GIM INTERNATIONAL

THE GLOBAL MAGAZINE FOR GEOMATICS
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geomares PUBLISHING

ISSUE 10 • VOLUME 31 • OCTOBER 2017

Geomatics Makes Smart Cities a Reality

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INTERGEO 2017: PREVIEW OF THE KEY EXHIBITORS

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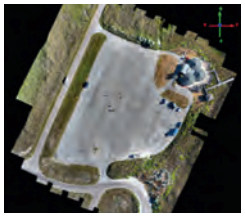

In keeping with tradition, the *GIM International* issue that is published in the 'Intergeo month' is a bumper-sized edition. This year, one of the key topics at the world's largest trade show for the geomatics sector is smart cities, and geoinformation plays a vital role in smart city strategies. In this issue, amongst many other articles on a wide range of topics, we zoom in on various geospatial aspects of smart cities.

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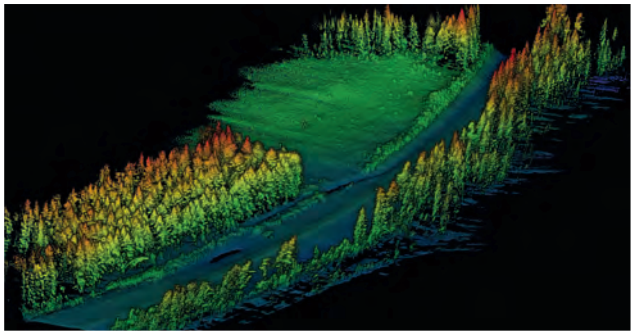

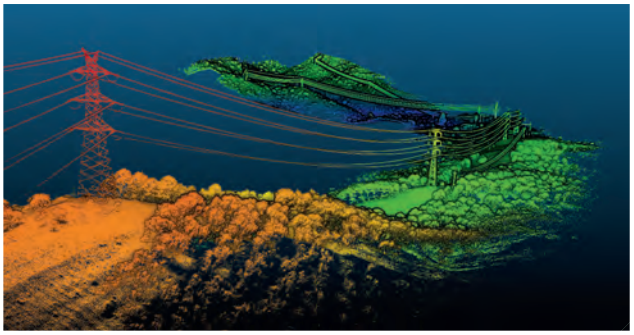

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Balancing soft and hard

In the discussions about the possibilities that technology provides us with in the geospatial field, one aspect is often forgotten: ethics. A 'soft' subject like ethics is not a common topic of conversation in an industry that is centred on hardware, speed and accuracy. But that could well change in the future. This issue of *GIM International* includes an interview with Yola Georgiadou, a professor of geoinformation for governance at the University of Twente's Faculty of Geo-Information Science and Earth Observation (ITC), The Netherlands (see page 16). Professor Georgiadou held a compelling keynote speech during the FIG Working Week in May of this year in Helsinki, during which she called upon the community to put the topic of 'geo-ethics' high on the agenda. Her biggest concern is that the citizens in the global south, often lacking secure land tenure, are victims of a datafying world in which their privacy is sacrificed in the process of 'fast-forwarding' the survey of large areas. This accelerated process might indeed give those citizens land tenure security, but the data acquired using unmanned aerial vehicles and also through crowdsourcing could be used wrongfully by companies or governments that do not necessarily have the best intentions.

▲ *Durk Haarsma, publishing director.*

Professor Georgiadou calls for prudence in implementing technology of which the long-term consequences are unclear. She also believes it is important to go a step further than the principle of 'Do no harm' from the Code of Ethics; she wants to empower people to make autonomous decisions without undue interference. It can be difficult to strike the right balance between the upbeat mood that often goes hand in hand with the development of technologies and the new possibilities that they offer, and tempering that mood by pointing out that all those possibilities may also pose a risk.

It is certainly a balance that we need to be aware of and take into account, especially now that there is a fast-spreading realisation that geospatial information should be increasingly institutionalised in the day-to-day decision-making of governments across the globe. Much of that realisation is due to the good work of the Committee of Experts of the United Nations Global Geospatial Information Management (UN-GGIM). At the 7th session of UN-GGIM (see the report on page 48) held this August in New York, the World Bank announced its commitment to providing funds for developing countries to establish spatial data infrastructures: a great step towards security and welfare for countless people in those countries. The World Bank will certainly appreciate Professor Georgiadou's message for the geospatial community to survey in an ethical way, to regard privacy as a matter of importance and to safeguard people's freedom and their right to make autonomous decisions.

And now, Intergeo is on! From 26-28 September, the German capital of Berlin is the global hub of the geospatial community. There will no doubt be time to talk about 'soft' issues like privacy and so on, but it's also an excellent opportunity to admire all the amazing hardware and technology that will be on display in the halls of Messe Berlin for the three days of the event. The *GIM International* team will be at stand B3.061 (Hall 3.1). Enjoy Intergeo, and we hope to see you there!

Future of Surveyors: Moving up the Food Chain?

I attended an event at this year's Edinburgh Science Festival where the medical profession was debating the potential role and impact of IBM's 'Watson' – a supercomputer that combines artificial intelligence (AI) and sophisticated analytical software for optimal performance as a 'question-answering machine' that is already proving its worth in patient diagnosis. Doctors just won't have their normal 17 years to adopt new procedures with 'Watson' support knocking on their doors. I then learned that the architecture profession is also in a dilemma. Due to their reluctance to embrace and manage risk and teach the business of design and construction, it is estimated that 80 percent of the world is now built without architects. It appears that all professions are having to adapt quickly to the challenges of fast-evolving technical and business worlds.

How is the surveying profession coping? Do surveyors understand the far-reaching impact on their profession of the technology and business revolutions taking place throughout the geospatial sector, including mobile technology-based crowdsourcing, the combination of AI and Earth observation, simultaneous localisation and mapping (SLAM) systems of robotic mapping and navigation, and land registries being outsourced to the private sector? Will the surveying profession soon be considered an irrelevance as other more agile and better-prepared professions take advantage of these opportunities?

To be relevant, we must educate our students and continue to develop the capacity of our professionals to be as creative in business as they are in capturing, managing and analysing geospatial information. The current limited scope of surveyors is largely a result of being taught 'what to think' rather than 'how to think' about the geospatial business. Relevance is connected to five critical characteristics:

Scope – if we teach young professionals how to be as creative in the geospatial information business as they are in technology, it will open doors for revenue streams from intellectual property and new services to expand the influence of the problem-solving surveyor
Effectiveness – solutions to our global problems will only be achieved through collaboration with other professions. Courses must involve multidisciplinary teamwork to solve problems rather than being insular
Connectedness – we actively insulate our profession with lazy, self-indulgent 'geospeak'. In a world where social media and misinformation often reign, it is critical to get our message across to those we are trying to influence – such as politicians – clearly and effectively
Appropriateness – our solutions are often over-specified and too expensive for the customers' requirements. We need to more effectively listen to customer needs, better understand the cultural context and deliver fit-for-purpose solutions
Resilience – we must lift up our heads, we must see what is occurring in the world and we must adapt. This will require us to retain our global values.

To survive, surveyors will need to embrace profound change, move up the food chain by adding considerable value and be proactive in creating new, innovative markets. Otherwise we will become irrelevant and extinct.

▲ *Robin McLaren.*

3D Solutions to View Cities from Different Angles

Due to the progress of information technology and hardware, many organisations are seeking to use advanced 3D technology to display their spatial data. In line with this trend, Supergeo has come up with a 3D solution. With SuperGIS 3D tech, users are able to simulate any viewing angles that may previously have been difficult to achieve with 2D GIS software. The SuperGIS 3D solution will help people to grasp the overall information of a particular area effectively, making policy formulation and discussion easier.

▸ **http://bit.ly/2wd5bko**

SuperGIS 3D.

Start-up Wingtra Expands UAV Solutions to China and USA

WingtraOne UAV.

After being released earlier this year, the WingtraOne UAV is now spreading its wings across continents, making its first stop in the USA and China. According to Wingtra, the company behind the drone, users come from areas as diverse as surveying, precision farming, glacier monitoring and wildlife monitoring. Even after just a few months, the start-up is swiftly gaining popularity among professional mappers and surveyors. The Swiss company focuses on the combination of high range and usability. With drone technology emerging rapidly, users are increasingly turning to the unmanned aerial vehicle (UAV) market for aerial data collection. However, the choice has typically been between fixed-wing aircraft and multi-rotors. Fixed-wing aircraft offer long range but can be too cumbersome to use. Either they need long runways, limiting the options for take-off and landing, or need catapults. In contrast, multirotors offer great flexibility for take-off and landing and, in turn, ease of use.

▸ **http://bit.ly/2vROX6N**

Delphi Partners with Innoviz to Provide Lidar Solutions for Autonomous Vehicles

Delphi self-driving car.

Delphi Automotive has announced it has signed a commercial partnership agreement with Innoviz Technologies, a leading Israel-based company developing Lidar technology for the mass commercialisation of autonomous vehicles. Innoviz's proprietary Lidar sensing solutions will be integrated into Delphi's systems to provide car makers with a comprehensive portfolio of autonomous driving technologies. Innoviz Lidar technology utilises a solid-state design to provide longer-range scanning performance and superior object detection and accuracy capabilities. Long-range Lidar is critical for enabling Level 3 and Level 4 autonomous vehicles to travel at high speeds, as these vehicles will need to identify objects at significant distances and in great detail in order to operate safely.

▸ **http://bit.ly/2f7poCf**

International LowCost 3D Workshop to Be Held in Hamburg

The city of Hamburg, Germany, will be the venue of the 5th International Workshop LowCost 3D - Sensors, Algorithms, Applications being held from 28-29 November 2017. LowCost 3D is a series of international workshops on low-cost three-dimensional sensor systems and tools, ranging from low-cost acquisition devices like handheld scanning systems to inexpensive photogrammetric algorithms and processing software and applications. The organisation and hosting of these workshops, which were started by Prof Frank Neitzel from Technical University Berlin and Prof Ralf Reulke from Humboldt-University in Berlin, has so far alternated between these two universities and a total of four workshops have been held in Berlin since 2011. In 2017, however, the fifth workshop will be hosted by HafenCity University Hamburg. The main focus of the workshop is to discuss new developments in low-cost 3D sensor technology, algorithms and applications.

The Port of Hamburg.

▸ **http://bit.ly/2xaS9I6**

Over Four Thousand Students Participate in Virtual Field Trip

New Zealand students on a virtual field trip.

More young people than ever before are taking an interest in the geospatial industry; a record 4,000-plus students recently took part in the LINZ-led virtual field trip. Students from more than 150 schools took a virtual trip online to the east coast of New Zealand's North Island, where they heard from geospatial experts, rangers and historians about how they are using location-based technology to support their work. The theme was to map 'my Waahi' ('Waahi' means a place of historic importance). Each student chose a place important to them and learned how to visualise information about it – stories of its history, GPS locations and images – all on a 3D map. LINZ geospatial expert Duane Wilkins took students through the process for making their maps. They were taught how to pull data from the LINZ Data Service and plug it into simple mapping tools, such as Google My Maps. Students were on location taking part in field activities such as GPS data capture, mapping and capturing 360-degree photospheres to include in Google Street View.

▸ **http://bit.ly/2wOB6td**

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3D Laser Mapping Introduces New Airborne Lidar System

ROBIN +WINGS aerial mapping system.

3D Laser Mapping aims to help survey teams to cover more ground in a shorter space of time with a new aerial mapping system. The ROBIN +WINGS airborne Lidar system is an extension of the ROBIN mobile mapping unit which allows survey teams to mount the system to a backpack, vehicle or aircraft. The +WINGS system works with both single-pole and nose helicopter mounts and can be deployed in a range of sectors, including forestry, environmental monitoring and transportation infrastructure mapping. Graham Hunter, managing director at 3D Laser Mapping, explained that ROBIN +WINGS provides surveying teams with higher levels of flexibility than previously available with airborne Lidar systems. Most systems are designed to fix only to an aircraft or helicopter, yet ROBIN works for both ground and airborne applications, with the +WINGS add-on extending this flexibility to rotary and fixed-wing aircraft and gyrocopters.

▸ **http://bit.ly/2gPAsHW**

500,000 Square Kilometres of Satellite Imagery for European Commission

Yellow Canola fields in Poland (image by WorldView-2 satellite).

European Space Imaging has finalised the collection of nearly half a million square kilometres of satellite imagery for the European Commission. This marks the completion of its very-high-resolution (VHR) image acquisition for the 2017 Controls with Remote Sensing (CwRS) programme. With a 100% success rate, the company has once again demonstrated its capacity and reliability as Europe's leading VHR satellite image provider. The CwRS programme monitors agricultural land for which farmers have been granted subsidies under the EU's Common Agricultural Policy (CAP), which amount to around EUR40 billion per year. European Space Imaging has been the major provider of VHR satellite data to the programme since 2003. EU Member States give European Space Imaging an individual collection window for each of the 842 agricultural zones spread all over Europe, and on average it has 51 days to gather the data. Cloudy weather over Latvia, the United Kingdom, and Ireland made the operation particularly challenging this year.

▸ **http://bit.ly/2wdr2YR**

Integrated UAV Multispectral Mapping Solution for Agriculture

Agrowing UAS.

Icaros, a leading provider of aerial imaging software, and Agrowing, a leading supplier of multispectral sensors and analytics software, are launching an integrated unmanned aerial vehicle (UAV) product that bundles Icaros' OneButton software into Agrowing's solution stack. This automates the entire workflow, from image capture through to generation of fully indexed orthomosaic maps for agriculture. As part of the agreement between the companies, Agrowing will offer an exclusive product bundle that includes Agrowing's multispectral sensor, Icaros' OneButton Standard Edition, and Agrowing's agriculture solution. The combined features enable Agrowing users to process imagery into high-fidelity fully indexed orthomosaic maps for agriculture, which are crucial for professional precision analytics. Agrowing's sensor technology represents an advanced patent-pending multispectral solution to capture four 8MP or 10MP bands each, for NDVI and all other vegetation indices on a single sensor. The technology turns DSLR cameras into high-end multispectral cameras.

▸ **http://bit.ly/2wE9BT1**

City of Coatesville Brownfield Redevelopment Project

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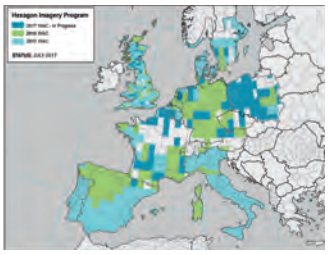
HxIP: Updates to 2017 Airborne Imagery Collection Plans



2017 European acquisition.

The Hexagon Imagery Program (HxIP), an important source of professional airborne imagery provided through the cloud, has announced updates for 2017 airborne imagery collection plans of wide area coverage (WAC) at 30cm accuracy and urban area coverage (UAC) at 15cm accuracy. By the end of 2017, the HxIP will update its content for more than 3.9 million square kilometres in North America. This includes a refresh of 18 previously captured US states and completes the full coverage of the continental United States, Hawaii, Puerto Rico, the US and British Virgin Islands, and select areas of Alaska. In addition to the 30cm programme, the HxIP is expanding its 15cm collection by 100 cities for a total of 347 US urban areas covering more than 492,000km². The HxIP also includes 23 Canadian cities at 30cm, with efforts underway to refresh and expand the Canadian library. This year will see the addition of approximately 650,000km² in Europe, bringing the Western European coverage to more than 2.2 million square kilometres. Including countries such as Italy, Germany, Spain, France and Poland, this coverage expands the HxIP on the global stage, making it one of the world's most comprehensive imagery programmes.

▸ **http://bit.ly/2xTwvGt**

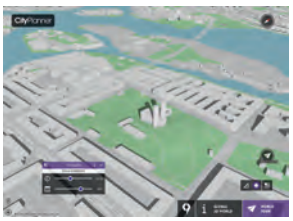
Indoor Reality's VR Helps Users Become Immersed in 3D Mapped Buildings

Indoor Reality has updated its 3D mobile mapping system to integrate it with Google DayDream so users can now take virtual building walkthroughs using a virtual reality (VR) headset. Virtual reality app developers can capture and process data needed using Indoor Reality's hardware platform and its automated cloud-based processing pipeline to generate photorealistic 3D virtual models of building interiors with no human intervention. Avideh Zakhor, founder and CEO of the company, describes it as a great supplement to the web-based interactive walkthrough currently available. Accessible within the Indoor Reality cloud processing platform, the VR content creation is now available to all customers currently using Indoor Reality's IR-500 handheld device or IR-1000 backpack system.

Indoor Reality's VR.

▸ **http://bit.ly/2vROP5j**

Cloud Solution for Collaborative Urban Planning



Agency9 CityPlanner.

Agency9, known for its technology in large-scale streaming and 3D visualisation solutions, has announced the release of free global 3D terrain and buildings in CityPlanner – its cloud solution for collaborative urban planning on the web. Agency9 currently serves many customers with web-based 3D visualisation tools in CityPlanner. With the release of the free global 3D world in CityPlanner, the company aims to further stimulate the transition of users to 3D using modern planning paradigms, as well as to lower the financial hurdle of adopting such services. According to Håkan Engman, CEO of the Swedish company, bundling free 3D data with the service allows any city in the world to start using CityPlanner instantly, without the lead time of acquiring data. CityPlanner represents a new generation of 3D tools for the preparation of plans, project communication and citizen dialogue in smart cities. The solution is presently used by many cities for urban planning, promotion, GIS presentation and crowdsourcing.

▸ **http://bit.ly/2eLc6Lb**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5 Questions to... Tristan Allouis, YellowScan

The combination of unmanned aerial vehicles (UAVs or 'drones') and Lidar is regarded as the next geospatial frontier, but the barriers are gradually being overcome. What do you see as the main developments?

The main trend is the miniaturisation of the instruments; if you compare an aerial Lidar system from 20 years ago to YellowScan's products today, the weight, dimensions and power consumption have been reduced by a factor of 20 or more. And we're striving for even lighter instruments to meet users' requirements in terms of accuracy, range, access to remote rugged terrains and near-real-time data production. In other words, we aim to do more with less. Another important development is user friendliness and reliability. Whereas the first instruments on the market were operated by specialists, now we can serve land surveyors, archaeologists, civil engineers or forest scientists with turn-key, fully integrated Lidar systems that can be mounted on any drone.

When should one consider using a Lidar-equipped UAV?

Lidar is the most suitable solution for beneath-vegetation 3D modelling and short-time data processing needs – a georeferenced Lidar point cloud can be produced just minutes after the flight without the need for ground control points. Lidar is also the best solution when shadows are an issue or light is too low. Since it is an active sensor, Lidar has its own light source and is insensitive to light conditions. A Lidar-equipped UAV has the advantage of higher productivity than terrestrial laser scanning (TLS), with lower investment and mobilisation costs than aerial laser scanning (ALS). Furthermore, using UAVs bridges the gap between the very accurate land surveying of small areas and the very large-scale, high-productivity Lidar on aircraft. The typical size of a UAV survey today is about 1 to 10 square kilometres. The UAV-Lidar also enables the survey of hard-to-access zones on foot or by aircraft. For example, one of our customers in the archaeology field succeeded in obtaining the microtopography of a 10ha archaeological site which had been discovered in the 19th century but never explored because of its thick vegetation cover.

How about combining Lidar and photogrammetry?

This combination is very interesting for architecture and industrial survey, when the combination of sharp edges from Lidar and visual information from photogrammetry is needed.

For which markets/applications does YellowScan foresee the most potential?

Mainly for topography in all its variations, civil engineering, mining, corridor mapping, forestry, archaeology, etc. There is also value in the augmented reality field for the movie and video game industries. 3D mapping for the development of autonomous vehicles can also be a great potential market. However, this application is more likely to be led by mobile Lidar, with marginal use of UAVs.

You held your International User Conference in June 2017. What were the most striking outcomes of the event?

We were pleased to welcome customers and partners from all over the world, for whom we organised high-quality presentations from expert speakers in various application fields: archaeology, forestry, power line surveying, mining and civil engineering. The attendees appreciated the case studies as they demonstrate our commitment to customer support and demonstrated how YellowScan solutions are used in so many applications, ranging from tree-growth detection and disaster recovery in Japan to power line maintenance in Spain and even archaeological vestiges of pre-Columbian raised fields in South America. Our guests enjoyed the very interactive workshops and panel discussions about the future of Lidar for drones as well as the exchange of best practices for managing a Lidar mission. They were also informed about the first urban-zone survey in France, combining UAV-Lidar, TLS and handheld Lidar to map Château de Flaugergues in Montpellier inside out!

More information
www.yellowscan.fr

GIM INTERNATIONAL INTERVIEWS PROFESSOR YOLA GEORGIADOU

Geo-ethics Requires Prudence with Private Data

In today's datafying world, we continuously leave – unintentionally – digital traces of our daily lives. These traces can reveal a lot about us, our beliefs and our actions to parties who are not the intended recipients of such information. In May this year, Professor Yola Georgiadou held a compelling keynote speech during the FIG Working Week in Helsinki. She called for prudent use of data acquired during the rapid land surveying of developing countries and for action to protect citizens' privacy. *GIM International* talked to her about the topic that has become so dear to her: 'geo-ethics'.

What actually is geo-ethics?

Geo-ethics is about fairness in the way we – citizens – and our resources and land are made visible, represented and treated as a result of our production of digital data in a datafying world. I have to give credit here to Dr Linnet Taylor of Tilburg University for framing the original definition for data justice, which I adapted here for geo-ethics. We have to find ways to make sure that all of us who produce digital data while carrying on with our daily lives are represented and treated fairly.

Why has geo-ethics become more important over the past few years?

Engineering professions have always had a Code of Ethics, and this is a good thing. Geo-ethics is now becoming extremely important because we produce digital data as we live our daily lives. Every click we make, every search on Google, every post on Facebook or phone call we make leaves geolocated digital traces. Entities that are not accountable to us may collect, store and analyse these digital traces and use them to influence our behaviour in several ways: from how we buy things to how we vote for our political representatives. In the past we were asking 'What can my data tell me about here, about this location, about where I am?', but now the question has changed dramatically; it has become 'What can my data tell you about me?' And if that 'you' is our government that we have elected and is accountable to us, it may be okay, but if the 'you' is Facebook, Google, Apple or Amazon or any data broker we have not elected and who is not accountable to us, then we have a problem. That's why geo-ethics is so important right now!

Do you think an entity like the European Union is currently doing enough to protect its citizens in this sense?

The EU has certainly made some progress, such as with the Data Protection Directive issued several years ago and with the new regulatory framework, GDPR, that is coming into force next May. In liberal democracies, we have the luxury to protest and petition government for more privacy protection. In the Global South, there is often either no protection or, sometimes, active censorship by authoritarian governments. And in those places we, as researchers from the North, promote tools and solutions. For example we generate high-resolution imagery with drones for urban planning, or develop innovative apps and tools for land and water security, among other things. We should be sensitive to what such technological interventions mean to people on the ground and whether we are actually harming them instead of helping.

Do you see a way to safeguard the privacy of people in the Global South?

Personally, I would be willing to support a movement that advocates for people from the Global North to pay for internet access to cross-subsidise the access of people from the South so that they don't have to pay. That way, we wouldn't have to commodify our privacy to corporations in exchange for free internet services – but I wonder how popular such a cause would be among other people.

Well-known geospatial companies like Fugro, Trimble and Esri might hold large volumes of privacy-sensitive data as well. In your view, should they uphold a certain set of rules or code?

Absolutely. And I believe that engineers working in these big companies in the Global North are adhering to the code of ethics of their profession. Whether we are surveyors or civil engineers, we all pledge to do no harm while exercising our profession. But what happens for instance when data is collected with apps – often not by companies that we know – that are becoming popular in the South? We collect data about individuals and their land, often without asking ourselves, 'Who will have access to this data, and who is the data controller that can guarantee that the only purpose for which the data will be used is, say, land tenure security and not something else, e.g. land grabbing?'

What do you feel are the most important aspects of a set of standards to which private companies carrying out land administration projects should adhere?

Context, purpose and consent are three important aspects. First, information always flows within a specific context governed either by explicit or implicit norms. Let's take 'travel', which is location-intensive. Even in this

▲ *Professor Yola Georgiadou has had a special relationship with the Global South throughout her entire career.*

simplest example, we can distinguish at least two travel contexts – travel for tourism and travel for refugee migration – each governed by different norms. Second, the purpose of data collection and processing should be guaranteed by a data controller, who decides on the purposes and means of personal data processing and can be held accountable for non-compliance. Third, data should be collected with the informed consent of the people who provide the data – who may not only be vulnerable but also unable to consent. These three aspects, if agreed upon with the government for which the company is carrying out the work, can minimise the harm and maximise the benefit of land administration projects, especially when innovative land tools are being used.

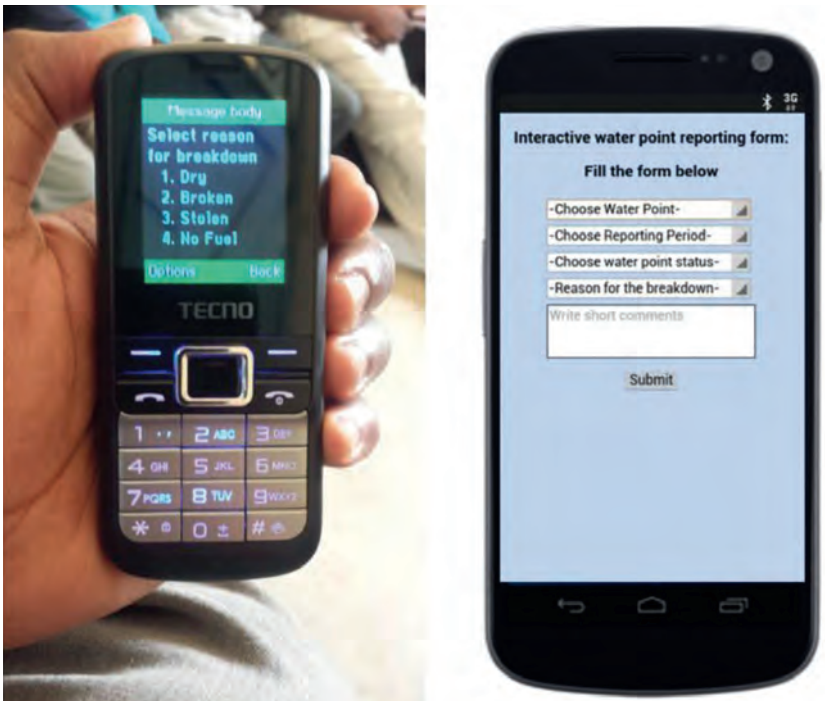
Do you think that geo-ethics is high enough on the agenda of decision-makers in, for instance, UN-GGIM?

The time is ripe for geo-ethics to be put on the agenda if it is not already there. It's possible that similar global bodies with broader digital information protection mandates are using alternative terms. The term 'data justice', for instance, is now becoming quite popular in the literature. Data justice refers to all sorts of data, which may or not be pinned to a geographic location.

In your research, have you seen any examples of data being misused?

I am often uncomfortable with how high-quality geodata collected for one purpose may later be used for other purposes, especially in political regimes known for being repressive. For example, one

I AM OFTEN UNCOMFORTABLE WITH HOW HIGH-QUALITY GEODATA COLLECTED FOR ONE PURPOSE MAY LATER BE USED FOR OTHER PURPOSES



▲ *Data collected by innovative apps to communicate with service providers could be misused.*

of my colleagues used drones to map the capital city of a country in the Global South at high resolution for urban planning purposes. The raw images collected from a height of 50 metres above ground revealed details of human behaviour on the streets that may be considered suspect or even criminal by the local police. Of course, these details disappear in the mosaic formed by combining the raw images, but the question remains: 'Who has access to the raw images and derived products, and for which purpose, other than the original purpose, will the data be used?' Similarly, the collection of names and mobile phone numbers of thousands of vulnerable people so that they can use innovative apps to communicate with service providers and complain about failures in these services may backfire if those names and phone numbers are used in a different context and for a different purpose than originally intended. I see two issues here. First of all, we – as researchers from the North who work in the South and learn a lot and build our careers on their backs – have to be much more careful with the private information people entrust to us. Second, we have to think about how to protect digital data representing people and their property in the South, especially when their governments are not yet considering these issues.

It's not all bad, is it? Gathering geoinformation can enable governments to make better decisions, can't it?

Yes, it certainly can. But there's no automatic correlation between better data and better government performance; it's more complicated than that. We first have to understand how governance processes work in specific contexts and for this we need theory and methods from the social sciences. Only then can we start deliberating about the most suitable ways to automate some governance processes, with respectful and sensitive technological interventions and innovative land tools that do not disrupt the local social fabric and can be fine-tuned and improved over longer periods of time.

In Helsinki you called upon FIG as well as other geo-related societies to take action to safeguard location-based data and the privacy of vulnerable people in the developing world. What should FIG and the other industry societies do, exactly?

Well, the consensus is that a large percentage of people on the planet lack secure land tenure and that innovative technology will play an important role in solving this problem. FIG needs to think about what ethical issues may arise when its members intervene in the South. As a professional community that counts legal and technical experts from both the North and South among its international membership, FIG is uniquely qualified to engage in geo-ethics. Surveyors already adhere to the traditional and valuable engineering Code of Ethics, but we now need a different thinking to handle the question of 'What can my data tell you about me?'

So basically you're calling for prudence in implementing technology as well, because we don't know what it will do in the long term, right?

Exactly. We should first understand how land or water or urban governance works on the ground and then figure out how we can design technological interventions that go with the grain. The aim should not be to merely 'Do no harm' but to empower people to make decisions autonomously and without undue interference.

What message do you have for the decision-makers, the geomatics professionals that are reading* GIM International*?

The world has changed. Big corporations are determining our lives much more than before. They are becoming more powerful than nation states and the data they collect about us, without us noticing, may be used to influence us. This takes away our freedom and our fundamental right to make decisions for ourselves, autonomously and with the people we love, and not because somebody predicts our behaviour and influences us to vote for this person or to buy that product. So we are losing our freedom. We are instrumentalised. We are becoming products. We have to be aware of that – not just in our personal life, but also in our professional life because it influences that as well. ◀

YOLA GEORGIADOU

is a professor of geoinformation for governance at the Faculty of Geo-Information Science and Earth Observation (ITC) of the University of Twente, The Netherlands. Before joining ITC she earned a doctorate in geodetic engineering, on rotation modelling of a deformable Earth, at the University of Stuttgart, Germany. She is a past member of the Board of the GSDI Association, of the Capacity Building Working Group of CODI-Geo, United Nations Economic Commission of Africa and of the Executive Committee of the International Society of Digital Earth (ISDE). Her research is at the interface of geoinformation technology, policy and global development. She studies whether and how people enact, organise and institutionalise geoinformation technology in various domains (water, environment, urban and land policy) and how infrastructure – the informational, social and material underpinning of human action – is built, maintained and breaks down. Her methods are qualitative. Her normative orientation is 'working with the grain' of institutions and organisations in the Global South.

A COMPARISON OF MOBILE INDOOR SCANNING METHODS

Autonomous 3D Modelling of Indoor Spaces

Mobile scanning can be an equally accurate yet more cost-effective solution than traditional terrestrial laser scanning done with tripods. To succeed, however, mobile scanners not only require a suitable combination of sensors, but also reliable and continuous knowledge about where the scanners are located and the direction in which they are pointing during scanning. There are multiple ways to achieve this, which has led to the development of various scientific and commercial solutions. This article compares several mobile scanning solutions for 3D modelling of indoor spaces and highlights their strengths and weaknesses.

In modern society, people tend to spend more time inside buildings than outdoors. Nevertheless, indoor spaces are – by far – less digitised than Earth's surface. Modelling more indoor spaces from 3D measurements would satisfy many needs, and especially so if those measurements could be done rapidly, cost-effectively and accurately. Mobile scanning is a promising technology in this context.

RAW MATERIALS

Point clouds are the raw materials for 3D models. Mathematically, a point cloud is a set of points in a three-dimensional (3D) coordinate system. These points can be obtained from digital imagery or with laser scanning. In the case of imagery, prominent solutions use structure from motion (SfM) or its real-time variant, visual simultaneous localisation and mapping (SLAM). The structure, i.e. the geometry of indoor spaces, is triangulated from digital images visualising the same spots from different perspectives that can be acquired during motion. However, due to challenging lighting conditions and the scarceness of textures in indoor spaces, laser scanning appears to be the most promising approach so far.

TERRESTRIAL LASER SCANNING

Points are obtained from range measurements by the laser. The laser scanner emits a beam that is reflected with a revolving mirror to obtain a two-dimensional (2D) profile from the surroundings. If this 2D scanner is then simultaneously rotated on top of a tripod, it performs a 3D scan of the environment. Currently a single terrestrial laser scanning (TLS) scan is the most precise way of acquiring a dense point cloud of the surrounding environment. Due to occlusions, however, several scanning locations are needed – even in a relatively simple space – to achieve full coverage. It is possible to

▲ *Figure 1, A point cloud of Aalto University's Startup Sauna.*

combine multiple tripod scans by using human-deployed scan targets in the field and software automation in the post-processing phase, or simply human intervention in the latter. Either way, this involves a considerable amount of manual labour.

MOBILE SCANNING

Mobile scanning is faster than any scanning done using tripods and therefore provides more cost-effective solutions. There is a caveat, however: the range measurements cannot be used on their own. It is also necessary to know from where the measurements were taken, and pointing in which direction. If the scanner is sitting on top of a tripod, the pose of the scanner (its position and attitude) are usually known or can be determined easily. Scanning and moving at the same time, however, reduces point cloud accuracy because the scanner pose estimate is less accurate. After going mobile and having traded off some point cloud accuracy in favour of time savings, the challenge is how to reclaim some of this lost accuracy to reach the accuracy level that is required for indoor modelling.

LOCALISATION

At the heart of a precise 3D point cloud is an accurate trajectory. Determining the pose of the scanner must be both continuous and reliable. Satellite signals typically do not reach inside buildings, which means that the trajectory must be obtained relatively, by correlating newly obtained measurements with those obtained earlier since the start of the scan. In other words, the question of the scanner's location is answered by observing that the overlap of the data is coherent with itself. For example, when a wall is scanned twice, this data must be coherent with itself. This is the principle of SLAM.

Determining the pose requires a 3D Cartesian vector and a 3D angular vector. In other words there are six unknowns, or six degrees of freedom. These do not need to be solved at the same time. One trick to simplify the problem is to omit the height direction. Some methods use this and some do not; some use it as an initial estimate.

COMPARISON

There are thus multiple ways to localise the scanner. Not only are there different combinations of multi-sensor systems that can be assembled, but there is also a sandbox form of freedom in incorporating the algorithmic side, which deeply affects whether a certain approach is successful (please note that SLAM refers to a range of tools and methods, and not to any specific data processing algorithm).
In the scientific paper on which this article is based (Comparison of the Selected State-Of-The-Art 3D Indoor Scanning and Point Cloud Generation Methods, see 'Further Reading'), to evaluate the strengths and weaknesses of these different methods the authors analysed the performance of eight different scanning methods and compared them against a reference taken with a survey-grade TLS. Three different test sites were used, and the evaluated methods are listed in the table above.

Method	Properties		Captured data		
	Range	Data gathering	Hallway	Car park	Startup Sauna
TLS	270 m / 120 m	1 Mpts/s	1 h, Leica	2 h, Leica	4 h, Faro
VILMA	< 120 m	1 Mpts/s		w	
Würzburg backpack	160 m	0.1 Mpts/s	w	w	w
NavVis	30 m (laser)	6 x 16 Mpx	w	N/A	
Matterport	6 m	3x 0.3 Mpx	1 h	2 h	3 h
SLAMMER	120 m	2x 1 Mpts/s	w	N/A	
Zebedee	15-30 m	~0.05 Mpts/s	w		
Leica Pegasus	100 m	2x 0.3 Mpts/s	w		
Stencil	100 m	0.3 Mpts/s	w	w	

▲ *Table 1, Introducing the evaluated methods. Capture time is walking speed (w), or measured in hours (h). N/A indicates that the 2D method could not reconstruct the 3D trajectory.*

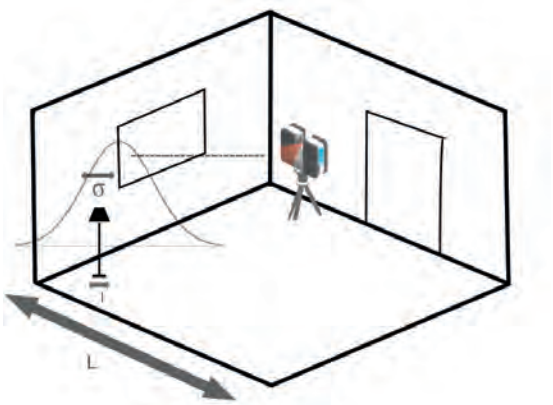
Method	Strength	Weakness
TLS	Survey-grade	Cumbersome and slow
VILMA	Proof-of-concept in 6 DoF intrinsic localisation with one 2D scanner	Experimental
Würzburg backpack	Proof-of-concept in laser-only backpack	Experimental
NavVis	Precision, photo-realistic point clouds	Use restricted to near-flat surfaces
Matterport	Photo-realistic VR	Inaccurate for a non-mobile method
SLAMMER	Precision	Experimental, use on flat surfaces only
Zebedee	Handheld	Low data capture rate for non-online method
Leica Pegasus	Seamless indoor-outdoor (SLAM-GNSS) registration	Indoor localisation
Stencil	Online map	Double surfaces

▲ *Table 2, Strengths and weaknesses of the evaluated methods.*

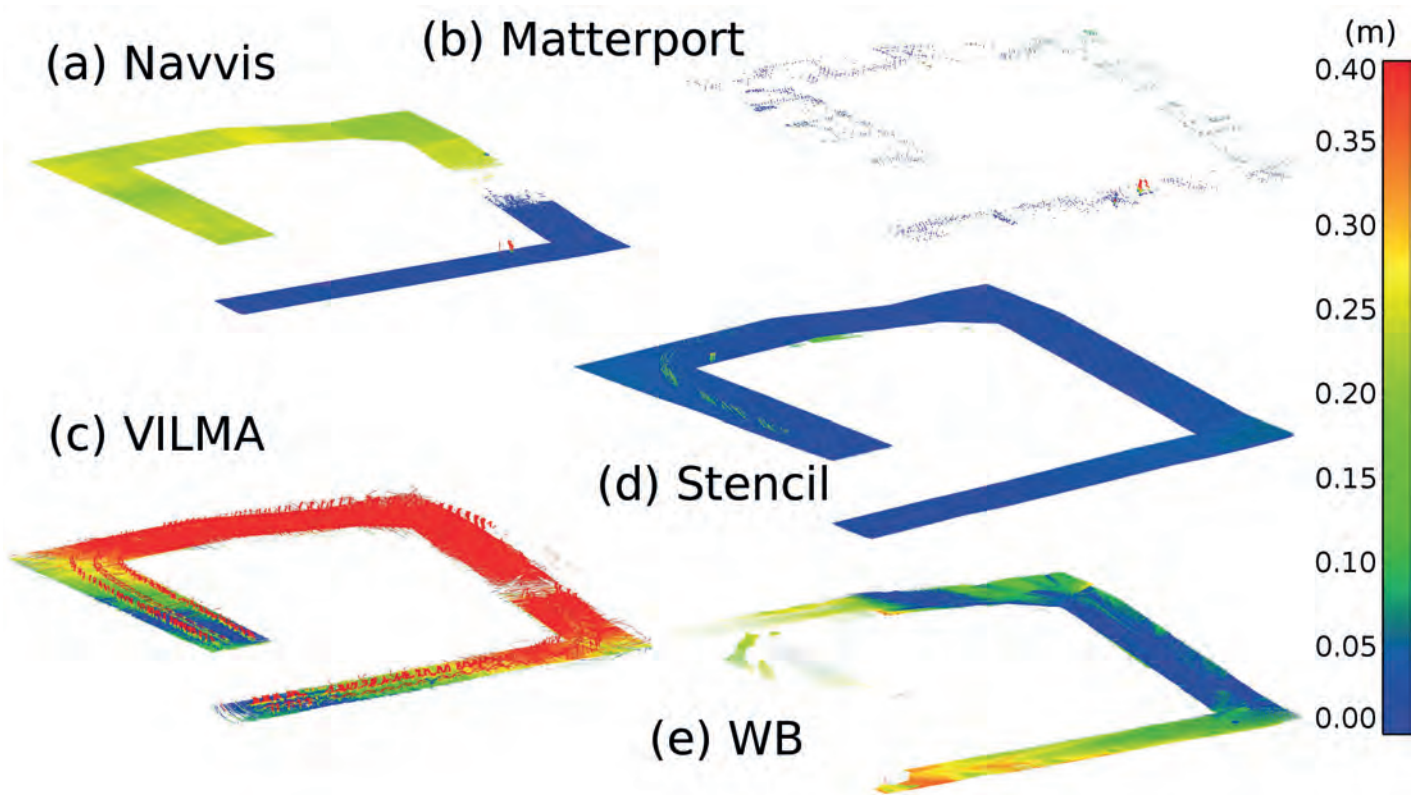
DIMENSIONS

When choosing the method to localise the scanner it is important to take into account the physical properties of the environment. The results of the comparison study show that estimating the scanner pose in two dimensions – as is done by the NavVis system – only produces less error in the 3D point cloud provided that the floor is flat. However, a wheeled platform such as NavVis is not navigable in all indoor spaces.

A scientific backpack from the University of Würzburg employs one horizontal 2D laser scanner to perform a more reliable localisation in two dimensions. Then the data from another scanner operating in 3D is used to calculate vertical corrections to recover the six degrees of freedom. Despite its potential, no commercial system uses this approach yet.



▲ *Figure 2, Features with multiple length scales exist in indoor environments.*



▲ *Figure 3, Difference to the reference in height elevation.*

Theoretically, localisation may begin in an even-lower dimension. The scientific device VILMA, from Aalto University, makes use of a theoretical solution to obtain the trajectory first in 1D, and then employs SLAM to expand the trajectory estimate to two, three and finally six degrees of freedom.

For versatile needs in staired or otherwise complex indoor environments, one valid commercial option is ZEB1 from GeoSLAM Ltd or one of its successors. Because the problem of determining the pose as a function of time is quite challenging, ZEB1 uses an inertial sensor to find a working estimate for the pose that can then be refined by correlating the measurement data.

ROBUSTNESS

In addition to software development in mobile laser scanning, hardware is also improving. Localisation robustness is gained through multi-line scanners. In contrast to current 2D laser scanners that produce just one row of pixels, these multi-line scanners capture whole images, which increases geometrical constraints for a more accurate trajectory computation. For example, Kaarta Ltd's Stencil solution employs a 16-row Velodyne for increased robustness. The product is a strong candidate for indoor 3D measuring.

SENSOR FUSION

Leica Pegasus:Backpack is a product available from Leica Geosystems. It mounts two Velodyne-16s to a backpack with a GNSS receiver for seamless indoor-outdoor positioning. However, it would seem that the multitude of sensors impacts somewhat on the overall performance, leaving Pegasus behind ZEB1 and Stencil in terms of point cloud accuracy.

COMBINING BOTH WORLDS

Matterport is a product that lies between the two worlds of terrestrial scanning and mobile mapping. It combines a tripod-mounted depth camera system with cloud services that offer automated data post-processing. The scarcity of points in Figure 3 does not indicate that there is something amiss. On the contrary, the cloud is already thinned for 3D modelling purposes, and its accuracy – although less than that delivered by ZEB1 and Stencil – is undoubtedly adequate for various applications. On the downside, the 6-metre sensor range forces the user to do a lot of footwork.

INDOOR CHALLENGES

Indoor spaces are challenging due to the fact that features span various length scales. For example, in the sketch in Figure 2,

APPLICATION EXAMPLES

3D point clouds of indoor environments offer a range of applications. During construction, the progress of the work can be followed digitally. Scanning updates keep track of completed phases and lead to automated updates for project schedules and delivery order dates, while also redefining critical paths so that resource reallocations may be suggested. Georeferenced verification of completed construction phases reveal possible problems and any need for revisions. In addition, construction permits issued by city officials become digitally manageable through building information modelling (BIM). The final checking of the built result can be digitally compared to the approved plans if the just constructed indoor spaces can be scanned. Digital archiving of the plans reduces public spending and improves archive usability. The as-built data is ready to be applied for renovation plans. Sustainability is achievable through thermal models of buildings that reveal the extent and source of heat losses.

the width of the lamp leg has an entirely different length scale than the width of the room. The challenge is that the scanning method precision should be sufficient to capture the smallest sub-centimetre features while simultaneously being computationally able to track spaces spanning hundreds of metres. On the one hand, if the precision is not sufficient, the smaller features are incorporated into larger ones in the measurements, deforming their shapes. On the other, if the method attempts to capture spaces spanning large distances, there needs to be an efficient way to compress the data. Figure 2, Features with multiple length scales exist in indoor environments.

RESULTS

There are multiple ways that may be used to differentiate the methods in terms of point cloud accuracy and precision. Differences can be sought between two point clouds A and B, between two similarly cut subsets of these point clouds, or between control points. In this comparison the authors have used the first two approaches. Figure 3 shows a subset of a point cloud, i.e. a ramp floor, captured in a car park. Note how the closest point accuracy behaves for different methods.

CONCLUSION

Relative positioning is mundane in geomatics for 3D point clouds obtained with a tripod and scan targets. With a continuously moving scanner, however, the situation is more complicated. Combining the best solutions from the current state of the art should provide an answer for the multitude of needs in 3D indoor modelling. Meanwhile, the best scanning accuracy is obtained from the wheeled NavVis platform, with Stencil being a good portable solution. ◀

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ABOUT THE AUTHORS

Ville Lehtola is a senior researcher at the Finnish Geospatial Research Institute: a perceptionist with research interests in lasers and vision, robotics and automation, and positioning. Holding a doctorate in computational statistical physics, he has a background in high-performance computing and superclusters.

Harri Kaartinen is a research professor from the Finnish Geospatial Research Institute who coordinates and conducts research on performance and quality issues related to laser scanning sensors, systems and applications.

Andreas Nüchter is professor of telematics at the University of Würzburg, Germany. Andreas works on robotics and automation, cognitive systems and artificial intelligence. His main research interests include reliable robot control, 3D environment mapping, 3D vision and laser scanning technologies.

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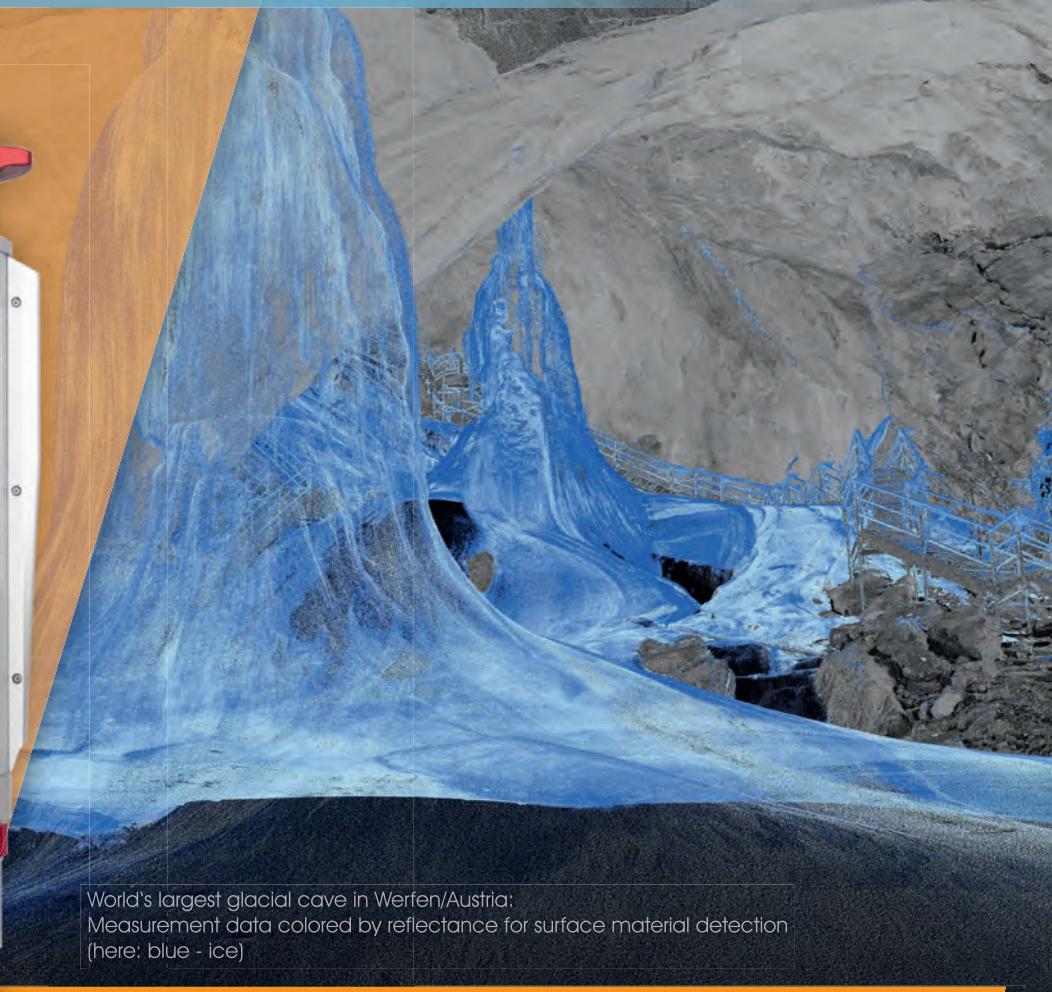

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ENRICHING 3D BUILDING MODELS WITH NON-SPATIAL DATA

Geomatics Makes **Smart Cities** a Reality

Today, the main use of 3D building models is for visualisation purposes. However, such models also have huge potential for supporting the 'smart city' concept. Disaster management, 3D cadastres, energy assessment, noise & pollution monitoring and visibility analysis could all benefit from enriched 3D building models. To demonstrate this potential, the authors present three case studies in which 3D building models have been enriched with non-spatial data. The datasets can be visualised and managed online within a web-GIS platform.

The technologies for capturing and processing 3D geodata are rapidly advancing. Aerial images processed with dense image matching algorithms result in automatically generated dense point clouds. Likewise, the data capture rate of Lidar sensors is still rising. As a result of these developments in geodata acquisition technology, the availability of 3D geodata is steadily increasing. Indeed, photogrammetry and Lidar together with 3D city modelling tools form the essential foundation for creating 3D textured building models.

SMART CITIES

The current use of 3D building models is mainly confined to visualisation, which leaves many other potential applications underexploited. This is a pity, since urban managers and planners could benefit tremendously from 3D city models. This is especially true in light of the rapid urbanisation worldwide, which requires continuous monitoring of energy consumption, noise pollution and many other 'smart city' applications. Therefore, the major challenge for today's geomatics professionals is to create affordable technologies that make optimal use of geodata and automated 3D city modelling tools. This includes the combination of these geomatics products – consisting of reconstructed 3D geometries – with non-spatial data such as building materials, number of floors and data captured by smart meters and noise sensors. Such efforts will result in a richer understanding of urban ecosystems and thus increase the liveability and safety in ever-expanding cities. More than half of the world population is already living in cities (an urbanisation milestone that was reached back in 2008) and it is envisaged that this share will be two-thirds by 2050, so there is a clear need for more efficient mapping, understanding and management of urban areas.

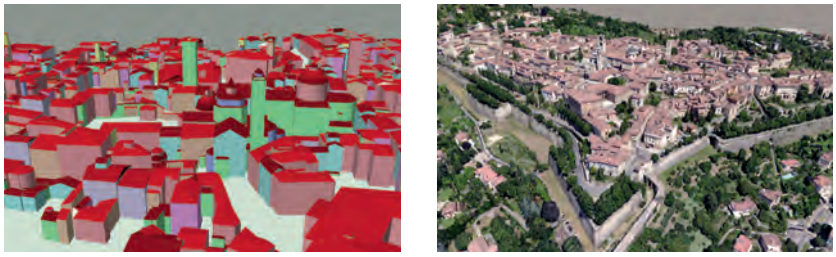
BOTTLENECKS

Airborne imagery has been and continues to be the main source for detailed 3D modelling of urban scenes. Nadir and oblique aerial images can be captured with high ground sampling distances (GSDs) providing highly detailed RGB and point cloud data. The main bottleneck in exploiting the full potential of 3D city models lies not in the availability of geodata, but rather in the lack of fully automatic and broadly applicable software tools. For example, commercial tools for processing aerial images do not enable the integration of the relative orientation parameters of multi-camera systems, which capture both nadir and oblique images, as constraints in the bundle adjustment. Furthermore, the matching of oblique and nadir images does not run smoothly. Added to this, during mapping, the available building primitives do not represent all possible architectural shapes, particularly in historical city centres, and façade point clouds are generally not considered during the fitting of primitives.

NON-SPATIAL DATA

Enriching 3D city models with non-spatial information supports visibility analysis, urban

▲ *Figure 1, Dense 3D point clouds of Trento, Italy (left), Graz, Austria (centre) and Bergamo, Italy.*



▲ *Figure 2, LOD2 models of the historical city centre of Bergamo created by fitting geometric primitives to the point cloud (left) and by applying the 3D mesh approach.*

planning, establishment and maintenance of 3D property cadastres, emergency response, estimation of the photovoltaic potential of roofs and energy demands, and other needs. These types of information are essential for city planners, policymakers, public administrations and many other users. The enrichment of 3D building models with additional information requires the realisation of a scalable system able to store, manipulate, analyse, manage and visualise different types of spatial and non-spatial data and their interrelationships.

BERGAMO, TRENTO AND GRAZ

From an algorithmic point of view, the production of 3D city models from dense point clouds can be classified into two main groups. The first group fits templates of specified roof shapes or building shapes to a point cloud. The second group simplifies 2.5D or 3D meshes derived from the point cloud until they meet ad-hoc geometric and semantic criteria. These two main groups have both been applied to aerial images of Bergamo (Italy), Trento (Italy) and Graz (Austria). Images of Bergamo and Trento were acquired by AVT/Terra Messflug GmbH Austria and of Graz by Vexcel. The size of the captured area is 5.3km by 5.6km for Bergamo, 3.5km by 1.5km for Trento and 3.0km by 1.5km for Graz. Table 1 provides further details about the three aerial surveys.

The aerotriangulation (AT) was performed with ground control points (GCPs) and GNSS observations of camera centres, included in the bundle block adjustment process as observed unknowns. The AT accuracy reaches values below the mean GSD of the captured images. Dense point clouds were then produced using the nFrames SURE image matching software. After georeferencing, two distinct workflows were adopted to create the 3D building representations at the second level of detail (LOD2). Whereas LOD1 shows buildings as blocks with flat roofs, for example, LOD2 shows finer details such as roof shapes and protrusions in the façades. The Hexagon/tridicon suite of tools was applied to create the 3D building models, fitting roof primitives to the pre-segmented point cloud (hence the first group of 3D modelling approaches) for Trento and to the simplified 3D meshes for the Graz dataset. For the Bergamo dataset, both approaches were applied (Figure 2).

The reconstructed geometries of buildings have been enriched with energy-performance certificates, artificial night-time light locations and emissions, building property details and other non-spatial information. The building property details consist of, amongst other things, the owner's name, the number of floors, the number of rooms and building surface materials.

	Bergamo	Trento	Graz
Area	5.3km x 5.6km	3.5km x 1.5km	3.0km x 1.5km
# nadir images	100	400	20
# oblique images	4300	-	160
Camera	UltraCam Osprey Prime	UltraCamXp	UltraCam Osprey Prime
f nadir [mm]	82	100	51
f oblique [mm]	123	-	80
GSD [cm]	12	10	12
along/across overlap	80/60%	80/60%	75/65%

▲ *Table 1, Details of the three aerial surveys; f: focal length of the camera, GSD: average nadir GSD in nadir images; all cameras are from the Vexcel stable.*

WEB-BASED VISUALISATION

The 3D building models and the linked non-spatial information are stored in two different data containers. Efficient managing of both data containers may be done through a service platform accessible from a web-based client. In collaboration with Trilogis Srl, the authors developed a dedicated web-GIS platform based on the NASA Web World Wind API to store, access, analyse and update the heterogeneous information linked to the 3D building models. The main potentialities of the approach include: (1) 3D navigation, data visualisation and rendering, including sources of artificial night-time light and thermal maps; and (2) data query and editing, displaying non-spatial data in pop-up windows where information can be edited, enriched and updated. An example for the city of Trento is shown in Figure 3.

CONCLUDING REMARKS

3D geodata and geoinformation technologies will be key in supporting smart city concepts. 3D city modelling has attracted significant attention in recent years with numerous potential application fields, but

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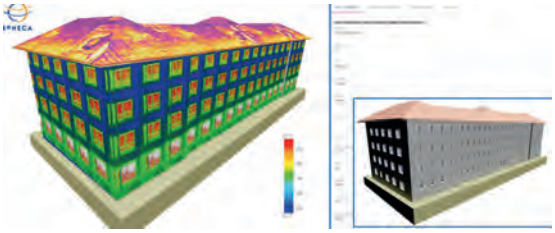

Figure 3, 3D building geometries visualised and managed online within the web-GIS platform; LOD1 (top left), LOD2 (top right) and LOD3 (bottom).

there are many remaining challenges. One such challenge is that 3D buildings should represent more than just a realistic view of the urban environment, and an extension towards semantically enriched 3D city modelling is envisaged. Secondly, 3D modelling still lacks important automated components, and existing tools should be generalised towards the representation of different and more realistic urban scenes. Thirdly, the development of a common standardised data model is required, along with advances in hardware and software to manage massive datasets efficiently.

ACKNOWLEDGEMENTS

Thanks are due to project partners Trilogis (Italy), AVT/Terra Messflug GmbH (Austria), Municipality of Bergamo (Italy) and Municipality of Trento (Italy).

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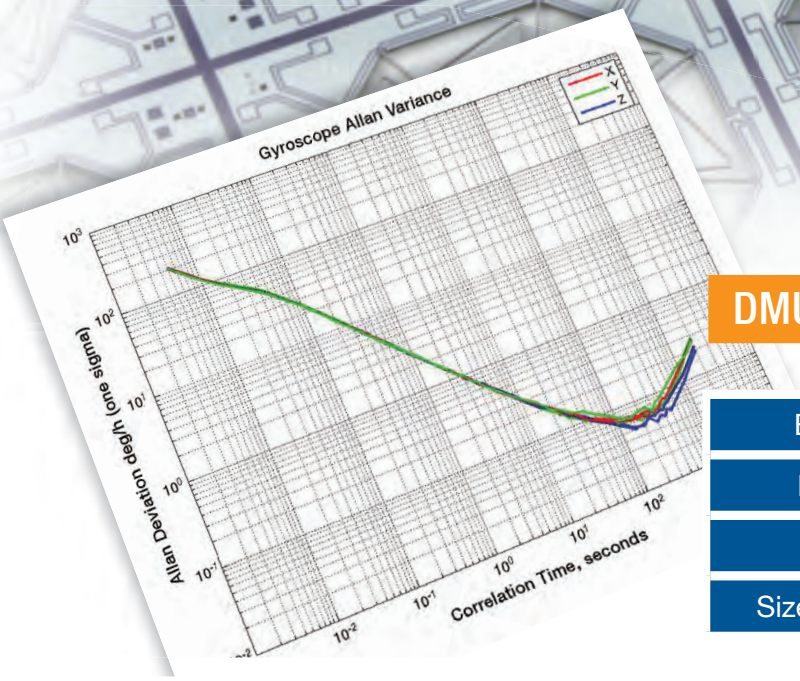

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AN EXTENDED DATA MODEL FOR THE NETHERLANDS' CADASTRE AND LAND REGISTRY

Re-linking Survey Documents with the Cadastral Map

Since its foundation in 1832 the Netherlands' Cadastre, Land Registry and Mapping Agency ('Kadaster') has been registering land rights complete with a survey of parcels and their relation with landowners. Documenting the spatial extent of parcels is a fundamental component of these registration activities. Nevertheless, this parcel-oriented registration has its limitations with respect to the collected field data.

To meet the public's growing expectations with regard to the cadastral map, Kadaster has started a programme to improve the geometric quality. This requires more transparency and accessibility to the related survey data. Therefore, a 'boundary-oriented' focus is essential as a first step in this process.

USE OF SOURCE DATA

The new perspective requires a restructured workflow. An extended data model has been designed. This model includes the complete archive of Kadaster's field data. The source documents prepared in the field represent a sketch of observed boundaries including an overview of all observations – such as ground control points being used, distances, bearings, parallel and perpendicular relations – collected by different types of instruments (which in the last decade have mainly been GPS-based). The cadastral map improvement programme is based on the reconstruction of all historical field documents with all observations at once.

LAND ADMINISTRATION DOMAIN MODEL

The extended data model is based on the Land Administration Domain Model (LADM), which is an internationally accepted standard (ISO 19152). The LADM sub-package 'Survey and Representation' contains options and solutions for the design of the data model.

FIELD DOCUMENTS AND CADASTRAL MAP

Kadaster's survey data registration consists of two components: the cadastral map and the field documents. The cadastral map is available as open data. It covers all actual parcels in The Netherlands, including the territorial waters. It serves as access to all linked documents of a parcel, e.g. deeds and field documents. Nevertheless it merely has an index function and depicts the locations of parcel boundaries by approximation after adjustment of calculated coordinates based on field observations to the map. The precise and detailed description comes from the field documents: measurement reports drafted by land surveyors, about one or multiple boundaries of one or more parcels.

At the start of the registration programme, all parcels and boundaries were initially mapped. Since then the cadastral registration have been subjected to many changes because of dynamics in people-to-land relationships. These changes are recorded on new field documents, reporting only the new established boundaries. As a result, a parcel's survey data is dispersed; retrieving the correct survey takes several steps, as it is demonstrated by the encircled boundary in Figure 1.

PARCEL IDENTIFIERS

The relation between field documents and the cadastral map is expressed by a parcel-oriented number. All parcels on the cadastral map are given a unique parcel identifier which corresponds to the parcel boundary representations on the field documents. Every modification to the parcel's extent results in one or more new parcel identifier(s), and this is updated on the cadastral map. The actual changes in the extent are recorded on the field documents, on which both the expired parcel identifiers and the new parcel identifiers are noted. These notifications allow and enable the reconstruction of the history of a parcel and its related boundaries.

TYPES OF SURVEY DATA

The field documents have evolved over time in line with technical developments. In former times field documents were paper-based reports on which the boundary locations

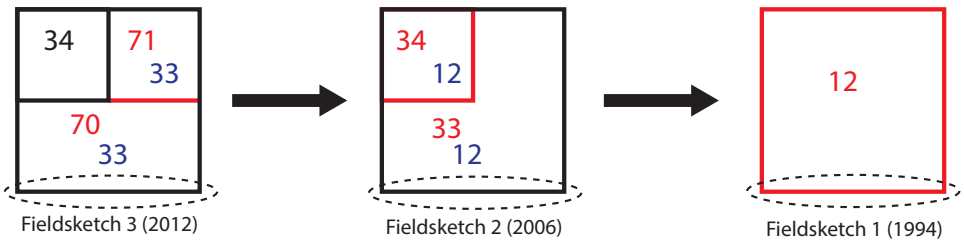
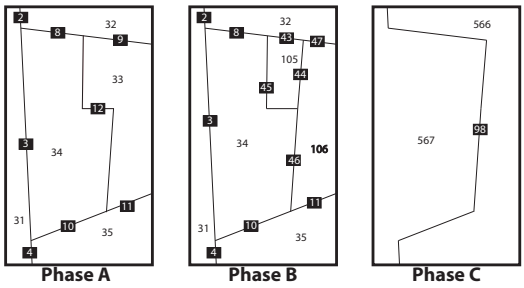
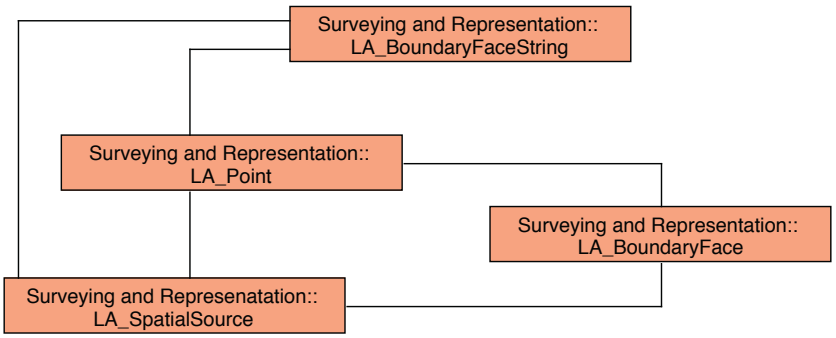


Figure 1, Parcel-based referencing on field sketches. New parcel numbers/boundaries are shown in red, expired parcel numbers/boundaries are shown in blue and unchanged parcel numbers/boundaries are shown in black.



▲ *Figure 2, Three phases of dynamics in the cadastral map, including boundary identification (for clarification). In Phase C, Boundary 98 seems a simple object at first glance, but it is actually a complex object composed of several former boundaries, while Boundary 12 has partly disappeared.*



▲ *Figure 3, The class diagram of the LADM sub-package 'Survey and Representation'.*

were recorded in terms of distances and bearings to terrain objects such as buildings. Nowadays, GPS equipment enables high-precision measurements to be input straight into the coordinate reference system and stored in digital files. This has led to wide variety in the cadastral registration system and different types of survey data for boundaries.

COMPLEX LINK

Boundaries do not have a unique identifier (only a database identifier), and matching the correct survey data on a field document to its related boundary on the cadastral map requires human intervention and expert knowledge. This complication is strengthened by the cadastral registration dynamics: parcels are split when a part of a parcel is sold, or parcels are merged following land consolidation. This results in a very complex link between field documents and the parcels in the cadastral database over time. This fragmentation is demonstrated in Figure 2.

SURVEY AND REPRESENTATION PACKAGE

The 'Survey and Representation' sub-package has a special focus on geodata acquisition and the infrastructure of cadastral properties. The sub-package facilitates a structure to store and manage all related objects, such as spatial sources and spatial data (Figure 3). The sub-package consists of four different classes and it feeds into the spatial unit package.

EXTENDED DATA MODEL

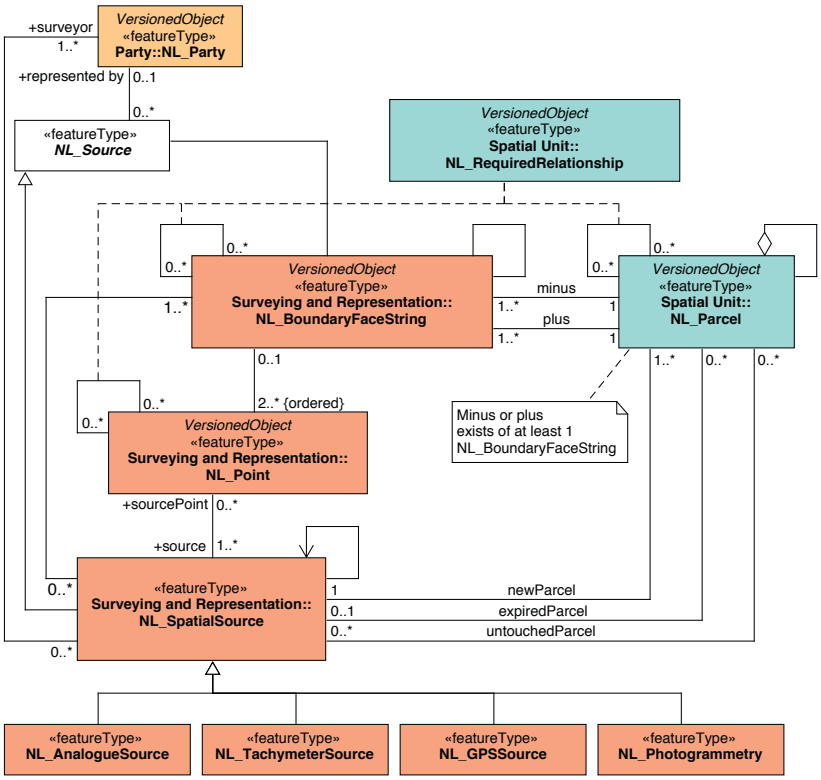
The extended data model is illustrated in Figure 4. Since it is applied in The Netherlands, all classes are marked with the prefix 'NL_' and it uses the 'Survey and Representation' sub-package as a template. The most elementary requirement of connecting the field documents to the cadastral map is covered by the general structure of the sub-package with the LADM classes NL_SpatialSource, NL_Point, NL_BoundaryFaceString and NL_Parcel. The different classes include a unique identifier, where each object in the model is considered as a unique object. This makes it possible to refer survey data to specific boundaries or individual points. Therefore, survey data can be derived much more quickly and unilaterally. Further extra descriptions can be added to the objects in order to distinguish different types of objects, like topography, auxiliary lines or administrative boundaries.

BOUNDARY RELATIONS

If a cadastral boundary runs (partly) along the edge of a building, the relation between both lines can be declared by the statement of the class NL_RequiredRelationship; 'overlaps'. A second application of this class is to relate various spatial sources to an object with the statement 'equals'.

HISTORY

In the LADM many classes are inheriting the superclass 'VersionedObject'; this superclass enables the recording of all changes to an object over time. This facilitates the various adjustments of objects and observations. NL_SpatialSource is the only class which does not inherit the VersionedObject class, since spatial



▲ *Figure 4, The 'Survey and Representation' sub-package adapted for Kadaster.*

sources represent events. These events are the 'suppliers' of history for other objects. History management is also implemented in the data model via self-associations, i.e. an object can refer to a previous (earlier) object. This facilitates the representation of cadastral dynamics in parcels and boundaries. Points have a self-association too, since in some ways they refer to other points. This is the case when GPS points are measured at random places and intersection points are created with a boundary's starting points and ending points.

CONCLUDING REMARKS

This article has highlighted the current issues of cadastral map and field documents in The Netherlands. The increasing complexity in the relationship between survey data and the cadastral map needs to be eliminated. A solution is proposed by the design of an own data model, which uses the LADM sub-package 'Survey and Representation' as a template. This data model creates a direct link to all different cadastral objects. The data model facilitates an overview of the survey and mapping quality of all boundaries and enables a much better accessible portal for survey data. The improved relationship between survey data and the cadastral map creates many opportunities for better expectancy, accessibility and usability of the cadastral map, e.g. more dedicated communication about the quality of boundaries or by generating user-friendly and custom-made information documents for 'do-it-yourself' reconstruction. The final ambition is to improve the geometrical quality of the cadastral map in such a way that it has a corresponding quality with the field documents to meet users' expectations. This data model is a first step in that process. ◂

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Eric Hagemans graduated with a degree in geodesy from TU Delft in the 1980s. After working for several engineering companies, he became a professor in geodesy and photogrammetry and manager at the University of Applied Sciences in Utrecht. For the past three years he has been working at Kadaster where he is responsible for the cadastral map improvement programme as well as geodetic innovation within the Survey Department.

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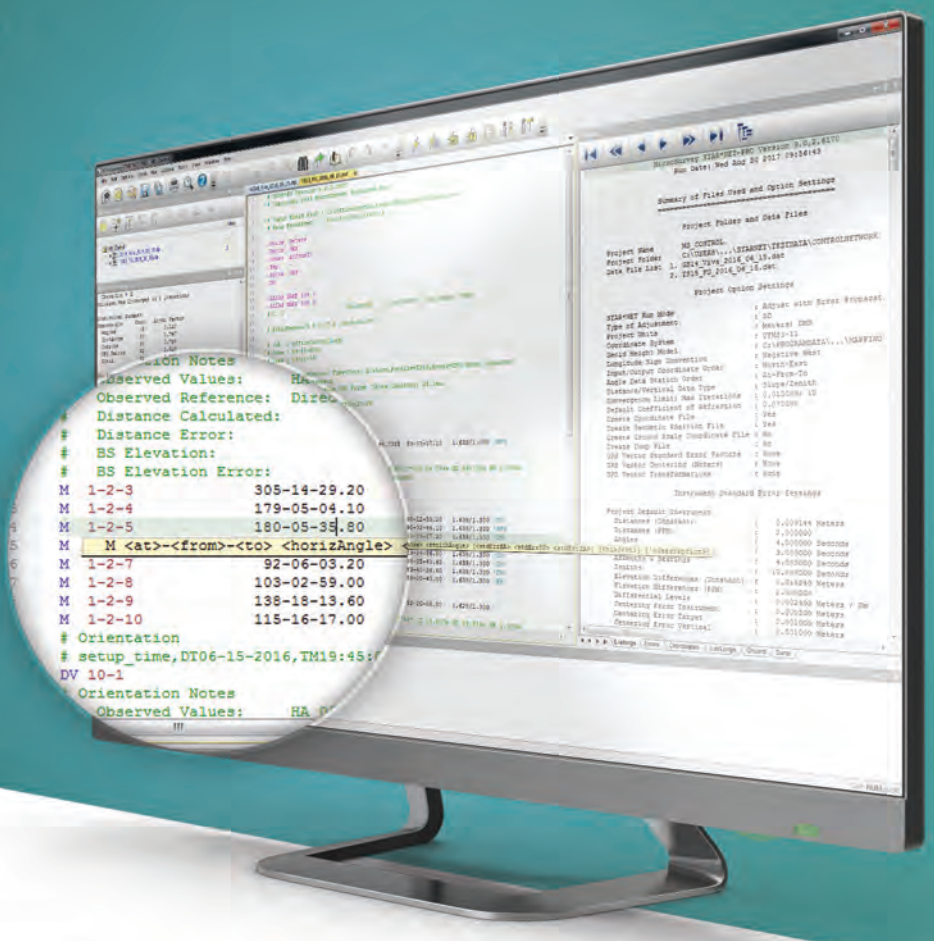

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AUTOMATED COLOURING OF WALLS, CEILINGS AND FLOORS

Coloured Point Clouds from In-built Cameras

Terrestrial laser scanners equipped with in-built cameras are well suited for identifying surfaces in point clouds of building interiors. The colours from the images can be automatically projected on the planar structures, resulting in a textured 3D model of rooms, halls, corridors, stairwells and other indoor spaces. Besides this, using computer vision methods, sockets, switches and other objects attached to walls can be automatically identified in the 3D model and their x,y,z positions determined. The authors present a case study.

Many terrestrial laser scanners (TLSs) not only acquire range measurements from which 3D coordinates of points can be calculated, but are also equipped with an in-built RGB camera which produces spherical panoramic RGB images.

SCANNER

One of the TLS devices equipped with an in-built camera is the Faro Focus 3D scanner, which has been used in the present case study (Figure 1). The device weighs 4.2kg and can measure close to one million points per second. A built-in 8MP camera captures RGB imagery which makes it possible to automatically assign colour to each and every point of the point cloud. High dynamic range (HDR) is a technique for capturing images with multiple exposure rates and merging them into a single image. HDR cameras enable image capture even in poor lighting conditions, making surfaces visible in dark or bright areas. The resulting images provide spherical panoramic RGB views.

ASSUMPTIONS

Using a laser scanner and a spherical camera in tandem makes it possible to assign fully automatically natural colour information to each and every point in the point cloud. When constructing 3D models from point clouds, however, not all points are equally useful. For example, when one wants to model walls, ceilings and floors, returns from furniture, plant pots and coffee cups are superfluous. An automated procedure should take account of the presence of irrelevant points, and such an approach requires some assumptions. One of these is that walls, floors and ceilings can be geometrically modelled as planar structures which are visible in at least one scan with a sufficiently high point density. Furthermore, all point clouds and images have to be registered in one and the same coordinate system and have uniform scale. A further assumption is that the vertical direction is known and, when the interior consists of multiple spaces, so too are the thicknesses of walls.

HDR CAMERAS ENABLE IMAGE CAPTURE EVEN IN POOR LIGHTING CONDITIONS

DATA ACQUISITION AND 3D MODELLING

Seven interior spaces have been scanned from seven scan positions resulting in a

Figure 1, Faro Focus 3D scanner with in-built panoramic camera.

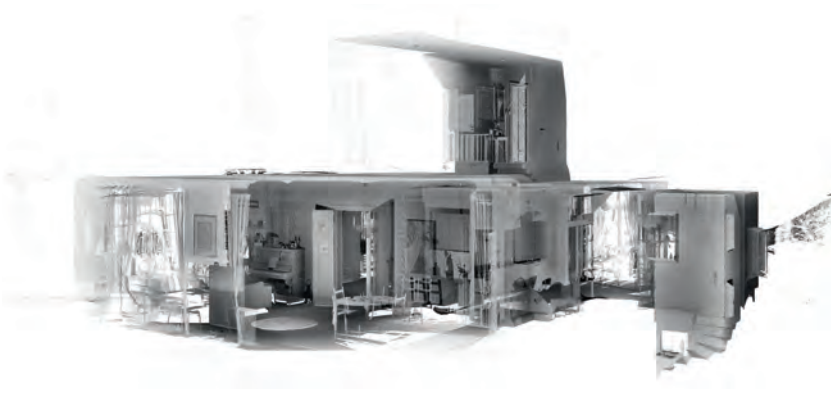
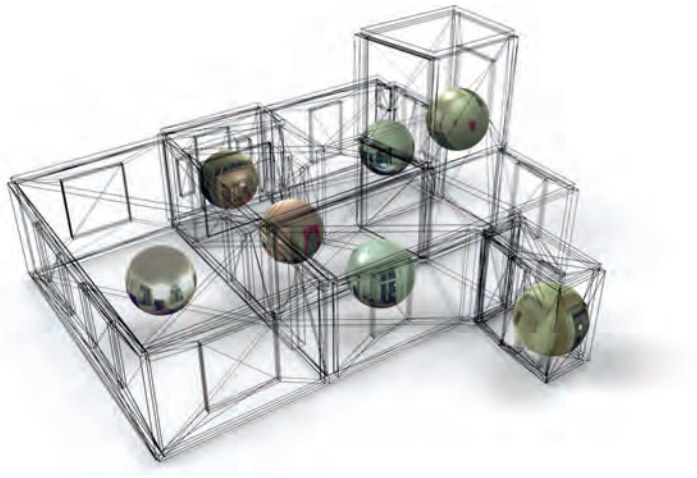


Figure 2, Point cloud of seven registered scans with front wall removed for a better view of the interior.



▲ *Figure 3, Coarse geometric outlining shown as wireframe and panoramic spheres at the positions where the scans were taken.*

point cloud of 77 million points (Figure 2). After registration of the point clouds aimed at bringing all points together in the same coordinate system, first a coarse 3D model of the interior has been manually created from a low-resolution mesh. This has resulted in a geometric outlining in the form of a wireframe of the room surfaces without windows and doors (Figure 3). To be useful for assigning colour to the surfaces, the coarse wireframe has to be refined. For this the authors developed an automated procedure to detect rectangular planes by grouping similarly oriented triangles that lie in the same plane. From each plane of similarly oriented triangles, the smallest rectangular patch is determined. Next, each patch is subdivided into pixels with predefined resolution, e.g. 1mm, to which colour is assigned. This is obtained from the nearest scan which captures the patch by intersecting the line connecting the pixel and the scanner with the panoramic image. Of course, the pixel may be occluded by furniture and other objects present in the line connecting pixel and scanner. This will cause the wrong colour to be assigned to the pixel. This can be avoided by removing points that do not lie on the room surfaces, but this will inevitably lead to colourless gaps. For appealing visualisations, inpainting techniques may help to fill these gaps. Removal of points not lying on the surfaces will be the subject of future research.

RESULTS

The colour quality of the surfaces is good in areas where the colour information corresponds to the real surface (Figures 4 and 5). The coloured surfaces can be input for object detection. Figure 6 shows an example of the automatic detection of a socket using computer vision classification methods. Wrong colours can be assigned to patches when furniture or objects are

▲ *Figure 4, Reconstructed ground floor (left) and wall and window surfaces; black parts are not visible in any of the scans.*

▲ *Figure 5, Two views of the coloured wireframe with ceilings removed to view the interior.*

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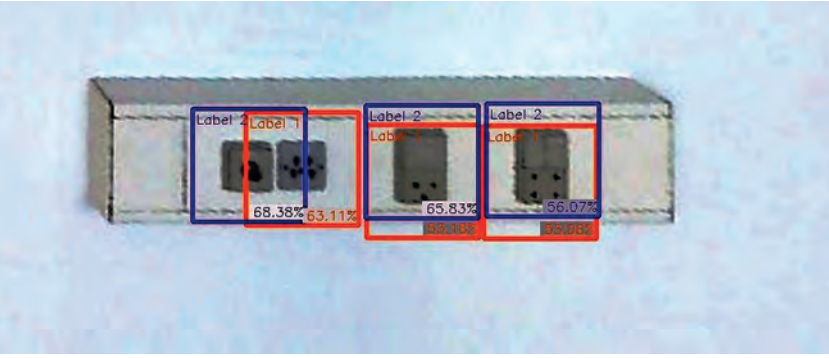
present in the line between patch and scanner. The average distance of triangles that will be grouped together needs to be precisely specified; this parameter is mainly determined by the thickness of walls and the resolution of the scanner. In general, the quality is good enough for performing object detection.

CONCLUDING REMARKS

This approach may be used for enriching building information modelling (BIM) models with semantic information. Furthermore, the RGB images provide details of wall decorations such as posters, images, signs and other non-geometric information which may be useful for certain applications. Added to this, the colour information can be used to generate smaller 3D models suitable for interactive visualisation while preserving details present in the images. For example, the initial point cloud requires 1.77GB of storage capacity and the uncompressed imagery needs 223MB, while the web export of the coloured wireframe requires only one HTML file of 8.08MB. The source code is available at https://github.com/DURAARK/orthogen.



▲ *Figure 6, Sockets automatically detected in the coloured 3D model.*

ACKNOWLEDGEMENTS

Thanks to Per-Kristian Hansson for conducting the scanning and registration, and to Paul Pierce for granting permission to use the data. ◀

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HOW TO PRODUCE HIGH-QUALITY 3D POINT CLOUDS

Structure-from-Motion Photogrammetry

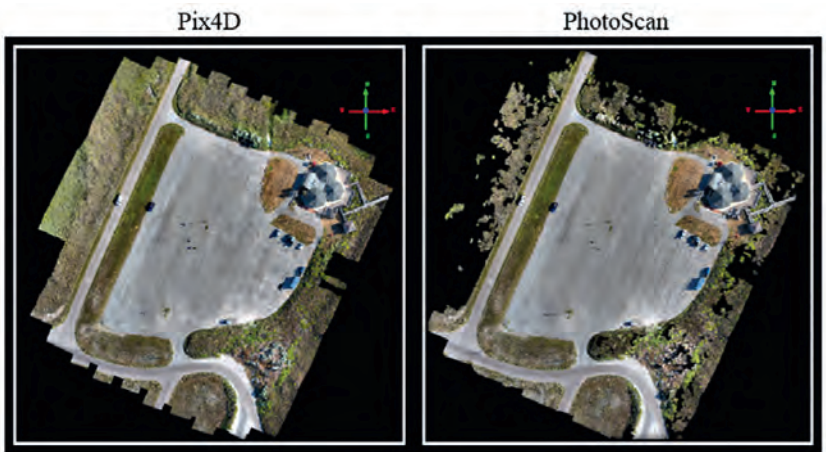
Anyone involved with structure-from-motion (SfM) photogrammetry has probably questioned which type of processing software is necessary for them to produce quality 3D point cloud data. Many SfM software packages exist that allow for the generation of 3D point clouds from image sequences acquired via unmanned aerial systems (UASs). Each of these software packages provides different workflows and parameters for implementation of SfM processing and for point cloud densification using multi-view stereo (MVS) algorithms.

It is well known that SfM/MVS point cloud fidelity is influenced by several factors, including terrain characteristics (e.g. surface texture). The influence of terrain on SfM software solutions is difficult to characterise and not well examined. As an attempt, this study compares differences in point clouds generated by three different types of SfM software: two well-known commercial packages, Pix4D and Agisoft PhotoScan, and an open-source set of tools called OpenDroneMap.

TERRAIN TYPES

Five terrain types were imaged utilising a DJI Phantom 3 Professional UAS. These terrain types included a marsh environment, a gently sloped sandy beach and jetties, a forested peninsula, a house, and a flat car parking area. The house survey was the only survey that provided an oblique-perspective 3D point cloud comparison. Each set of imagery was processed with each software package and the point cloud results were directly compared to each other.

Each drone survey was automated so that human error could be minimised during the image collection process. The Pix4D Capture application was chosen for flight automation because it gives the user different options of flight paths (grid mission, double grid mission, circular mission) and offers a larger range of flying heights. Other options that can be controlled with this application are speed, image overlap and camera angle.



▲ *Figure 1, Differences between Pix4D and PhotoScan due to more densification obtained by Pix4D in short, grassy terrain surrounding the car park.*

DATA PROCESSING

The first step of the data processing was to verify that all three software packages utilise the same camera calibration model. The camera calibration model is responsible for triangulating the derived 3D points based on the internal camera parameters. The camera model used for this study was a typical five-parameter camera model (R1, R2, R3, T1, T2) where R1, R2 and R3 describe the radial distortion while T1 and T2 describe the tangential distortion. After the calibration model was confirmed, the software settings were analysed and chosen in a manner that allowed for the most similar settings to be set across the three software packages based on recommended or default settings for the version of software at the time of this study (autumn 2016). This was done in an attempt to minimise point cloud differences caused by dissimilar settings.

A total of 15 point clouds were generated: five terrain types each processed by three different software. The three point clouds of a common terrain type were compared against each other to better understand how each SfM software package handled different terrain types and to see how the quality of the point cloud data differed. The following characteristics and statistics were recorded

for each point cloud: the density, the average spacing of the points, and the total number of points as well as the minimum, maximum, mean and standard deviation of the X, Y and Z coordinates. Tables 1 to 4 summarise the recorded statistics.

POINT CLOUD DENSITY

When looking at these tables it is easy to see that Pix4D and Agisoft PhotoScan stand out as being very close in the comparison between density, spacing and number of points. When considering the number of points, the following percentages were determined. For the marsh experiment, Pix4D produced 7.3% more points than Agisoft PhotoScan and 99.01% more than OpenDroneMap. The beach process resulted in 15.58% more points than Agisoft PhotoScan and 99.2% more than OpenDroneMap. For the peninsula survey, Pix4D created 53.4% more points than PhotoScan and 99.9% more than OpenDroneMap. This is due to false matching issues over water that Pix4D handled better based on the settings utilised. PhotoScan could likely be reprocessed to resolve this concern. Out of all the surveys, the car park survey resulted in the highest-density point clouds among all three software packages. Pix4D generated 15.03% more points in the car park than PhotoScan and 98.8% more than OpenDroneMap. The difference between Pix4D and PhotoScan was due to more densification obtained by Pix4D in short, grassy terrain surrounding the car park (see Figure 1). In contrast, PhotoScan outperformed Pix4D in point density for the oblique-perspective house survey with 26% more points and 96.6% higher than OpenDroneMap.

	Density (ppm²)	Spacing (m)	No. of Points	
Marsh	3,415.32	0.02	181,954,551	Agisoft Photoscan
	3,770.58	0.02	196,394,900	Pix4D
	55.884	0.13	1,935,784	OpenDroneMap
Beach/Jetties	2,979.84	0.02	118,840,450	Agisoft Photoscan
	3,598.25	0.02	140,769,094	Pix4D
	42.38	0.14	1,132,233	OpenDroneMap
Forested Peninsula	1,692.77	0.02	22,378,076	Agisoft Photoscan
	2,386.54	0.02	47,996,628	Pix4D
	2.374	0.27	60,861	OpenDroneMap
Car Park	7,886.18	0.01	70,960,767	Agisoft Photoscan
	9,151.22	0.01	83,510,589	Pix4D
	112.473	0.1	1,010,131	OpenDroneMap
House	5,731.887	0.01	27,879,269	Agisoft Photoscan
	4,271.339	0.02	20,638,333	Pix4D
	265.295	0.06	941,111	OpenDroneMap

▲ *Table 1, Point cloud characteristics compared between the point clouds derived by three different SfM processing software packages.*

	Min X (m)	Max X (m)	Mean X (m)	StdDev X (m)	
Marsh	677,116.73	677,458.47	677,291.86	80.38	Agisoft Photoscan
	677,122.29	677,454.69	677,291.49	76.26	Pix4D
	677,163.96	677,439.48	677,301.40	62.06	OpenDroneMap
Beach/ Jetties	680,750.48	681,064.21	680,878.25	61.15	Agisoft Photoscan
	680,767.11	681,062.60	680,879.92	60.17	Pix4D
	680,782.17	681,054.74	680,888.07	52.69	OpenDroneMap
Forested Penin- sula	455,302.36	455,499.97	455,426.86	35.72	Agisoft Photoscan
	455,290.28	455,518.00	455,422.72	38.95	Pix4D
	455,146.70	455,454.55	455,381.14	40.67	OpenDroneMap
Car Park	675,653.78	675,763.31	675,710.51	23.71	Agisoft Photoscan
	675,651.44	675,763.37	675,710.14	24.27	Pix4D
	675,653.83	675,763.22	675,712.04	23	OpenDroneMap
House	669,097.70	669,182.19	669,138.46	18.6	Agisoft Photoscan
	669,098.74	669,180.85	669,137.88	14.38	Pix4D
	669,102.68	669,173.11	669,137.99	13.89	OpenDroneMap

▲ *Table 2, A comparison of the minimum, maximum, mean and standard deviation of the X coordinate between the point clouds derived by the three different SfM processing software packages.*

STANDARD DEVIATIONS

The standard deviations of the X and Y coordinates were all relatively close to each other, showing that there is not much horizontal variability between the point clouds. The marsh survey resulted in Agisoft PhotoScan and Pix4D having very similar mean vertical coordinates, with average separation of only 8 centimetres, while OpenDroneMap placed its point cloud over 65 metres above the other two. When relying only on the GPS onboard the UAS, one can expect to see large differences between point clouds along the Z axis. Similarly, the beach and jetties survey reveals a large vertical separation between Pix4D and the other two packages by an average of 15.65 metres. For the car park survey, ground control targets were utilised for absolute accuracy assessment. From this survey, Agisoft PhotoScan had a mean Z value of 1.53 metres, Pix4D had a mean Z value of 1.54 metres and OpenDroneMap had a mean Z value of 1.47 metres. This resulted in a range of 0.07 metres between the three, and only a 1-centimetre difference in mean Z values between PhotoScan and Pix4D (Z here is based on North American Vertical Datum 88).

RELYING ONLY ON THE GPS ONBOARD THE UAS PRODUCES LARGE DIFFERENCES ALONG THE Z AXIS

The statistics uncovered some interesting facts about the house survey, which used higher image overlap (90%) and lower altitude (20m) relative to the other surveys. Interestingly, the mean Z values were 168.03 metres for Agisoft PhotoScan, 167.79 metres for Pix4D and 168.86 metres for OpenDroneMap, giving a range of 1.07

	Min Y (m)	Max Y (m)	Mean Y (m)	StdDev Y (m)	
Marsh	3,058,487.82	3,058,757.35	3,058,620.17	56.12	Agisoft Photoscan
	3,058,497.28	3,058,751.74	3,058,624.69	53.39	Pix4D
	3,058,511.36	3,058,735.34	3,058,614.06	49.62	OpenDroneMap
Beach/ Jetties	3,062,623.20	3,062,905.64	3,062,762.08	58.5	Agisoft Photoscan
	3,062,626.30	3,062,900.29	3,062,762.42	57.18	Pix4D
	3,062,627.88	3,062,863.34	3,062,768.85	44.8	OpenDroneMap
Forested Peninsula	3,685,333.51	3,685,528.40	3,685,453.74	41.7	Agisoft Photoscan
	3,685,304.60	3,685,545.13	3,685,438.85	44.22	Pix4D
	3,685,245.03	3,685,488.61	3,685,425.53	41.51	OpenDroneMap
Car Park	3,052,731.89	3,052,870.73	3,052,795.90	35.8	Agisoft Photoscan
	3,052,731.89	3,052,870.81	3,052,795.58	35.98	Pix4D
	3,052,731.89	3,052,870.52	3,052,794.68	34.73	OpenDroneMap
House	3,694,415.51	3,694,490.50	3,694,453.95	17.55	Agisoft Photoscan
	3,694,417.14	3,694,490.49	3,694,452.96	14.17	Pix4D
	3,694,421.02	3,694,487.42	3,694,453.94	13.57	OpenDroneMap

▲ *Table 3, A comparison of the minimum, maximum, mean and standard deviation of the Y coordinate between the point clouds derived by the three different SfM processing software packages.*

	Min Z (m)	Max Z (m)	Mean Z (m)	StdDev Z (m)	
Marsh	-76.88	-63.48	-71.45	0.77	Agisoft Photoscan
	-72.46	-66.1	-69.96	1.15	Pix4D
	-9.7	-3.73	-6.09	1	OpenDroneMap
Beach/ Jetties	-46.16	-28.14	-38.03	1.24	Agisoft Photoscan
	-78.27	-42.33	-47.31	1.66	Pix4D
	-39.62	-33.05	-36.15	0.85	OpenDroneMap
Forested Peninsula	55.15	120.44	83.95	11.25	Agisoft Photoscan
	46.29	96.36	73.77	6.98	Pix4D
	-211.11	85.81	46.65	49.51	OpenDroneMap
Car Park	1.11	1.76	1.53	0.09	Agisoft Photoscan
	0.66	1.83	1.54	0.09	Pix4D
	1.18	1.84	1.47	0.11	OpenDroneMap
House	161.24	177.24	168.03	1.86	Agisoft Photoscan
	164.11	177.54	167.79	2.02	Pix4D
	166.09	176.01	168.86	2.14	OpenDroneMap

▲ *Table 4, A comparison of the minimum, maximum, mean and standard deviation of the Z coordinate between the point clouds derived by the three different SfM processing software packages.*

metres between the three. Considering the extreme differences along the Z axis seen in the other surveys without ground control, this is surprisingly low. A higher image overlap and higher image resolution, along with oblique perspective imagery, probably aided each software package in more uniformly resolving points within the X, Y and Z coordinate space; since this would likely result in a higher number of images per matched keypoint during the initial processing, it would help better solve the location of points and camera exterior orientation across all three software packages. Scene texture of the built environment could also play a part.

OPEN SOURCE

Pix4D created the point cloud with the highest density for four out of five surveys. The point clouds produced by Agisoft PhotoScan were found to be less dense and have fewer points than those in Pix4D's results, except for the oblique-perspective house survey. Nevertheless, the average point spacing of the point clouds was 0.016 metre, with the closest spacing being 0.01 metre and the furthest being 0.02 metre. This demonstrates the understanding that even though PhotoScan produced a less dense point cloud than Pix4D, it maintained a very close point spacing. OpenDroneMap is an open-source project which means two things need to be considered. Firstly, this is an ongoing project where people voluntarily contribute to the improvement of the software. As time goes on, assuming that people continue to aid in the development, OpenDroneMap should become more proficient, more accurate and more user friendly. Secondly, OpenDroneMap is free to use. Having a software package that is capable of producing point cloud data and orthomosaic images at no cost to the user is not something to be taken lightly.

CONCLUDING REMARKS

Each software package provides a more or less robust set of processing parameters that can be tuned for a specific project. Inherent differences between the processing parameters utilised across the software are responsible to a degree for the differences observed in this study. While this work aimed to minimise the influence that differing parameters had on the results, some differences are unavoidable. Iterating through different sets of parameters for each software package could likely have resulted in different or better results for each of these surveys. This, however, was not the intent of the work. Rather, this study aimed to compare SfM software solutions in order to gain a greater understanding of UAS-SfM point cloud uncertainty over different types of terrain. Furthermore, this work in no way attempts to endorse or recommend one software package over the others. The results are reported as is, with the caveats as above. In fact, the authors are avid users of each software solution examined here. Finally, the important take-home point is that point cloud quality of UAS-SfM software solutions is driven by many factors, of which one is terrain. ◀

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BREAK NEW GROUND

BY **MONICA LENGOIBONI**, **CHRISTIAAN LEMMEN** AND **JAAP ZEVENBERGEN**, FACULTY OF GEOINFORMATION SCIENCE AND EARTH OBSERVATION (ITC), TWENTE UNIVERSITY, THE NETHERLANDS

DOCUMENTATION OF OVERLAPPING AND SECONDARY LAND RIGHTS

Innovative Tools for **Tenure Recordation**

Aimed at protecting the land rights of underrepresented citizens, fit-for-purpose land administration promotes alternative approaches to facilitate aiding and improving land tenure security based on the STDM. This article examines innovative tools and technologies for documenting overlapping and secondary land rights that formal land registration systems fail to take into account.

Fit-for-purpose land administration promotes alternative approaches to facilitate aiding the process of, or the improvement to, land tenure security. In many contexts, overlapping or secondary land rights have been lost through formal land registration systems ('secondary land right holders', the males being the primary right holders…). Consequently the livelihoods of those relying on the overlapping and secondary land rights have been negatively affected as formal registration confirms the primary ownership rights within land parcels. Those alternative approaches are based on the philosophy and approach of the Social Tenure Domain Model (STDM), which aims at recording land rights of the underrepresented. The STDM philosophy promotes recording of a range of land rights including de-facto ones, as well as capturing a variety or multiplicity of tenures that often overlap, which the formal registration systems have been unable to accommodate.

INNOVATIVE TOOLS

Nowadays, digital data technologies are easily available and increasingly accessible for all budgets. Moreover, policy discourses on land tenure reform and tenure security have triggered the development of innovative tools to record tenure information quickly and affordably. A variety of innovative tools/technologies compliant with the STDM philosophy and approach have arisen. Some examples include the STDM software tool by GLTN – UN-Habitat, SOLA (Solutions for Open Land Administration) OpenTenure by FAO, MAST (Mobile Application to Secure Tenure) by USAID, and Cadasta by Cadasta Foundation. These tools provide the technical requirements needed for tenure documentation, but are based on capturing boundary information via the use of satellite imagery or the use of mobile devices by members of the community.

LOW-COST APPROACHES

The flexibility in these land recordation techniques promotes low costs, adaptability to specific country contexts and transparency through the participation of the community.

The tools have already been implemented to adjudicate, demarcate and map tenure rights in various countries and contexts, including for example:

- use of SOLA Open Tenure in agro-pastoralist communities in Acholi Sub-region in Northern Uganda
- use of STDM in a nomadic community in Turkana County in Northern Kenya (a community whose pastoral land use requires seasonal migrations)
- use of STDM in an informal settlement – Mashimoni – in Nairobi, Kenya

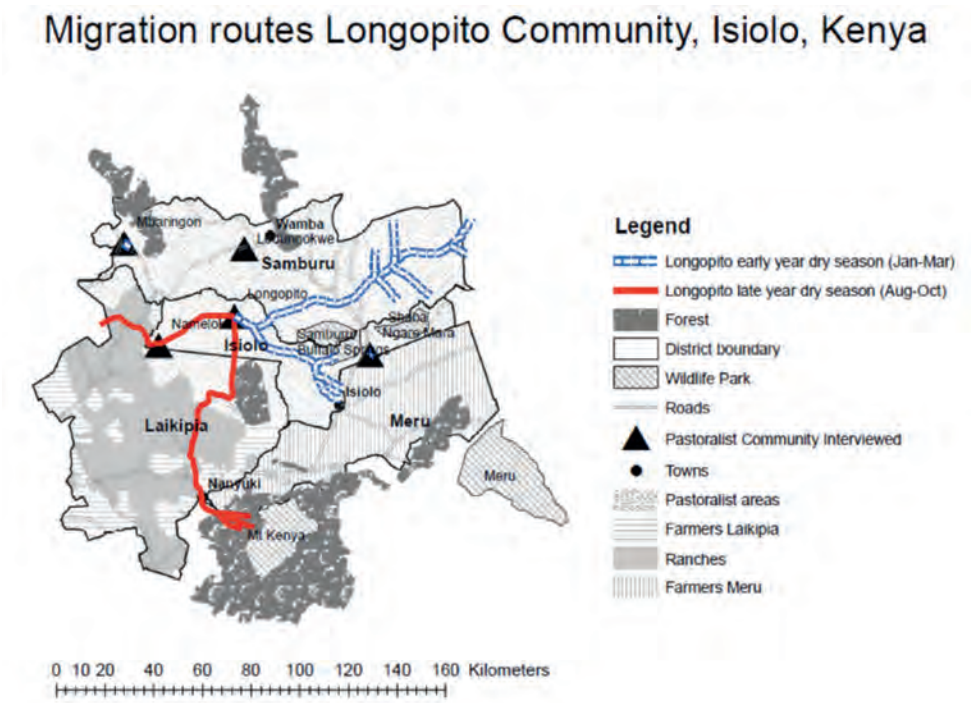

Figure 1, Example of seasonal migration corridors in Northern Kenya.

▲ *Adequate awareness about the nature of tenure types appropriate for different communities and preservation of these tenure types in the innovative tools can be key to the sustainability of the communities' tenure rights and livelihoods.*

– use of Cadasta to protect the tenure rights of the Ogiek community (a minority and indigenous hunter-gatherer community in Kenya)
– use of MAST in farming communities in the chiefdoms/customary areas in Zambia's Eastern province.

ABOUT THE AUTHORS

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NATURE OF TENURE RIGHTS

Implementers of innovative tools for tenure recordation aspire to work with communities in identifying and recording tenure information. It can be expected that the nature of tenure rights exercised by settled communities – e.g. a farming community or those in informal settlements –differ from those of pastoral or hunter-gather communities. The latter require mobility and access to seasonal resources, mainly in response to variability in climatic conditions.

ALL TENURE RIGHTS TO BE INCLUDED

Herein lies the need for attention to the nature of tenure rights for the various communities, and this begs the question: 'What types of tenure rights are being recorded in the innovative tools?' Are the tenure types included in the documentation exercise also taking account of the 'mobile' or 'flexible' ones, like the land-use practices of communities such as the seasonally migrating pastoralists or the hunter-gatherer communities in Kenya (see Figure 1)? Likewise, the agro-pastoral communities in Northern Uganda seasonally receive migrating pastoralists on the land – a reciprocal arrangement that allows both communities to exercise overlapping tenure rights. Do the innovative tools also record such rights?

NO ONE-SIZE-FITS-ALL MODEL

While interventions for tenure recordation promise to remedy the limitations of formal registration systems which impose a top-down, one-size-fits-all model for registering land rights, they still risk altering local practices and tenure arrangements by fixing tenure rights within land parcels and then tying communities to their parcels. Restriction of access to resources outside those parcels can result in a loss of secondary or overlapping tenure rights, especially if adjacent parcels are assigned to other communities.

CHARACTERISATION ERROR

Adjudication, mapping and recording of individual tenure rights can effectively be fixed within parcels. However, this can be a simplified approach to representing complex, overlapping tenure rights, and is likely to misrepresent the reality of local tenures. For example, recording tenure rights for seasonally migrating pastoralists or hunter-gatherers within a parcel assigns fixed rights within the parcel but overlooks their tenure rights on the migration corridors that enable access to seasonal resources. Tenure rights within parcels are inappropriate for the land-use practices of those communities. In such a case, procedures for adjudication, demarcation and recordation of tenure rights using the innovative approaches/tools

might end up replicating the conventional land administration tools' one-size-fits-all approach to fixing land rights on parcels. Such mistakes will ultimately replicate the problems associated with the loss of certain tenure rights in the formal land registration systems – albeit more quickly and cheaply. This would be a mistake and contradicts the very essence of the STDM philosophy and approach of capturing the diversity of tenure rights.

FUZZY AND DYNAMIC BOUNDARIES

Like the diversity of tenure rights suggests, there is a need to apply a less absolute notion of 'ownership' combined with a new way of thinking where tenure rights can overlap, especially in the temporal dimension. However, the physical boundaries of corridors are fuzzy and dynamic, and so too is the temporal dimension in some cases, e.g. 'just after the end of the rainy season'. Besides existing concepts such as 'fixed' and 'general' (or visual) boundaries, this fuzzy/dynamic type of tenure also has to be represented in land administration systems, which requires innovations in representation and visualisation.

CONCLUDING REMARKS

Adequate awareness about the nature of tenure types appropriate for different communities and preservation of these tenure types in the innovative tools can be key to the sustainability of the communities' tenure rights and livelihoods. Perhaps different tenure rights ought to be adjudicated, recorded and managed under multiple spatial layers. A combination of different spatial layers may better represent the relationships between the different tenure rights and also their spatial overlaps. Awareness of the differences in tenure relationships and proper adjudication, recording and management of those rights may help with better management and decision-making and may avoid replicating the problems associated with the loss of local tenure rights in formal land administration systems. ◂

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EIGHT YEARS OF SUSTAINED GIS-BASED LAND MANAGEMENT SUCCESS

Digitally Transforming Cadastre in **Jamaica**

Prior to 2000, less than half of the parcels in Jamaica were formally registered, and even the simplest of land transactions took weeks to complete. In 2001, those delays and a public outcry about widespread land fraud led to bipartisan support to merge all of Jamaica's cadastral departments. A modern system of record immunised to fraudulent transactions was established. That became Jamaica's official National Land Agency (NLA) and was the first step in the country's land management digital transformation. Since then, the NLA has experienced extraordinary improvements in processing times and performance – all because of the digitisation of its system of record and GIS-enabled transparency.

One of the NLA's primary missions in 2001 was to construct a land database to maintain its parcel records in a digital environment that linked to a spatial component and was designed to be used by everyone via an interactive viewer. Through that front end, the public would be given access to the country's land records with a digital map as the backdrop. On the back end, a parcel data management system would be used to maintain the spatial and attribute components of Jamaica's cadastral database. Esri's ArcGIS and parcel fabric standard played a key role in the preparation of the spatial data.

Additionally, Esri's ArcGIS and parcel fabric standard played a role in the digitising and georeferencing of Jamaica's spatial records for display on a map of the nation. GIS smoothly interoperated with Jamaica's existing embedded systems, speeding up the recording of land and property and greatly minimising the fraud attributable to the easy doctoring of Jamaica's vulnerable storehouse of analogue records.

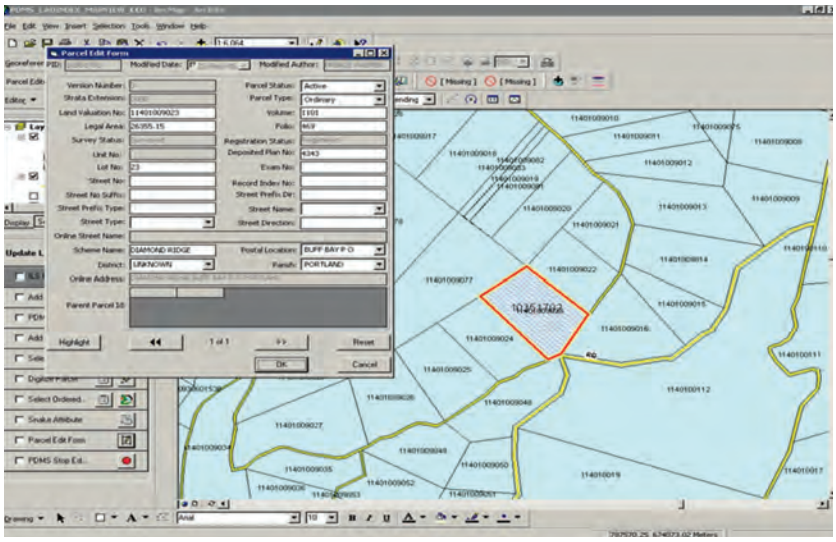
DATABASE PHASE

By 2004, the NLA had completed the digitisation of its land records into a single database, now known as the Aumentum

▲ *iMap Jamaica delivers easy access for both public-sector and private-sector users to authoritative parcel ownership and valuation data.*

Registry implemented by Thomson Reuters. With its disorganised records being the primary culprit in its slow workflows, the first phase of Jamaica's cadastral revolution was to establish a digital system that tracked the entire history of records from when the assessor entered the basic information into the database to the end of transactions. This immediately sped up workflows and investigations. In addition, automation was used to eliminate manual steps prone to human error. Template forms replaced lengthy coding and custom creation. To ensure security and authentication, an audit trail was required at the end of each step. "Aumentum specified the information required to move transactions forward," says CEO Elizabeth Stair. "This helped us maintain document integrity and eliminated the possibility of staff not knowing what to do next or who had the document throughout the process chain."

The Parcel Data Management System (PDMS), with ArcGIS at its core, was linked to Aumentum Registry and enabled the visualisation of the records in their locational context. Additionally, the PDMS authenticated each parcel through the automatic issuing of parcel identification numbers. Unfortunately, this part of the reform got off to a rocky start mainly due to the lack of resources. Initially, the NLA designed the PDMS software along with former Esri partner NovaLIS, but the increasing need for advanced editing functions and interoperability required coding that the agency had neither the expertise nor the money to perform. "At that time, whenever a new version of the base GIS was installed, staff had to manually migrate codes, which resulted in bugs and crashes," explains Stair. "The server had to be rebooted several times a day." Shortly thereafter, support to begin internal capacity building was given to properly address the situation and better engage the public.



▲ *The parcel fabric enables easy parcel editing through task-driven workflows.*

DIGITISATION OF LAND RECORDS AND PARCEL DATA HAS DRAMATICALLY IMPROVED PERFORMANCE

ENGAGEMENT PHASE

Changes in the access to spatial data began in 2010. When a local insurance company named Guardian Group came to the NLA to purchase a parcel dataset, the agency's managers seized the opportunity to create a stable public geographic information system (GIS) by partnering with the company. It would involve pulling from the spatial data which, before then, was just being maintained on the back end. Guardian Group wanted to use this system to show which homes were situated in the path of floods and landslides in order to determine risk. For presentation purposes, the company also wanted the ability to display the data in a digital map with layers that could be turned on and off. The NLA, on the other hand, wanted a system that would allow it to provide spatial data and parcel records to the public in a simple way. The agency entered into a public-private partnership deal with the insurance company to provide the desired data in exchange for the company hosting a publicly available version of the map it was developing. That map came to be called iMap Jamaica, and it marked a significant change in how the agency engaged its customers with the aid of technology. The iMap Jamaica deal mutually benefited the NLA, Guardian Group and the country as a whole. Ultimately, it helped anyone in Jamaica to see the country from a top-down perspective. They could zoom in on properties and search for other parcels, addresses and valuation numbers. Everyone – from insurance companies to real-estate professionals to homeowners – could benefit from it.

In collaboration with the National Spatial Data Management Department (NSDMD), the NLA today also provides basic free parcel data to planning authorities for the development plans for their respective parishes. This is part of the agency's initiative to aid national development through data sharing. In addition to sharing, the agency has also adopted Esri's parcel fabric standard that enables easier serving and editing of parcels. "The parcel fabric model enables us to continually update parcel data for display in the map viewer," says Stair. "It also helps us maintain the integrity of our cadastral database."

METRICS

Since the completion of the digitising of its land records and PDMS expressed through iMap Jamaica, the NLA has experienced extraordinary improvements in processing times. Before 2001, first registrations typically took 70 days to process, changes such as transfers took 25 days, and survey checks took a staggering 26 weeks. By 2010, the time needed for registration and changes had been halved and survey checks were reduced to 40 days. And performance is even better today – all because of the digitisation of its system of record and GIS-enabled transparency.

Encouraged by these numbers, the NLA recently decided to magnify efficiency even more with a new public interface. Currently, the iMap Jamaica portion of its system is undergoing a facelift using the Esri platform. The new version is due to be launched next year. ◀

UAS Technology: Smarter Solutions for Smart Cities

Smart cities is a term increasingly being used within the geospatial industry, generating debate around how best to facilitate these connected, reactive environments as they gain popularity. Reports suggest that by 2020 we will be spending USD400 billion globally on building smart cities in a bid to help cities become more responsive and, in turn, safer and truly sustainable.

I've long been a subscriber to the belief that drone technology can play a big role in supporting the development of smart cities and deliver tangible benefits to communities. Unmanned aerial systems (UASs or 'drones') are already being used by thousands to improve city life in countries across the globe, from documenting humanitarian disasters to mapping construction sites. These numbers are only expected to increase as more businesses seek out end-to-end solutions that can optimise business operations. According to a report from Tractica, it is predicted that by 2025 annual revenue from commercial drone-enabled services will grow to USD8.7 billion.

Consider infrastructure as an example. Governments urgently need to invest in improving urban transport links to create sustainable, future-proof ecosystems. UAS technology has huge potential in developing infrastructure; already it can be used to map sites such as high-speed railways and bicycle paths, to connect communities, reduce traffic on main roads and bridge the economic divide between regions. With the need to advance smart city programmes quickly, drones offer flexibility, allowing surveyors to map long corridors efficiently at the start of projects and collect in-depth data to aid decision-making at an earlier stage. Additionally, drones can be used to identify infrastructure failures and disruption – from building collapses and the impact of adverse weather conditions, to congestion on roads and damage to railway networks. This monitoring capability can help speed up the analysis of issues and generate solutions more quickly, minimising pressure on public bodies.

The use of aerial geospatial techniques also addresses current challenges around health and safety on high-traffic, complex sites or at accident scenes. The move away from terrestrial methods for such surveying missions reduces the risk to workers, whose well-being may be compromised by being on the ground.

Sustainable food production is another hot topic, as urban agriculture is increasingly seen as an integral part of smart cities. Here, drone providers can again have a seat at the table. In addition to helping urban planners identify appropriate spaces that could be used to support food development, UAS technology can be applied more frequently to monitor yield and types of vegetation, such as drought-tolerant plants. In agriculture more generally, we've seen an uplift in the number of agronomists using drones to obtain a bird's-eye view of crops, cover areas more quickly and gain greater insights. This technique can be applied to smart cities, to monitor trends in urban vegetation and provide actionable data that will help cultivate truly sustainable environments.

While there are significant opportunities for UAS solutions to make a difference to the development of smart cities, it's important that regulations are considered at the outset. Geospatial professionals and commercial drone providers have a vital role to play in this, to ensure our skies remain safe and that airspace congestion is managed effectively. By getting on the front foot and exploring the potential of disruptive technologies, we can put in place smart solutions today for smarter cities in the future. ◀

ABOUT THE AUTHOR

Jean-Christophe Zufferey is the CEO and co-founder of senseFly, the leading provider of professional drone solutions. He is a pioneer in the field of small, bio-inspired, autonomous flying robots, holding a PhD in mobile robotics from the Swiss Federal Institute of Technology in Lausanne (EPFL) where he has taught and managed numerous robotics projects.

Seventh Session of UN-GGIM Gains Speed and Direction

This summer at the United Nations headquarters in New York, USA, 400 delegates from 90 countries showed made great progress in taking both practical and strategic action to implement and strengthen geospatial information management for the Member States. This included the development of frameworks, guidelines, norms, standards and capacities, all with a particular focus on the 2030 Agenda for Sustainable Development. Following the adoption by the United Nations Economic and Social Council (ECOSOC) of the resolution on 'Strengthening institutional arrangements on geospatial information management' in 2016, this year's Session of the UN Committee of Experts on Global Geospatial Information Management (UN-GGIM) showed that the adoption of that resolution has also strengthened the speed and direction for the process of UN-GGIM itself.

▲ *UN headquarters, New York.*

The Committee started off by electing its co-chairs: Tim Trainor of the US Census Bureau for UN-GGIM Americas, Mr Li Pengde of the Chinese National Mapping Agency for UN-GGIM Asia-Pacific, and Ms Dorine Burmanje, CEO of the Dutch Cadastre for UN-GGIM Europe. They all took their turn in leading the meeting in an orderly, and often upbeat, manner.

NEW WORKING GROUPS

It is certainly worth mentioning that the 7th Session of UN-GGIM welcomed and applauded the establishment of a new Working Group on Marine Geospatial Information, as proposed by the USA's NOAA and supported by the International Hydrographic Organization. It was subtly mentioned that two-thirds of the globe is covered by water, and such a large area of the world definitely deserves a group of experts devoted to it. The new Working Group will work on linking geospatial information in the very important coastal areas where land and sea meet and where the majority of the world's citizens are living. Another new Working Group was established, namely on Legal and Policy Frameworks. The Committee also adopted the Strategic Framework on Geospatial Information and Services for Disasters and endorsed an overarching framework for national institutional arrangements on geospatial information.

WORLD BANK

The World Bank's Director of Strategy and Operations Anna Wellenstein held a presentation for the Committee in which she announced that the World Bank is partnering with UN-GGIM to assist low-income countries in developing their national geospatial information systems by helping with resources for the implementation of spatial data infrastructures. Following that announcement Anna Wellenstein and Stefan Schweinfest officially signed the agreement to underpin the newly established collaboration. This was accompanied by loud applause by the delegates; obviously, funds are often the bottleneck in developing countries and the World Bank has not been investing in SDIs until now. When asked for their reactions, the delegates overwhelmingly described this development as "significant", "positive" and "very important".

WHERE IS THE DATA?

Numerous side events are a traditional feature of the UN-GGIM Conference in New York. One notable event this year was the Special Forum on the 2030 Agenda for Sustainable Development: 'Where is the Data?'. More than

200 delegates attended this one-day forum that explored how the geospatial community will measure, monitor and report on the progress of the 17 SDGs and their associated targets and indicators with geospatial information using both new and already available data. One of the keynote speakers at this forum was Google's Ed Parsons, who can always be relied on to share some new insights. This year, for instance, he cautioned the geospatial community that SDIs are the problem, not the solution. According to Parsons, an SDI is aimed at "our little industry" and not for the greater good. Food for thought: "We are not the red tulip in the field of yellow ones".

▲ *The 7th Session of UN-GGIM in progress.*

MEXICO CITY

The Committee looked ahead to the Fifth High Level Forum on United Nations Global Geospatial Information Management, which will be hosted by INEGI in Mexico City in November of this year. The High Level Forum in Mexico will be based on the theme of 'Implementing the Sustainable Development Goals: The Role of Geospatial Technology and Innovation'. The Eighth Session of the UN-GGIM Committee of Experts will be held at the United Nations headquarters in the first week of August 2018. ◀

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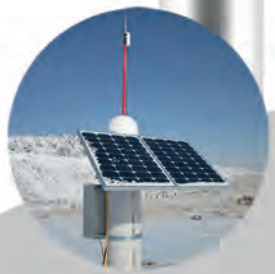



www.chcnav.com

Discover Mapping and Surveying Treasures on the *GIM International* Website

***GIM International* serves a very large community of professionals with a diverse range of interests in innovative applications in numerous industries. As a result, we have built up a wealth of articles over the years. To help you navigate your way through our huge archive, we've put together a selection of the 'most read' and 'most shared' articles. The topics of the features our readers like most are a fitting reflection of the broad nature of the geomatics business – ranging from smart cities to land administration and from surveying in the mining sector to interferometric synthetic aperture radar (InSAR), plus everything in between. The introduction of each article is published here; to read the full version of the feature, go to www.gim-international.com. We hope you enjoy this selection, and we encourage you to visit the Archive section of our website regularly in search of more mapping and surveying treasures.**

The Necessity of a Modern Cadastral System

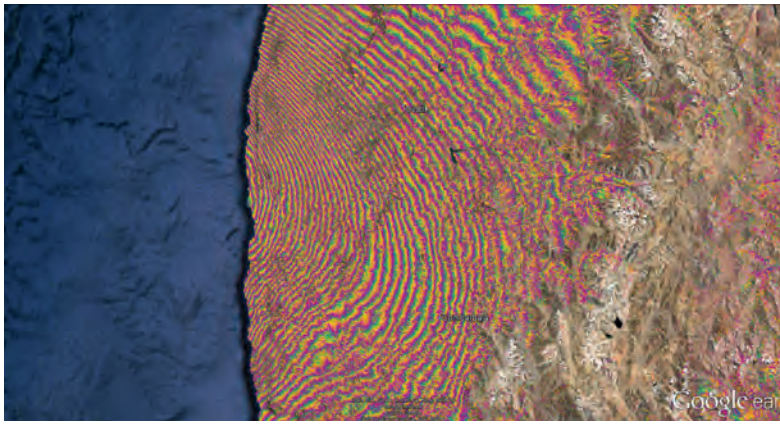
A well-functioning land administration system, or cadastre, is the foundation of national stability and social welfare. A government can make a thousand promises or grandly announce a comprehensive vision to boost the country's economy, but without an efficient and effective cadastral system the authorities will never be able to deliver. When considering the economic status of a country, it is wise to zoom in on the progress of its land administration policy. The relationship between land administration and prosperity/growth is evident.
In 2000 the renowned Peruvian economist Hernando de Soto, globally recognised for his work on the informal economy and an evangelist of property rights, published a book titled *The Mystery of the Capital*. In his book, he outlines the struggle of poor people in developing countries to obtain legal titles to property. De Soto, who *Time* magazine named as one of the 100 most influential people in the world, considers land titling as a fundamental factor in shaping household capital for people living in poverty. Former UN Secretary-General Kofi Annan praised him for his new insights into how we capture economic growth and development.

▲ *Orthophoto overlaid with a cadastral map.*

Satellite Radar Interferometry

Interferometric Synthetic Aperture Radar (InSAR) is a beautiful and powerful technology for surface deformation modelling and elevation mapping. However, InSAR also has the reputation of being a complex technology which is challenging to understand. This edition of Technology in Focus aims to explain the concept of InSAR.

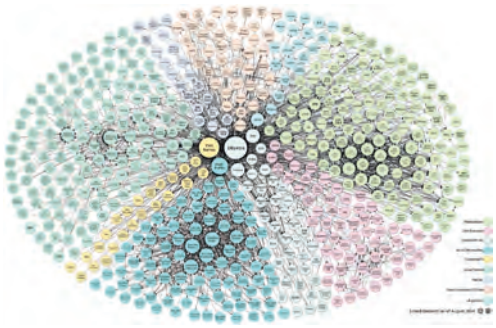
Synthetic Aperture Radar (SAR) is an active remote sensing technique that acquires images of the Earth in the microwave spectrum with wavelengths in the order of centimetres. Electromagnetic waves of this size can penetrate clouds, which makes SAR an all-weather remote sensing system operating day and night. SAR instruments for Earth observation are found on airborne, space-borne and even terrestrial platforms and are based on the same principles, but this article will focus on satellite radar systems. Various SAR satellites have been developed and launched since the 1990s, with the European Sentinel-1A satellite being the most recent addition to the skies.



▲ *Interferogram showing the earthquake that occurred in Chile on 16 September 2015.*

Smart Cities and Linked Data

The European Union defines a 'smart city' as "a city well performing in 6 key fields of urban development, built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens". Amongst the key fields are smart mobility and a smart environment. Smart cities rely heavily on reliable, accurate and available data. Linked open data (LOD) is a way to make that data available and therefore to 'enable' the smart city. Linked data (LD) refers to data that is made available in a structured way through the internet. Linked open data (LOD) takes the linked data concept one step further and exposes the linked data to everyone on the internet. LOD is based on the 5-Star Open Data scheme, which was developed by Tim Berners Lee, one of the founders of the internet in the early 1980s.



▲ *Linked data sources cloud in 2014 (Source: lod-cloud.net).*

Grow with Your Needs

SP60 GNSS Receiver

Have you ever dreamed of a product that would grow with your needs?

The SP60 offers a high level of flexibility to cover any survey demand from simple post-processing, through UHF or Long Range Bluetooth base and rover systems to sophisticated RTK and RTX rover solutions.

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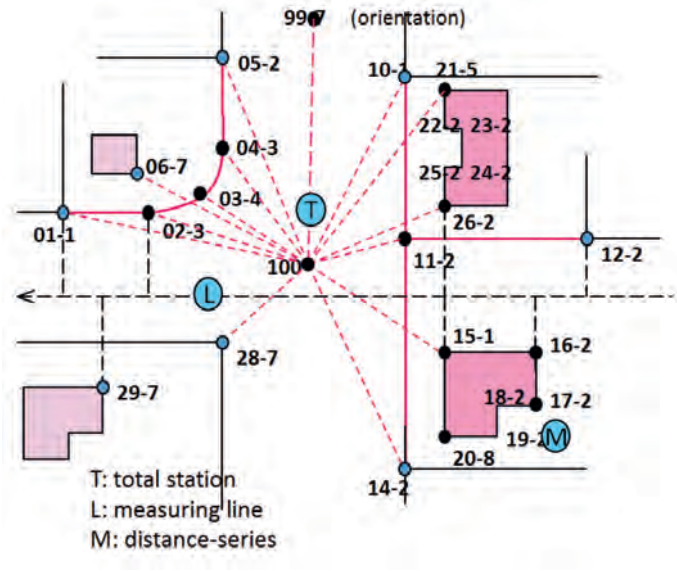
SPECTRA PRECISION

Geomatics and Surveying in Support of Land Administration

Today's geospatial technology means that land administration systems can increasingly be implemented for the benefit of all. It is now possible to conceive approaches to capturing the unrecorded geometry of boundaries for the billions of unrecognised land interests or spatial units. In addition, new approaches are becoming apparent for the maintenance of collected data. Examples from the field show that we're well on the way to responding to the challenge. From a geomatics and geoscience perspective, many tools are already available to support development, but further steps are needed to operationalise them at scale. Read on for an article investigating a few of the emerging options.

Land information tells us about the ownership, use, value and development of land – whether statutory, informal or customary. It provides an overview of people-to-land relationships. It shows us how people relate to the space around them. The information can be used to realise responses to major societal challenges, e.g. the UN 2030 Agenda for Sustainable Development. Geoinformation and Earth observation provide the inputs. These include satellite and drone imaging and mapping, global navigation satellite system (GNSS) positioning, cartography, spatial data infrastructures and many surveying sub-disciplines. This article takes a look at how each of these tools is helping to operationalise land administration at scale – and also what challenges need to be overcome to realise the potential.



▲ *Results from a conventional cadastral survey – with total station and measuring line (Courtesy: Berry van Osch).*

Read the full articles at www.gim-international: simply enter the title in the search box and go!

Surveying in the Mining Sector

Geospatial data forms the foundation of mining. The rapidly evolving innovations in the geomatics sector are bringing previously unforeseen opportunities that will provide a major boost, both to mining surveyors and the mining industry as a whole. Read on for an article which starts with some history – after all, we should never forget where we came from – and then goes on to present a general outline of surveying in the mining industry, with a focus on the survey equipment and the technologies that are being used today.

Surveyors in the mining industry fulfil an essential function since they provide indispensable information to all the other mining disciplines. Mining surveyors are responsible for the accurate measurement of areas and volumes mined, plus the precise representation of the surface and underground situation on mining plans.

▲ *Surveying an open-pit mine with the Maptek I-Site 8820.*

The Advancing Industry of Geoinformation

At the start of this year, *GIM International* conducted a readers' survey aimed at gaining a clear picture of the current state of the geospatial industry. With more than a thousand replies received, the response was better than expected and resulted in valuable insights: which new technologies hold the most promise? What is the role of UAVs in today's geospatial industry? Which other market trends are visible? And how do geomatics specialists view the future of their profession? With consideration of various fields of application – such as mining, forestry, agriculture and building & construction – this article takes you on a journey through the geospatial landscape in 2017.

GNSS, Lidar, photogrammetry, remote sensing, total stations and unmanned aerial vehicles (UAVs or 'drones') are all being used on a large scale. The total station has been called 'the surveyor's workhorse' and is still a familiar sight in today's world. Building information modelling (BIM), a topic that has received overwhelming attention during trade shows and conferences in the last couple of years, is being adopted slowly but steadily. As the survey reveals, many geomatics professionals are confident that BIM will evolve to play an increasingly crucial role in building documentation, and just over 20% of the respondents are already working with BIM. While BIM is still establishing itself, geographic information systems (GIS) have already secured a solid position in the market and are now commonplace.

◀ *The UAV plus Lidar combination is rapidly gaining ground among surveyors.*

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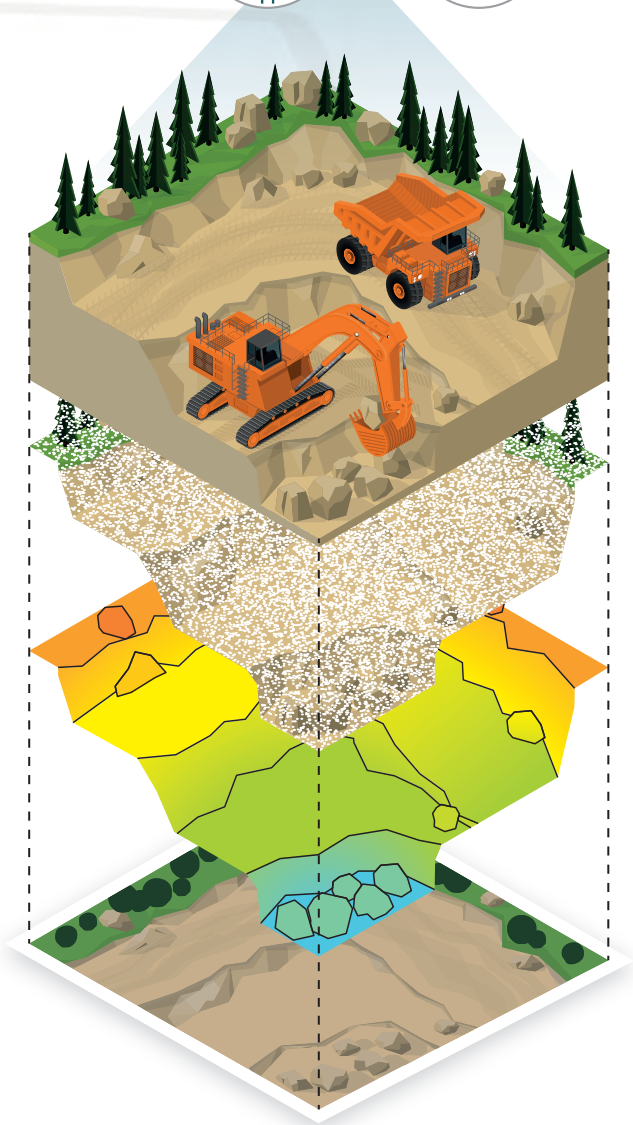

Mining

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The **Future** Starts Now

The discussions in recent years regarding the oldest legal profession – land surveying – have centred on the aging professional membership and how new technology has dramatically altered the way work is now performed. This implies a future which has recently been summed up at the FIG Working Weekend as a 'change or die' environment. Geomatics engineering has been at the forefront of this change. Nevertheless, a problem persists which I – as a representative of geomatics engineering students through my roles as president of the Geomatics Undergraduate Engineering Student Society (GUESS) and as senior advisor to the Engineering Undergraduate Society (EUS) at the University of New Brunswick (UNB) – would like to discuss here: students entering university are not commonly exposed to geomatics nor do they envision it as a possible career option.

From the Canadian perspective, this can be partly explained by the fact that there are only three English-taught degrees in geomatics engineering and only one French-taught one. Furthermore, these are mostly hidden within larger engineering faculties. Speaking on behalf of my own department at UNB, we are commonly known as 'the folks who keep to themselves on the top floor of the engineering building'. Few know what we do or what we are capable of. I believe it's time for that to change. Although enrolments are on the rise, it would be a dream come true to attract the brightest minds to our departments and ultimately to the profession!

Some have argued that we should not want to flood the professional-surveying job market, and this is inherently true. But today it is apparent that geomatics engineers have more avenues for employment than ever before, ranging from GIS to hydrographic surveying and from data management to remote sensing, so there are many diverse opportunities for students to pursue.

The question remains: how can we encourage students to study geomatics engineering? This is obviously a tall order and one that a student-society president cannot tackle on his own. However, hopefully the national geomatics competition for students described below will go some way towards achieving that aim.

THE NATIONAL GEOMATICS COMPETITION

During a weekend-long consulting engineering competition – the National Geomatics Competition (NGC) based in Fredericton, New Brunswick, Canada – university/college students from undergraduate geomatics programmes will be presented with a problem involving the various aspects of geomatics. Working in teams of three, they will be given six hours in which to devise a solution, which they will present the following day. Social events will be held throughout the weekend as well as an awards gala.

The goal in creating this event is threefold:
1. To increase the visibility of the geomatics profession and of the respective degree programmes
2. To give students the opportunity to showcase their knowledge and talents while networking with their future colleagues
3. To inspire the next generation of geomatics engineers to participate in future events, work hard and think big.

Currently, the NGC is being planned as a Canadian event from 16-19 February 2018, with the vision of opening it up to international institutions in the future. Therefore, if you or your educational institute are interested in attending, please contact me. Likewise, if your organisation is interested in supporting the competition, please do not hesitate to reach out.

Justin Collett
jcollett@unb.ca

BE A PART OF HISTORY, SUPPORT THE FIRST EVER

NATIONAL GEOMATICS COMPETITION

WHAT: A WEEKEND GEOMATICS BASED CONSULTING COMPETITION GIVING TEAMS 6 HOURS TO CREATE A SOLUTION FOR A PROBLEM DEALING WITH THE VARIOUS ASPECTS OF GEOMATICS. EACH TEAM WILL PRESENT THEIR SOLUTION TO A PANEL OF JUDGES, WITH AN AWARDS GALA TO FOLLOW.

WHO: UNDERGRADUATE GEOMATICS STUDENTS

WHERE: UNIVERSITY OF NEW BRUNSWICK FREDERICTON

WHEN: FEBRUARY 16 – 19, 2018

WHY: PROMOTE THE PROFESSION, INSPIRE FUTURE PROFESSIONALS AND NETWORK!
FOR MORE INFORMATION, VISIT OUR WEBSITE: NATIONALGEOMATICSCOMP.CA
OR CONTACT THE COMPETITION CHAIR: JUSTIN COLLETT AT JCOLLETT@UNB.CA

Back in Berlin!

After a three-year absence, Intergeo – the world's leading trade show and conference for mapping and surveying professionals – is back in the German capital of Berlin. The first edition of Intergeo's predecessor, called the 'General Meeting of the German Society for Geodesy, Geoinformation and Land Management', was held in Eisenach, Thuringia, back in 1872. Much has changed since then. In 1995 the event was held for the first time under the new name of Intergeo, which reflected its international focus as the global hub of the geospatial community. In the two decades that followed, thousands of geomatics experts made their way to Germany every September/October to see the latest trends and developments for themselves. For me personally, 2017 will be my eighth consecutive edition of Intergeo and it is definitely the highlight of my year. Three days packed with meetings, handshakes, friendly smiles, old friends, new contacts and good discussions – those are basically the key ingredients of my Intergeo experience. But your own visit to Intergeo is quite possibly based on other reasons and expectations. As content manager at *GIM International*, I have seen the sector change substantially over the past eight years. I remember the UAVs (or perhaps we should refer to them as 'drones' just like the outside world does – why should we isolate ourselves by using our own term?) taking the stage for the first time, and I've seen the industry, especially the big players, increasingly shift towards all-in-one mapping solutions. At the same time, new kids on the block are trying to disrupt the industry – and that's not necessarily a bad thing; we need new approaches and perspectives to drive progress. Once again, I'm really looking forward to learning about new solutions for capturing our reality and exciting innovations that will fast-forward new mapping applications.

While there will be numerous new exhibitors at Intergeo 2017, many of the established names will be there again too. This Intergeo Preview lists a selection of the key companies that will be showcasing their latest solutions in Berlin.

We will of course be at Intergeo ourselves, so please stop by to have a chat with the members of the *GIM International* team and learn more about advertising or editorial opportunities (Hall 3.1, Stand B3.061). We're looking forward to meeting you!

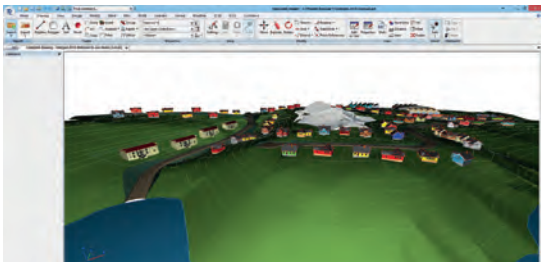
Kind regards,
Wim van Wegen
Content manager, *GIM International*

▲ *Wim van Wegen.*

Adtollo

Topocad streamlines your work flow, from the drawing board to finished construction. It is a flexible and modular 3D CAD system, allowing you to import and combine a wide range of formats, all while maintaining original file format data. With a user base of contractors, municipalities and governments this easy-to-use software brings order to your chaos. The TOP format is compatible with both coordinate data, CAD data and GIS data, and you can work with different types of data such as vectors, raster, terrain models and point clouds. Now, you can combine point clouds with traditional types of measurements and data collection to quickly and meticulously create fully interactive 3D models. With Topocad you're no longer just looking at a flat blueprint – you're really stepping in and experiencing your vision. Adtollo: we simplify and create efficient processes for those who build communities.

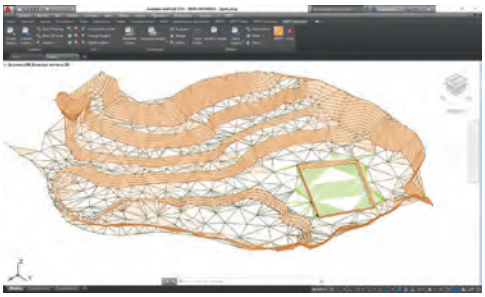
http://adtollo.se/en/topocad/ **Hall 2.1, Stand A2.037**



APLITOP

APLITOP specialises in the design and implementation of applications for surveying and civil engineering. The company has developed a broad variety of solutions for field survey and setting out, CAD-based software for civil projects, and special applications for point clouds, tunnels and photogrammetry. APLITOP has 94 distributors in seven zones, with more than 15,000 active licences worldwide, allowing the company to continue being considered as a reference of technical response, quality and service in this sector. Industry professionals can see the company's new developments at its Intergeo stand or on APLITOP's social networks. APLITOP: Our experience, your best work tool.

www.aplitop.com **Hall 4.1, Stand B4.003**



▲ TcpMDT, a full solution for surveying and civil engineering projects.

CHC Navigation

CHC offers the brand-new M6 RTK receiver to those customers wanting to work in GNSS networks only. With the introduction of M6 and also the new, mid-range i70 receiver, CHC has completed its new, multi-frequency and multi-constellation GNSS rover range, marketed since last year's Intergeo when the high-end i80 was introduced. New product: the Apache 5 is a small, unmanned boat equipped with a single-frequency echosounder and multi-frequency RTK GNSS receiver, for hydrographic surveying of small channels, rivers, lakes and shallow water. CHC designs, manufactures and markets a wide range of professional solutions for the geomatics industry including GPS/GNSS receivers, controllers and solutions for mass data collection. Employing 1,000 professionals, it has a strong international presence on all continents: China (Shanghai), Hungary (Budapest), USA (Salt Lake City & Sharpsburg), India (Gujarat) and Thailand (Bangkok).

www.chcnav.com **Hall 3.1, Stand A3.014**

ComNav Technology

As a high-performance GNSS RTK receiver, the T30 substantially minimises weight and size, combining a GNSS board, Bluetooth and adjustable TX/RX UHF, Wi-Fi and 4G modem into one rugged device for demanding surveying tasks. Its built-in tilt sensor supports maximum 30° pole tilt with 3cm compensation accuracy, and you can check the electronic bubble on the controller for fast survey in the field. Thanks to the advanced QUANTUM technology, it remarkably improves position availability and reliability, meeting your RTK survey demands even in harsh environments. Moreover, two 3,400mAh hot-swap batteries help to extend working hours and ensure fluent workflows in the field.

www.comnavtech.com **Hall 2.1, Stand C2.033**

geo-FENNEL

▲ geo-FENNEL GPS system FGS 1 in use on a construction site.

The geo-FENNEL FGS 1 was created for use in particularly challenging environments. The FGS 1 combines innovation and precision in one system – a robust all-rounder for every construction site. This ultra-modern GPS system can process all available GNSS signals, or select and assimilate user-defined sources. The integrated interference suppressor makes it possible to work at any location. The FGS 1 developed by geo-FENNEL is a lightweight, compact system which is easy to operate. Beneath the slim design lies innovative technology: a digital radio, a 3G/UMTS/GSM modem, hot-swappable dual batteries and expanded memory capacity of up to 16GB with a mini-SD card. The geo-FENNEL FSG 1 antenna has a Bluetooth interface as well as a radio connection (Rx/Tx). In addition to all this, the system is compatible with third-party software and supports field applications like MicroSurvey FieldGenius and Carlson SurvCE. See for yourself and make your work on the construction site easier with the geo-FENNEL FGS 1.

www.geo-fennel.com **Hall A3, Stand C3.001**

GreenValley International

GreenValley International is a provider of complete 3D mapping turnkey solutions. Its founding members are experts in the fields of Lidar system development, forest ecology and point cloud processing. The company's focus on creating a comprehensive 3D mapping workflow is underscored by its ability to integrate geospatial hardware, software and services. Just like its clients, GreenValley International values precision, accuracy and compatibility – which has resulted in the creation of products such as LiBackpack, a handheld, terrestrial Lidar scanner. This incorporates Lidar and simultaneous localisation and mapping (SLAM) technology to seamlessly scan outdoor to indoor settings. A handheld tablet screen allows the user to visualise the point cloud in real time. Using the flagship software LiDAR360 enables the dataset to then be visualised, analysed and processed in a myriad of ways such as visualisation tools, model generation, classification and automatic strip alignment. Depending on project needs and specifications, GreenValley International is able to offer in-depth consultation or comprehensive project management. A quality end result has allowed clients to effectively complete projects requiring digital terrain modelling, tree segmentation, power line analysis, BIM and more.

www.greenvalleyintl.com **Hall 4.1, Stand C4.021**

Hemisphere GNSS

Hemisphere GNSS is an innovative technology company that designs and manufactures high-precision positioning products and services for use in OEM/ODM, marine, machine control & guidance, agriculture, and L-band correction service markets. Hemisphere holds numerous patents and other intellectual property and sells globally with several leading product and technology brands including Athena, Atlas, Crescent, Eclipse and Vector for high-precision applications. Hemisphere is based in Scottsdale, AZ, USA, with offices located around the globe, and is part of Beijing UniStrong Science & Technology.

The S321 GNSS survey smart antenna.

www.hgnss.com

Hall 2.1, Stand C2.008 – with STONEX and UNISTRONG

Hi-Target

Visit Hi-Target at Intergeo in Berlin to experience upcoming GNSS, GIS, mobile mapping, 3D laser scanning and USV technologies. The company will be holding various live demos to enable the audience to share in the advanced technologies and solutions. Established in 1999, Hi-Target today successfully promotes RTK production localisation implementation and occupies the leading status in China. To serve the industry perfectly, Hi-Target can provide equipment, software, solutions and services to users active in digital cultural heritage, 3D digital cities, topographic mapping, deformation monitoring, digital factories, tunnel engineering, construction BIM, street map services, urban management, mine 3D measurements, city gas pipeline networks, water pipeline monitoring, precision agriculture and also marine and hydrographic mapping and surveying. Hi-Target has its own R&D team and comprehensive product lines. The company is specialised in devices, system integration, data services and suchlike – what are called 'comprehensive industry solutions' including product hardware, industry application software and support services. To learn more, follow Hi-Target on Facebook: https://www.facebook.com/HiTargetGlobal/

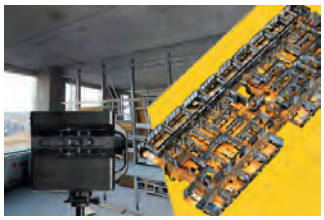
http://en.hi-target.com.cn **Hall 1.1, Stand C1.061**

Leica Geosystems

Revolutionising the world of measurement and survey for nearly 200 years, Leica Geosystems creates complete solutions for professionals across the planet. Along with other divisions of Hexagon, a leading global provider of information technologies that drive productivity and quality across geospatial and industrial enterprise applications, Leica Geosystems' precise and accurate instruments, sophisticated software and trusted services deliver value every day to those shaping the future of our world. Come experience these solutions at Intergeo in Berlin, where professionals across a wide array of industries can discover instruments, software and services to meet their unique needs.

www.leica-geosystems.com **Hall 1.1, Stand A1.024**

Matterport



The Matterport Pro2 camera allows you to create immersive walkthroughs of existing conditions that can be annotated, edited and shared across key stakeholders as well as used to create CAD or BIM deliverables.

- Replace thousands of photos with immersive 3D spaces for complete, efficient communication
- Solve disputes and handle RFIs faster and more efficiently with higher context
- Reduce site visits for owners, architects or any stakeholder
- Enhance your remote quality-control process
- Get finished point clouds within hours of scanning, with zero post-processing
- Deliver best-in-class turnover packages with finished project scans linked to asset information

Matterport saves 80% of the time it takes to measure a space and more than doubles the speed of modelling in BIM or CAD. The Matterport camera can cover a commercial space at a rate of 280-560 square metres an hour.

www2.matterport.com/aec-gim **Hall 5.1, Stand B5.005**

Myzox Japan

Myzox has been a leading manufacturer of surveying accessories since 1959. For nearly 60 years, the company has been developing original surveying equipment which surveyors need. The flagship product, the Z-220 wide-angle prism, is one of the highlights in the latest product lineup. Its repairability, 0mm prism constant and lightweight design are three key features of the Z-220. By using optimal survey instruments and Myzox survey accessories, surveyors get the best results, even on challenging job sites. At Intergeo 2017 Myzox will be showing the Z-220 prism, the monitoring prism and other essential surveying accessories.

www.myzoxjapan.com **Hall 2.1, Stand A2.002**

Myzox Z-220 wide-angle prism and new wide-angle prism coming soon.

Phase One Industrial

With a stand full of inspiring and exciting technological products, the Phase One Industrial team will be on hand to demonstrate the company's range of cameras and processor systems built specifically for unique professional requirements in applications such as aerial photography, mapping, homeland security and inspection. As a company dedicated to research, development and manufacturing of specialised industrial camera systems and equipment, Phase One Industrial understands the customer needs. Amongst some of the new products on show will be the recently launched integrated drone solution, the iXU-RS range of cameras with its unique central leaf shutter design and the well-received 4-band multi-spectral solution.

Industrial.phaseone.com **Hall 4.1, Stand B4.002**

Racurs

Racurs has a 24-year history of success in the Russian and worldwide geoinformatics markets. Since its creation in 1993, the company has developed innovative digital mapping software for processing aerial, space and terrestrial imagery trading known as PHOTOMOD. Today PHOTOMOD is the most popular digital photogrammetric software in Russia and is also used in 80 countries all over the world.

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At Intergeo, Racurs is offering a special discount on a PHOTOMOD purchase and upgrade.

www.racurs.ru **Hall 1, Stand E1.040**

RIEGL

RIEGL is expanding its comprehensive sensor and system portfolio. RIEGL's proven Smart-Waveform Lidar technology is well known for delivering high-end sensors and systems for demanding surveying missions. At Intergeo, you can see the newest introductions within RIEGL's sensor and system portfolio to find the perfect solution for your needs. RIEGL's latest advancements in terrestrial laser scanning will also be unveiled at the event, including the company's latest development for topography and mining. For airborne laser scanning, new sensors and systems – from special varieties of the miniVUX-1 to a sophisticated dual-wavelength high-altitude/large-scale mapping system – will show RIEGL's expertise. A new, increased-payload RIEGL UAV, the RiCOPTER-M, is ready to take off for demanding missions, offering advanced performance and safety. Visitors can experience the new items in the RIEGL product portfolio, meet with the team of international experts and network with the worldwide RIEGL community.

www.riegl.com **Hall 4.1, Stand C4.032**

SATEL

SATEL is one of the world's leading experts and innovators in independent radio technology. The company's solutions support business activities with secure, mission-critical connectivity. They are used in a wide range of industrial applications including land surveying, precision farming, machine control and many more. Radio technology has many benefits from an environmental, operational and financial perspective. It can also be used to help make our planet a greener place.

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- Strong expertise, service and support

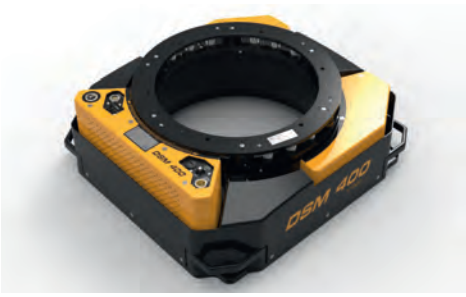
The SATEL Compact-4BT combines UHF radio modem, Bluetooth and internal battery with IP67-classified housing. The small SATELLINE-M3-TR489 radio module has three frequency-band options: 450, 869 and 915MHz. SATEL – At your service globally!

www.satel.com **Hall 1.1, Stand A1.035**

SOMAG AG Jena

SOMAG AG Jena develops, manufactures and sells gyro stabilisation mounts for data acquisition and surveillance sensors in the air, on the ground and offshore. At Intergeo 2017 in Berlin, SOMAG AG Jena will present its latest development, the DSM 400 – a stabilisation mount made for medium-format cameras and sensors. An innovative design, highly modern materials and newest drive systems generate an extremely lightweight system, making it a perfect fit for usage in drones and ultralight aircraft. An important advantage of the DSM 400 is the newly designed and simplified control panel – additionally to the FMS port (2x RS 232 interfaces), this mount generation is now equipped with a USB port for easy connection to any computer. Furthermore, the SOMAG Mount Control app enables a multitude of control and analysis possibilities without the need for an external control panel or other third-party software.

www.somag-ag.de **Hall 4.1, B4.023**



Integrated Technologies

Integrated Technologies (InTech), a division of Trimble, is a market leader in high-precision GNSS positioning solutions and robust wireless communications that maximise productivity and enhance profitability for customers. InTech's range of OEM GNSS boards provide multi-frequency and multi-constellation capabilities. Trimble's proven technology utilises all available satellite constellations for fast and accurate heading and centimetre-level real-time positioning. InTech leverages a wide range of communications and GNSS technologies to serve a broad cross section of major markets with its scalable communications and precise positioning modules. Some of these markets include survey, autonomous vehicle guidance, energy, agriculture, robotics, avionics, port automation, marine, mining and oil & gas.

intech.trimble.com **Hall 4.1, Stand C4.050**

Teledyne Optech

Teledyne Optech has been pioneering the design and manufacture of advanced Lidar systems for over 40 years. Widely recognised for its technological depth, the company has decades of experience in Lidar, photogrammetry, GPS integration and waveform digitisation. The Teledyne Optech airborne Lidars integrate high-precision metric cameras to lead the market in efficient surveying platforms. The Galaxy boasts a newly upgraded 1MHz measurement rate, while the multispectral Titan offers simultaneous topo/bathy surveying and the Eclipse drives down costs by eliminating the in-air operator. The company's airborne solutions also include the CZMIL Nova, which collects accurate bathymetric data at unparalleled depths. On the ground, the versatile new Polaris TLS delivers a productive and user-friendly workflow, the Lynx mobile survey system collects dense and accurate data at highway speeds, and the ultra-light Maverick mobile mapping system can map virtually anywhere on a vehicle, Segway or backpack. Teledyne Optech will be presenting its new Lidar technologies at Intergeo.

▲ *Polaris terrestrial laser scanner.*

www.teledyneoptech.com **Hall 2.1, Stand C2.040**

Vexcel Imaging

As a leading provider of digital aerial and terrestrial sensor systems and fully integrated processing software, Vexcel Imaging offers cutting-edge technology combined with a progressive service concept for constant product upgrades, world-class support and one-stop solutions. The comprehensive digital aerial camera portfolio provides a wide range of imaging capabilities from wide-area mapping to nadir and oblique camera systems. On the terrestrial side, the vehicle-based mobile mapping system, UltraCam Mustang, efficiently captures geopositioned panoramic imagery aligned with 3D point clouds. At this year's Intergeo Vexcel Imaging will be showcasing its latest product innovation for indoor and off-road capture, the UltraCam Panther. This versatile portable platform simultaneously captures full-spherical imagery and video, precision-Lidar 3D data and highly accurate geopositioning information in both indoor and outdoor environments.

www.vexcel-imaging.com **Hall 4.1, Stand C4.022**

YellowScan

YellowScan is committed to providing the best integrated imaging systems and customer support for demanding UAV applications all over the world. It has developed the world's lightest all-in-one Lidar surveying solutions. Since 2012, the team's dedication to fulfil high-resolution and high-quality survey requirements has been fuelling research and development. This year at Intergeo, YellowScan is presenting its next-generation Lidar systems:

- Mapper II: the upgraded version of the Mapper with improved accuracy and direct georeferencing workflow.
- YellowScan Vx: the new Lidar system designed for higher flight altitudes and best accuracy & precision.

Intergeo visitors can discover these new developments, view datasets acquired by the various systems and discuss and build their Lidar projects with the YellowScan team.

▸ **www.yellowscan.fr** **Hall 4.1, Stand D4.050**

Zoller + Fröhlich

▲ *Z+F's IMAGER 5016.*

For more than 20 years, Z+F has been developing and manufacturing phase-based laser scanners for various surveying applications. From the beginning, the company has put a strong emphasis on innovations. This led to numerous developments – such as the first stand-alone laser scanner in 2006, the first laser class 1 phase-shift laser scanner in 2010 and the first laser scanner with an integrated indoor positioning system as well as GPS in 2015 – which were all industry firsts. In addition to state-of-the-art 2D and 3D laser scanners, Z+F also offers potent software packages for processing point clouds and innovative accessories, such as the Z+F Smartlight and the Z+F T-Cam. At Intergeo 2017, Z+F will be presenting innovative hardware and software solutions that enhance the applications and opportunities of laser scanning.

▸ **www.zf-laser.com** **Hall 4, Stand A4.008**

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FIG Congress 2018: Istanbul

The 26th FIG Congress will be held from 6-11 May 2018 in Istanbul, Turkey. This event is the meeting place for the international community of surveying, geodesy, cadastre, topographic mapping, valuation, land and geospatial professionals – from survey companies, professional organisations, academia, geospatial software and services providers, governments, engineering companies and interested parties. The theme of this exciting week-long conference is 'Embracing our smart world where the continents connect: enhancing the geospatial maturity of societies'. Scientists, experts, managers, policymakers and decision-makers, stakeholders and students from all over the world are invited to join the discussions on issues affecting the international surveying, land and spatial community today and in the future. The Turkish Chamber of Survey and Cadaster Engineers (CSCE) will host this main FIG event.

A few years ago, the profession identified the need for providing reliable, evidence-based open and/or low-cost data which will describe a 'spatially enabled' society. But today we realise that we have an additional task to ensure that these data and tools are used intelligently by society and governments. The challenge for the profession is to develop further skills properly in order to increase the usability of such spatial data, to process this available information and to develop fit-for-purpose tools to enable societies to 'uncover' the missing information and reduce inequalities.

The event includes the FIG General Assembly and the 4th FIG Young Surveyors event. Together with the exhibition and a combination of side events and social/technical activities, the FIG Congress 2018 will be of interest to participants from all over the world and will be a memorable, not-to-be-missed experience. The technical programme will be a mixture of invited speakers in high-level sessions and an open call where around 400 to 500 papers are expected. Abstracts for papers must be submitted by 15 November 2017, and the deadline for submission of peer-review papers is 1 October 2017.

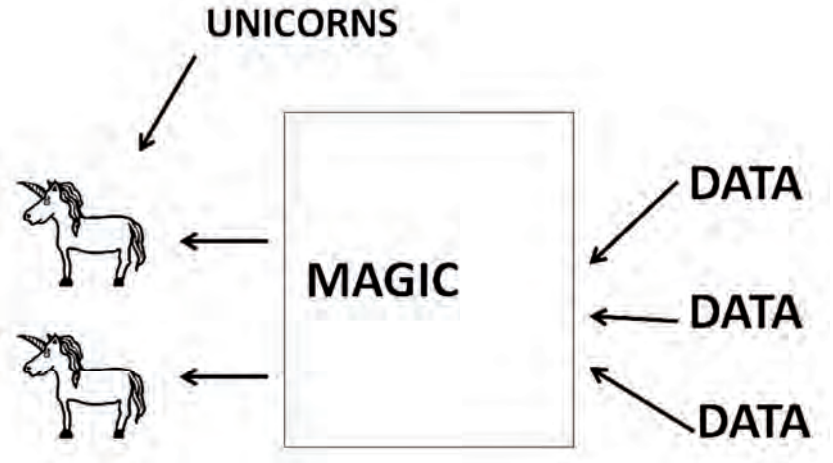
The Local Organising Committee at the FIG Congress 2018 stand during the FIG Working Week 2017 in Helsinki, Finland.

The history of Istanbul dates back to ancient Greek and Roman times. It is one of the most impressive and attractive cities where cultures and continents meet – at the border of Europe and Asia. Istanbul is a world-class venue for a conference and exhibition and it is an ideal environment for social tours combined with widely renowned gastronomy. Don't miss it!

Orhan Ercan, Co-Congress Director
Louise Friis-Hansen, FIG Director and Co-Congress Director

More information
www.fig.net

Spatial Data Infrastructure: Think 'Adaption' and 'Cultivation' Rather than 'Construction'



While recent advances in geospatial technologies offer great promise, the specifics of whether and how data and information are used too often remain a black (magic) box; spatially enabled decision-makers are a bit like idealised unicorns. Without a keen knack for navigating political and administrative influences, spatial enablement can at times seem like the stuff of magic and unicorns – a fantasy. Simply creating and providing useful information does not mean that it will be used, or used wisely.

Similarly, a 'partnership framework' for spatial data infrastructure can seem like a mythical

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item. Harold Seidman, a 20th-century public administration scholar, likened the quest for effective inter-agency coordination to the mediaeval search for the philosopher's stone…:"If only we can find the right formula for coordination, we can reconcile the irreconcilable, harmonise competing and wholly divergent interests, overcome irrationalities in our government structures, and make hard policy choices for which no one disagrees."

Thankfully, GSDI members – Faculty of Geo-Information Science and Earth Observation, University of Twente [1] and KU Leuven—University of Leuven [2] – conduct interdisciplinary and longitudinal research that is advancing our understanding of the geospatial data ecosystem. These institutions grapple with complex issues affecting data collection, data sharing and interoperability – namely, adaptation and cultivation. Both are co-authors of papers in the recently published special issue on innovative geoinformation tools for governance in the *ISPRS International Journal of Geo-Information* [3].

One paper, entitled 'Evolving Spatial Data Infrastructures and the Role of Adaptive Governance', emphasises the importance of having a mixture of governance approaches to support inter-agency coordination. The authors found that central governments are simultaneously expanding their ability to steer, while still enabling dialogue and participation. Another paper, entitled 'Tensions in Rural Water Governance: The Elusive Functioning of Rural Water Points in Tanzania', shows the significance of a cultivation approach, which allows for improvisation. The authors stress that the development of administrative, financial and computing technologies best not be viewed as a well-defined process with pre-configured start and end states; unforeseen consequences and drift from the expected are inevitable. Both papers are open access, and GSDI encourages the geospatial community to take a look.

More information
[1] Faculty of Geo-Information Science and Earth Observation, University of Twente, www.itc.nl
[2] Public Governance Institute, KU Leuven—University of Leuven, http://soc.kuleuven.be/io/english
[3] Special Issue on innovative geoinformation tools for governance http://www.mdpi.com/journal/ijgi/special_issues/geoinformation_governance

Inter-Commission Committee on Theory

The IAG is organised into the following components: Commissions, Services, the Global Geodetic Observing System and Inter-Commission Committees. Currently, only the Inter-Commission Committee on Theory (ICCT) is active within the IAG. The ICCT was established after the IUGG XXI Assembly in Sapporo in 2003, to succeed the former IAG Section IV on General Theory and Methodology as theories and methodologies matter to all IAG components. At the IUGG XXIV Assembly in Prague in 2015, the ICCT became a permanent entity within the IAG structure.
The overall objectives of the ICCT are to act as the international focus for theoretical geodesy, to encourage and initiate activities to advance theory in all branches of geodesy, and to monitor developments in geodetic methodology. To achieve these objectives, ICCT interacts and collaborates with the IAG Commissions, Services and GGOS.
The ICCT steering committee for the period 2015-19 consists of President P. Novák (Czech Republic), Vice-President M. Crespi (Italy), Past-President N. Sneeuw (Germany) and representatives from the IAG components. ICCT activities are undertaken by so-called 'joint study groups', of which there are currently 13:

1. High-rate GNSS
2. Multiresolutional aspects of potential field theory
3. Advanced computational methods for recovery of high-resolution gravity field models
4. Integral equations of potential theory for continuation and transformation of classical and new gravitational observables
5. Fusion of multi-technique satellite geodetic data

Participants at the recent Hotine-Marussi Symposium, May 2017.

6. Regional geoid/quasi-geoid modelling – theoretical framework for the sub-centimetre accuracy
7. Earth's inner structure from combined geodetic and geophysical sources
8. Multi-GNSS theory and algorithms
9. High-resolution harmonic analysis and synthesis of potential fields
10. Time-series analysis in geodesy
11. Space weather and ionosphere
12. Geophysical modelling of time variations in deformation and gravity
13. Definition of next-generation terrestrial reference frames

The ICCT convenes geodesy sessions at major international geoscientific conferences, organises regular Hotine-Marussi symposia on mathematical geodesy, initiates summer schools on theoretical geodesy, and maintains a website. The immediate focus of the ICCT is organising the IX Hotine-Marussi Symposium on Mathematical Geodesy in 2018.

More information
www.iag-aig.org
http://icct.kma.zcu.cz

Nautical Cartography: Standards, Education, Competence

Navigating the ocean environment is hazardous, and nautical cartography plays a significant role in promoting safe maritime operations. The safety of shipping and lives at sea is an essential objective of nautical charting, whether it be by traditional paper charts or by Electronic Navigation Charts (ENCs) integrated into the vessel's bridge systems. Nautical cartographers have always needed to produce and present graphically complex ocean information that tests their professionalism. With the development of ENCs, nautical cartographers have had to be even more flexible and competent as they compile multifarious datasets into a multiplicity of chart presentations. In an international context, adherence to approved international standards is critical, but the underpinning of the applications needs to be founded on accepted cartographic principles. Any cartographer working to deliver modern international chart services must demonstrate competence, and ICA – through its Working Group on Marine Cartography (co-chairs Ron Furness (Australia) and Lysandros Tsoulos (Greece)) – has played a significant role in promoting standards to ensure this. The standards for nautical cartographers are known as International Hydrographic Organization (IHO) Special Publication S-8 (www.iho.int/iho_pubs/IHO_Download.htm#draft); this document is now accompanied by Guidelines for the Implementation of Standards of Competence for Hydrographic Surveyors and Nautical Cartographers describing the competencies expected.

Saudi Arabian participants on the Category B Nautical Cartography Course, IIC Academy, India.

The standards described in this documentation were finalised, after five years of intensive work, at the annual meeting of the FIG/IHO/ICA International Board on Standards of Competence for Hydrographic Surveyors and Nautical Cartographers (IBSC) held in Wellington, New Zealand, during March 2017. ICA has been closely involved with the revision of these standards from previous versions. Promulgation of the new standards is anticipated during the latter part of 2017. The new standards have taken guidance from the curriculum approach known as 'constructive alignment'. The focus is on describing intended learning outcomes (ILOs) based on defined content within an assessment regime designed specifically to test students' knowledge against the ILOs. In the view of the IBSC, "competency equals education & training plus experience". Approved educational programmes in Category A introduce subjects from the beginning at the 'underlying principles' level, and Category B programmes introduce subjects from a 'practical' level. According to this framework, the Category B Standard will be aimed at the basic educational and training requirements for nautical cartographers (S-8). The Category A Standard will be aimed at the theoretical educational and foundational background necessary for nautical cartographers in charge, and cartographic managers who will develop specifications for nautical charts, establish quality control and quality assurance systems, and respond to the

specific requirements of a full range of cartographic projects. One of the three following levels of knowledge is associated with each element of the standards: basic knowledge of the subject providing familiarity with the concepts; intermediate knowledge of the subject as far as theory and principles are concerned, sufficient to enable their application in practice; and advanced, thorough knowledge of the subject in all its aspects to enable its application in all hydrographic and nautical cartography activities.
Safety at sea requires excellence in defining and adopting standards, quality in educational provision, and the acquisition of competence by practising nautical cartographers.

More information
www.icaci.org

ISPRS Symposia in 2018

It is just over one year since the last ISPRS Congress where the new Technical Commission structure was installed and the new commission presidents were elected. On behalf of the Council, I would like to invite you to the ISPRS symposia which they will organise in 2018.

Technical Commission I (TC I) – Sensors – is managed by President Stefan Hinz from Germany and Vice-President Raul Queiroz Feitosa from Brazil. The TC I Symposium will be held in Karlsruhe from 9-12 October 2018. http://tc1-symposium2018.ipf.kit.edu/

President of TC II (Photogrammetry) Fabio Remondino from Italy and Vice-President Takashi Fuse from Japan are preparing for the symposium in Riva del Garda, Italy, from 4-7 June 2018. http://www.isprs.org/tc2-symposium2018/

Remote Sensing is the subject of TC III which is in the hands of Jiang Jie, from China, and Ahmed Shaker, from Canada. This symposium is moving to a new geographical location in Beijing, China, and will in fact open the series of ISPRS symposia in 2018 (7-10 May). http://www.isprs-tc3.tianditu.com

Participants who would like to attend both the TC I and TC IV Symposia have the possibility to do this in one trip by travelling from The Netherlands to Karlsruhe. The TC IV Symposium, dedicated to Spatial Information Science and led by Sisi Zlatanova, The Netherlands, and Suzana Dragicevic, Canada, will take place in Delft from 1-5 October 2018. http://www.isprs.org/tc4-symposium2018/

TC V – Education and Outreach, headed by Senthil Kumar and P.L.N. Raju from India, is the final Commission symposium to be held in 2018. Taking place in New Delhi from 27-30 November, it will close the ISPRS symposia year. TC V also includes activities of the younger generation, represented by the ISPRS Student Consortium. Symposia papers will be published either in The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences (ISPRS Archives) or in The ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences (ISPRS Annals).

The ISPRS symposia offer a platform to present advances which members of our society have achieved in the two years since the last congress. The submission deadlines can be found at the individual symposia websites.

2018 is the premiere year of the newly restructured Technical Commissions. The ISPRS Council believes that the symposia will prove that the decision to reduce the number of commissions from eight to five will attract more participants than in previous periods. I am sure that many of you will find a good reason to attend one of these symposia and present results of your research, experience or practice.

Lena Halounovà
ISPRS Secretary General 2016-20

More information
www.isprs.org
www.acrs2017.org

From left to right: Fabio Remondino, Jiang Jie, Stefan Hinz, Sisi Zlatanova and Senthil Kumar.

2017

OCTOBER

GEOMATIC AND GEOSPATIAL TECHNOLOGY ASIA 2017
Johor Bahru, Malaysia
from 4-5 October
For more information:
www.geoinfo.utm.my/ggt2017

ESRI EASTERN AFRICA USER CONFERENCE
Dar es Salaam, Tanzania
from 4-6 October
For more information:
www.esriea.co.ke/user-conference-2017

THE YEAR IN INFRASTRUCTURE CONFERENCE
Singapore
from 10-12 October
For more information:
www.bentley.com/en/yii/home

RACURS CONFERENCE - FROM IMAGERY TO DIGITAL REALITY
Hadera, Israel
from 16-19 October
For more information:
conf.racurs.ru/conf2017/eng

CHINTERGEO
Xiamen, China
from 20-22 October
For more information:
www.chintergeo.com

COMMERCIAL UAV EXPO AMERICAS
Las Vegas, United States
from 24-26 October
For more information:
www.expouav.com

INTERNATIONAL LAND USE SYMPOSIUM (ILUS) 2017
Dresden, Germany
from 30 October-3 November
For more information:
ilus2017.ioer.info

NOVEMBER

THE 7TH CHINA SURVEYING, MAPPING AND GEOINFORMATION TECHNOLOGY & EQUIPMENT EXHIBITION
Nanjing, China
from 8-10 November
For more information:
www.tleerw.com/en

LOWCOST 3D 2017
Hamburg, Germany
from 28-29 November
For more information:
http://lc3d.net/

2018

MAY

GEO BUSINESS 2018
London, UK
from 22-23 May
For more information:
www.geobusinessshow.com

JULY

42ND COSPAR SCIENTIFIC ASSEMBLY AND ASSOCIATED EVENTS
Paris, France
from 14-22 July
For more information:
www.cospar-assembly.org

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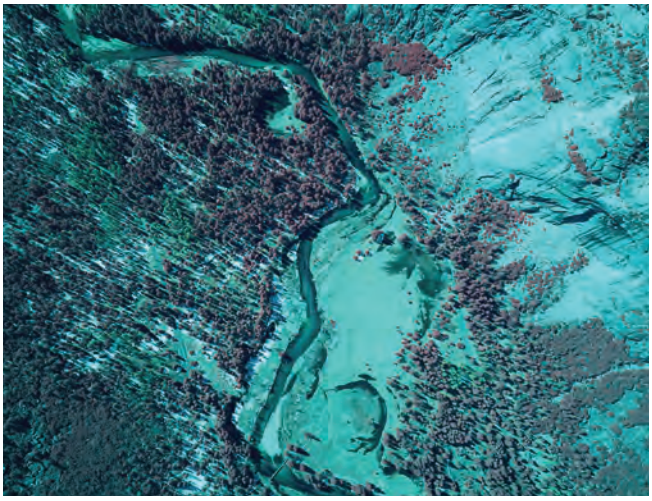

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