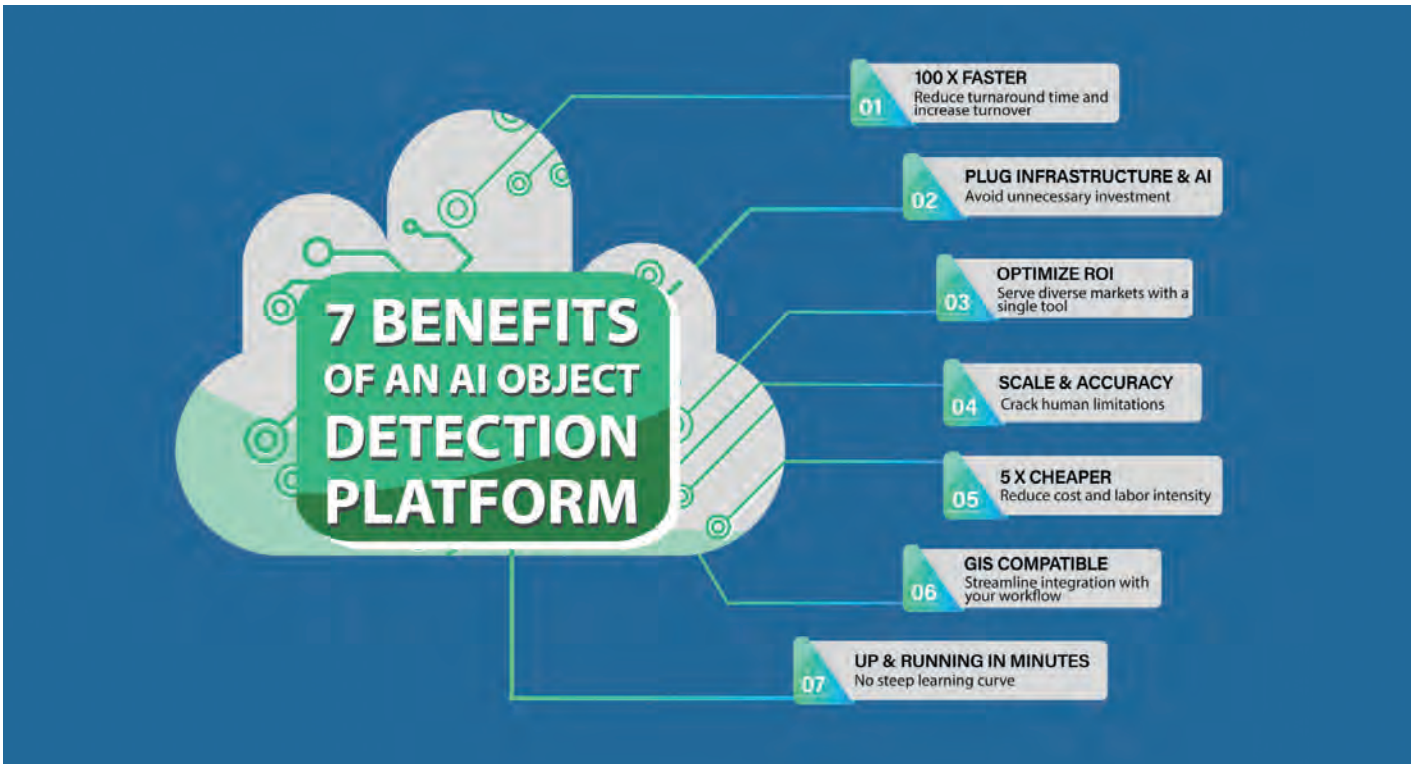
Incorporating Picterra into the production pipeline of a UAV, aerial or satellite mapping business has multiple benefits. This list presents the top seven reasons:

1) 100x faster – Reduce turnaround time and increase turnover

Firstly, not only can AI improve the accuracy of the project, but it can also reduce the time to delivery. The entire workload of mapping, detecting and extracting data can take days if being done manually. Instead, AI-powered automated detection can shorten the delivery time from days to minutes. Furthermore, by being freed from the repetitive manual process, you can use that amount of time to work on a new project or acquire new clients.

2) 90% cheaper than developing an in-house AI programme – Avoid unnecessary investment

You don't need to invest in infrastructure or R&D. GPUs and highly specialized expertise are expensive. For instance, several thousands of dollars are needed to use a high-end GPU virtual machine on cloud



▲ *These are the top 7 ways Picterra's turnkey solution accelerates mapping-business operations.*

services, on top of which the expertise required in-house can quickly bring the expenses to tens of thousands of dollars per month. With an online platform, these are built-in components you can directly leverage on. With Picterra, you get state-of-the-art machine learning algorithms and infrastructure without the need for extra expertise.

3) One tool for all – Serve diverse markets with a single tool

Maximize your ROI by using a single tool for all of your feature extraction projects. Thanks to the versatility and flexibility of the object detection algorithms Picterra deploys, you can customize them and count objects such as trees, sheep, solar panels, shipping containers or buildings today. At the same time, you will be able to craft a detector for any other type of object.

4) 95% accuracy – Crack human limitations

The AI-powered platform can detect objects faster and more efficiently than a human being. It is able to cover large areas and spot tens, hundreds or thousands of objects in the blink of an eye. In addition to the scale at which it can operate, AI can also improve the accuracy of the detections. Even the most meticulous person is bound to make mistakes while carrying out monotonous manual detection over a large scale. This is where automation helps by learning features, performing the same steps accurately every time they are executed and focusing the human expertise on challenging and rare features.

5) 5x cheaper than manual detection – Reduce cost and labour intensity

The same heavy workload being repeated with every project requires more cost and labour intensity to deliver the results in time. In contrast, once created, automated detection can be executed again and again, without additional cost at a much faster pace. By integrating AI in the process, the overall timespan can be reduced which translates directly into cost savings.

6) Streamline integration with your workflow

You can run AI object detection on satellite images or orthophotos produced with any photogrammetry software in the market, such as Reality Capture, DroneDeploy, Agisoft Metashape, SimActive Correlator3D or Pix4Dmapper. Picterra allows you to analyse the detections, derive statistics and generate customized reports you can deliver to your clients. You can also export the detections as georeferenced layers in various formats that are optimized to match your workflow on ArcGIS and other GIS software.

7) Build and run a detector in 10 minutes – No steep learning curve

Last but not least, the Picterra platform offers you an intuitive user interface that allows you to build and run your own detectors in just a few clicks.

AI OBJECT DETECTION IN ACTION

Picterra was used to perform automated analysis of the content of an orthomosaic of a neighbourhood of the German town of Walddorf. Seven object categories were mapped and localized over the urban scene, generating GIS layers and a report as outputs.

- Roofs: up-to-date detections give local governments and insurance companies insights on discrepancies on declared values and a correct parametrization of the prime.

- Swimming pools: local governments can localize swimming pools and compare this

information with building permit registers. Moreover, tax declaration discrepancies can be spotted.

- Vehicles: car dealers can use this information to target marketing campaigns, local governments to plan parking infrastructure and road network adaptations, and real estate agencies to spot and assess the most frequently visited areas and shop windows.

- Road marks: up-to-date detections provide key insights to local infrastructure and traffic agencies or insurance companies when analyzing the geographic prevalence and distribution of traffic accidents. Moreover, this supports an efficient maintenance planning of road marks.

- Solar panels: determining their prevalence and geolocation unlocks key market insights for energy companies and solar panel manufacturers. An optimized management of the supply and demand of renewable energy also requires up-to-date information on the solar panel locations.

- Manhole covers: water and utility companies need this information in order to plan maintenance and network expansion.

- Trees: detecting trees in proximity to key assets provides insurance companies with valuable risk assessment information. Detecting trees encroaching on buffer zones is also key to infrastructure planning such as gas pipelines or overhead power lines.

	INSURANCE	UTILITIES & INFRASTRUCTURE	GEOMARKETING	REAL ESTATE	GOVERNMENT & URBAN PLANNING	MANUFACTURERS
Roofs	●		●	●	●	●
Swimming Pools	●	●	●	●	●	●
Vehicles	●	●	●		●	●
Road Marks	●	●			●	
Solar Panels	●	●	●	●	●	●
Manhole Covers	●	●			●	
Trees	●	●	●	●	●	

A single feature extraction project can serve multiple industries.

CONCLUSION

Picterra offers a powerful, cost-effective, cloud-based object detection solution that can be incorporated in UAV, aerial and satellite mapping pipelines to scale up and diversify location intelligence products and services.

MORE INFORMATION

www.picterra.ch

The outputs of the platform include object counts, surface area calculations and georeferenced detections.

SUZHOU FOIF CO.,LTD.

It's professional

NEW CHANCE
NEW SUCCESS!

A90

Cutting-edge RTK receiver

- Up to 555 channels
- Smart design, maximum productivity
- Third-generation incline measuring: Perfectly achieves precise measurements
- WiFi connection: Realizes WebUI control which is designed to modify settings and monitor the receiver status
- Multiple softwares(including Android) bundled, third-party softwares (FieldGenius, SurvCE) optional

FOIF® since 1958

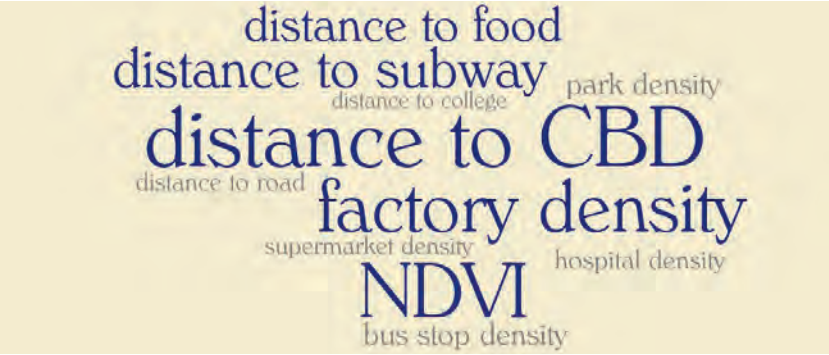
www.foif.com

A HIGH-RESOLUTION REMOTE SENSING-BASED APPROACH

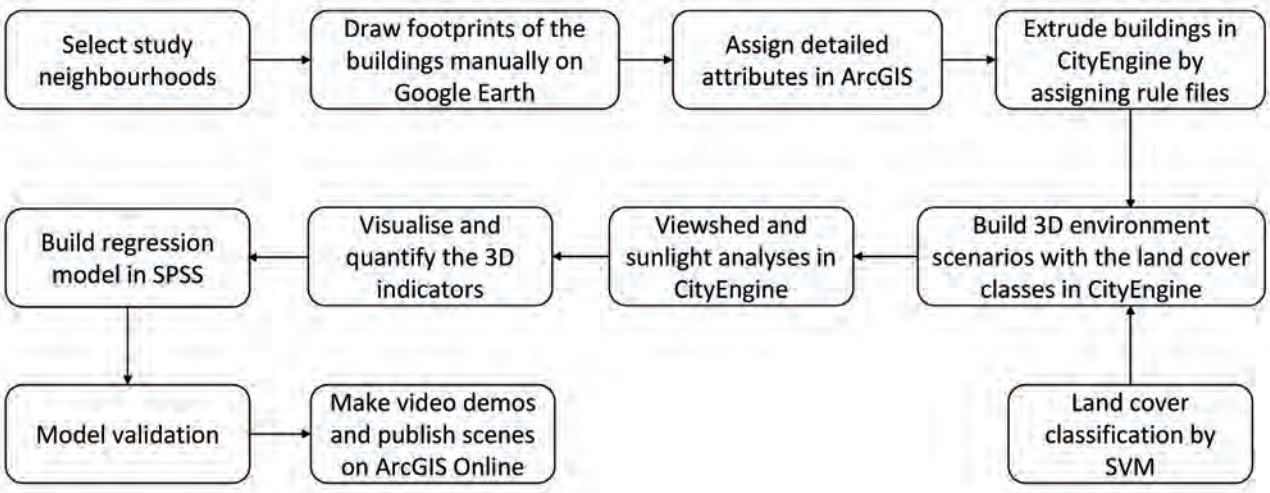
3D Modelling for Property Valuation in China

Rapid urban development in China has transformed the cityscapes, with a dramatic increase in high-rise buildings. However, the current 2D property valuation methods neglect the vertical dimension, even though that aspect contains significant indicators that impact property value – such as types of views, scope of vision and daylight. 3D modelling of geographical data can help to change this in high-rise and highly-density areas, going beyond 2D to enable identification of complex property characteristics in the vertical dimension too. This article presents research to explore a 3D modelling approach using remote sensing data for more precise property valuation.

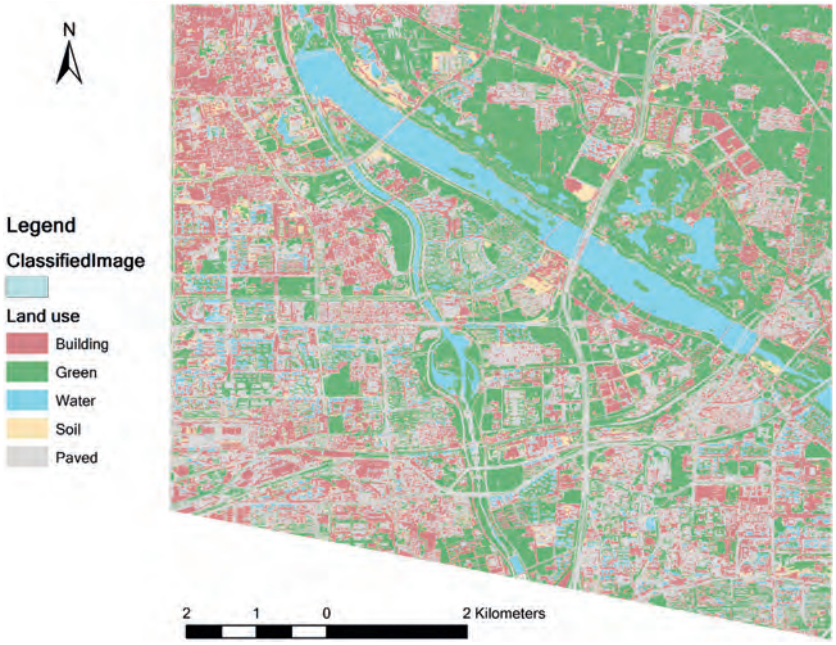
The accelerating urbanization has put great pressure on land in China, posing a challenge of how to accurately define property characteristics and values. However, the integration of GIS and property valuation are mainly based on two dimensions. When it comes to handling the complexity of vertical developments in urban areas, current methods are incapable of describing a property's 3D characteristics in detail and providing precise information on spatial variations between properties. In view of the considerable rise in property prices and the technical advancements in GIS, 3D modelling is becoming increasingly relevant for property valuation in urban areas in order to better describe the complex property characteristics, especially in the vertical dimension, as recent research in China shows.



▲ *Figure 1: The 2D indicators included in the 2D model (Blue: significant at 0.05 significance level; Grey: not significant).*



▲ *Figure 2: The 3D modelling workflow.*



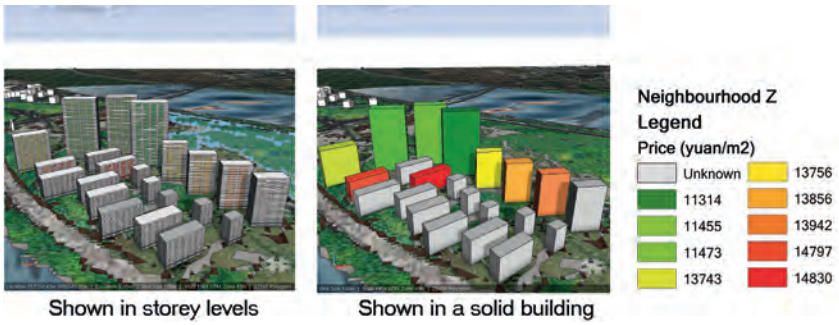
▲ *Figure 3: The classified image of the study area with an overall accuracy of 87.5%.*

STUDY AREA

Xi'an, the capital city of Shaanxi Province, is located in the mid-western area of China. Xi'an serves as the educational, political and economic centre of Shaanxi Province and wider northwest China. It also attracts tourists from around the world. Xi'an was chosen for the research project because of its data availability and its property market, which has particularly flourished over the past few years. Although it is both costly and time-consuming to investigate the effects of 3D indicators, the anticipated results at the neighbourhood scale can be useful, giving prospective buyers a fast estimate of the property price in a specific neighbourhood and also making the study feasible in terms of computation and data collection.

HIGHER LEVEL OF DETAIL

3D modelling and its interactive functions for property valuation has so far not been very popular among both the municipal government and the real-estate developers in Xi'an; it has only been explored by real-estate developers in a few large cities (e.g. Shenzhen). The Xi'an municipal government does use some 3D modelling, but mainly in the field of urban planning and the use cases are limited due to the low levels of detail (LOD) influenced by the huge cost, low technology and public security policy. However, 3D modelling can be developed to a higher LOD to serve more purposes in the future (e.g. emergency management). Real-estate developers utilize 3D modelling for architecture and landscape design, but they rarely use it for sales purposes because they believe/perceive the traditional 2D sales tools to be effective and intuitive. The reform of the Hukou policy has contributed to substantial population growth in Xi'an and is thus creating a higher demand for housing. Now that the property market in Xi'an is a seller's market, the real-estate developers have no impetus to develop new technologies. Therefore, a suitable 3D modelling approach should be determined by considering the local circumstances.



▲ *Figure 4: The property price variations of a sample neighbourhood shown in 3D at the neighbourhood scale.*

EXPLORING THE 2D-BASED METHOD

In this research project, first a regular hedonic price model with 2D indicators was applied. Generally, most research concluded that property price variations could be generalized by different statistical models. However, the R^2 scores of 2D methods applied in this research, ordinary least squares (OLS) and geographically weighted regression (GWR), were too low to generalize a model (0.111 in OLS and 0.217 in GWR), which meant the models of current 2D indicators (Figure 1) could not explain the property price variations. The reason may be the use of first-hand property price data which was generated under the fixed-price and purchase-restriction policy established by the Xi'an municipal government, whose primary purpose was to stabilize property prices. Therefore, the prices may not show a significant impact from the geographical locations and surroundings.

THE 3D MODELLING PROCESS AND RESULTS

The preparation for a 3D model was divided into two main steps: land cover classification based on remote sensing data, and 3D data structure construction (Figure 2). The multispectral images used for the classification were from the Chinese satellite Gaofen-2, with a resolution of 4m, and Sentinel-2, with a resolution of 10m. The classification was executed by a support vector machine and validated by visual interpretation (Figure 3). 3D data structure construction was conducted in ArcGIS for creating height attributes for the 2D floor plans, which could be directly linked in CityEngine. In the 3D modelling process, two high-rise neighbourhoods were explored. The 3D indicators taken into consideration were view type, sky view factor (SVF), sunlight and property orientation. These were determined based on the local knowledge acquired by a questionnaire issued to Xi'an residents. The first three indicators were simulated by built-in functions in CityEngine: Viewshed and sunlight analysis. Property orientation was set up as a dummy variable. The regression results revealed that the R^2 of the 3D method (0.451) was significantly higher than those of the 2D methods. SVF, sunlight and property orientation were proven to have a significant influence on property price at 0.05 significance level. The findings disclosed

that the 3D method could explain property price variations better than 2D methods. The 3D visualization in CityEngine also showed excellent performance regarding quantifying and analysing 3D indicators (Figure 4).

VALIDATING THE 3D MODEL

The regression results of the 3D model were validated by leave-one-out cross-validation and the results turned out to be quite good, with a 9.76% error of predicting the property price. However, no research has ever set up a threshold or developed an approach for this kind of model validation. The analysis of the 3D indicators was all simulated in software and it would be time-consuming to collect them through fieldwork. Therefore, the validation of the 3D model will remain an important issue to be solved in the future.

A WAY FORWARD

This research proved the 3D modelling approach, with its vivid visualization and powerful calculation, to be effective for high-quality property valuation. It shows a way forward in which property valuation can be conducted in a more comprehensive, precise and cost-effective way with high-resolution remote sensing data and 3D data structure support. Moreover, it can be widely implemented and adapted to other fields, e.g. for setting the price standards for future property tax in China. The researchers recommend more exploration in two aspects in particular. First, visualization and quantification of 3D indicators can be developed further. Accuracy can be improved with a higher LOD. Besides this, different calculation techniques may influence the research outputs, so it is necessary to develop an efficient method for quantifying 3D indicators. Second, this research contained a huge amount of manual work. Therefore, further exploration of automated techniques is recommended. ◀

FURTHER READING

3D scenarios of the neighbourhoods studied: http://bit.ly/2IEA3Wy and http://bit.ly/2IyI4NJ

ACKNOWLEDGEMENTS

This work was supported by ITC and thanks are due to Dr Jong Wang and Dr Xia Li for data support.

ABOUT THE AUTHORS

Yue Ying obtained her MSc degree from the Faculty of Geo-information Science and Earth Observation (ITC), University of Twente (UT), Enschede, the Netherlands, with a specialization in land administration.
✉ vickyimmortal2@163.com

Dr Mila Koeva gained her doctorate from the University of Architecture, Civil Engineering and Geodesy, Sofia. She is an assistant professor in 3D land information at UT, co-chair of ISPRS WG IV/10 and project coordinator of its4land, a multidisciplinary European Commission Horizon 2020 project.
✉ m.n.koeva@utwente.nl

Dr Monika Kuffer received her PhD degree from the University of Twente, an MSc in human geography from the TU Munich (Germany) and an MSc in geographic information science from the University of London (UK). She is an assistant professor at the Faculty ITC of UT. Her main areas of research are urban remote sensing, analysing the urban form and dynamics and spatial statistics.
✉ m.kuffer@utwente.nl

Dr Kwabena Asiama received his MSc and PhD degrees from the University of Twente (ITC) in the Netherlands. He is currently a researcher at the Geodetic Institute of the Leibniz University of Hannover, Germany. His main areas of research are real estate valuation, land use planning, land tenure and governance, and customary land administration.
✉ kwabena.asiama@gmail.com


One System.
Dual Use.
Yes, You Can Do Both!
Designed to easliy move from a UAV to a ground vehicle. Optimize your ROI.
Spend more time scanning, only 30 seconds to initialize.
We Make 3D Mapping Easy. Learn more on our website. www.LiDARUSA.com
20 YEARS ANNIVERSARY CELEBRATION
LiDARUSA
Fagerman Technologies Inc.
RIEGL inside
Surveying Mapping Streetview Imaging
LiDARUSA
www.LiDARUSA.com

HOW FREE REMOTE SENSING TECHNOLOGY CAN HELP CITIES PREPARE FOR CLIMATE CHANGE

Big Data, Rising Tides

In view of the increased vulnerability of cities to climate and disaster risks, accurate and up-to-date geospatial data is fundamental for a more resilient urban planning approach. Publicly available geospatial datasets are increasingly becoming the foundation stone for more informed urban planning decision-making and better investment prioritization. Today, satellite data can help cities to better prepare for natural disasters such as urban flooding and make more informed investment decisions.

For many residents of Kampala, the capital of Uganda, the start of the rainy season brings a sense of apprehension nowadays. Originally built on seven hills surrounded by wetlands, the city's rapid growth has pushed settlements into flood-prone areas. Furthermore, extreme rainfall events now hit more frequently, as shown by destructive flash floods in May 2019. With the city's water table saturated and drainage channels blocked, the flood waters blocked roads, entered houses and swept away livestock. More than 500 households were affected, according to the Uganda Red Cross. Some of the photographs that went viral locally showed a chicken farmer who saved his birds by putting 300 on the roof of the brooder.

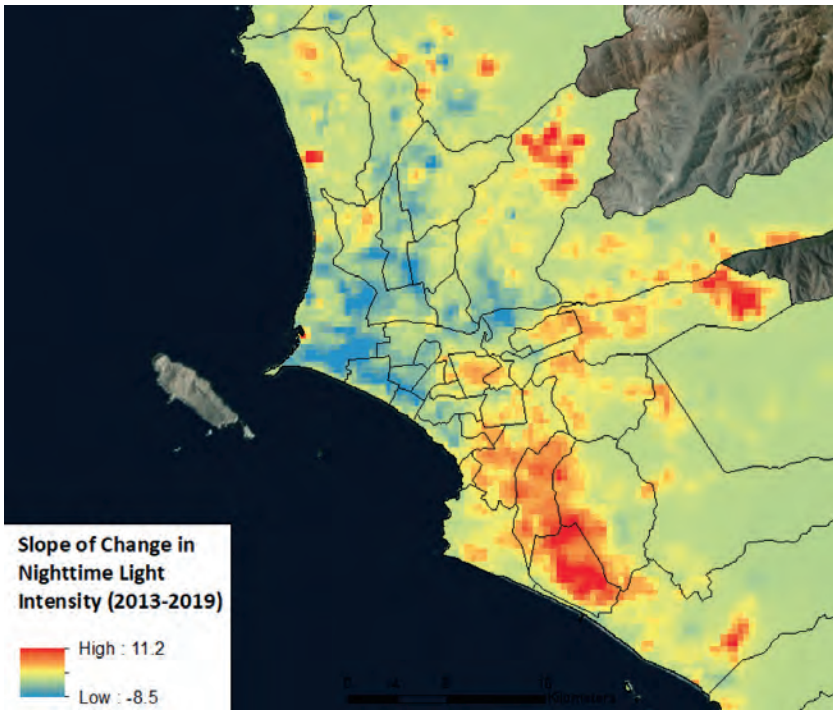
As climate change makes its impact felt, Kampala is just one of hundreds of cities around the world whose leaders face a generational challenge due to increased flooding. Whether from heavy rains, coastal floods or the creeping impact of sea-level rise, restoring harmony between cities and water is a crucial task that requires the use of geospatial data at scale. Fortunately, cities are becoming increasingly data-rich environments. Flood and stream gauges help to monitor water levels within and around cities, climate and weather models are becoming more accurate in forecasting catastrophic flood events, and satellite and aerial imagery is becoming increasingly accessible and playing a vital role in monitoring the impact of flood events.

BIG DATA FOR RESILIENCE

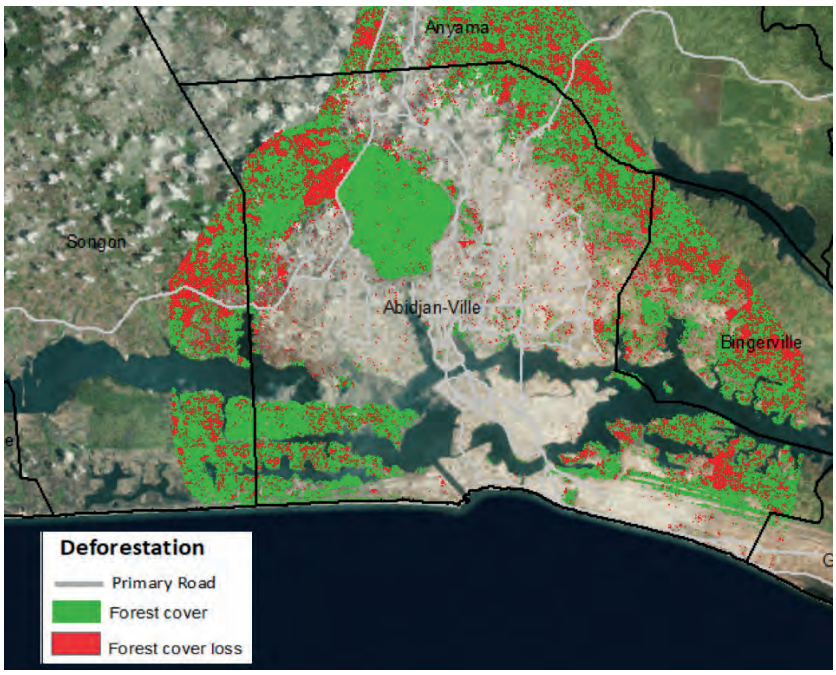
Between 1950 and 2019, the share of the world's population living in urban areas rose from 30% to 55%, and the number of people living in such areas is likely to increase by a further 2.5 billion in the coming decades. By reducing trade costs and fostering innovation, cities have helped to lift hundreds of millions of people out of poverty in Africa and Asia. Yet the very agglomeration effects that make cities such powerful engines of economic progress also present a cost: the increasing concentration of people, buildings and infrastructure in high-risk coastal areas. It is estimated that up to 325 million extremely poor people will be living in the 49 most hazard-prone countries by 2030, particularly in South Asia and sub-Saharan Africa.

Unplanned settlements, inadequate drainage investments and challenges with solid waste disposal add to the problem.

Adapting today's cities to climate change requires addressing many pieces of a jigsaw puzzle: from investing in drainage and transportation to communicating early warning messages to vulnerable communities. But while their exposure to flood risk continues to grow, cities are also fast becoming data-rich environments. Internet-derived data together with satellite imagery offers a well-developed set of options to understand flood risk, shape policies



▲ *Lima: Economic growth hotspots as derived from night-time light data.*



▲ *Abidjan: Deforestation in city environs affects flood susceptibility.*

to reduce it and prioritize investments in drainage and flood defences.

SATELLITE IMAGERY: 3 WAYS TO UNDERSTAND CITIES

In the past, expensive satellite imagery and limited computational power only allowed analysis of small geographical areas, e.g. the ability to count building footprints in a small neighbourhood or calculate the volume of live vegetation in a single agriculture field. This model is now being replaced thanks to publicly available and free satellite data that captures every location on Earth every few days and in a spatial resolution of just a few metres. Indeed, the increasing availability of satellite data has transformed how we use remote sensing analytics to understand, monitor and achieve sustainable development goals. As satellite data becomes ever-more accessible and frequent, it is now possible not only to better understand how Earth is changing, but also to utilize these insights to improve decision-making, guide policymaking, deliver services and promote better-informed governance, e.g. to help diagnose an issue of concern – such as flooding – and inform debate on remedial steps.

In the run-up to an investment planning conference convened by the World Bank's City Resilience Program, which would be attended by around 30 cities, the Global Facility for Disaster Reduction and Recovery (GFDRR) and New Light Technologies Inc. utilized free satellite imagery to address the following three questions:

• QUESTION 1: WHICH PARTS OF THE CITY EXPERIENCE FLOODING?

Flood risk assessment is a mature and long-standing field. Flood modellers typically use digital elevation models (DEMs) and local rainfall data to identify flood zones (e.g. the area of a city expected to flood during a 1-in-50-year event). Traditional flood models built with engineering expertise are indispensable when designing a flood mitigation plan. Yet hydrological models often miss areas that experience persistent flood problems. Blocked drainage channels, new construction and changes in vegetation cover all influence the interaction of water with the urban fabric. Many residents in developing-world cities lose possessions or experience health impacts from flooding, even where flood maps show them in a dry zone.

Thanks to the EU's Copernicus mission in particular, the availability of free satellite imagery that can capture snapshots of actually experienced flooding is increasing. Sentinel-1 imagery relies on Synthetic Aperture Radar (SAR) – a radar sensor that is capable of detecting flood extents regardless of cloud cover – while Sentinel-2 provides high-resolution electro-optical imagery which can capture water content on Earth.

To supplement existing flood models, the research team mapped each major flood event that had occurred across 30 cities since 2015 and for which imagery was available. The identified flood extents show areas that have been affected by standing water in each city and that are thus more vulnerable to urban flooding.

• QUESTION 2: WHICH CITY ZONES ARE THE FOCUS OF ECONOMIC GROWTH?

Night-time light data has produced a slew of academic studies since the 1990s, with the intensity of artificial lights – as seen from space – proving to be closely correlated with gross domestic product (GDP). Economists have used DMSP-OLS, a key imagery source from the USA's Defense Meteorological Satellite Program, to estimate, for example, economic trends in North Korea or to monitor economic development in countries where GDP figures may be scarce or unreliable. But while DMSP-OLS has allowed time-series comparisons since 1992, its resolution is relatively coarse and additional processing is required to mitigate a 'blooming' effect around urban areas or to make DMSP-OLS's eight satellites comparable.

Analysts can now utilize a higher-resolution source for night-time light data: the Visible Infrared Imaging Radiometer Suite (VIIRS), which captures imagery at up to 500m resolution. This means that it is now also possible to estimate spatial trends in economic activity down to the neighbourhood level. The research team has used a slope-of-change method to identify economic growth, trends and hotspots since 2012, marking high-growth city districts as 'hot' and areas of steady or declining economic activity as 'cool'.

• QUESTION 3: WHICH AREAS IN THE CITY HAVE GREEN SPACES THAT COULD ABSORB MORE FLOOD WATER?

The high-resolution imagery captured by Sentinel-2 allows for systematic extraction of open spaces, parks and gardens in urban settings. The widely used Normalized Difference Vegetation Index (NDVI) effectively picks out vegetation from multispectral imagery, benefiting from the unique reflective properties of chlorophyll. Additionally, the research team used analytical products derived from Landsat satellites to pick out areas that show extensive trends of deforestation. This enables suggestions regarding locations where reforestation in a city's watershed could contribute to preventing excess run-off that floods businesses and neighbourhoods, for example.

NETWORK EFFECTS

Just as analysis of satellite data is no longer limited to researchers with government connections or super-computers, the field of road network analysis is also being democratized by new technologies. Shortest-path analysis and routing engines have for decades been used by logistics firms to plan their vehicle itineraries or by emergency services to position their assets. Yet building a GIS road network remained onerous and time-consuming. Moreover, 'hidden choices' about how to represent city streets or intersections in the model have hampered cross-city comparisons.

So how can we compare road networks across 30 cities? Fortunately, data science tools such as OSMNx and Pandana – two open-source packages produced by researchers from the universities of Southern California and Berkeley respectively – have automated the process of importing road data from OpenStreetMap and transforming it into a mathematically valid graph object. This allowed the project team to pinpoint the most critical intersections that should be safeguarded from risks such as flooding and landslides. Criticality was highest in cities such as Cap-Haitien, Haiti, where 58% of shortest paths between network locations pass through a single point (a bridge at the north end of town).

CONCLUSION: FROM DATA TO DECISIONS

The availability of valuable satellite imagery resources such as sentinel and VIIRS at global scale begs further exploitation. Indeed, cities are becoming data-rich environments just as their vulnerability to climate change grows. Deriving more insights from free and currently under-exploited imagery sources can play a major role in driving the policy debates and investment choices that will enable cities to withstand natural hazards and climate change in the future. ◀

ACKNOWLEDGEMENTS

The research team included Brad Bottoms, Jenny Mannix, Madeline Jones and Brooke Hatcher (New Light Technologies Inc.) and Gaurav Bhardwaj (World Bank).

ABOUT THE AUTHORS

Ran Goldblatt is chief scientist at New Light Technologies. He holds a MA and PhD in geography and the human environment. Goldblatt's research focuses on remote sensing and geospatial analysis, at scale, and the development of methodologies and tools for monitoring natural hazards, LCLU changes, and economic development.
✉ ran.goldblatt@nltgis.com

Nicholas Jones is a disaster risk management specialist at the Global Facility for Disaster Reduction and Recovery (GFDRR), where he leads on data science at the GFDRR Labs team. He has worked at the World Bank / GFDRR since 2010.
✉ njones@worldbankgroup.org


EOS
Positioning Systems
ARROW SERIES™
High Accuracy Field Mobility
Submeter with EGNOS, 1cm with RTK
SafeRTK™ for poor cell coverage areas
GPS/Glonass/Galileo/BeiDou, L1/L2/L5
4cm real-time accuracy anywhere in the world
WWW.EOS-GNSS.COM
Made in Canada

A Little Innovation Goes a Long Way

The Netherlands' Cadastre, Land Registry and Mapping Agency, was the first mapping authority in the world to fully automate the production of multiscale maps and data. This was a huge accomplishment, because although the mapping community had buzzed about the potential of automating multiresolution geospatial map production for decades, many were still sceptical that it could even be done. The feat is even more impressive considering that it was carried out by a small, motley team that was in a bind.

In 2010, the government in the Netherlands legislated that the Netherlands' Cadastre had to update the nation's topographical maps more frequently – every two years instead of every four to six years. At the same time, however, the geoinformation department at the Netherlands' Cadastre was facing staff and budget cuts as a result of the ongoing global recession. The department was going to have to produce more information at a quicker clip with fewer people.

MULTIRESOLUTION GEOSPATIAL MAP PRODUCTION

Ben Bruns, the manager of the Netherlands' Cadastre's GIS customer solutions department, knew that his team was going to have to innovate. He had received a tip from Jantien Stoter, a professor at Delft University of Technology who was also a consultant at the Netherlands' Cadastre that Esri had some automation technology that was ready to use. Bruns took that information and ran with it. "Within half a year, we had accomplished automatic generalisation," said Vincent van Altena, a senior GIS specialist at the Netherlands' Cadastre, referring to what would become multiresolution geospatial map production. "It wasn't perfect, but it was fully automated. Even the most severe critics were amazed at what we had done."

"The system takes the Netherlands' Cadastre's best-scale data, which is TOP10NL, and automates the process from beginning to end, using that data to automatically produce the map products it needs," said Mark Cygan, Esri's director of national mapping and statistics solutions. "The system encapsulates the production process in 400 geoprocessing models, which are aggregated into three big geoprocessing models. The team can then push what Ben calls the make map button to generate maps for the whole country in one pass."

AUTOMATIC GENERALISATION

Now, the Netherlands' Cadastre delivers updated and higher-quality topographical maps of the Netherlands in less than two years. And, according to Cygan, the organization keeps improving.
"The last I saw, the Netherlands' Cadastre was able to do all the 1:50,000-scale maps for the country in two weeks with one operator," said Cygan.

But the innovation didn't stop there. After automating the Netherlands' Cadastre's 1:50,000-scale maps, the team was soon able to automate the Netherlands' 1:100,000-scale maps, as well as the

▲ *Thanks to Esri, the Dutch Kadaster delivers updated and higher-quality topographical maps of the Netherlands in less than two years.*

country's basemap, which has 15 different zoom levels. Then the geoinformation division automated all its maps with scales ranging from 1:25,000 to 1:1,000,000.

"This was Ben's vision from day one, when he started with automatic generalisation," said Iris Reimerink, a senior GIS specialist at the Netherlands' Cadastre. "The day we did it was a milestone for him. I remember him saying, 'I knew this was possible long before we started it.'"

Once the Netherlands' Cadastre had figured out how to automate its own map products, Bruns and his team set out to share what they did with other mapping agencies around the world. In the ensuing years, the team hosted four workshops that national geospatial authorities from at least 25 countries attended. The group not only taught these agencies about the technology that makes automation work, but it also shared how it handled the change management part of the process.

"Mapmakers from Ordnance Survey Ireland (OSi) attended the workshops, and there's a direct correlation to the incredible automation work they have done over the past few years," said Cygan. "Same with Great Britain's Ordnance Survey (OS) and many other mapping authorities around the world." While all this was accomplished by a skilled team of people working both at and with the Netherlands' Cadastre, "it was Ben's leadership, and the belief of Cadastre's executives in his leadership abilities, that made it all possible," added Cygan.

TESTING GROUND

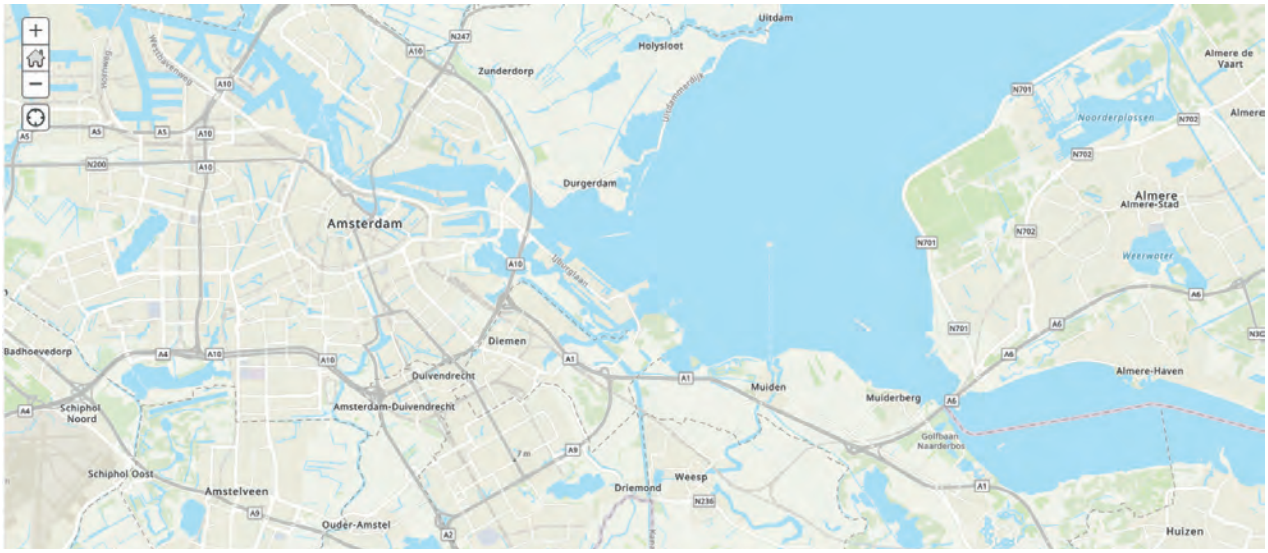
Bruns, who has a master's degree in geoinformation technology from Vrije Universiteit Amsterdam, began his career at the Netherlands' Cadastre as a cartographer. He quickly progressed into management roles, including the head of one of the cartography division's sections, the product manager for topography, and the manager of GIS customer solutions. According to several colleagues, he's always found ways to innovate.

Around 1995, he was commissioned to lead the Dutch contribution to the Vector Map (VMap) program, an international project that encouraged countries to digitize and share their map data. In addition to being project leader, Bruns was an active developer on VMap, cooperating with both IT and production staff. When VMap was replaced by the Multinational Geospatial Co-production Program (MGCP), a defence initiative aimed at digitizing and sharing high-resolution vector data for places dealing with humanitarian or military crises, the Netherlands' Cadastre's topographic service (which is now the geoinformation department) became a testing ground and quality control centre under Bruns' leadership.

Bruns was also closely involved in the development of TOP10NL, a 1:10,000-scale topographic geodatabase of the Netherlands. "Ben was one of the originators of this," said van Altena. "He designed the data model along with his colleagues and led the technical implementation. That's really important because if there was no TOP10NL, automatic generalisation would not have been possible."

▲ *Ben Bruns, the manager of the Netherlands' Cadastre's GIS custmer solutions department. Automatic generalisation would not have been possible without Bruns' imaginative leadership style.*

It also wouldn't have been possible without Bruns' imaginative leadership style. When his team suddenly had to accelerate map production, he came up with a concept called HIGH5, which brings people from different departments and backgrounds together for five weeks to solve a problem. "This was one of the first times we used HIGH5," recalled van Altena. "The results



▲ *Amsterdam area as displayed on the topographic base map of The Netherlands.*

were so promising that we got the green light to keep using it."

CUSTOMER-ORIENTED APPROACH

As the Netherlands' Cadastre waded deeper into automation, Bruns and his boss, Ulrike Schild, head of geoinformation at the Netherlands' Cadastre, also adhered to the lean management philosophy. "The philosophy is, you have a lot of spillage in a production process, so you need to try to eliminate that. The best way to do that is to evaluate all individual production steps, and if it does not add customer value to your end product, it has to go," explained Marc Post, who's also a senior GIS specialist for the Netherlands' Cadastre. "This customer-oriented approach was something completely new within the Netherlands' Cadastre, and it took a lot of effort and courage to introduce that into a world of traditional cartographic work." "This had a huge impact on production acceleration," added van Altena.

Another management philosophy that Bruns abides by is having a heterogeneous team. "The members of his teams must have different expertise," said van Altena, whose background is in theology. "If people from different backgrounds are able to communicate with each other, they can come up with different ideas."

"In his quest for a team, Ben is looking for unique characters, not copies or clones," said Reimerink, whose training is in conservation and GIS. "Each member of my team is creative, tenacious, independent, and stubborn," said Bruns. "Incredible innovations arise from the energy that comes from giving these distinctive people space and direction." "He also truly believes that everyone on his team is doing their best and is being honest about what's going on," added Post, whose background is in conservation as well. "Without that trust, the innovation doesn't happen."

NEW RULES

In the same vein, Bruns trusted the Netherlands' Cadastre's customers to tell his team what they wanted to see in their maps and involved them directly in the automation process. "Cartographers have a traditional way of doing things, according to a list of specifications, but to automate our map production, we had to create new rules," Post explained.

"Ben's team members said, these maps aren't going to look like they did in the past, but they'll meet customers' needs," said Cygan. "They then went directly to users and asked, is this map going to meet your needs and do everything you need it to do? All of the Netherlands' Cadastre's major customers were happy with the results, and many said they couldn't tell the difference from previous maps. Other mapping agencies, including OSi and OS, are finding the same thing."

> *"CARTOGRAPHERS HAVE A TRADITIONAL WAY OF DOING THINGS, ACCORDING TO A LIST OF SPECIFICATIONS, BUT TO AUTOMATE OUR MAP PRODUCTION, WE HAD TO CREATE NEW RULES"*

Now that the Netherlands' Cadastre has a handle on automatic multiscale mapping, Bruns' team is in the process of developing an automatically constructed 3D topographic dataset for the Netherlands, taken from point clouds and 2D base data. The geoinformation division is also exploring using machine learning techniques for topographic data. It seems that the innovation will never stop.

Visit https://go.esri.com/mapping-innovation for more information. This article originally appeared in the summer 2019 issue of *ArcNews* magazine

View of a typical Dutch landscape: The Dutch municipality of Wijdemeren seen from above.

Point Clouds – the Representation of the Third Kind

GIM International has published – and will no doubt continue to publish – many articles about point clouds: huge collections of (surface) points. Taken together, they represent the world at its best: up to date, and with every detail there is to be known. Most articles pay particular attention to the data acquisition of such point clouds, as they are obtained from 1) Lidar time-stamped reflections with the advantage of indicating 'empty' space between the observation point(s) and surface points, and 2) images by structure from motion (SfM) and dense image matching (DIM) techniques with the benefit of colour-enriched points.

Nowadays they are not only obtained by high-end professional equipment, but also ever-more point clouds are ever-increasingly captured using low-cost (consumer) hardware such as smartphone cameras and (relatively) cheap Lidar systems developed for self-driving cars and indoor robotics. This development also bridges the gap from outdoor to indoor mapping. The indoor 'terra incognita' where we all spend more than 80% of our lives is yet to be captured and represented to its full extent by point clouds. In other words, the world as we know it – and which is thus its own best model – is being sensed increasingly appropriately and more often, more densely and with more (derived) attributes by point clouds.

But just because all these point clouds are available, it does not automatically mean they are used to their full potential. Instead, point clouds are still misused for deriving polyhedral 3D city models with a relatively low level of detail (LOD). The necessary steps to obtain a better LOD are not that easy, not least because the detail is in the point cloud itself. Deciding which points contribute to which polygon of the (hopefully) watertight polygonal mesh unlocks a new version of the well-known quote from *Animal Farm* (George Orwell): "All points are equal. But some points are more equal than others". Only the end user can decide which points are really important – and that is impossible if the majority of the points are discarded (thus losing their connection) after being processed into 3D city models.

Moreover, this modelling step takes time and requires a lot of manual effort. Most buildings have some kind of architectural design and thus are not simply extruded blocks with an arbitrary roof shape. Therefore, fully automatic processing of LOD2 models that meets the user requirements seems to be so problematic that most digital-twin models are still partly 'handmade'. Such 3D models are outdated as soon as they are published, and no one knows how well these city models represent reality because the link with their original point clouds is not maintained.

Other researchers opt for a voxel-based, volumetric, Minecraft-like representation. The main disadvantage is the need to set a fixed orientation and a fixed sampling rate of the building blocks. However, as they look unrealistic, people are less likely to regard them as the truth than polyhedral representations.

▲ *Change detection in Dutch Point Cloud Height Model AHN2-AHN3 – MSc Geomatics student project, TU Delft.*

One statement always made in regard to handling huge point clouds is that they are… huge. Well yes, they are, which is why much can also be said in favour of such large '3D' (which are often actually only 2.5D) city models. For example, one very big advantage of point clouds is that they are relatively simple: effectively merely a bunch of X,Y,Z coordinates with some attributes. Well-accepted file-based standards (LAS/LAZ) have proven their value for the dissemination of point clouds. Smart structuring and (fast) queries from point clouds maintained in a DBMS with the continuous level of detail of point clouds as the fourth dimension is an ongoing research activity with promising results.

So the handling of point clouds is important, but the key issue – as stated above – is their effective use for explorative visualization and analysis purposes. First of all, the 'rich' point cloud paradigm underlines the concept of dense 3D point clouds by enriching them with comprehensive geometric, radiometric and semantic properties. They become 'smart' when the point clouds themselves are aware of these properties. Visibility analysis for decision-making provides far more detailed and realistic results if it is based on point clouds, especially when vegetation has to be taken into account.

And let us not forget the capabilities of the human cortex. We humans are still very adept at detecting details in 3D scenes. Some outstanding points which might be lost in a 3D modelling process could be more important than all other points in the scene. Which parts of a building are built as designed, and which are not? This explorative use of point clouds is supported by analytical tools like point cloud-based change detection, but also by high-end 3D point cloud visualization tools on screen, and even better in a point cloud-based augmented reality environment.

Last but not least, why spend so much time, effort and money on collecting point clouds, regard them as input data, process them into a derivative and then discard them? If you think about it, it is kind of ridiculous. Instead, I believe point clouds should be considered as the third kind of representation, alongside polyhedral surface representations and volumetric voxel representations. But they can provide far more insight (as they are more or less the reality) through explorative visualization and analysis. So my advice is: use them – as is, and directly!

ABOUT THE AUTHOR

Edward Verbree is an assistant professor at Delft University of Technology, the Netherlands. His thanks for help and inspiration in writing this column go to Martijn Meijers, Peter van Oosterom and Mathias Lemmens, as well as many MSc students of geomatics and GIMA at TU Delft.

e.verbree@tudelft.nl

REVIEW OF ISPRS GEOSPATIAL WEEK 2019

Sensors, Satellites and Science: the Power of Geoinformation

Every two years, the photogrammetry and remote sensing community gathers at the ISPRS Geospatial Week. The event comprises a combination of workshops organized by various ISPRS Working Groups and other stakeholders involved in the geospatial profession. The 2019 edition, which was held from 10-14 June in Enschede, situated in the eastern part of the Netherlands, proved to be a true geospatial hub bringing together a wide range of geomatics-related activities and applications.

Creating a better, safer world – that broadly sums up the objective of the ISPRS Geospatial Week participants. With projects covering innovations for land tenure, an efficient method to detect seals in the Arctic and the use of artificial intelligence for mobile robot navigation, the common denominator was a focus on developing solutions to the issues faced by our planet, now and in the future. This year's programme consisted of around 275 oral presentations – spread across five different tracks during the day – and more than 100 poster presentations. The sessions were organized around 13 workshops reflecting the hot topics in photogrammetry and remote sensing at present.

INSPIRING KEYNOTES

The opening keynote was delivered by Edward Anderson of the World Bank. He shared his experience on World Bank projects dealing with various geospatial technologies such as open data for resilience, innovations in spatial planning, community mapping with UAVs, and early warning systems. Anderson pointed out how the Tanzanian Urban Resilience Programme (TURP) in Dar es Salaam, Tanzania, is combining wide-scale in situ geospatial data collection with unmanned aerial vehicles (UAVs or 'drones') and machine learning for disaster risk management. On the subsequent days, a further nine keynote speakers presented the latest technical advances in their fields, varying from UAVs in agriculture and forestry monitoring to urban energy simulation and semantic 3D city models. Some presentations even went beyond the realms of our own planet; Randolph Kirk, Scientist Emeritus at the USGS, demonstrated in his keynote how NASA's Europa Clipper mission will investigate the ice shell and ocean, geology and composition of Jupiter's moon.

UAVS AND ARTIFICIAL INTELLIGENCE

Over the course of the week, participants had an opportunity to learn about the latest advancements in the field through a series of talks and poster presentations as well as

▲ *Opening ceremony of the ISPRS Geospatial Week 2019.*

▲ *Mila Koeva, member of the organizing committee, delivering a presentation.*

a total of ten keynote speeches that opened workshops and joint sessions. The use of machine learning and computer vision for the improvement of geospatial data quality and analysis was a recurring theme across various workshops. One prominent example of this was a keynote speech by Margarita Chli from ETH Zurich. She presented the work of Vision for Robotics Lab, focused on building SLAM algorithms that will allow UAVs to better understand and reconstruct their surroundings. Besides that, participants were able to learn more about the enormous variety of applications of remote sensing and photogrammetry, from the use of UAVs to detect Antarctic seals and penguins to monitoring urban subsidence and ground deformation using InSAR.

▲ *Keynote speaker Craig Glennie from the University of Houston, USA, explained the principles of Lidar and the difference between SPL and full-waveform Lidar. (Image courtesy: Jan Böhm / Twitter)*

DEEP LEARNING

Plenty of attention was paid to the artificial intelligence trend at this year's ISPRS Geospatial Week, including in the papers presented (e.g. in the Semantics3D workshop). Other recurring topics throughout the conference included automatic extraction and object detection. For example, Simon Hensel from Niederrhein University of Applied Sciences in Krefeld, Germany, presented a workflow for generating LOD3 CityGML models – including structured facades – based on textured LOD2 CityGML models by adding window and door objects. Another presentation in the Semantics3D workshop was delivered by Emre Özdemir (Fondazione Bruno Kessler), who updated the audience on the classification of aerial point clouds using deep learning. The research project is focused on 3D building reconstruction based on the classification of aerial point clouds without ancillary data (i.e. data from sources other than remote sensing that is used to assist in analysis and classification or to populate metadata). The project work includes a deep learning approach based on specific geometric features extracted from the point cloud.

SINGLE PHOTON LIDAR

One of the most popular sessions was the joint session on single photon Lidar (SPL) – which is not entirely surprising, as it is safe to say that SPL is one of the most promising recent advances for mapping applications. Keynote speaker Craig Glennie from the University of Houston, USA, explained the principles of Lidar and the difference between SPL and full-waveform Lidar. He also outlined the stages in the development of these techniques, explaining that large sums of money have been invested in high-altitude Lidar operation for military purposes and the links with Icesat. In the same session Gottfried Mandlburger compared full-waveform Lidar flown at 750m against SPL flown to give a corresponding point density. He concluded that SPL requires fewer flight strips to cover the same area due to the higher flying altitude and the resulting broader swath width, but that the waveform Lidar 3D point clouds provide a sharper and more concise mapping of both topography and buildings.

LAND ADMINISTRATION TOOLBOX

The its4land project consortium chose the ISPRS Geospatial Week for the official launch of the its4land Land Administration Toolbox, which contains six tools designed to help land administration communities in developing countries. A workshop was held to present the core ingredients of the toolbox, which include software tools for recording land tenure information based on hand-drawn sketch maps, UAV-driven workflows for land tenure data acquisition, and semiautomatic and interactive delineation of visible cadastral boundaries. All the tools are integrated in a software platform for publishing and sharing land information via geocloud services. Moreover, the toolbox combines consultancy services in the field of needs assessment and governance as well as capacity-building models for innovative technologies.

BUSINESS MEETS SCIENCE

A particular highlight of the conference was its focus on collaboration between academia and the geospatial industry. During breaks between the workshops, the delegates had the opportunity to meet with a range of industry representatives and attend talks by sponsoring companies presenting cutting-edge technologies that allow for the capture and analysis of geospatial data. The programme included presentations by companies such as Pix4D, RIEGL and Agisoft. The visible synergy between business and science adds a valuable dimension to events such as the ISPRS Geospatial Week. Sander Oude Elberink, member of the organizing committee, comments: "The industry presentations were well attended, with many scientists interacting with the presenters representing the companies. Likewise, many delegates from private companies attended the scientific sessions. On the sensor side, new insights were presented into Lidar sensors such as the single photon Lidar systems. This illustrates that business and science need each other in order to make progress." According to him, vendors are opening up parts of their data processing to gain more insights from scientists.
While this can be said of many industries, it may be even more true for our geomatics profession; it is fair to say that innovation is fundamental for business, and there are huge mutual benefits to be gained from collaboration between business and science. The ISPRS Geospatial Week proved to be a great example of this, and the organizers of the next edition (which will be held in Dubai in 2021) are strongly recommended to keep this in mind. ◀

FURTHER READING

- ISPRS Archives: Volume XLII-2/W13, 2019: https://bit.ly/2TRsOw1
- ISPRS Annals: Volume XLII-2/W13, 2019: https://bit.ly/2zdLxse

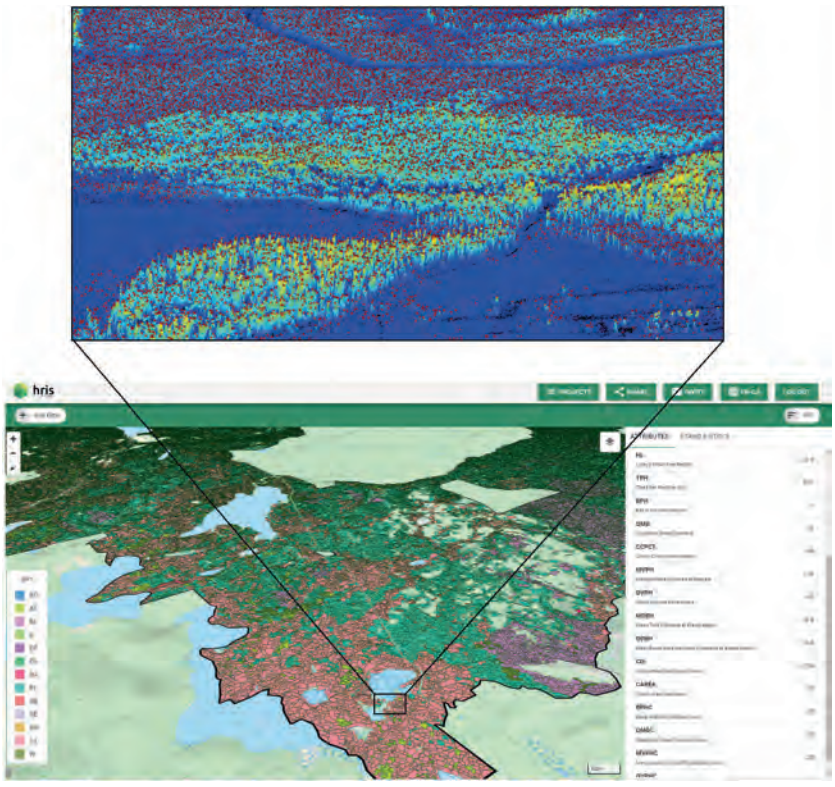
MORE INFORMATION

www.gsw2019.org

HRIS AND A TRILLION TREES

Need for High-resolution Geospatial Information for Forest Resource Planning

Precision forestry technology is moving forward at an amazing pace, with advancements in global positioning systems, remote sensing platforms and data sources, cloud geospatial engines, mobile GIS data collectors and advanced selective logging machinery. Without accurate and reliable vegetation inventory information, however, this new arsenal of precision forestry tools falls short for operational forestry. Not knowing exactly where and how a specific tree stock is growing in the landscape makes it very difficult to selectively log or plant that resource for inventory supply management or, as more and more groups are exploring, to plant more of it to enhance our atmospheric carbon sinks.



▲ *Top: Airborne Lidar point cloud with false-colour tree height and individual treetop point vectors showing one of the key data inputs for HRIS.*
Bottom: The HRIS online data viewer used to query and navigate forest resource inventory attributes at the microstand level.

New research on global forest cover potential indicates that planting trees by the billions could be one of the most cost-effective ways to significantly reduce atmospheric carbon levels and help combat climate change. In practice this makes a lot of sense; trees sequester carbon from the atmosphere and store it in their stems and in the ground. However, there are many complex growth-process logistics to consider when contemplating planting new forests, and many variables to consider when quantifying and managing their carbon storage potential. How fast will the trees grow in a given location? What kind of forest community and structure fosters or hinders tree growth? How will climate change affect their growth potential? And what forces might slow them down or drive mortality before they reach their full carbon sequestration potential? These are difficult questions to answer at local, regional and global scales.

HRIS

New technology advancements in very-high-resolution remote sensing and geospatial analytics are emerging that now allow foresters, silviculturists and data scientists to account for and measure growth dynamics

for the trillions of trees on the planet (current estimates put the global tree count at 3.04 trillion) as part of sustainable natural resource management solutions. For example, faced with the challenge of creating highly accurate inventories for millions of hectares of forest managed in British Columbia, Canada, Tesera Systems created its high-resolution inventory solutions (HRIS). Based on advanced geospatial data fusion and processing methods, the resulting high-resolution inventory product combines detailed stand biometric information from ground plots, high-density airborne Lidar, multispectral aerial and/or satellite imaging, and a suite of climate, topographic and hydrological indicators. This enables generation of statistically verifiable accuracy and precision forest attribute estimates at the microstand level (0.2-5 ha). Moreover, it produces estimates of growth and yield potential for any given stand of trees in a landscape.

BETTER ALIGNMENT

The HRIS viewer helps foresters utilize this massive amount of data by putting detailed and reliable information about their changing forest resources at their fingertips. This powerful web GIS portal enables them to navigate and spatially query millions of high-resolution inventory attributes generated from the stand biometric geospatial models. The stand productivity index that incorporates climate metrics, actual tree growth and yield observations allows foresters and land managers to make short/medium/long-term plans. Hence, they can better align their operations with carbon storage targets, for example, or with regulatory guidelines for forestry-specific climate mitigation strategies.

Forest landscapes can change significantly from year to year due to natural disturbance dynamics such as fire, floods, disease and human activities. As forest inventory solutions continue to leverage higher-resolution and higher-frequency satellite radar and multispectral imagery sources, along with machine learning techniques to automatically update and improve the inventory dynamics models, such solutions have the capacity to scale across vast areas (i.e. millions of hectares) and offer ongoing updates to changes in forest resources. Forest managers need access to reliable, detailed and dynamic forest stand and stock databases in order to successfully target their reforestation efforts and assess deforestation impacts. Such information also helps regulators to gauge local and regional changes in forest inventory in the context of global carbon cycles and major climate mitigation initiatives.

Humanity tends to disagree on plans of action for large global problems when the data is uncertain, missing or outdated. With reliable tree inventory information in the hands of decision-makers and workers on the ground we can move forward with sound plans and actions to mitigate losses and reduce risks in the forestry sector with respect to climate change. If we take it upon ourselves as a global society to plant a trillion trees to increase global carbon sequestration, it surely would be invaluable to track how those plantations are performing and how much carbon they are storing. Using highly accurate geospatial data from sources such as Tesera's high-resolution inventory technology, we can more confidently plan, manage and adapt to the changing needs for forestry resources, not only considering timber and wood/pulp products, but also other ecosystem values including global carbon restocking and storage needs. ◀

FURTHER READING

- https://science.sciencemag.org/content/365/6448/76
- https://www.nature.com/articles/nature14967
- https://hris.tesera.com/
- https://viewer.hris.tesera.com/p/knifecreek?layers=Outdoors,boundary

ABOUT THE AUTHOR

Dr Cassidy Rankine is a remote sensing scientist at Tesera Systems, a provider of innovative geoinformatics, machine learning, web and cloud geoprocessing solutions. The company is based in Calgary, Alberta, Canada.
✉ cassidy.rankine@tesera.com

5 Questions to... Professor Ghang Lee

The Rail BIM 2030 Roadmap Project

The Rail BIM 2030 Roadmap has been developed collaboratively by the Korea Railroad Research Institute, Yonsei University and the Korea Rail Network Authority. It explains the five phases of building information modelling (BIM) adoption and diffusion strategies from 2018 to 2030 for the advancement of the South Korean railway industry in the 4th Industrial Age ('Industry 4.0'). We asked Professor Ghang Lee, director of the Building Informatics Group (BIG) at the Department of Architecture and Architectural Engineering at Yonsei University in Seoul, South Korea, five questions in order to find out more about this project.

Can you please briefly explain the background to the Rail BIM 2030 Roadmap?

The Korea Rail Network Authority (KR) is a government agency that oversees and manages the entire railway lifecycle, including the high-speed, conventional and urban rail infrastructures. Considering that the first large public BIM project in South Korea was organized in 2008, KR adopted BIM relatively early; KR conducted its first BIM project in 2009 and a further eight before 2018. Nevertheless, not many people within KR knew about these BIM projects because they were conducted at project level rather than company level. The knowledge and experience gained through the projects vaporized because they were done in an uncoordinated manner without a good roadmap and strategies.

What is the current status of the project?

To overcome this problem, Yonsei University was asked to develop the Rail BIM 2030 Roadmap for KR in association with the Korea Railroad Research Institute (KRRI) as part of the Rail BIM project funded by the Ministry of Land Infrastructure and Transport of Korea (MoLIT). The main difference between previous roadmaps and the Rail BIM 2030 Roadmap is that the Rail BIM 2030 Roadmap categorizes the BIM phase by how BIM is utilized, whereas the other BIM roadmaps categorized each phase by the size of a project (such as floor area or project cost), submissions (CAD drawings versus IFC models, COBie files) and so on. The Rail BIM 2030 Roadmap is based on the BIM Utilization Level (BUL) model, which was developed following studies of BIM lasting more than ten years. When we developed the roadmap, two of the critical questions were how to tell whether KR has reached the next level, and how to conduct a project to enable us to accumulate ever-more knowledge about BIM and subsequently share it. The last two sections of the Rail BIM 2030 Roadmap address these questions. The final version of the roadmap was released in August 2018 in English and Korean and is free to download. (see Further Reading).

How important is cadastral data in your BIM strategy?

Cadastral data is an essential part of any railway project. If a planner, designer or contractor fails to coordinate a railway design with existing cadastral maps, the project will not only be delayed but will also face critical over-budget issues. Thanks to 'BIM on GIS' technologies, a BIM model of rail infrastructures can be overlaid onto a GIS model to check potential spatial clashes and constructability issues as well as civil complaints in the early phase of a project. Unsurprisingly, BIM-GIS integration is one of the goals of phase 1.0 of the Rail BIM 2030 Roadmap.

3D visualization plays a major role in the project. Can you give us some examples?

The fundamental and core way of using BIM is for public hearings and design coordination. It is becoming the norm to use 3D visualizations of projects in meetings and public hearings by displaying a BIM model on a big screen or using virtual reality or augmented reality technology. These 3D visualization technologies are also often used in a project's exhibition hall to help people better understand the project and ultimately reduce the social cost and huge financial burden that can occur later on in a project.

What other technologies are involved in completing the Rail BIM 2030 Roadmap?

In a BIM project, it is crucial to update the BIM model by reflecting any changes made on site. This is often referred to as 'site-model synchronization'. If the BIM model does not reflect the actual site conditions, all the coordination meetings become meaningless. 3D scanning such as laser scanning or photogrammetry is often used to capture the site conditions, and drones are often used to cover large or high areas. Furthermore, there is growing use of cloud-based BIM tools and repositories to synchronize BIM models created and managed by multiple project participants. Nowadays, we are seeing the construction industry adopt ever-more manufacturing technologies and management techniques such as off-site construction and lean construction. There are growing efforts to use robotics, big data and artificial intelligence in construction, but these have not yet become commonplace. The Rail BIM 2030 Roadmap aims to achieve this stage by the 2030s.

Further Reading

http://big.yonsei.ac.kr/railbim/

About Professor Ghang Lee

Professor Ghang Lee is director of the Building Informatics Group (BIG) at the Department of Architecture and Architectural Engineering, Yonsei University, Korea. His main interests include building information modeling (BIM), requirements engineering, interoperability and construction automation. He has published over 200 works, including *The BIM Handbook* (3rd edition).

factrics

marketing by facts

TECHNICAL B2B MARKETING

for smart engineering companies

www.factrics-marketing.com

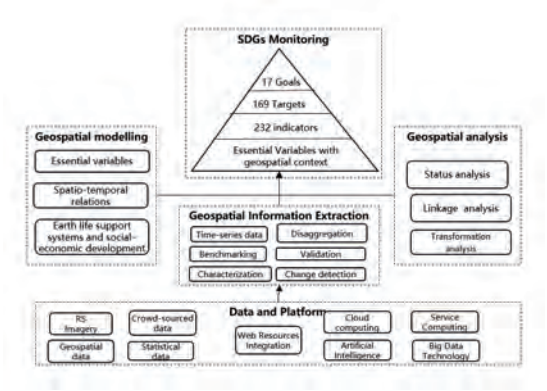
Geospatial Information-enabled SDGs Monitoring for the 2030 Agenda: An ISPRS Scientific Programme

In September 2015, the United Nations adopted Transforming Our World: the 2030 Agenda for Sustainable Development. This is a global development plan to address complex and diverse global development plan to address the complex and diverse challenges and to provide a shared blueprint for peace and prosperity for people and the planet. Many of the issues affecting sustainable development can be analysed, modelled, and mapped within a geographic context, which in turn can provide the integrative framework necessary for global collaboration, consensus and evidence-based decision-making. As pointed out by Greg Scott and Abbas Rajabifard, the global geospatial community now has a unique opportunity to integrate and connect geospatial information into this global development agenda in a more holistic and sustainable manner.

The 2030 Agenda is anchored by 17 Sustainable Development Goals (SDGs), 169 associated targets and 232 indicators. To support their monitoring, the 2030 Agenda calls for "data which is of high quality, accessible, timely, reliable and disaggregated by income, sex, age, race, ethnicity, migration status, disability and geographic location and other characteristics relevant in the national contexts". The UN IAEG-SDGS WGGI has identified the need to exploit the contribution exploit the contribution to be made by a wide range of data, including Earth observations and geospatial information (UN-GGIM, 2018). UN-GGIM also noted that the integration of statistical data and geospatial information would be key to the monitoring of many indicators. It further noted that it is impossible to measure and monitor many of the SDG indicators without the use of timely, accurate and up-to-date geospatial data and information.

As one of the most influential scientific societies in the geospatial field, ISPRS has been actively engaged in the related activities of UN-GGIM and GEO. It has supported the global land cover mapping, urban initiatives and suchlike with GEO and the task forces on geospatial disaggregation and capacity building, among others, with UN-GGIM. In addition, ISPRS has supported some preliminary studies through its scientific initiatives or educational and capacity-building initiatives in the past few years. In order to further its support of the SDGs, it is of critical importance for ISPRS to establish a new programme to bring together and coordinate all related resources from geospatial communities to provide the needed geospatial data, information and expertise for SDG monitoring.

The overreaching goal of this ISPRS Scientific Programme is to advance and achieve the geospatial-enabled monitoring of SDGs by mobilizing and integrating resources from ISPRS and its members. The goal can be achieved by the following specific objectives: 1) identify key scientific and technological challenges of geospatial information and Earth observations for SDG monitoring; 2) showcase the use of geospatial information and Earth observations as well as statistical and other data sources; 3) develop novel and innovative methods for deriving essential geospatial variables for SDGs through e.g. machine learning, big data analytics; 4) establish geospatial knowledge services and collaboration platforms; 5) increase awareness and understanding of the vital and integrative role of geospatial information and Earth observations; and 6) build capacities in using geospatial information and Earth observations. Working with its members, ISPRS can contribute to data and platforms, geospatial information extraction and geospatial analysis and modelling towards the geospatial information-enabled monitoring of SDGs (See Figure).
It is expected that this programme, once implemented, will strengthen the voice of ISPRS in the international communities about the progress and contribution of geospatial information from imagery in support of SDGs monitoring. The programme will further promote closer collaboration between ISPRS and other intergovernmental organizations (such as UN-GGIM and GEO) and NGOs (such as ISC, Geo-Union, ICA, FIG, etc.), and strengthen its scientific leadership role on the geospatial information-enabled monitoring of SDGs.



▲ *Areas where ISPRS can contribute through its expertise.*

ACKNOWLEDGEMENTS

The author would like to thank his colleagues Yifang Ban, Maria Antonia Brovelli, Songnian Li and Hao Wu for their contributions to this column. ◀

Jun Chen is the chief scientist of the National Geomatics Centre of China and the first vice president of the ISPRS. He has previously served as the president of ISPRS and in many other important roles in GEO, UN-GGIM, etc. His expertise includes mapping, spatial data infrastructure, image processing and geospatial standards.
✉ chenjun@ngcc.cn

SURVEY EQUIPMENT TRAINING

opti-cal surveyequipment.com

A DIVISION OF PLANT

Opti-cal offer training across the whole of the UK, covering a wide range of topics and allowing you to customise the course to your requirements.

Courses include:

- Total Stations
- GPS/GNSS
- 3D Laser Scanning, including hand-held
- Ground Penetrating Radar
- Cable Location (CAT and Genny)
- Levelling and Infinity
- Mobile Mapping
- Machine Control (Simulation)

Choose training on site, at your offices or at our service centres.

Contact us now to discuss your training needs:

0330 678 0181

training@surveyequipment.com

www.surveyequipment.com

find us on

MAPLESS TOPOGRAPHIC PRODUCTS ARE THE FUTURE

3D is the New Normal in Switzerland

Switzerland is unique in that it is still the only country to have switched entirely to 3D for its national object-oriented topographic database. As users increasingly discover the advantages in terms of new workflows and services, nobody regrets leaving the 2D era behind. According to Swisstopo, the extra dimension creates no extra costs – only extra benefits.

It took the Swiss Federal Office of Topography (Swisstopo) ten years to build an object-oriented topographic database in 3D, with the last objects having been completed in 2019. "Nothing is excluded now; everything you can think of is available in 3D. Even the administrative boundaries, which are legally not defined in 3D, are for practical reasons projected on the 3D terrain model," states André Streilein, head of topography at Swisstopo. The difficulties and costs associated with the new data infrastructure were not caused by the third dimension, he says. "There was no specific 3D work. Since we already used photogrammetry, we were already measuring in three dimensions, only we never used the third dimension. The main effort was related to changing from a system of cartographic-based databases to a single topographic-based one. That was the real objective; we just incorporated the 3D element too." Swisstopo migrated several legacy multi-scale databases into one high-resolution topographic landscape

▲ *André Streilein: "The financial benefits of 3D are huge for the country as a whole. And ultimately it's about how we survive as a society." (Image courtesy: Jeroen van Berkel, VBB)*

model comprising over 25 million uniquely referenced objects. This scale-independent database is maintained via orchestrated rule-based production workflows to enforce the highest levels of data quality and efficiency. "The main challenge for us over the past years has been the 'degeneralization'. All the cartographic generalization had to be undone and the features of the objects had to be mapped just as they appear in reality. We now have everything at a degree of detail to allow the generation of 1:5,000 maps." Most Swisstopo products (including 2D ones) and services are derived from that single topographic landscape model (TLM) and the corresponding 100%-consistent digital terrain model (DTM).

▲ *City of Lausanne (swissTLM 3D).*

DATA CAPTURE AND MAINTENANCE

The coordinates of every vertex of all TLM objects are recorded in the same way nationwide with an accuracy of 20cm, except for features which are not defined at 20cm (such as forests). Every year, one third of the country is subject to remote sensing by aerial photogrammetry. Swisstopo uses Lidar and photogrammetry for the terrain and also for the surface models. Unmanned aerial vehicles and satellites are used for complementary up-to-date information in the areas that are not flown that year. Information collected by local authorities is also important input. Nothing is measured terrestrially any more. "Time is only spent on fieldwork if the photogrammetry processing employees have a specific query, such as: 'Is this the right underground connection to an underpass?'. In that case, our field staff – who are not necessarily qualified surveyors – verify the situation in the field, armed with a copy of the database. They mostly only have to say yes or no."

'NOTHING IS MEASURED TERRESTRIALLY ANY MORE'

Nowadays, the main challenge for Swisstopo in the updating process is to shorten the update cycles. A new version of the total topographic database is formally released every year, and some parts are even updated more often. That does not mean there is a new version of every separate product in that frequency, even though everybody assumes that the data in digital maps is both up to date and correct. "In our TLM, the 'Verified' label is the only guarantee of 100% quality and correctness," says Streilein. "The local authorities inform us whenever they start work on infrastructure projects. That goes into our database with the label 'Under construction'. As soon as new or changed infrastructure is released by the authorities, it is in our database within the space of a week under the label 'Built as planned'. The object appears in our aerial imagery a maximum of three years later and then it is labelled 'Verified'."

GOVERNMENT CURRENCY

The Swisstopo website has more than 30,000 unique visitors per day, to access the topographic database, orthophotos, terrain data and geological information. All the geodata recorded by other governmental organizations is also published in the national geodata portal coordinated by Swisstopo. Furthermore, Swisstopo is of course involved in many projects. For the Federal Office for Environment, for example, they monitor glaciers or the vegetation development in areas that have suffered forest fires. Public-sector organizations have to pay for Swisstopo's services in 'government currency'. André Streilein explains: "We send them an indicative invoice. We do not want a situation in which government organizations have to make a profit by billing each other or have to use poor-quality data because they need to save money. But in Switzerland the government wants to ensure awareness of the costs."

Citizens can view the data for free, while the private sector has to pay real money. Swisstopo is required to generate a return of about 27% per year on the public investment. "Therefore, we license our data for commercial re-use. The licensing cost depends on the intensity of use by the companies. Basically it is based on trust, but they have to report back to us on how they used the data. We hardly ever have problems with companies trying to manipulate us."

In Switzerland, the question 'Why not use Google Maps?' is not uncommon. "The answer is not only that our work is more precise, but also that we are unbiased by commercial or political interests, which is the main value. You can trust it. It's not like a Google search, in which you get different results depending on what kind of hardware you use or your location or the time of day. This 'Google Maps' question is less common in the public sector. Most Swiss politicians understand that, in this day and age, the federal geographic data infrastructure is as important as the infrastructure of highways or railways and that the state has to have full control of these databases, from content to quality assurance."

BENEFITS

Around 15 years ago, before the creation of the TLM, Swisstopo sent out questionnaires across Switzerland, asking 'What do you need in 3D?'. It received almost zero response. Now

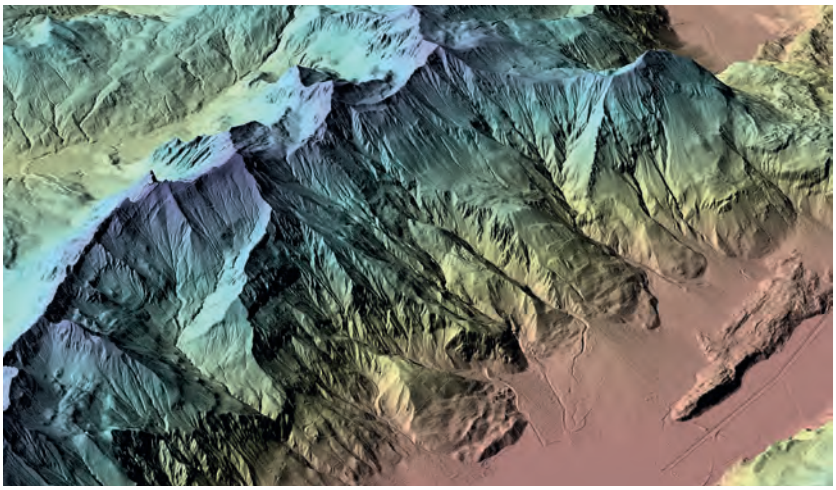
that the products are in use, the customers are generally pleased and are better able to indicate what else they want. Users are discovering that they can do things that were not possible with 2D data. Architects can integrate 3D data with their BIM data, road authorities can directly include the steepness percentage in their calculations, 'smart city' applications need 3D, and so on. "The financial benefits are huge for the country as a whole. And ultimately it's about how we survive as a society," comments Streilein. For example, Switzerland wants to have pulled out from nuclear energy by 2050, so the Federal Office of Energy needs to stimulate solar energy. In conjunction with them and with the Meteorological Office, Swisstopo made a solar cadastre based on 3D roof data (roofs are separate objects in the TLM) and built a web application around it. That enables people to see whether it is worthwhile for them to invest in solar panels in their particular situation. They can share the output from the app – a PDF specifying the type and quantity of panels, location on the roof, costs, return on investment, etc. – with an installation company and then use it to apply to their local government for a subsidy. The number of solar panel installations has soared in Switzerland since the launch of this solution because it has made things easier for citizens.

The existing IT infrastructure back in 2008 was insufficient to optimally share the benefits of all the data and services becoming available; something had to be done to create more computing capacity. Today, with approximately 80TB of data being exchanged with around 13 million customers per month and up to 3,000 map tiles delivered per second, cloud computing has proved to be the right choice. The capability to scale the solution (AWS from Amazon) vertically and horizontally within minutes resulted in year-on-year growth in usage of 50% over the last ten years while concurrently reducing the cost of data-unit transfers. The cloud's ability to store and disseminate data has allowed the creation of products that can push information in near real time.

NO MORE MAPS

On the topic of time, the next step is 4D. Every object in the database has a time stamp of when it came into existence and when it was entered into Swisstopo's database. The first point is debatable, however. Take a new train tunnel, for example – does it come into existence upon physical completion, at the official opening ceremony, or the first time a train passes through it? Dr Streilein admits: "This poses a new question for topographic institutes. We've chosen the moment to be when the railway company first uses it in its timetables."

4D comes as no great surprise, but a national mapping agency thinking about the 'era after maps' does. Swisstopo has launched a project to gain a better understanding of how the next generation will use geographic information. "Maps are losing their role as transmitter of geographic information," he states. "We 'older' people understand maps, because we learned to use them at school, as scouts, in the military, etc. Today's young people use GPS-based localization information and want to see realistic images." Swisstopo is therefore investing in augmented reality so that people using a smartphone or other device will only see real-world images on their screen along with the data they need for a specific task. Today it is still possible to see underlying maps, but in the future users will ask for a photorealistic image of where they are and/or want to go and the information they 'need' from organizations related to the objects concerned. Some Federal Spatial Data Infrastructure datasets are currently being transformed into linked data so every object will have a unique resource identifier (URI). Different organizations can connect with it and the user obtains (real-time) information from different sources in one search. "It is not a problem for the database in principle. But we must transform the database into products that the future user needs. That's the challenge!" concludes André Streilein. ◀



▲ *Lake Brienz and Brienzer Rothorn (swissALTI 3D).*

ABOUT SWISSTOPO AND ANDRÉ STREILEIN

Swisstopo, the Swiss Federal Office of Topography, is the national mapping agency of Switzerland, a mountainous country at the heart of Europe spanning a total area of 41,285km² (15,940 square miles). The agency plays a vital role as Switzerland's geoinformation centre by collecting, managing and publishing official spatial data. Swisstopo measures, records and documents Switzerland's landscape and underground structure. It is renowned worldwide for the quality and accuracy of its maps. Other significant offerings include altitude and landscape models, aerial photographs, orthophotos, geological data and maps, as well as internet and mobile applications such as the Swiss Federal Government's map viewer: map.geo.admin.ch.

Dr André Streilein is head of the department of topography at the Swiss Federal Office of Topography in Bern. Before he joined Swisstopo, he worked for several years as a senior researcher and assistant professor in the field of photogrammetry and remote sensing at ETH Zurich (Switzerland) and TU Delft (the Netherlands). He has a long-standing history in senior positions within various national and international organizations and served as vice-president research of European Spatial Data Research (EuroSDR).

ABOUT THE AUTHOR

Frédérique Coumans is contributing editor for *GIM International*. For more than 25 years, she has been covering all aspects of spatial data infrastructures as editor-in-chief of various magazines on GIS, data mining and the use of GIS in business. She lives near Brussels, Belgium.
✉ fcoumans@vbkcontent.com

USING PHOTOGRAMMETRIC AND LIDAR DATA

Updating the Cadastre in Ecuador

The integration of photogrammetry and Lidar can lead to generating synergies and economic savings. The two techniques were used together to detect irrigation and drainage canals for a project aiming to improve irrigation methods and create the related land registry in the province of El Oro in Ecuador.

For over 60 years, the decentralised provincial government in El Oro, Ecuador, has been committed to the agro-productive development of the province. As part of this, it has promoted the construction, management and maintenance of a network of irrigation and drainage canals, thus supporting investments in the agro-productive sectors. To improve the efficiency of the water resources management, the government set itself the target of updating the users' register and surveying the technical and economic assessment of irrigation and drainage systems in the 'Pasaje - Machala', 'Pasaje - El Guabo - Barbones' and 'Santa Rosa' territories. The aim of this survey was to identify the number of actual users of irrigation systems, quality of service, use and occupation of land, the types of crops and the type of irrigation system installed.

SCOPE OF THE PROJECT

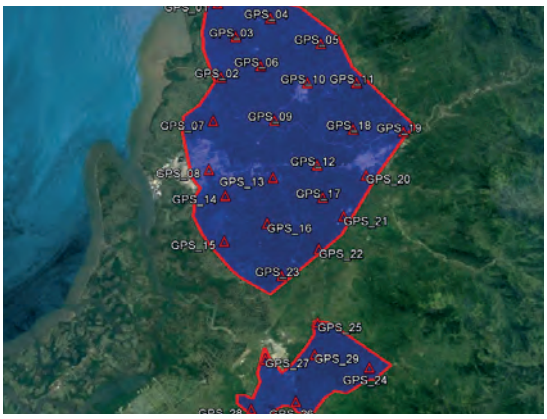
The project involved a total area of approximately 54,900ha, covered by about 15,000ha of known irrigated land, which, before the survey was thought to be served by about 200km of canals. It was estimated that the area cultivated by the users of irrigation and drainage systems was equal to about 20,000ha and 1,500 plots, with a ratio of 2 users per plot, for a total of about 3,000 users (Figure 1).

From a government perspective, the results would provide a significant basis for territorial planning (irrigation, viability, urban expansions, and the prevention of hydro-geological instability). The results would allow further agricultural development in the area through the optimisation of irrigation and canal management systems. Last but not least, the results would allow the government to optimise the property taxes and the implementation of fiscal equalisation mechanisms.

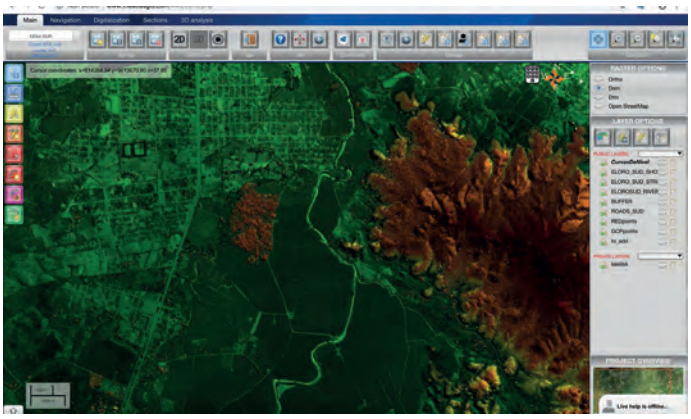
The more technical aim was to extract canals with almost fully automated techniques and, as much as possible, their geometric characteristics. The requirements of the project were very stringent (of the order of 10cm in planimetry and 6cm in altimetry) and the available time limited. The cartographic basis was defined by a geo-referenced photogrammetric survey integrated with Lidar data. As a platform, a Bell 206 helicopter was used (Figure 2). The results were disclosed through a structured GIS using the web-based AtlasGIS from MEDS Amsterdam.

▲ *Figure 1: The project area of the province of El Oro in Ecuador.*

▲ *Figure 2: The Bell 206 helicopter that was used in the survey.*



▲ *Figure 3: The localisation of the GCPs.*



▲ *Figure 4: Overview of the drainage and irrigation canals.*

TOPOGRAPHIC OPERATIONS

The Lidar and photogrammetric survey was based on a network of Ground Control Points, built according to IGM specifications (Instituto Geográfico Militar) of Ecuador regarding the location of ground control stations and the observation times of the static GNSS measurements (Figure 3).

During the photogrammetric survey, a GNSS receiver was set up on one of the topographically surveyed points in such a way as to occupy a barycentric position with respect to the area overflown. The receiver, set up in this way, had a sampling interval of 2Hz and was active at least one hour before and one hour after the flight period. For the complete survey of the 29 vertices of the topographic network, four dual frequency Leica 1200 GPS and Glonass receivers were used. The processing of the static GNSS survey was also done to IGM specifications. The adjustment computation was performed with the Leica Geo Office 7.0 software giving an overall accuracy below half a centimetre horizontally and a maximum of one centimetre in height.

PHOTOGRAMMETRIC SURVEY

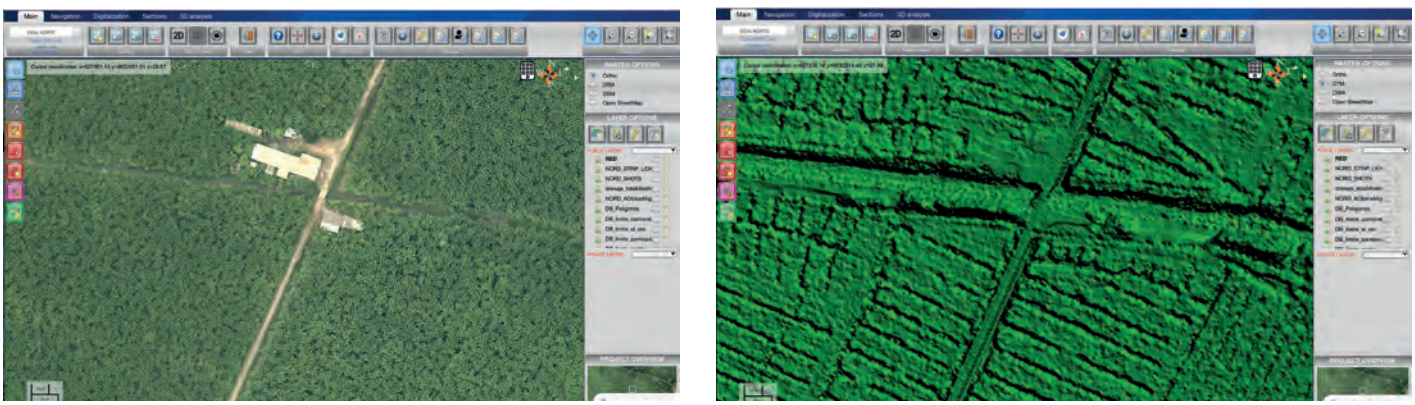
For the photogrammetric part of the survey, a medium-format Leica RCD30 camera of SwissLiDAR was used. This camera has a 53mm focal length, a resolution of 8956 x 6708 pixels and a pixel-size of 6 microns for the visible part of the spectrum. It can also collect Near Infrared (NIR) with a resolution of 4478 x 3654 pixels and a pixel-size of 12 micron. The camera is integrated with a dual frequency L1 / L2 NovAtel SPAN GPS and Glonass receiver and an IMU sensor rigidly mounted on the camera body. The survey was designed to create a GSD (Ground Sample Distance) of 10cm. The flight operations were carried out in the hours around noon to limit the shadows.The deliverables of the photogrammetric part of the survey were a RGB ortho-image with 10cm resolution, a CIR (Colour Infra-Red) ortho-image and a NDVI (Normalized Difference Vegetation Index) with a resolution of 20cm.

LIDAR SURVEY

A Leica ALS70 Lidar sensor, property of SwissLiDAR, was used. This Lidar is characterised by a frequency of 250,000 points/sec and a height accuracy better than 10cm (1σ) (Figure 4).

The survey was planned in such a way that a density of 6 points / sqm would be obtained. Every strip of data was mosaicked in the Prometheus software of MEDS Amsterdam to verify the correct alignment between the data in each strip and the ground control points. The strips were also processed to obtain a high quality, dense point cloud that was compatible with the technical specifications required. The Prometheus software used homologous points in the overlap of strips and around the overlaps to assess the best translation between the strips to reduce potential geometry inconsistencies. The Lidar point cloud was then classified using algorithms developed for this project to identify what belongs to the 'ground' and what is above ground (vegetation, buildings, etc.). A specific difficulty in this project involved the challenging cirumstances represented by the banana plantations.

The algorithm as implemented in the Prometheus software involved the following



▲ *Figure 5: An area depicted in the orthophoto (a) and the same in the representation of the DTM (b), with the canals highlighted.*

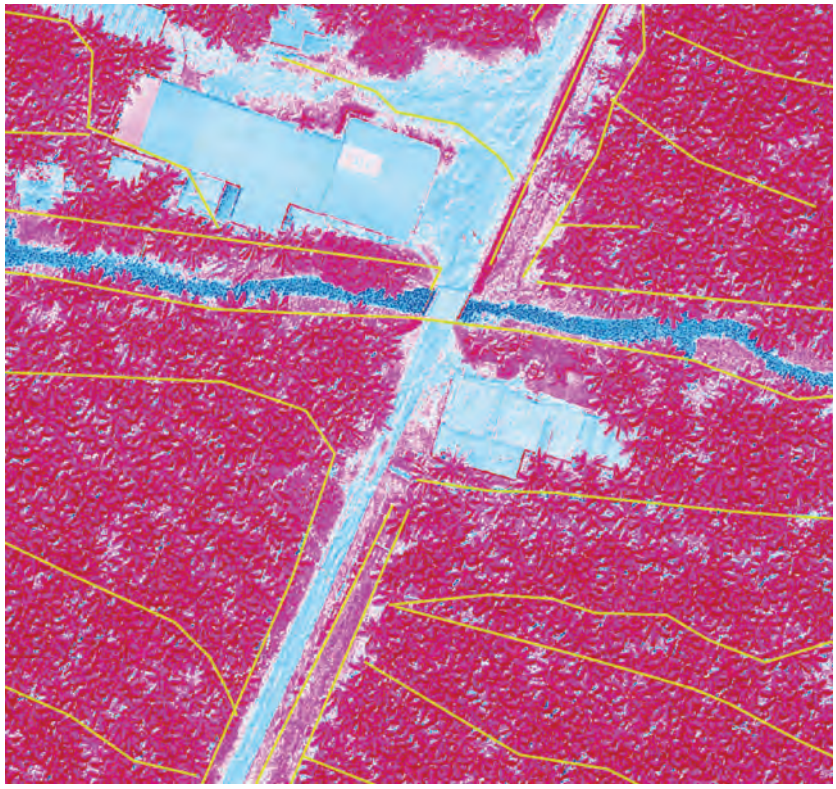
steps (Figure 5). It first subdivided the point cloud based on the chorographic characteristics such as the type of area (urban, agricultural, free plantations etc). It then searched for objects with special geometries, like buildings, infrastructures and anything man-made above ground and classified them as 'above ground'. With the resulting point cloud, a mesh of points was generated for those points that undoubtedly belonged to the ground and, through successive iterations, the mesh was reinforced with all the 'ground' points. The mesh thus created was then used to search and extract canals. After the extraction of the canals, they were semi-automatically classified in three hierarchical orders. For this, a section was classified in profile mode on AtlasGIS and the remainder of the canal followed using its relative arrangement based on the profile.

The deliverables of the Lidar data were a Lidar point cloud, both in overall and in 'ground only' version, a digital terrain model (DTM) and digital surface model (DSM) with a resolution of 20cm and, finally, contour lines for every 10m height difference.

RESULTS OBTAINED

All data in this project has been uploaded to AtlasGIS. With this software, the user can view the data through custom sections in areas of interest, see the 3D point cloud, calculate land movements, perform hydrogeological analyses, do advanced 3D measurements, etc. The database created is an effective tool for territorial management both from a technical and an administrative point of view. It can be used for the planning of territorial interventions, the implementation of methods for managing territorial-based economic units and to allow equalisation mechanisms from a fiscal and land-based point of view.

Through the analysis of the land morphology, it was possible to identify, with almost completely automated techniques and with a very low error rate, an additional 400km of canals on top of 200km of already detected canals. As a result of the survey, the irrigated and therefore taxable surface increased from around 15,000 to over 37,000ha, with a significant advantage in terms of eligible land. The comparison with the actual situation of irrigated land was possible using NDVI images, through which the actual use of irrigation water could be assessed by analysing the vegetation status and water stress of planted areas. It is estimated that the entire survey operation was fully paid for with the first year of new taxation (Figure 6). In addition to the objectives above, it is now also possible to use the digital models and ortho-imagery to improve hydrogeological knowledge. An example is the mitigation of significant issues affecting the area through using predictive rainfall models, based on the prepared geometric models integrated with the geological and agronomic properties of the land. The infrared ortho-imagery has allowed the identification and highlighting of vegetated areas. This information can now become a basis for subsequent multi-temporal analysis in subsequent surveys. ◀

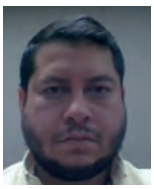


▲ *Figure 6: The comparison with the actual situation of irrigated land was possible using NDVI images.*

BIOGRAPHY OF THE AUTHORS

Giovanni Righetti, agronomist engineer, is the head of the MEDS company. His main fields of scientific interest are Lidar surveys, development of cartographic (web) services and infrastructure monitoring.
✉ g.righetti@medsamsterdam.eu

Gabriele Garnero is professor of geomatics at the Degree Courses in Planning Sciences at the Polytechnic University of Turin. His main fields of scientific interest are studies on photogrammetry and remote sensing applications, architectural surveys, application of GNSS and digital cartography, GIS and cadastral applications.
✉ gabriele.garnero@unito.it



Darwin González Romero is general coordinator at the Secretariat of Environmental Management at the Prefecture of El Oro, Ecuador. He was educated as an agricultural engineer at the technical university of Machala.
✉ gr.darwin@gmail.com

The Role of Surveyors in the Evolution of BIM

Building information modelling (BIM) is becoming more commonplace within construction sectors globally, combining technology with improved collaboration to better manage projects and give them the best chance of complying with time and budget constraints. However, the BIM life cycle and efforts to espouse it are almost futile if surveying is taken out of the equation or, more realistically, brought in too late. It can be good to have a structure that is successfully using BIM to be delivered on time and within budget, but if it or any of its components are in the wrong position the consequences can be catastrophic.

It sounds obvious, but all construction sites are situated on land, which naturally throws up topographical and positional challenges: the remit of a surveyor. If BIM is to reach its potential, surveyors – with their geospatial expertise and knowledge of implementing technology to provide ongoing, reliable and accurate data – should therefore be involved as early on in the process as possible. That is the view of Survey4BIM, a cross-discipline industry working group that Topcon has been supporting and sharing best practice with since 2015.

LOCATION, LOCATION, LOCATION

Despite location being the fourth-biggest decision driver for construction projects – behind cost, time and complexity – it can sometimes be taken for granted. However, the position of a building is actually its most

▲ *The position of a building is actually its most valued attribute. In the case of The Shard in London, for example, more people care about the view from the top, or how it looks from different directions, than what it took to build it. At its most basic level, that is exactly the purpose of surveying within BIM: putting things in the right place. (Image courtesy: Dronepicr / Wikipedia Commons)*

valued attribute. Take The Shard in London, the Empire State Building in New York or the Burj Khalifa in Dubai, for example; more people care about the view from the top, or how it looks from different directions, than what it took to build it. At its most basic level, that is exactly the purpose of surveying within BIM: it puts things in the right place. There is a lot more to it than that, though. Surveyors play a vital role in the successful management of construction projects, providing a continuous update of location-based information throughout the entire process, from conception to demolition. They use their specific geospatial skills and awareness of BIM to evaluate location data, guide clients through the latest technology and ensure the successful implementation of coordinates on a site to facilitate maximum precision. In turn, this means every part of a structure is where it should be, and expensive errors and inefficiencies are avoided. Not only that, but the integration of surveying within BIM also underpins the entire foundation of location-based models, which create digitally connected communities and are the backbone of the 'digital twin' concept.

TOO LITTLE TOO LATE

One of the main factors hindering the evolution of BIM is the fact that surveyors are often not called in until halfway through the BIM life cycle. This is most commonly during the actual construction stage when, for example, it transpires that the coordinates are not working. Defining which coordinate systems to use at the beginning would have avoided such a predicament.

For BIM to perform as intended, a geospatial partner needs to be involved right from the start to validate and quality assure. By reviewing a client's objectives, the surveyor can advise on how to spec out the tender and make sure that the client understands exactly what sort of questions they should be asking at each stage in terms of survey information. Such collaboration means all parties are aware of which factors can impact timescales and costs so they can collectively steer the project towards successful completion and beyond.

The best way to appreciate how surveying fits in with the BIM process is to look at the complete life cycle of a project from conception through handover to operation. At all stages of this cycle there is a necessary requirement for fit-for-purpose survey information. The following framework outlining the advantages of surveyor support throughout the construction process is an adaptation of the one set out in Survey4BIM's guide called 'Survey and the Digital Plan of Works'.

THE ROLE OF THE SURVEYOR THROUGHOUT THE BIM LIFE CYCLE

1. Strategy: At this early stage, the surveyor is able to obtain a full overview of the project and provide broad-based survey data and information to be used as background to the project, as well as define the coordination scheme. The most important element for survey practitioners to advise on as part of this is the type of geospatial information that will be available to stakeholders so they can identify where coordination or mis-coordination can occur. By introducing a geospatial opinion at this stage, all available data will be appraised in a geospatial context and any missing geospatial data can be sourced.

2. Brief: As project objectives and the initial brief are developed, the surveyor can undertake feasibility studies, review site information and advise on survey requirements, supplying coordinated airborne, remote and terrestrial data to enable strategic decisions to be made. The survey will be carried out according to the brief, survey procedures will be correctly applied and data critical to the project's success will be made available. The quality of survey data will also ensure that plans fit well with the existing conditions on site.

3. Concept: The surveyor will analyse the preparation of the concept design – including the proposals for structural design, building services systems, specifications, preliminary cost information and project strategies – looking at any alterations to the brief. They will typically be consulted to clarify unclear data or look at gross errors resulting from field mistakes. At this stage, site coordination may also be refined and the surveyor should ensure the chosen coordinate system is suitable. Any issues resulting from initial contractor mistakes are highlighted, geospatial design flaws are detected, time schedules are updated and the granularity, scale and level of detail of the survey are clarified.

4. Definition: Once the concept is approved, the developed design will be prepared. Surveyors will be needed to ensure project elements are in a suitable format for survey tasks, and that survey data can be easily consumed in the common data environment and is fit for purpose for the end user. All of this means that gaps in survey data will be filled, the survey can be repurposed and carried out again if project definitions require changes, and any re-surveying to fix issues can be used to inform and update the project timescale.

5. Design: The technical design is then prepared in accordance with the design responsibility matrix, with project strategies including all architectural, structural and building services information, specifications and specialist subcontractor design.

▲ *Modern 3D software environments combine datasets – civil, mapping, BIM and survey data – from multiple mass data sensors.*

▲ *A robotic total station and scanner in one, which allows for quicker construction verification.*

Surveyors will check and confirm that the technical data provided is suitable for survey work and that survey data collected can be used to update the technical design. This allows for a continuous as-built view as the site is prepared, meaning site control can be managed and maintained and design changes can be verified.

6. Build and construction: This is when off-site manufacturing and on-site construction begin in accordance with the construction programme, with any design queries from the site being resolved as they arise. To do this, surveyors will manage and maintain site control, supervise contractors on site to ensure correct coordination is used, and feedback regular as-built data to the common data environment to minimize design failure creep. This vigilant eye on survey quality means updates on site progress and any required changes will be given efficiently.

7. Handover and closeout: Once the building contract is concluded and the completed structure is handed over, surveyors may have to re-establish suitable control points if the facilities manager is intending to work on site using geospatial data for navigation. The surveyor will highlight any shortcomings of the brief before validation and as-built verification work and make sure the site coordinates are clear and easy to understand.

8. Operation: While the building is in use, surveyors will be able to locate services in the site coordinate system and could be party to a service contract by providing data updates to maintain currency of site data. This means geospatial data will be consistent, holistic and used in the correct manner, and unbiased advice will be given on the survey strategy to suit data management.

UNLEASHING THE POWER OF BIM

Precise measurement is crucial in the life cycle of any structure, be it a building, a road, a bridge or a rail network, and that is exactly where the skill of a surveyor comes in. However, the role of surveyors goes beyond merely supplying and curating content; they are a fundamental contributor to a project's short-term and long-term success. Survey is a key driving element of the entire BIM process.

At the moment, surveyors are enabling useful information to be communicated with ease, making the feedback loop much quicker than it used to be. This results in increased efficiency, avoidance of error, more sustainable construction and a reduction of waste. However, the real opportunity ahead of us is to make national digital twins a reality which, in a construction situation, will enable even more efficient allocation and even fewer costly positioning faults. Surveyors simply need to be given the chance to show what they can do. ◀

ABOUT THE AUTHOR

Andrew Evans is a specialist in application engineering and high-precision positioning who has been with Topcon for over ten years, supporting projects to adopt technology to facilitate collaborative working and automate workflows. His technical specialisms include all elements of mass data capture and analysis, including augmented reality and BIM processes relating to survey. He is a Chartered Engineer and a Fellow of the Chartered Institute of Civil Engineering Surveyors.

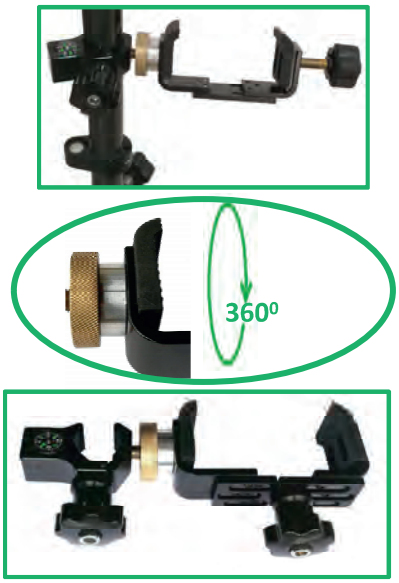
✉ aevans@topcon.com

GEO-ALLEN CO., LTD.

Punctuality / Quality / Rigor / Service (Found in 2002)

Patent No. ZL 2013 2 0115329.3

Patent No. ZL 201920979256.X



Patent No. ZL 201920980236.4

HALL 1 - I 1.062, INTERGEO 2019
17-19, SEP, STUTTGART, GERMANY

www.geoallen.com e-mail:geoallen@vip.163.com Fax:+86-512-6862-9776 Tel:+86-512-6802-6320

flight altitude	point density	estimated coverage	
		per flight	per day
50 m	43-65 pts/sq.m	0.25 sq.km (25 ha)	2.5 sq.km (250 ha)
75 m	29-43 pts/sq.m	0.40 sq.km (40 ha)	4 sq.km (400 ha)
100 m	22-32 pts/sq.m	0.90 sq.km (90 ha)	9 sq.km (900 ha)
125 m	17-26 pts/sq.m	1.20 sq.km (120 ha)	12 sq.km (1200 ha)
150 m	16-24 pts/sq.m	1.40 sq.km (140 ha)	14 sq.km (1400 ha)

scanning speed	line spacing	roadway to scan per day	
		1-3 lanes	4-6 lanes
18 km/h	5 cm	108 km	54 km
36 km/h	10 cm	216 km	108 km
54 km/h	15 cm	324 km	162 km
72 km/h	20 cm	432 km	216 km

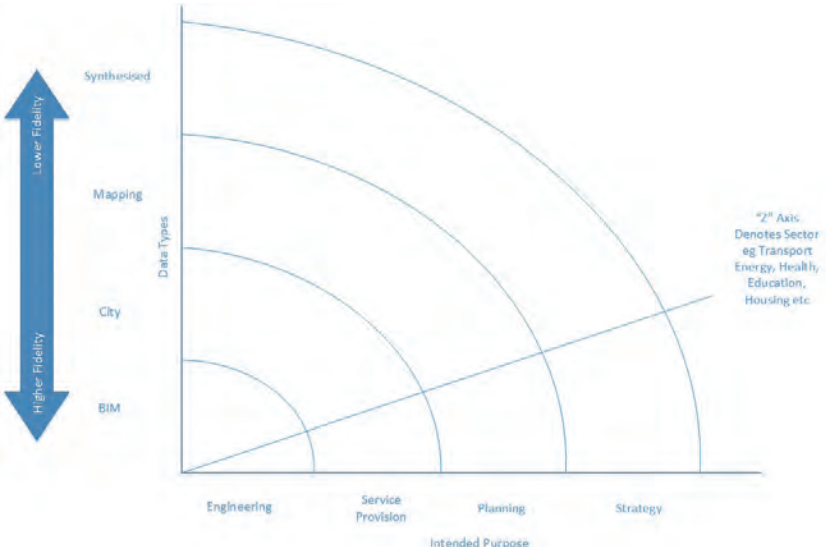
What Do BIM, GIS, IoT, BMS, Telemetry and CAD All Have in Common?

Over the last three years, building information modelling (BIM) has undergone rapid development around the world. The value chain of design, construction and operation of built assets faces various challenges of change, some of which are of a technological nature. These include the transition from drawing in 2D to modelling in 3D with object reference and linked information. There is also an explosive increase in the volume of data on projects, including from new recording methods such as unmanned aerial vehicles (UAVs or 'drones'), lasers, geo-radars, and the increased use of sensors and data transfer devices on the Internet of Things (IoT). As that data comes in so many shapes and sizes, there are continual efforts to enable interoperability.

Firstly, let us explore what exactly 'interoperability' means. The interoperable approach uses a fixed schema, which enables the theoretical bi-directional exchange of data between two compliant applications. However, the approach has proved unreliable at both data exchange and bi-directional support due to technical compliance by large software vendors and the complexity of setting up such tools. Therefore, we should perhaps be more concerned with data integration which connects a superset schema to enable all data to be exchanged, whatever it may be. This is especially attractive in this area of engineering due to its complexity and the ever-expanding need to incorporate other contextual data to add operational and service value to asset information.

In connection with data integration, we need to ask ourselves what BIM, GIS, IoT, BMS, telemetry and CAD all have in common. The answer: they are no ordinary data; they all benefit from being geolocated in some way. Many professionals in the world of GIS have long understood the benefits of geolocation. In engineering, on the other hand, the approach to geolocation has often been from the microscopic perspective of the asset being built relative to itself, rather than relative to the wider world or city view. This micro/macro perspective is interesting as it starts to provide context for the challenges of integrating geolocated information. At first glance, it looks easy. After all, there are only so many types of location methods. We can map from one to the other, so geolocation must surely provide the ultimate primary key to all data in the world, right? Well, maybe, but is this really true?

The issues of grids (including snakes), topology, moving grids and planets not being as round as we would like are all interesting, well-known and well-documented challenges in the GIS community. A less-discussed wider challenge is: even if we did geolocate all of the data types described above, what could we do with that information? And how does the state and fidelity of the data affect its ability to be used safely for which purposes? The figure shows a number of different data types and potential uses. This illustrates how each part of the vast community involved in the built and natural environment has developed an ecosystem that is suited to its needs. Engineering and architecture are moving towards an integrated world of geometry and data, described by objects. The accuracy of the geometry can be to several decimal places; however, the typical tolerance of construction can be up to 50mm. As we move along the axis and reduce the fidelity of data, the use cases change: from service provision to planning and strategic purposes. Data also has a temporal component; it ages as the asset ages. Briefing data is very different from handover data, and sensor data provided by the emergent IoT world offers yet another dimension. This leaves us with another fascinating question: which piece of data is correct, and how do I know I have that piece of data in front of me to solve my current problem? Data provenance and state are two concepts we have not heard about much to date. But get ready… you soon will. ◂



ABOUT THE AUTHORS

Dr Ilka May is CEO of LocLab Consulting, a company specializing in digital twins and virtual reality in the field of the built environment. In 2015 Ilka led the authoring of the strategic BIM roadmap for Germany. For mostly public-sector clients, owners and operators, she develops digitalization strategies and delivers BIM implementation programmes.
✉ ilka.may@loclab-consulting.de

Dr Mark Bew MBE, chairman of PCSG Ltd., was a key contributor to the UK government's Construction 2025 strategy. Prior to this he chaired the UK BIM Task Group, which delivered the BIM Level 2 programme. Mark also led the development of the government's Digital Built Britain Strategy (BIM Level 3).
✉ mark.bew@pcsg.co.uk

SinoGNSS®
By ComNav Technology Ltd.

To make your work
easier is our original motivation

T30 GNSS
Receiver

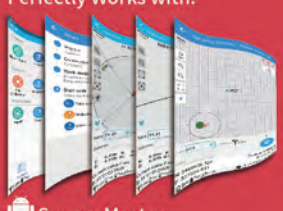
T30 GNSS Receiver featuring full-constellation tracking capability, tilt compensation, 4G/WiFi/Bluetooth® connection, and easy survey workflow with Android-based Survey Master Software, Dustproof&Waterproof design makes T30 GNSS Receiver perfectly and effectively work even in harsh environments. Collect more accurate data easier and faster no matter for beginners or professional surveyors.

Features

- L-BAND — Support L-Band and PPP
- Two 3400mAh Hot Swap Batteries
- Rugged Al-mg alloy Housing
- All Constellations
- Tilt Compensation
- 4G Tx & Rx — Built-in 4G/ TX & RX
- 67 — IP67

INTERGEO 2019
September 17. - 19. 2019
Stuttgart, Germany
Booth Number: F1.013

Perfectly Works with:



Survey Master

Google play
Download for free

SinoGNSS®
By ComNav Technology Ltd.

Sales@comnavtech.com
www.comnavtech.com

GIM International Guides You through Intergeo 2019

Intergeo is celebrating its 25th anniversary this year, marking an excellent occasion for the geospatial industry to showcase the latest achievements. Stuttgart will host this year's edition of the world's leading trade show for the mapping and surveying profession, although the event has in recent years grown into a much broader and interdisciplinary meeting place for more than just the geoinformation sector alone. *GIM International* is happy to introduce you to a series of renowned companies that are exhibiting at Intergeo 2019 on the following pages.

In addition, we will be present in various ways during the three-day geospatial community gathering in Stuttgart. You will find our bumper Intergeo issue of *GIM International* everywhere, whether it is in our 'Grow your Knowledge' bag that will be distributed to the early visitors at the entrance every day, or in one of the media corners in the exhibitor halls – or of course at our booth (A3.052) which we will be sharing with Geo-matching, the online product platform for surveying, positioning and machine guidance.

But there is more in store. On Thursday, we will be organizing two sessions at the Intergeo conference, with renowned speakers from institutions and companies within the geomatics profession. The first part of the *GIM International* conference track is titled 'Geomatics in the Next Decade' and will start at 9:30 in the Forum with the keynote address of Esri's Lawrie Jordan. We can assure you that this session is going to feed you with intriguing new insights on the direction in which our industry is heading. The second track, also held in the Forum, is called 'The Many Faces of Mobile Mapping' and will provide you with the newest developments and trends in mobile and airborne mapping in all its forms, focusing on both photogrammetry and Lidar technology.

Be sure you make the most of your visit to Intergeo. At *GIM International*, we aim to be a good guide in order to get this mission accomplished. The hundreds of exhibitors will give you an extraordinary – and sometimes mind-boggling – impression of the industry as of today, and also a glimpse of tomorrow's geospatial world. Don't miss the opportunity to add the right context to your Intergeo experience and visit our conference sessions on Thursday!

If you would like to meet our team in person, why not send an email to Sybout Wijma (sybout.wijma@geomares.nl) or Wim van Wegen (wim.van.wegen@geomares.nl) to discuss advertising and editorial opportunities. If you would like to learn more about Geo-matching, get in touch with Peter Tapken (peter.tapken@geomares.nl). We wish you a valuable and pleasant time in Stuttgart!

INTERGEO
KNOWLEDGE AND ACTION FOR PLANET EARTH
STUTTGART 2019
17 – 19 SEPTEMBER

Atmos UAV

Founded in the Netherlands in 2013, Atmos UAV is a Delft-based company specialized in the design and production of high-end aerial surveying and data-collection drones that allow professionals to effortlessly gather geospatial data from the sky, enabling them to make more informed decisions. The company's flagship is the drone model Marlyn. Marlyn is the first fully autonomous hybrid (VTOL and fixed-wing) drone for mapping and surveying. With its patented design that combines the best of both worlds, Marlyn can take off vertically from anywhere, and map quickly and efficiently producing high-quality outputs (with centimetre-level GSD) for professional users. It is the only drone in its class that is built to perform even in harsh and windy conditions, while its easily swappable payloads provide operators with an unprecedented flexibility. To facilitate its fast growth, Atmos is currently attracting new talent to expand the team, as well as new distributors in order to bring Marlyn closer to professionals around the globe.

www.atmosuav.com
Stand no. B4.021

CHC Navigation

CHC Navigation, a developer of GNSS-based solutions with a global presence across the world, is showcasing its latest geospatial solutions and GNSS technology at Intergeo 2019 in Stuttgart with special focus on GNSS-based integrated solutions including its new land survey i90 GNSS RTK receiver, Alpha3D mobile mapper for 3D data acquisition, APACHE3 USV for bathymetric survey and P2 GNSS sensors for RTK networks infrastructure. The new CHCNAV i90 GNSS receiver offers integrated IMU-RTK technology to provide robust and accurate GNSS positioning, in any circumstances. Unlike the standard MEMS-based GNSS receivers, the i90 GNSS IMU-RTK combines state-of-the-art GNSS RTK engine, calibration-free professional IMU sensor and advanced GNSS tracking capabilities. Survey projects are achieved with high productivity and reliability, pushing the boundaries of conventional GNSS RTK survey.

www.chcnav.com
Stand no. B3.052

ComNav

Founded in 2012, ComNav Technology is a world-leading high-tech company focus on high-precision BDS/GNSS technologies. ComNav Technology engages in R&D, manufacturing, sales and services, aiming to provide worldwide customers with high-precision GNSS chips, modules, terminals, software and solutions across industries. The company is committed to being an innovator and leader in high-precision BDS/GNSS technologies and applications. So far, ComNav Technology has already sold its products and solutions to more than a hundred countries with total quantity of more than 300,000 units of modules (receivers) in ten different industries. With a strong tradition of innovation, ComNav Technology is continuing to invest at least 20% of its annual revenue into R&D every year to pursue the best of GNSS technologies and solutions. The final goal is to provide the best products and solutions to worldwide customers.

www.comnavtech.com

Stand no. F1.013

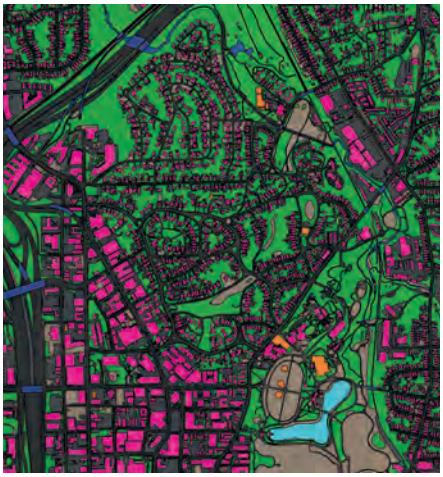
Hexagon

To make the most informed decisions, to provide the most accurate services and to move your business from being just a provider to a trusted partner, you must fully understand the world around you. Hexagon's reality capture technologies offer unique solutions for professionals across many industries, such as surveying and construction, to best understand their environment and better execute their work. When the physical world is captured, visualized and analysed, a smart digital reality is formed where actionable information is revealed that is vital for deep learning, precise planning and near-perfect execution. At Intergeo, Hexagon's wide portfolio of reality capture solutions will be on full display for hands-on demos while product experts will be available to answer your questions and walk you through the end-to-end workflows. Next-generation innovations will be available for exclusive first looks, and visitors will experience digital ecosystems in fun and exciting ways.

https://connect.hexagongeosystems.com/intergeo2019/GIMInternational

Stand no. B1.022

Ecopia



Ecopia leverages AI to convert high-resolution images of the Earth into HD vector maps. This digital representation of the real world offers unique insight for decision-making at scale, and with the accuracy of a trained GIS professional. From enhanced geocoded footprints, to global feature extraction services including roads, buildings, pavements, waterways and more, Ecopia is leveraging the most innovative machine learning techniques across the globe, with imagery from its partners, at a fraction of the cost of traditional mapping methods. These extraction services help governments, civil engineers, insurance companies, telecommunication firms and others across the globe to make critical decisions faster and at scale. Visit Ecopia at Intergeo in Stuttgart to learn more!

www.ecopiatech.com

Stand no. B4.022

Hi-Target

Hi-Target International Group is showcasing its full range of products at Intergeo 2019. All products will be presented in practicable solutions with hardware, software, cases, data and results, and the team will provide professional introductions and Q&A. Solutions will cover: machine control, monitoring, indoor positioning, aerial mapping & Lidar, surveying & engineering, Hi-RTP, GIS, etc. Hi-Target will also introduce new products at Intergeo, such as the new iRTK5, which is integrated with high-performance IMU making the tilt survey work much easier and more practical. What's more, in 2019 Hi-Target will celebrate the 20th anniversary of its establishment and will launch its new corporate identity at Intergeo.

http://en.hi-target.com.cn/

Stand no. K1.005

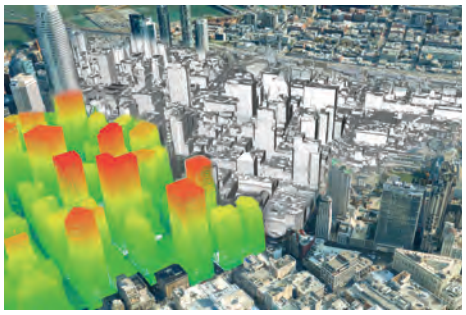
MGGP Aero

MGGP Aero delivers state-of-the-art mapping, Lidar, geovisualization and 3D mesh model solutions for customers in Europe. The company innovates in the growing geospatial industry, operating a fleet of aircraft armed with more than 30 sensors. MGGP Aero specializes in orthophotography, Lidar, oblique imagery, 3D mesh modelling, hyperspectral and visualization web services for any kind of geospatial data. It is constantly expanding its international reach and looking to establish successful partnerships around Europe and beyond. Specialized corridor mapping and utility management services are provided by MGGP Aero and VIMAP, two companies of the MGGP Group. Visual inspection, detailed oblique photography and collection of 3D Lidar point clouds are combined in a single helicopter flight to maximize efficiency. Actionable asset condition reports, engineering models and data analysis are then delivered in the dedicated, comprehensive software. The company is able to provide critical insight for all linear assets including electricity, gas, roads and railways.

www.mggpaero.com

Stand no. I1.075

nFrames

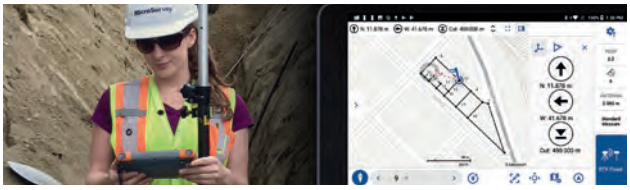


The Germany-based company nFrames is known for its world-leading photogrammetry software technology. The SURE technology is designed for large-scale mapping applications such as citywide and countrywide production of DSM, true orthophoto and 3D meshes from aerial imagery. At Intergeo, SURE version 4.0, including new modules for Lidar data processing enabling new workflows for hybrid Lidar and imagery sensors, will be presented. Enhancements in the DSM and true ortho production increase the output quality for even higher automation, including in challenging dataset configurations. A new generation of the 3D mesh extraction algorithm delivers even sharper edges, more detail, smoother surfaces as well as crisp texture at high throughput. 3D mesh streaming – particularly for web applications – has been highly optimized utilizing data partitioning, compression and smart loading patterns.

www.nframes.com

Stand no. C3.062

MicroSurvey



MicroSurvey Software has been developing complete software solutions for surveying and forensic mapping since 1985. This year MicroSurvey is excited to introduce its next-generation FieldGenius for Android product, along with its latest innovations in STAR*NET and its MicroSurvey CAD products. Specializing in the development of industry-specific solutions, MicroSurvey produces mobile software for use with total stations and GPS, as well as a full complement of desktop solutions to increase efficiency and productivity in the office. From single-user applications to country-wide government implementations, MicroSurvey solutions are used around the globe for land surveying, engineering, mapping, law enforcement, forensic and accident reconstruction.

https://microsurvey.com/fga

Stand no. B1.022

Phase One Industrial

Aerial cameras and image processing systems built for multiple applications such as mapping, surveying, agriculture, inspection, 3D modelling, machine vision, homeland security, and more.

See our range of high-resolution cameras for aerial imaging applications, including our fully integrated 190 megapixel, 4-Band multi-spectral, and iXM-RS 150MP and 100MP solutions. Our iXM 100MP and 50MP cameras are ready for integration with multiple UAV platforms. Also on display, our new long-range 150, 180 & 300mm lenses - designed for aerial and ground inspection.

- Cameras - 50MP-190MP - performance, reliability and accuracy in low weight and cost-effective systems.
- Aerial systems - RGB, CIR, NIR, 4-Band - Complete systems offer easy integration into existing or new setups, manned or unmanned.
- Software - iX Plan, iX Flight, iX Capture - Quickly and easily plan and lighten the workflow for operator, pilot and image processor.

phaseone.industrial.com

Stand no. H1.022

Racurs

The Racurs company has a 25-year-long history of success in the Russian and worldwide geoinformatics market. The visitors to Intergeo 2019 have unique opportunities to preview the new PHOTOMOD 6.5 and PHOTOMOD Cloud software. The 6.5 version of PHOTOMOD offers a new algorithm for bundle adjustment, which significantly speeds up the adjustment for low-quality block layout and smart automation detection of incorrect points. The remote sensing data processing speed is increased using a new distributed processing implementation. Moreover, the new version radically improves the quality of 3D-model generation and visualization, and provides new 3D-feature extraction tools. PHOTOMOD Cloud is a fully functional cloud version of PHOTOMOD which can be installed either in a cloud service or in the local enterprise network. Visitors to the Racurs stand at Intergeo can get a special discount on PHOTOMOD purchases and upgrades.

http://racurs.ru

Stand no. K1.053

RIEGL

RIEGL's dedication to "Innovation in 3D" is presented in its continually advancing product portfolio for terrestrial, mobile, airborne, and unmanned laser scanning. As always, the latest developments will be showcased at Intergeo, including the latest high-end sensors and systems. Discuss your requirements with the RIEGL experts and find the perfect solution for your business. Meet and network with the worldwide RIEGL community in Stuttgart.

RIEGL Presentations:
- IASEXPO Forum, 17 September, 12:30-12:40
"UAV-borne LiDAR for Surveying: Latest Developments and Trends"
- Smart City Solutions, 18 September, 12:30-13:15
"Automated Tree Inventory - a Real Life Application of Full City MLS Scanning"
- IASEXPO Forum, 19 September, 13:00-13:20
"Using LiDAR Technology for Alpine Mapping Tasks - Avalanche Documentation"

www.riegl.com

Stand no. I1.024

Satlab Geosolutions

Satlab Geosolutions is a Sweden-based geospatial solution company with offices around the world. Founded by a group of passionate and pioneering engineers, with more than 40 years of experience between them, the management team is made up of veteran industry experts who value customer needs. Focusing on research and development, Satlab offers unique hardware and software with integrated solutions, with an aim to increase on-site productivity for professional users. In the geospatial world, professionals require accurate surveying and mapping systems to build the future of tomorrow, while preserving the world that we live in. At Satlab Geosolutions, experts are creating and delivering the solutions and products with Swedish engineering and technology to ensure that professionals can rely on it in any circumstances, from the moment they power it up. Join Satlab to unlock your mobility!

www.satlab.com.se

Stand no. K1.005

SBG Systems

At Intergeo, SBG Systems is presenting the Quanta UAV series, a brand-new line of inertial navigation systems (INS) dedicated to UAV-based surveying integrators. Because SBG Systems wants UAV surveyors to benefit from autonomy for additional survey lines, the company has designed a small, lightweight and low-power inertial navigation system offered on two levels of accuracy. Quanta UAV and Quanta UAV Extra have been developed for compact Lidar to high-end BVLOS mapping solutions. They provide precise orientation and centimeter-level position data delivered both in real time and post-processing. This direct georeferencing solution eliminates the need for ground control points and greatly reduces the need of overlapping. Qinertia, SBG's post-processing software, completes the Quanta UAV offering. It gives access to offline RTK corrections from more than 7,000 base stations located in 164 countries. Trajectory and orientation are greatly improved by processing inertial data and raw GNSS observables in forward and backward directions.

www.sbg-systems.com

Stand no. F1.064

SOUTH

This year, SOUTH Group will be attending Intergeo, the world's biggest event for the geospatial community, for the seventeenth time. This Chinese manufacturer, already in operation for 30 years and highly active in the international market, has gradually increased its display of products over the years. In spite of its humble beginnings at Intergeo 2003 with a tiny 3x3m booth, SOUTH Group has now successfully redefined the Made-in-China label with its survey products. This year, it will be presenting even more new products. For example, total stations with Android OS and a 2000m reflectorless range, GNSS RTK with insight imaging, a VTOL fixed-wing drone with 2.5-hour endurance, multi-platform lightweight Lidar systems, and an unmanned boat with marine survey systems. You're invited to Booth A1.046. Please be there!

www.southinstrument.com

Stand no. A1.046

Zoller + Fröhlich

Zoller + Fröhlich offers a new generation of laser scanners which allows beginners and professionals to reach new levels in their projects. The Z+F IMAGER 5016 is small and light. The ergonomic streamline design features a passive cooling system, IP54 rating and two handles for better grip while carrying and during setup. In particular, mounting the scanner on high tripods and overhead applications have now become much easier. Due to innovative developments, the maximum range of the Z+F IMAGER 5016 has been extended to up to 360m (1,180ft), thus establishing new opportunities and applications. The maximum measurement rate of more than 1 million points/sec guarantees highly accurate results even over long distances. The Z+F IMAGER 5016 includes all-powerful features like an integrated positioning system and a high-definition HDR camera which comes with internal LED spots to shed light into dark environments for colour imagery.

www.zf-laser.com

Stand no. G1.014

Vexcel

Developing cutting-edge digital aerial cameras, mobile mapping systems and photogrammetric processing software with innovative approaches beyond well-trodden paths together with constant product upgrades and world-class support has made Vexcel Imaging one of the market leaders in this area. The industry-leading UltraCam aerial sensor portfolio covers all applications in airborne photogrammetry: from nadir to oblique to wide-area data collection. On the ground, the portable and vehicle-mounted UltraCams help customers meet even the most demanding mobile mapping challenges. Processing of the UltraCam data is done with the UltraMap photogrammetric software suite offering an end-to-end processing workflow for highly automated generation of exceptional-quality point clouds, DSMs, ortho imagery and 3D textured TINs. In addition, the Vexcel Data Program offers a cloud-based aerial image library, empowering organizations with geospatial intelligence. Vexcel already powers the Geospatial Intelligence Center (GIC), the leading industry initiative for insurers and first responders.

www.vexcel-imaging.com

Stand no. B3.020

Geo-matching

Geo-matching is the product platform for surveying, positioning and machine guidance. It is a unique tool that matches potential buyers with manufacturers and where professionals can find and compare products and manufacturers for their projects. Filter by product theme, product category or application area to find a suitable solution. It is also possible to add your products to Geo-matching to reach a worldwide audience of geospatial technology professionals. Do you want to learn more about Geo-matching? We are also at Intergeo! Please feel free to contact Peter Tapken (peter.tapken@geomares.nl) to make an appointment or visit our booth!

www.geo-matching.com

Stand no. A3.052

A JOURNEY THROUGH HISTORY

The Surveyors of Our World

In today's data-driven society, in which location-based services have become an omnipresent part of everyday life, there is no doubt that surveying is all around us. But did you also know that surveyors have been indispensable to the development of the world since civilization began? In this brief journey through history, John F. Brock provides a surprising and entertaining look at the importance of surveying through the ages, from ancient times up to the modern day.

It is not difficult to conjure up an image of how people in ancient civilizations may have divided up their lands. They certainly occupied holdings of tenure from the earliest period that the hunter-gatherer nomads decided to settle down at a permanent site, with the domestication of animals and construction of residences. In terms of the written word, the concept of boundaries is well established in the first book of *The Bible* (Genesis); when Adam and Eve are cast out through the gates of the Garden of Eden after eating the wrong apple, this can be seen as being indicative of a fixed line of demarcation. Even God himself engages in some survey activity when it is stated in the Book of Proverbs (8:27): "When he prepared the Heavens I was there; when he set a compass upon the face of the depth."

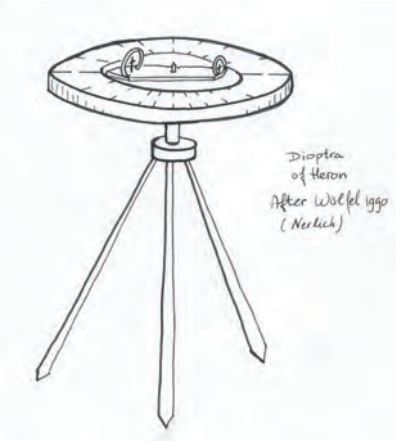
SCRIBE SURVEYORS

Well before historical records began, the Druids set out the first stages of Stonehenge in a radial pattern (sometime around 3100 BC). The famous stones were actually placed about 2600 BC, which just so happens to coincide with the erection of the only surviving example of the Seven Wonders of the Ancient World: the Great Pyramid of Giza. These giant dedicatory monuments were brilliantly surveyed and orientated to True North within a few arc minutes by the legendary 'scribe surveyors' of this prolific civilization, whose surveying duties were widespread. Textual evidence of their work dates as far back as a stone tablet from 3050 BC, which mentions the 'Stretching of the Cord' ceremony during the foundation ritual of any construction. The cord in question was the sacred measuring rope used by the surveyors, divided into 100 cubits. It is depicted in two superb ancient statues of two scribes holding the cord in their lap and winding it into the ram's head of Amun cache. The scribe surveyors were kept busy reinstating boundary stones after inundations, measuring and calculating crop yields for taxation and setting out all of the capital works undertaken by a host of pharaohs who depended upon their 'Surveying Administration' to manage the affairs of the Royal Estate and supervise the needs of ever-expanding dominion. One pharaoh of the New Kingdom (around 1360 BC) known as Akhenaten even had his surveyors mark out the perimeter of his new city in Southern Egypt with spectacularly inscribed boundary stones. Many of the rock inscriptions, which are known as the Boundary Stelae of Akhenaten, can still be seen today.

BOUNDARY STONES

Surveying information has always been passed down to future generations. For example, two of Ancient Greece's noted philosophers/mathematicians, Thales and Pythagoras, travelled to Egypt to learn about the renowned practical applications of numbers for field surveying. This gave these two revered scholars the framework for the theorems which later came to bear their names. While researching the history of surveying in both Ancient Egypt and Ancient Greece, I came across a man called Hero (or Heron) of Alexandria. He was clearly a Greek surveyor of eminence who was credited with making many amazing inventions such as the syphon and valve. But more notable, from my perspective, was his treatise on a surveying instrument: the dioptra. In his detailed description, the instrument bears striking similarities to the modern-day theodolite, albeit lacking optical enhancement. I have ascertained that he lived between 10 and 70 AD. I was puzzled by the absence of boundary stones in Greek surveying, especially since they were so prolific in the two cultures on either side chronologically (the Egyptians and the Romans). On my most recent trip to Greece in 2015, however, I discovered an inscribed

▲ *Rope stretching to measure property dimensions in Ancient Egypt. (Reproduction, courtesy: Metropolitan Museum of Art)*



▲ *Drawing of a 'Diopta by Heron' by Marcus Audens.*

▲ *Three of the four US presidents whose images are carved into Mount Rushmore were surveyors.*

boundary stone from the Ancient Agora near The Parthenon in Athens dating from 550 BC. I was delighted at this find, which marked the start of a real connection between the three revered ancient civilizations.

RIGHT ANGLES

Within the hierarchical structure of Ancient Rome, surveyors were esteemed and highly regarded. Some of their highly precise levelling work is still evident in the many aqueducts, roads and edifices which grace the landscape today. They were responsible for marking out new cities and allotments for landholders as well as being called upon to resolve boundary disputes, both in the field and in court. Roman towns were always laid down in a grid pattern. This pattern originated from Egyptian town plans and had been modified by the Greeks, and the Roman surveying instrument called the 'groma' was the perfect tool to achieve 90-degree intersections.

The orthogonal street configuration is clearly visible in the unearthed archaeological site of Pompeii. There, it is also possible to identify a workshop which was run by a surveyor called Verus just before the site was buried by lava from Mt. Vesuvius in 79 AD. The surveyor's name was found on premises, along with the base and upper metal pieces of a groma together with metal marking spikes, drawing equipment and a portable sundial on a box used to transport writing implements which would have been utilized to determine time and orientation. Another Pompeiian surveyor named Popidius has been identified from his headstone, which bears a relief of a groma on it.

In a solid demonstration of the essential contribution of Roman surveyors, they were entrusted with the duty of marking out international border lines separating the Roman Empire from its adjoining foreign neighbours. Roman legions consisted of about 5,000 men, including an elite group known as 'The Immunes' comprising 200 specialists in architecture, building, stone masonry, engineering and surveying. Within that group was a team of ten surveyors called a 'metator'. We know that three legions were responsible for constructing and surveying Hadrian's Wall and subsequently Antonine Wall along the northern extremities of the western Roman colony of Britannia: the II, VI and XX legions. This meant that within the legions responsible for these projects there were just 30 surveyors

▲ All Roads Lead to Rome *by Peter Jackson. The surveyor in the centre of the painting is using a groma: a device for measuring angles. A fire has been lit in the distance to show the line of the road.*

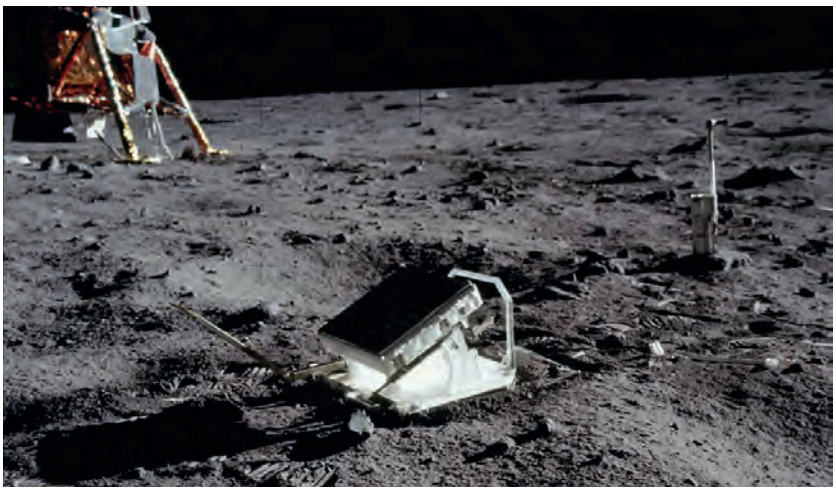
available for any survey work required. A remarkable discovery has since been made along the Antonine Wall between Glasgow and Edinburgh: 19 distance slabs carved in stone by the surveyors to commemorate each section of the wall they erected, dating approximately from 138-142 AD. Each dedicatory stone bears Emperor Antoninus's name along with the name of the legion and the length of wall completed, some of which are accurate to the nearest half a Roman pace (i.e. five Roman feet).

GUNTER'S CHAIN

Following on from the end of the Roman period (in about 460 AD), surveying continued to be performed by responsible professionals – throughout the Dark Ages and beyond the Magna Carta in 1215 on behalf of King John, during the time of the Sheriff of Nottingham. In fact, I even recall seeing an episode of the black-and-white TV series *Robin Hood* in which the king's surveyors take measurements using a knotted rope with surprising historical authenticity.

It was not until Professor Edmund Gunter from Gresham College in London University invented his Gunter's chain (around 1620) that a metallic measuring implement became available to boundary surveyors. This rather cumbersome device consisted of a metal chain of 100 links (each link measured 0.66 English foot, i.e. 20.12cm). This was eventually superseded in the 1880s by long rolls of crinoline wire – rolled up in a canvas casing for ease of transportation, unwrapping and re-rolling – were used to ascertain distances of up to 330 feet (approx. 100 metres).

When electronic distance meters were invented in the 1950s, such tape measures became obsolete for long distances; now, surveyors are able to make long-range measurements that are accurate to within a couple of millimetres. In conjunction with the 50th anniversary of the landing of the first man on the moon in 1969, I have recently been researching the Apollo Lunar Surface Experiments Package (ALSEP). This project has always interested me, ever since I learnt that 'Buzz' Aldrin placed a bank of retroreflectors on the moon's surface in the Sea of Tranquility. They have been used to continuously measure distances for the past 50 years, currently mainly from two Earth observatories (one in Fort Davis, Texas, USA, and the other in Nice, France). Thanks to super-powerful Lunar Laser Rangers, the distance between the Earth and the moon is now known with an accuracy of less than one centimetre!



▲ *A retroreflector left on the moon by astronauts on the Apollo 11 mission. The Lunar Laser Ranging experiment, which is still ongoing, measures the distance between surfaces of Earth and the moon.*

▲ *Surveyors in the colonial period measured distances using chains. The favoured form was the Gunter, introduced by the English mathematician Edmund Gunter in 1620. (Courtesy: National Museum of American History)*

FAMOUS HISTORICAL SURVEYORS

In more recent history, a plethora of monuments or natural features have been built or named in tribute to surveyors. One particularly fine example is the naming of the world's tallest mountain in honour of Indian surveyor-general Sir George Everest. Numerous rivers, mountains and other features now bear the name of James Cook, who was first trained as a land surveyor in Newfoundland under Samuel Holland and other great Canadian surveyors. And James Cook himself was clearly proud of being a surveyor, since he quite deliberately wrote the word in copperplate font on his brilliantly executed maps.

Gutzon Borglum carved the heads of four US presidents into the Black Hills of South Dakota on Mt. Rushmore between 1930-39. Three of those men had previously been surveyors – George Washington became district surveyor for Culpeper County at age 17, Thomas Jefferson was district surveyor for Albermarle, and Abraham Lincoln was deputy district surveyor of Sangemon County in Illinois.

HOLLYWOOD

I particularly enjoy trawling through Hollywood movies to spot representations of surveyors, and there are actually many examples. Surveyors have been played by great actors including Randolph Scott (*Carson City* and *Heritage of the Desert*), John Wayne (*The Fighting Kentuckian*), James Mason (*Journey*

to the Centre of the Earth), Brad Pitt (*Seven Years in Tibet*), Hugh Grant (*The Englishman That Went Up a Hill But Came Down a Mountain*), Daniel Day-Lewis (*There Will Be Blood*) and Nicole Kidman (*Queen of the Desert*). Surveying has even featured in TV series: from MacGyver making a 'theodolite' from two sticks, a pair of earrings and some gaffer tape and Peter Graves also using a theodolite to keep track of a suspect vehicle in *Mission Impossible*, to Jennifer Garner pretending to be a surveyor in a stakeout to catch baddies in an episode of *Alias* (complete with a designer red hard hat!).

▲ *James Cook was clearly proud of being a surveyor, since he quite deliberately wrote the word in copperplate font on his brilliantly executed maps.*

CONCLUSION

Clearly, surveyors are not only everywhere, but have also been indispensable to the evolution of civilized societies throughout history. And although day-to-day surveying activities may be changing as modern technology continues to advance, the role of surveyors is set to become even more important in the geospatial world of the future. ◀

ABOUT THE AUTHOR

John Brock has been a private land surveyor since 1973. He holds a Bachelor of Surveying (University of New South Wales, Australia, 1978) and an MA in Egyptology (Macquarie University, Sydney, 2000) and became a Registered Surveyor in NSW in 1981. Today, he serves as the director of Brock Surveys at Parramatta.
✉ brocksurveys@bigpond.com

Call for Papers: FIG Working Week 2020

amsterdam FIG WORKING WEEK 2020 10 – 14 MAY

The theme of the FIG Working Week 2020 in Amsterdam, the Netherlands, is 'Smart Surveyors for Land and Water Management'. During the week, the 'smart surveyor' will take centre stage, with a focus on smart sensing technologies and new spatial data processing technologies based on the ever-evolving and converging fields of geodesy and geoinformation. With only ten months to go, the FIG Working Week 2020 will be the platform for smart surveyors from all over the world to evaluate their actual and future role in achieving the UN Sustainable Development Goals. FIG invites you to share your expertise on 3D geoinformation, crowdsourcing, robotics, artificial intelligence, simultaneous localization and mapping (SLAM), apps and mobile devices, point cloud processing, UAVs and blockchain technology, in the context of land and water management.

The digital transformation and new challenges affect our professional standards and practice. They are also affecting surveying education, which needs continuous review and requires innovative teaching approaches and lifelong learning solutions. Training and capacity building depend not only on skilled trainers and/or advanced technology, but also depending on political will, management understanding and priorities. Therefore, papers related to these domains are more than welcome.

FIG Working Week is the main event of the year for all ten FIG Technical Commissions as well as the FIG Networks, Task Forces and Permanent Institutions. The main objective of the FIG Working Week is to bring together experts from academia, government/public administration and industry to report on recent developments, trends and research results. The conference programme will feature keynote speakers and specially invited speakers for sessions focusing on the overall theme. Speakers at the technical sessions present their own research and are selected through the open call-for-papers procedure. This is an exceptional platform for industry practitioners, innovators, scientists, researchers, academics and students to discuss current research that is shaping a new world society.

Submission deadlines:

- An abstract and full paper for peer review: 1 October 2019
- An abstract for non-peer-review: 1 November 2019 (full paper: 7 February 2020)

More information
www.fig.net/fig2019

Reflecting on the IAG EUREF Symposium

The EUREF symposium was held in Tallinn, Estonia, from 22-24 May 2019 and attracted 115 participants from 30 countries. The science sessions dealt with topics such as reference frames, European geodetic networks, observational techniques and applications. The programme included reports from the reference frame coordinator, the analysis centre coordinator and the tropospheric products coordinator. In the national reports session, 29 reports illuminated the latest achievements in the field of geodesy and reference frames in participating countries.

Continuing on from last year's resolution about the heights and gravity, the EVRF2019 was presented and adopted as the new realization of the European Vertical Reference System. It was stated that EUREF "…considering the availability of the new realization of the European Vertical Reference System (EVRS), recommends to adopt this new realization under the name EVRF2019 and encourages all the participating countries to agree to the publishing of their EVRF2019 heights on the EUREF website".

Martin Lidberg (Lantmäteriet, Sweden) was elected as the new EUREF chair. Wolfgang Söhne (BKG, Germany) is the new chair of the EUREF Governing Board. The new secretary is Karin Kollo (Estonian Land Board).

More information
https://sites.google.com/uniroma1.it/hotinemarussi2018

▲ *Group photograph of the participants at the EUREF2019 symposium.*

Looking back at the International Cartographic Conference 2019

The Bay Area of Tokyo, Japan, hosted the 29th biannual International Cartographic Conference (ICC) and the General Assembly of the International Cartographic Association (ICA) from 15-20 July this year. Sessions were held at two venues: Miraikan (the National Museum of Emerging Science and Innovation) and Plaza Heisei (the Tokyo International Exchange Center). A nearby additional venue, the Telekom Center, hosted exhibitions and the Tokyo Metropolitan Industrial Technology Research Center was the venue for the meeting of Japanese cartographers. Japan had last hosted the ICC in 1980, also in Tokyo.

The slogan of the recent conference was 'Mapping Everything for Everyone'. Around 950 participants from 75 countries took part in the conference, and 750 presentations were organized across 150 sessions. The International Cartographic Exhibition presented 385 maps and related objects from 30 countries. The Barbara Petchenik International Children's Map Competition exhibited 188 maps from 33 countries.

The Imperial Highness Crown Prince and Princess Akishino attended the opening ceremony, during which the Imperial Highness Crown Prince welcomed the conference delegates. They also inspected a special collection of the cartographic and children's map exhibition. Later on in the week, Princess Akishino paid a private visit to one of the conference's social events: the orienteering event.

The conference featured the following keynote speakers:

- Venkatesh Raghavan (professor of geoinformatics, Osaka City University, Japan): 'Beyond the Jargon: FOSS4G, OSGeo, Geo4All and ME4E'
- Steve Coast (vice president of TomTom): 'The Past, Present, and Future of OpenStreetMap'
- Ayako Kagawa (geographic information officer, Chief Cartographic Unit, Geospatial Information Section, Office of Information and Communications Technology, United Nations): 'The Role of Cartographers in a Sustainable Development World'
- Eric Gundersen (Mapbox CEO): 'Building a Living Map of the World Updated from Billions of Sensors'

The General Assembly elected the new Executive Committee of the ICA. The new president is Tim Trainor (USA) and the new secretary-general is Thomas Schulz (Switzerland). The following nominees have become the additional members of the ICA Executive Committee: Andrés Arístegui (Spain), Temenoujka Bandrova (Bulgaria), Philippe De Maeyer (Belgium), Liqiu Meng (Germany), Terje Midtbø (Norway), Vít Voženílek (Czech Republic) and László Zentai (Hungary). Menno-Jan Kraak becomes a member of the Executive Committee as past-president. ICA's new Strategic Plan was also discussed and accepted by the General Assembly. Furthermore, the General Assembly voted on the ICC 2023 venue, and Cape Town (South Africa) was chosen to host the event. The next ICC will be held in Florence (Italy) in 2021.

More information
https://icaci.org/calendar/
http://cartography.web.auth.gr/ICA-Heritage/Thessaloniki2019/programme.html
www.e-perimetron.org

The book titled *Mapping for a Sustainable World*, which will be a co-publication of the ICA and the United Nations Geospatial Information Section, will be published this summer – both as a hard-copy version and as an e-book. These cartographic visualizations support decision-making by local and national authorities as well as promoting public awareness of global issues to encourage these authorities to act.

▲ *Tim Trainor was elected as the new president of the ICA Executive Committee.*

Recent Developments and Promotion of Remote Sensing by ISPRS

ISPRS Technical Commission III on Remote Sensing (2016-2020) has this year once again been working to actively promote and support developments in the remote sensing field. With ten working groups and six inter-commission working groups, 22 workshops had been organized in eight countries/regions by the end of July 2019, with Annals and Archives published reflecting the latest research results in the fields of each working group.

With support from ISPRS Scientific Initiatives, WG III/1 conducted international benchmarking of terrestrial laser scanning approaches for forest inventories, while WG III/4 established a website to provide reliable and high-quality hyperspectral datasets and initiated a benchmark framework for validating novel processing and data analytics methodologies.

With the support of the ISPRS Education & Capacity Building Initiative, WG III/5 delivered two datasets to the scientific society to test new Lidar mobile mapping and multi-spectral Lidar technology. The two datasets paved the way for the scientific community to explore new Lidar technologies. The members of ICWG III/II have developed new techniques of planetary mapping and applied them in scientific analyses of planetary data and to support the Chinese Chang'e-4 lunar landing mission for topographic mapping and analysis of the landing site, localization of the lander and rover. A book entitled *Planetary Remote Sensing and Mapping* was published as ISPRS Book Series.

Four special issues were published based on the working groups' achievements: 1) 'Frontiers in Spectral Imaging and 3D Technologies for Geospatial Solutions' in Remote Sensing; 2) 'Laser Scanning' in Applied Sciences; 3) 'Frontiers in Spectral Imaging and 3D Technologies for Geospatial Solutions' in MDPI Remote Sensing; and 4) 'Geospatial Technology in Environmental Health Applications' in the *Journal of Environmental Monitoring and Assessment*. Four volumes of ISPRS Archives and one volume of ISPRS Annals were also published.

One of the main events organized by the commission was the successful mid-term symposium of TC III, which attracted more than 750 participants from 52 countries and regions. Three international seminars on construction and application of spatial data infrastructure were organized which provide financial support to more than 60 participants from developing countries. Three summer schools have been organized, and cooperation with international organizations has been enhanced. Looking ahead, TC III will continue to serve and support the remote sensing community.

More information
www.gsw2019.org
www.isprs-ann-photogramm-remote-sens-spatial-inf-sci.net/IV-5/53/2018/
https://bit.ly/2SQ4ARy

▲ *Mosaic generated from the left-eye images of the Chang'e-4 rover's panoramic camera. The lander and the shadow of the rover are visible.*

The Most **Trusted Brand** in Surveying

@surveygram, USA

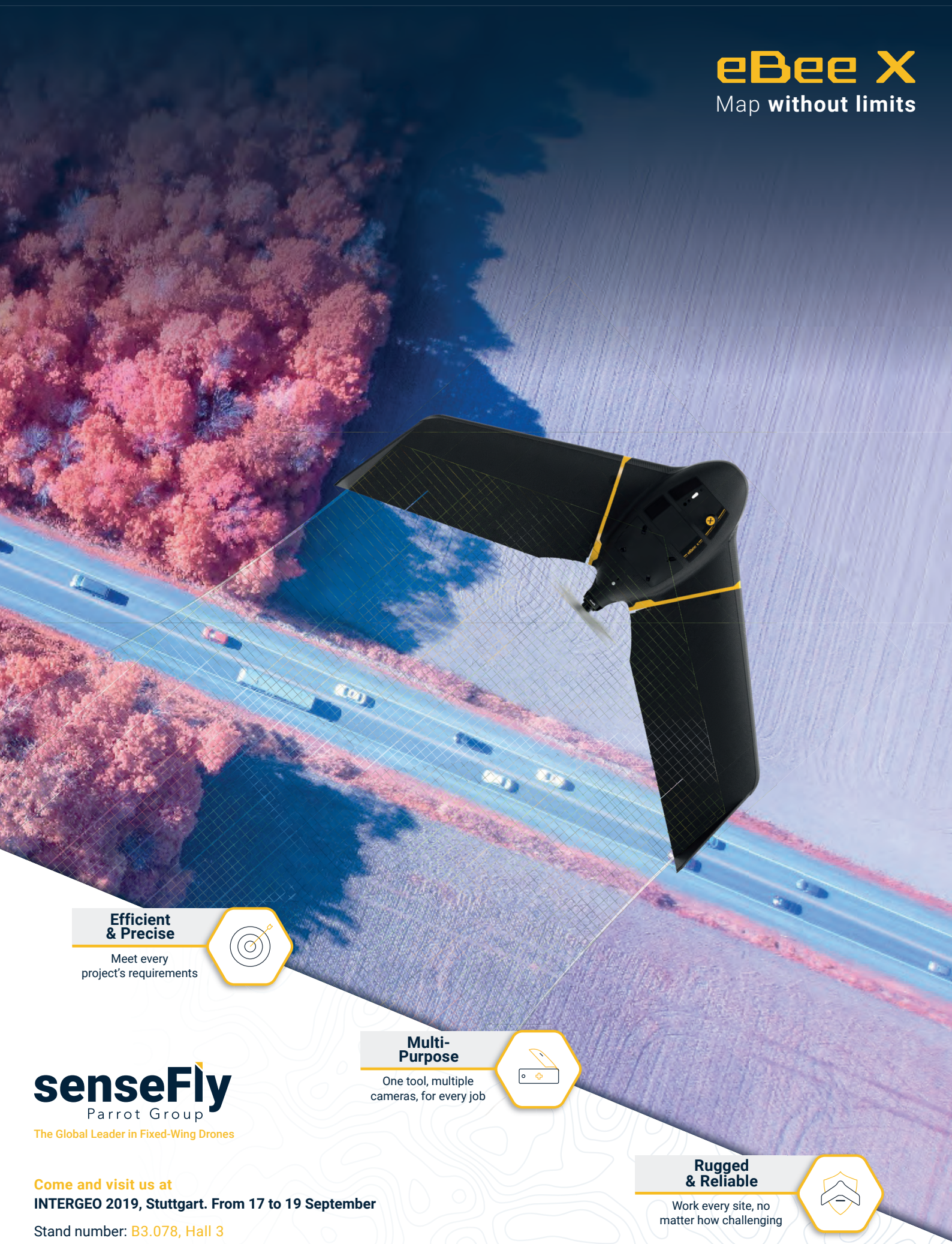
And the most powerful software to bring it all together.

Trimble

geospatial.trimble.com

eBee X

Map **without limits**



Efficient & Precise

Meet every project's requirements

Multi-Purpose

One tool, multiple cameras, for every job

Rugged & Reliable

Work every site, no matter how challenging

senseFly
Parrot Group

The Global Leader in Fixed-Wing Drones

Come and visit us at
INTERGEO 2019, Stuttgart. From 17 to 19 September

Stand number: B3.078, Hall 3

The eBee X is the fixed-wing drone for all your mapping needs. Designed to boost the quality, efficiency and safety of your data collection, it has a camera to suit every job, the accuracy and coverage to meet every project's requirements, and can work virtually every type of site.

Learn more: senseFly.com/eBeeX
Book a demo: senseFly.com/contact-us