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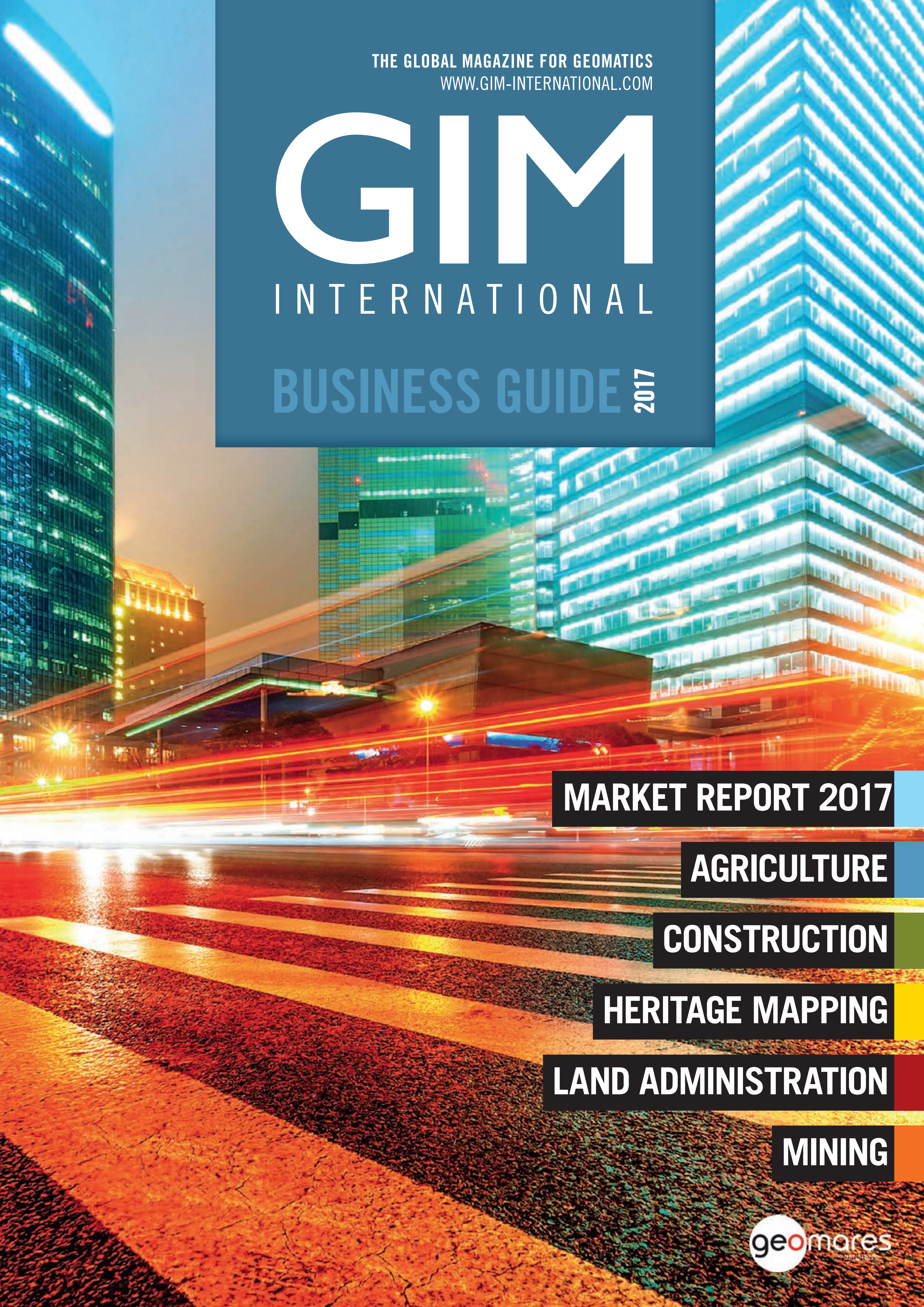

MARKET REPORT 2017

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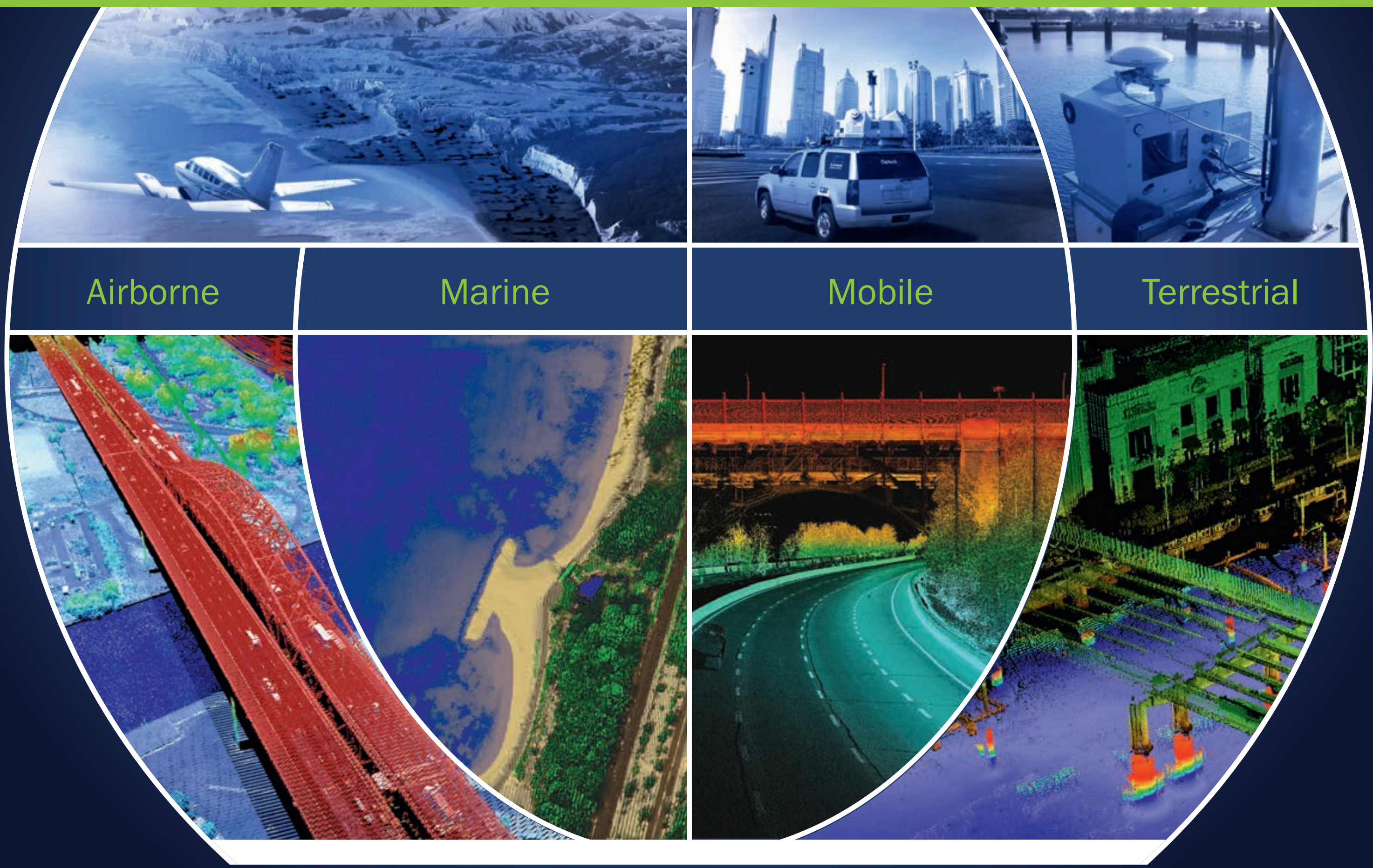
Airborne
Marine
Mobile
Terrestrial

This 2017 edition of the *GIM International* Business Guide contains features on agriculture, construction, heritage mapping, land administration and mining – all of which are verticals of the geomatics industry. Besides this, you will find an article that reveals the valuable insights we obtained from our readers' survey! Feel free to share your thoughts and provide us with your feedback by sending an email to Wim van Wegen: wim.van.wegen@geomares.nl.

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Readers' Survey Reveals Geomatics Growth

Our aim with this publication is to give you insights into where the market is heading this year, in terms of both technology and business trends. The Business Guide is also a great opportunity to look forward, and I personally love a bit of future-gazing! Last year's *GIM International* Business Guide 2016 included a series of short interviews in which we asked top entrepreneurs and businessmen from geomatics to predict the biggest trends for 2016. For instance Dr Johannes Riegl, CEO of RIEGL Measurement Systems, foresaw the rapid growth of the UAV market. His views were echoed by the general manager of South Surveying & Mapping Instrument who also identified UAV low-altitude photogrammetry and 3D laser measurement as being of growing importance. Ron Bisio, vice president of Trimble Geospatial Systems, saw geospatial systems evolving from basic land management towards productivity-oriented solutions in other fields, and Michel Stanier, COO of Teledyne Optech, expected great things from Lidar moving into the consumer arena. But now to the future! One year later, in January 2017, we asked our readers to share their thoughts on the developments in geomatics and which technologies will lead the way, and we received more than a thousand responses! Editors Wim van Wegen and Martin Kodde have analysed the results and their findings are summarised elsewhere in this publication. I won't spoil all the surprises here (I encourage you to read the article instead!) but I am able to reveal a few highlights. UAVs have become mainstream, for instance, and Lidar integrated with UAVs is now rapidly gaining ground amongst surveyors, according to the respondents. Apps and mobile devices are named amongst the biggest disruptors in the industry, whereas virtual reality and augmented reality are not catching on as quickly as might be expected. It appears that the decision-makers we interviewed a year ago were right on the ball with their forecasts – which is perhaps unsurprising given their strong involvement in the industry. One more thing I'd like to share with you is the positive market outlook of surveyors from all over the world. More than 70% of our respondents believe that the market will grow over the coming years and the overwhelming majority – more than 90% – expect the private sector to become more important through the transfer of knowledge and technology from government organisations to the private sector. So, if our readers are right, it looks like we are on a steady course towards a growing world of opportunities and markets in geomatics. And that's good news for us all!

▲ *Durk Haarsma, publishing director*

SURVEY OF GEOMATICS PROFESSIONALS REVEALS VALUABLE INSIGHTS

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.

GIS AND DATA

GIS technology is widely recognised by the respondents as a major enabler in their field. Almost 75% of the *GIM International* readers participating in this survey indicate that they use GIS on a regular basis in their work. Typical GIS usage still mostly relies on desktop applications, with a mere 5% of the respondents indicating that they have fully switched to online GIS, aided by products such as ArcGIS Online or Smart M.apps. The adoption of online GIS systems is currently greatest among end users of geographical information, whereas geoinformation professionals continue to require the extra power of a desktop application. The general belief among almost the entire group of respondents is that this situation is likely to change soon, however. For all manner of usage purposes, they expect the transition from desktop to online GIS to be completed in the next five years at most. This quick transition fits in with the professionals' general views of rapidly advancing digital technologies, with cloud technology as another major enabler. However, some readers rightfully point out that limited bandwidth and unreliable connectivity are major hurdles in regions such as Africa. If those issues are not addressed, the transition is expected to take a decade or more.
As the capabilities of GIS software expand, it facilitates the handling and processing of multiple types of data. This is resulting in ever-growing volumes of spatial data being stored by our respondents. In total,

▲ *GIS is also used for mobile applications.*

the survey participants store more than 84 petabytes of spatial data (1 petabyte equals 1,000 terabytes). If we extrapolate this to the entire geospatial industry, the amount of spatial data that is stored around the world is mind-boggling. However, that data is not evenly distributed throughout the industry: 80% of all data is held by less than 10% of the organisations participating in this survey, with only a handful of organisations storing over 10 petabytes of data. On average, most respondents currently store maximum 30 terabytes of data. Lidar data and satellite imagery are quoted as the largest datasets. In contrast to the high adoption rate for GIS, the usage of BIM is still very limited at only 20% of the respondents. BIM scores slightly higher in the infrastructure and oil & gas industries, but adoption remains low in the building & construction market. Given the growing importance of BIM, in particular for building & construction and infrastructure, this situation will need to change rapidly. The sheer amount of attention paid to the subject at the leading trade shows and conferences indicates that visionaries within the industry are aware of this fact – now the rest of the market just needs to realise it too.

▲ *UAVs have become a major tool for the professional surveyor.*

UAVS BECOME MAINSTREAM

Visitors to geospatial events were first confronted with a significant number of exhibitors showcasing their UAVs about five years ago. Back then, sceptics dismissed them as a hype. Now, just a few years later, the UAV has become a major tool for the professional surveyor. Findings from our readers' survey show that 37% of geomatics professionals make use of UAVs. They are widely utilised in all fields of application, with mining and agriculture topping the table. Projects in those fields tend to be less affected by legislative restrictions than, for example, urban locations, which has led to quicker adoption.

One eye-catching development in the surveying profession is the integration of UAVs and Lidar, which has only been commercially possible for the past couple of years. Despite this short market availability, the UAV plus Lidar combination is rapidly gaining ground among surveyors. Results from the GIM International readers' survey indicate that 15% of respondents use unmanned methods to capture Lidar data. With new (lightweight, flexible, easy-to-use and reasonably priced) solutions entering the market all the time, this trend seems set to continue. It's worth mentioning that there is also a significant market for high-end solutions, which may not be affordable for everyone.

The fact that UAVs are here to stay is good news – not only for manufacturers of unmanned aerial vehicles, but also for software developers since there is a rising demand for accurate and easy-to-use point cloud processing software for UAVs. Agisoft and Pix4D currently top the list of the most-used software solutions, but the readers' survey shows that there are many competitors in their slipstream; in this growing market, there are still plenty of opportunities for other providers.

DISRUPTIVE TECHNOLOGIES

For the purpose of the survey, *GIM International* identified IT, robotics/autonomous vehicles, apps/mobile devices, augmented reality, virtual reality, artificial intelligence, Internet of Things and blockchain as all being potentially disruptive technologies. The responses show that almost all of these are regarded as having a significant impact on the geomatics industry, except blockchain. This is somewhat surprising, especially given the fact that about a quarter of the respondents are working in the land administration sector and several recent articles in *GIM International* have advocated the potential of blockchain for land management purposes.

The respondents' top three disruptors include apps and mobile devices. These do indeed offer endless possibilities and are increasingly being used for cadastral purposes, as highlighted in the article 'Light Mobile Collection Tools for Land Administration' by Mathilde Molendijk, Javier Morales and

▲ *The survey responses show a positive picture of the market situation.*

▶

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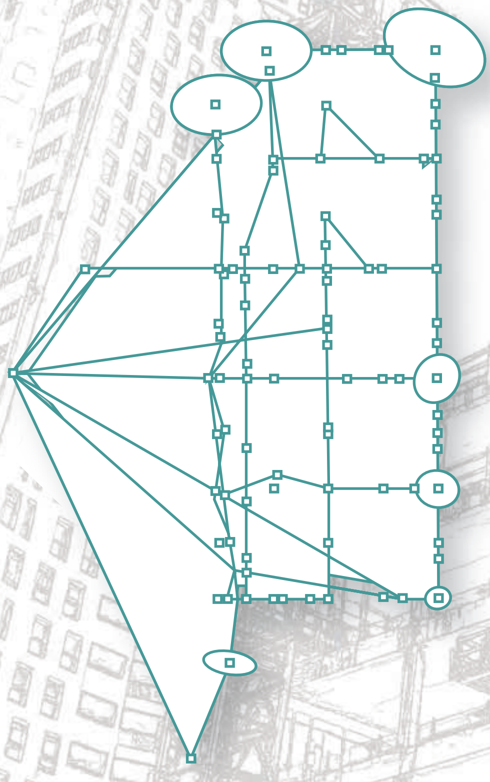

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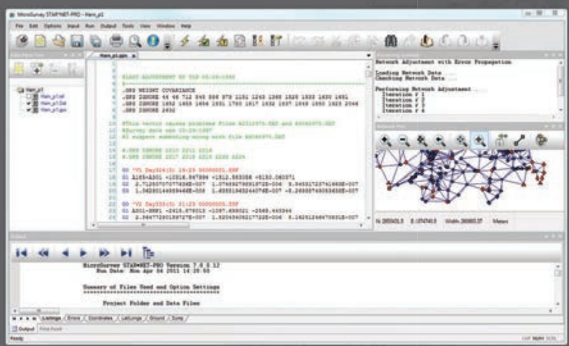

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Christiaan Lemmen. And as Brent Jones, Esri's global manager for land records and cadastre, wrote in a column for *GIM International*, "By combining technologies and leveraging standards, geospatial mobile apps can be rapidly deployed, eliminating the obstacles that typically impede land administration progress in developing economies".

Two of the buzzwords that have been heard at geomatics trade shows across the globe in the past year are virtual reality (VR) and augmented reality (AR). In numerous keynotes and presentations, both technologies have been hailed as two powerful tools that may well make a revolutionary impact on the survey industry. But although the spotlight has been shining brightly on VR and AR, today's geomatics professionals have relatively subdued expectations of working in a virtual or augmented world. The question is: are geomatics professionals simply more conservative than their peers in other industries, or are VR and AR – apart from being nice gimmicks – not actually beneficial for geomatics applications?

Rather than being a single, homogeneous world, the geomatics sector is made up of numerous different fields of application, and the perceived disruptive potential of some technologies varies depending on the respondent's particular field of work. Opinions are divided on the benefits of artificial intelligence (AI), for example. Geomatics professionals in agriculture (who rank AI as the second-most disruptive technology) and forestry (who even rate it as number one) are currently the most enthusiastic about the potential of AI. Perhaps the other geomatics professionals will become convinced of the opportunities AI offers in their work in the near future.

MARKET TRENDS

The responses to the survey paint a generally positive picture of the market situation. On average, over 70% of respondents believe that the market in which they are active will grow in the near future, while a further 20% expect it to stabilise. This sentiment is echoed throughout all market sectors but is most notable in mining, where a hefty 40% expect stabilisation of the market conditions. Among those respondents who expect their sector to decline, over 20% believe that there is still room for survey services to grow within that sector.

The overwhelming majority of respondents, more than 90%, anticipate that private-sector organisations will play an increasingly important role in the geoinformation market – even in land management, an area traditionally dominated by government organisations. Nonetheless, knowledge development remains a great concern. Multiple respondents from different regions and market sectors explicitly express their concerns about the lack of new students and professional development. This seems to be an issue that needs to be addressed if the geoinformation community wants to successfully capitalise on the expected market growth.

THE FUTURE OF SURVEYING

An often-heard remark is that the role of the professional surveyor is changing. Some people even say that anyone will be able to be a surveyor in the future, thanks to technological developments making it easier to operate equipment and lower prices making geomatics solutions more widely available. "Many jobs that don't require high precision will be performed by non-surveyors using mobile apps. Examples are preliminary surveys and estimates in farming and construction. Our job as surveyors will be more focused in areas and jobs that require specific knowledge and higher responsibilities," states one of the respondents.

Another development is the need for real-time data, which requires the time between acquisition and visualisation to be reduced. This can only be achieved by fully automating the data processing, which will change the work of surveyors currently involved in that step.

▲ GIM International's *Wim van Wegen exploring a VR environment at Intergeo 2016.*

TECH-SAVVY

Traditional survey techniques are still widely used and highly valued by readers of *GIM International*, but newly emerging geoinformation techniques are entering the arena. Although there may be a slight difference between the perception of geomatics professionals and the disruptive technologies that are being developed in parallel to the geomatics world – one may not always be aware of advancing technologies just around the corner – it is safe to say that future surveyors must be tech-savvy. Maybe this perspective will open up new opportunities to attract more young people into relevant education and subsequently the industry, as a career as a geomatics professional will be full of appealing high-tech devices and software. A marketing strategy to highlight the cool factor of 'geo' would be a great step in the right direction! ◀

BIOGRAPHIES OF THE AUTHORS

Wim van Wegen is content manager of *GIM International*. In his role, he is responsible for the print and online publications of one of the world's leading geomatics trade media brands. He is also a contributor of columns and feature articles, and often interviews renowned experts in the geospatial industry. Van Wegen has a bachelor degree in European studies from the NHL University of Applied Sciences in Leeuwarden, The Netherlands.

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Martin Kodde is a specialist in the field of geomatics with a keen interest in real-time 3D data acquisition. He has a bachelor degree in geodesy from Utrecht University of Applied Sciences and a master degree in geomatics from Delft University of Technology, both in The Netherlands. Kodde leads the Geo-ICT department at Fugro in The Netherlands, where he is also responsible for R&D in geoinformation. He is also a contributing editor for *GIM International*.

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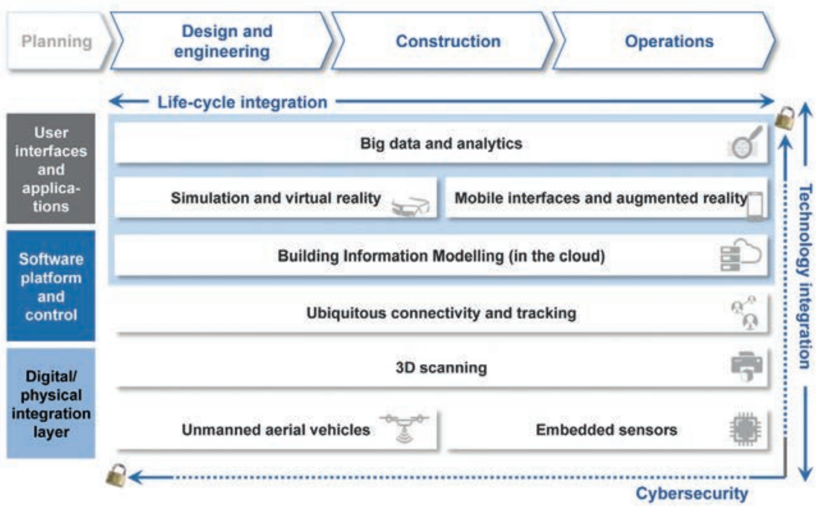
GEO-RELATED TRENDS IN ENGINEERING & CONSTRUCTION

Data Sharing is Smart

There could be many keywords representing important trends in the capture and use of spatial data in the engineering & construction industry, but 3D, BIM, AR and UAV are definitely high on the list. Uniting them all is one major cross-industry challenge: interoperability and data integration in support of much-needed higher workflow efficiency in the whole value chain.

▲ *Image courtesy: Jeroen van Berkel.*

The engineering & construction sector has been slower than most to adopt new technologies. While innovation may have occurred on the enterprise level, overall productivity in the market has remained almost flat for 50 years. In fact, labour productivity has fallen in the USA over the last 40 years. This slow pace of innovation matters because of the industry's sheer scope and scale; it accounts for about 6% of global GDP and is still growing. The world's urban populations are increasing by 20,000 people per day, all of whom need affordable housing plus well-functioning infrastructure for transportation and utilities. Successful adoption of modern processes will not only heighten productivity, but can also enhance the quality of construction work and improve safety, working conditions and environmental compatibility. The potential financial impact is high: a 1% rise in productivity worldwide could save USD100 billion a year. These conclusions all come from the World Economic Forum in its very thorough and well-informed first report on the sector (May 2016): *Shaping the Future of Construction: A Breakthrough in Mindset and Technology*. The recommendations in the report emphasise collaboration, a holistic view of project management and information sharing. "In other industries the digital transformation is now well under way; construction companies need to act quickly and decisively: lucrative rewards await nimble companies, while the risks are serious for hesitant companies."



▲ *Digital technologies applied in the engineering & construction value chain. Source: Shaping the Future of Construction (2016); World Economic Forum & The Boston Consulting Group.*

WHOLE LIFECYCLE

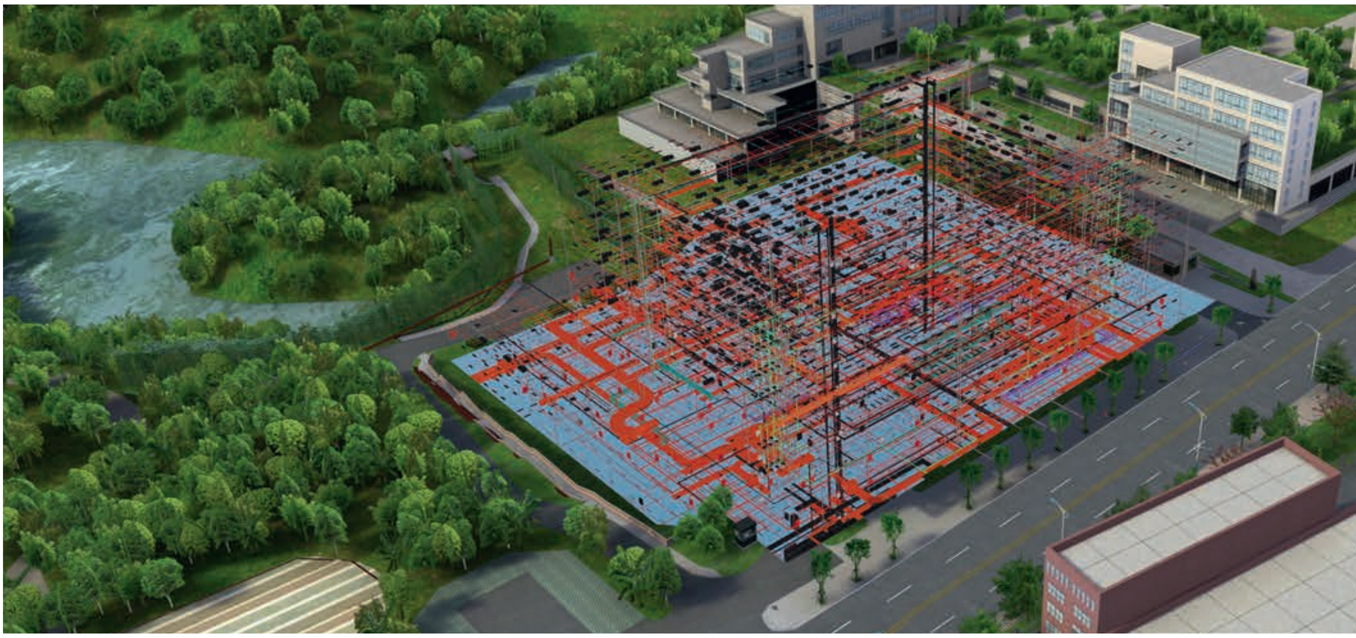
What is needed is better collaboration and information sharing between stakeholders throughout a construction's whole lifecycle. Further adoption of building information modelling (BIM) is crucial. No one can avoid the use of modern planning technology and smart design techniques any longer. Survey data from all possible sources can be integrated in the phase of parametric modelling, for simulation and augmented reality. A geospatial information system (GIS) is used in the location selection, planning, coordination, communication and asset management. It also plays its part in central tracking systems to increase the utilisation of equipment throughout the firm or across project partners. Sensor data, whether wireless or otherwise, is real-time integrated for performance and deviation analytics in all phases. While laser scanning itself is valuable as a tool for comprehensively capturing an environment as it actually appears, integration with CAD is needed in the design process. Software integrates point cloud data with the CAD drawings. The CAD Trends 2016 report, published by *Business Advantage*, shows that – in the worldwide CAD community – 27% of design work produces 3D models and 34% produces both 2D drawings and 3D models. 2D drawings automatically generated from 3D CAD or BIM models are regarded as important, yet BIM itself shows a drop in perceived importance since the same report in 2015. That can suggest a stagnation in the modernisation at the start of all processes involved. According to the World Economic Forum, optimising existing processes can lead to a reduction of completion times by 30% and costs by 15%. To put those figures in perspective: the UK government wants to achieve a 33% reduction in both the initial cost of construction and also the whole life-cycle costs of built assets by 2025.

A 1% RISE IN PRODUCTIVITY WORLDWIDE COULD SAVE USD100 BILLION A YEAR

INTEROPERABILITY

Technical challenges are likely to be overcome, but some financial incentives will probably be needed to change existing processes and increase collaboration. In the Autodesk publication *Redshift,* Dominic Thasarathar, Autodesk's strategist for the construction industry, referred to the market research findings that worldwide construction will grow by 85% over the coming years. The required financial input will be enormous. He expects that investors will start to require the use of BIM for new-build infrastructure projects as a condition of funding, because of the reduction in construction risk. Also, the projects will be embedded in a smart city philosophy. "Today, infrastructure planning is often focused on 'costs and assets'. Tomorrow, (spatial) big data, infinite computing, gaming engines and reality capture will support evaluating potential projects with the end goal in mind." Such as, 'What's the best combination of infrastructure to support increased economic growth in this part of the city?' According to Thasarathar, the construction and infrastructure sector will be asked to approach projects from the perspective of smart transport, smart energy, smart buildings, livable cities, etc.

But all this needs interoperability. "The lack of robust global arrangements on standards could in future forfeit the potential inherent in digital technologies," concludes the World Economic Forum report. "Standards in software systems, interfaces and communication protocols will facilitate the digitalisation of the industry as a whole; in particular, companies should establish standards in machine code for automated construction equipment, and in better interfaces between different systems such as BIM and GIS."



▲ *Work is needed for better interfaces between BIM and GIS. Image courtesy: Chongqing Survey Institute.*

GEODIGITAL MESH

An important development for the building industry is the fact that Autodesk and Bentley are working together to enhance interoperability between their portfolios of construction software and to ensure that design data exchange can now be extended to others. The commitment of GIS market leader Esri to work on the broadening of data sharing in the construction sector is also evident, such as in the annual Geodesign summits for instance. The 2017 event will focus on smart planning technology and geodesign techniques. In effect, all important players in the geomatics industry have signed or are due to sign agreements to increase interoperability: Topcon, Faro, Trimble, Bentley, Autodesk, Hexagon (including Leica products), Esri, and so on. They are adding functionalities and modelling dimensions, improving usability and simplifying reuse of data. They are taking the initiative to reach agreement on standards to improve the interoperability of different systems and disciplines. This will enable a workflow between GIS, design tools and asset management products as well as survey and machine control systems. Survey data will go directly into design, can be used to control smart building equipment, and then flow into asset management as as-built records. The partnerships are innovating the use of cloud and mobile technologies to extend the aspects of building information modelling, even at the point of work and in direct connection with ERP systems, etc. But progress is slow; even further integration between GIS and CAD is still welcome.

THINNED CLOUDS ARE ALSO WELCOME FOR DYNAMIC 3D MODELS IN SERIOUS GAMING FOR THE ENGINEERING MARKET

3D

Now that 3D capability is being delivered across the GIS platforms, the spotlight is shifting onto a tighter integration between BIM and 3D GIS. It remains difficult to use data not only in different formats but also of different levels of construction detail – from the different partners in a engineering project – in a GIS at the same time. The amount of modelling data to be handled is also a challenge. Chris Andrews, Esri's product manager for 3D, stated on ArcGIS Blog (April 2016): "We are seeing many examples of users attempting to merge GIS and BIM into higher value information projects and running into different issues when using industry-focused exchange formats when compared with agnostic geospatial ETL formats. The density of BIM information is often not only an issue for the traditional geospatial modelling paradigm but also for the end visualisation platform which, in 2016, is ubiquitously expected to be either web or mobile. We will be exploring how we can better adapt and extend our new and emerging 3D platform capabilities for distributing GIS and BIM 3D content, visualisations, and analysis."

All software vendors face the challenge of customers asking for high-quality visualisation of integrated data, bi-directional flow of edits and better tools for communicating integrated 3D content. Augmented reality (AR) is expected to assist: the (customer and) designers of all disciplines will be able to walk around the same site and visualise exactly how any changes would look and identify where the combined designs are less functional. Last year, at the largest European geomatics trade show Intergeo, many companies showcased their AR applications for urban planning, utility companies, etc., combining 2D and 3D GIS and CAD data with details otherwise invisible to the human eye.

LASER SCANNING

The trend towards 3D data capture and service delivery poses a challenge for surveyors too. 70% of American surveyors agree that the demand for 3D services is growing, but only 28% of them use 3D tools, concluded BNP Market Research in its market study to look at the trends in 3D surveying (*Point of Beginning* magazine, April 2016). Improved technologies and lower costs relative to the capabilities of the technology

remain the top drivers. "Despite the speed of adoption of 3D surveying, many professional surveyors feel the profession risks being left behind if it does not move faster." To give some study results, having increased to 66% since the previous study, modelling software continues to lead the list of 3D tools used by those 28% of surveyors. The use of aerial Lidar has declined to 23%, but a fierce rise could be seen in phase-based stationary terrestrial laser scanning (to 37%).

The differences between 3D laser scanners and conventional surveying equipment are large – not only in terms of the type of data collected and delivered, but certainly also the scanning speed and resolution (Faro, for example, achieves 976,000 points/second and 2 million points per square metre). Laser scanning solutions are now being developed specifically for surveyors who have to deliver georeferenced point clouds for an intelligent 3D model. BIM is for a large part about raising efficiency, so that is what the new products have to focus on. The time per scan decreases significantly thanks to enabling the operators to work as easily and smartly as possible. And allowing the creation of 3D BIM models directly from the registered point clouds can increase the processing productivity of the related office software by 50%.

LOW COST, LOW ALTITUDE

Worldwide, laser scanning is enjoying steady adoption in construction and extensive renovation projects to capture 3D data, and is increasingly being combined with the use of unmanned aerial vehicles (UAVs or 'drones'). Last year, the Finnish Geospatial Research Institute reported that for small-area surveys with complex terrain or objects rich in features, a UAV performs well to do the laser scanning – especially a rotorcraft, which allows for slow or even stationary flight speeds. In combination with relatively low-cost sensors, UAV-based laser scanning is becoming accessible to many construction companies for low-altitude missions; typical operation altitudes are 40-70 metres. When a simultaneous capturing of the terrain and street infrastructure is needed besides the construction features, the sensor package can include a GNSS-IMU device for observing and recording the sensor flight path and orientation. Depending on the accuracy and sensor performance of the flight path solution, it is possible to obtain a point cloud accuracy of 5 to 10cm, according to the Finnish experts.

'Photo capture' of 3D environments (or 'automated photogrammetry') refers to such a relatively low-cost sensor that could be mounted on a UAV. All that is needed is the use of a good digital camera, plus software to create accurate 3D models. According to marketing information from Bentley, processing multiple photos into complex 3D models is now simple and delivers good results, providing you take sufficiently close-range shots with a high-quality camera. "We've done many comparisons between laser scanning and photo capture, and we can absolutely achieve comparable resolution." For truly useful models in the construction sector, precisely located control points are still needed, along with a knowledge of state plane coordinates. And, as in laser scanning, edges and other fine features continue to be a challenge, so experts will be necessary to certify a model.

The CAD software development community also promotes 'reality meshes': much smaller and lighter files that are faster to process and work with, even in web browsers. Thinned clouds, for instance, are welcome for dynamic 3D models, such as in serious gaming for the engineering & construction market. Animation functionalities for virtual design & construction will be one of the next steps – as will, of course, figuring out how to economically store gigabytes worth of historical project data and serve on demand. ◀

BIOGRAPHY OF THE AUTHOR

Frédérique Coumans (Belgium) is contributing editor for *GIM International*. She has more than 20 years' experience of covering all aspects of spatial data infrastructures as editor-in-chief of magazines on GIS and on data mining & GIS-in-business.

WHAT'S HOT AND WHAT'S NOT IN PRECISION AGRICULTURE

Geoinformation in **Arable Farming**

Agriculture enthusiastically absorbs geospatial technologies. Precision farming practices in particular benefit from location intelligence. The future in agriculture with geospatial applications is bright. Besides more efficiency on the farm, geospatial technologies also offer new business opportunities and new sustainability concepts. But the adoption of geospatial innovations is lagging behind expectations. So what's hot and what's not? This article examines the state of the art in geospatial technologies in agriculture and attempts to forecast the trends.

By far the most popular geomatics technology among farmers is the global navigation satellite system (GNSS). Since farmers have had steering aids and fully automated machine guidance, their efficiency in field operations has increased by 10 to 15%. GNSS is a very versatile technology; it also helps farmers to map their fields, geolocate objects and track and trace their machinery or livestock. One application that utilises GNSS as a guidance and tracking tool is the routing of machinery in the field. The first step in this is to accurately measure the field boundaries where a crop can be grown. This information is used to design the optimal layout of driving lanes, taking the width of machinery, turning angles and the field geometry into consideration. This enables the detection of areas with inefficient machine manoeuvring which, in the optimal path plan, are ideally moved to the side of the field and/or given another function (e.g. as a nature strip). With the advent of robotic field work, planning an optimal path is an efficient way of instructing machines where to go. The next step is to calculate the routing along these paths in order to optimise the bulk cargo capacity on board the field machines. For instance, an optimal route plan for fertiliser spreading would minimise the time and distance to reload fertiliser.

▲ *Figure 1, The tractor 'cockpit' nowadays is full of screens to help the farmer with steering and location-specific application.*

▲ *Figure 2, GNSS allows optimised routing in the field, accounting for reloading of seed potatoes in this case.*

GNSS

GNSS is also an indispensable tool in what is called 'variable rate application': a method for giving the right dose of an input in the right place. Here, innovation is mainly driven by the use of sensors for environmental parameters, including soil conditions, water availability, vegetation monitoring and yield monitoring. Satellite remote sensing has always been an appealing way of monitoring large areas of agricultural land, but it is only recently that the Earth observation sector has become organised in such a way as to make operational data feeds to agriculture feasible. The European Sentinel satellites, which form part of the Copernicus programme, have given rise to new optimism since the continuous monitoring and the download functionality are unprecedented, at least in the public domain. The only drawback is that agricultural applications mostly rely on the optical sensors on board Sentinel-2, and successful imaging of agricultural land

▲ *Figure 3, A quadcopter UAV equipped with camera to map crop differences.*

requires clear skies. Given the fact that 90% of agricultural land worldwide is rain-fed, the abundance of clouds in the growing season is an obstacle. Nevertheless, the minimum six-day revisit of Sentinel-2 is a significant improvement on Landsat-8 (16 days).

UNMANNED AERIAL VEHICLES

For areas with too much cloud cover, unmanned aerial vehicles (UAVs or 'drones') are an excellent proxy. In a way, UAVs at last allow farmers to capitalise on almost 50 years of remote sensing knowledge and application ideas. Furthermore, the explosion of players in the marketplace, and their diversity, feeds innovation at every link in the chain between image acquisition and user application. For instance, software solutions for photogrammetry, image mosaicking, reflectance calibration, index calculations and related GIS functionalities are emerging at an incredible pace.

As in other sectors, UAVs are a major hype. The technology and regulations are improving every day, however, which means that at a certain tipping point the technology will become indispensable to all. And although UAVs are currently mainly regarded as platforms for sensors, they can also become the next-generation tractor on which all kinds of crop care implements will be installed. This capability is demonstrated by a Japanese application in which unmanned helicopters perform crop spraying, for example.

From an agricultural point of view, to optimally benefit from all these technologies the farmer must have an integrated system for the collection, storage, analysis and visualisation of all the data and tools. In this domain, too, the pace of advancement is very high: machine manufacturers, farm equipment suppliers and input suppliers (i.e. fertilisers, seeds, etc.) are offering data management tools with a geospatial interface. This is also attracting start-ups from various backgrounds who need little more than a software platform as a vehicle to create business value with their specific proposition.

BUSINESS OPPORTUNITIES

The rise of precision farming and the use of geospatial technologies bring all kinds of new business opportunities in domains including sensoring (data and/or equipment supply), machine guidance (and path planning), geospatial-based office applications to work with soil maps, remote sensing imagery, yield monitors and crop growth optimisation/decision support, not to mention a whole world of maintenance and support for all these new technologies. In this context, it is impossible to ignore The Climate Corporation, which is now part of Bayer through recent acquisitions. With Climate Corp data, Monsanto and now Bayer are able to combine soil, weather and crop growth information to prescribe which seeds and which agents are best suited for every field on Earth. And as they apply it to a huge set of customer information, this has become a totally new way of farming, called 'prescription farming' or 'decision farming'. Other opportunities involve market prices and crop acreages, allowing calculation of whether an additional supply of fertiliser or water will increase the yield sufficiently to deliver a payback or not. In another opportunity, on-demand growing and delivering of food now seems not too far off, although it also depends on the crop of course. This trend is already visible in horticulture – the non-geospatial agricultural example for arable farming – where retailers (in particular the emerging foodbox companies) are creating better demand-driven supply chains.

The most important question here is, do the investments and benefits coincide? Or are farmers the ones making the investments, while their suppliers and customers reap the benefits? While it is easy to make a clear business case for suppliers of machinery, fertilisers, seeds, agro-chemicals, etc. and for customers in the agrifood chain including retailers and food processing companies, farmers themselves have difficulties making a business case for precision farming ▸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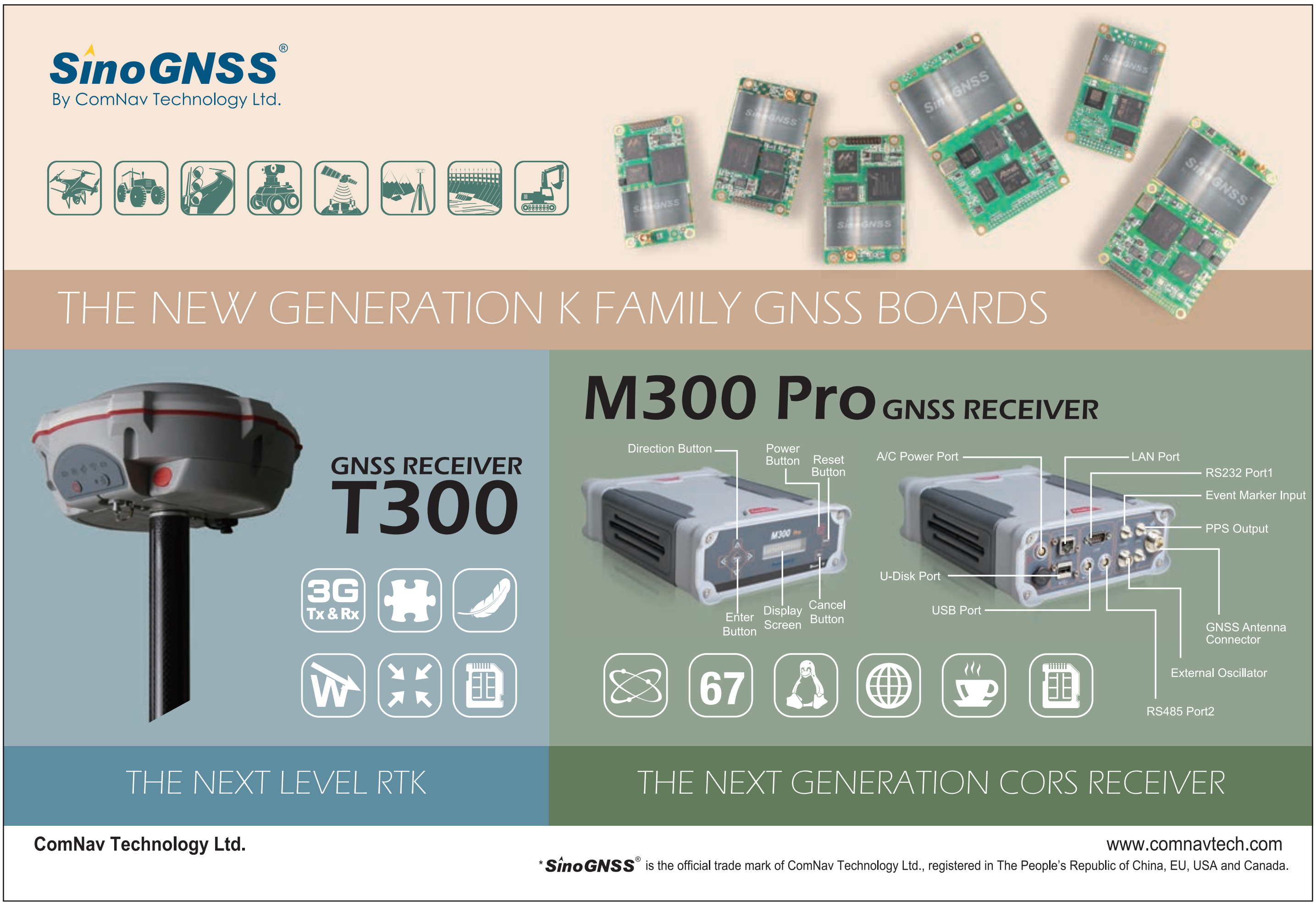
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▲ *Figure 4, A false-colour Sentinel-2 image of Zuid-Beveland, The Netherlands (Green, Red, and Near Infrared). The 10m-resolution image image shows in-field differences in crop performance.*

investments. Although there are only a handful of studies addressing the adoption issue, they show clear benefits for farmers when applying precision farming technologies – not only in resource efficiency (costs savings), but also in quality increases and yield increases. However, despite these positive studies, the impact on the farm's business is variable. In particular smaller farms can be reluctant to invest when the payback time is 10 to 15 years or more. The technological framework is very wide and complex. It is not easy to oversee the consequence of a choice for a certain brand or operational method. Certainly, the poor connectivity in many rural areas poses challenges in obtaining and sharing the data needed for precision farming applications. And, as mentioned above, the eagerness to 'own' a data platform so as not to miss out on the next level of farming is also leading to a lack of interoperability at all levels. Another major issue here is education, both at academic and vocational level, with a new generation of farmers only now (finally) starting to learn and experience the benefits of precision farming for themselves. Hence this is another opportunity for new businesses: forming collaborative partnerships with other farms can create the economies of scale necessary to reap the benefits from precision farming. Agriculture already has a tradition of doing this, e.g. mill cooperatives or machine-sharing schemes.

SUSTAINABILITY

Despite increasing societal demands for farms to produce the best possible food in a sustainable way, the slow adoption of precision farming is holding back sustainability improvements most of all. Precision farming technologies could dramatically reduce the ecological footprint of food production: 10-15% less energy use (fuel) and 10-20% lower inputs (e.g. crop protection agents, fertilisers and water) for the same level of production or, in other words, increased productivity per kilogram of fertiliser, litre of fuel, litre of water or man-hour. Hence there is an incentive for governments to stimulate the adoption of precision farming, as it will contribute to solving environmental issues as well as mitigating farming's contribution to greenhouse gas emissions. This is already resulting in new regulations. The European Commission is investigating opportunities to extend its concept of 'greening' towards the uptake of precision farming. This would imply that adopting these new technologies will increase one's 'licence to operate'; in other words, the technology will help farmers to improve acceptance of their activities by their neighbours, their personnel, their customers

BIOGRAPHIES OF THE AUTHORS

Tamme van der Wal works as a data scientist at Wageningen University & Research (WUR) where he is studying the development and adoption of digital farming. Over the past years he has been involved in studies for the European Commission, OECD and the Dutch Ministry of Economic Affairs into the relevance of drones and precision farming for improving agriculture. Furthermore, he is investigating the impact of digital farming on 'greening' and climate mitigation.

Henk Janssen works as a team leader at Wageningen University & Research (WUR). He has a special interest in precision farming and its opportunities for meeting the challenges in maintaining soil quality, reducing greenhouse gas emissions and ensuring optimal in-field route planning. In his team, the focus is on environmental data collection and the quality of data for monitoring purposes.

and by society at large. Needless to say, geoinformation will play a key role in achieving and monitoring this greening concept.

TRENDS

Agriculture will benefit from the revolution in information & communication technology taking place in all industries: robotisation, sensoring, smarter decision support systems, data analytics, etc. For the geospatial domain, the robotisation of field work is a particularly important challenge. It is a huge operation to guide robots – either on wheels or in the air – using navigation systems and sensors, to store all the data and integrate it in the relevant applications. But robots will eventually take over the dull, dangerous, dirty and perhaps even difficult jobs that are abundant in agriculture.

Furthermore, changes in society will cause a growing shift towards more demand-driven supply chains, requiring further integration of the business processes between the farmer and his suppliers on the one side and between the farmer and his customers on the other. That integration must lead to better chain performance and more optimal food production.

This article has focused on the application of geospatial data, tools and knowledge on farms themselves. Clearly geoinformation plays an important role in other areas of food production too, such as global food security monitoring, logistics, measures for disease containment, ways to administer and control subsidies and contracts, etc. In that sense, agriculture is no different to other industries, except that the 'factories' are outdoors and the machinery is mobile.

▲ *Figure 5, The result of GNSS planting: beautiful straight lines with optimal space between the potatoes.*


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AN OVERVIEW OF GEOSPATIAL METHODS IN MINING ENGINEERING

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. Starting with some history – after all, we should never forget where we came from – this article presents 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.

HISTORY

The disciplines of surveying and mining both date back to ancient times. The ancient Greeks not only developed the science of geometry, but they also developed the first surveying tool: the diopter, an astronomical and surveying instrument dating from the third century BCE. The diopter can be regarded as the ancient predecessor of the theodolite. The first land surveys can be traced back even further in time, to approximately 3,000 years ago when Egyptian surveyors divided up the fertile land around the mighty River Nile. Likewise, mining engineering is a field with a long history. Archaeological studies have revealed that mining played an important role in prehistoric times, as evidenced by the flint mines in the countries we today call England and France.

The Romans were renowned for their innovations in mining engineering. The copper mines in Rio Tinto in Spain – the best-known ancient mining complex in the world – are a striking example of this. While surface mining was the most common approach, the Romans also used more advanced methods and techniques. Tunnels were dug in order to extract valuable minerals such as gold and silver; this required great planning and advanced knowledge of surveying, mathematics and geometry. However, it was not until the 18th century, when the industrial revolution in the UK was well underway, that the role of the mining surveyor became a widespread and recognised profession.

One of the instruments used back then was the dial: a compass made especially for underground purposes. This method was often inaccurate; iron tools or iron ore deposits in the mine tended to interfere with the needle of the compass. But by the middle of the 19th century more sophisticated devices were being produced. These theodolites were equipped with telescopes, spirit levels and vertical quadrants, enabling the measurement of vertical angles. Theodolites made surveying more accurate by traversing, i.e. measuring fixed points in the mine, so it was no longer necessary to rely on the compass. A short time later, the theodolite had replaced the dial as the main tool of the mine surveyor.

Today, mine surveying is an exact science. Modern theodolites – using laser sighting and electronic data storage – coupled with a global navigation satellite system (GNSS) offer an accuracy that is probably beyond the wildest dreams of the early surveyor armed only with his simple dial and measuring chain.

MINE SURVEYING TODAY

Mining surveying can be summarised as ‘the digging of mine shafts and galleries and the calculation of volume of rock’, although it entails much more than this in practice. Geometric constraints – e.g. vertical shafts and narrow passages – demand the use of specific survey techniques. While the basic principles of surveying may have remained largely unchanged throughout the ages, the instruments used have not. Common technologies in mine surveying today include terrestrial laser scanning, airborne laser scanning (further referred to as ‘Lidar’), airborne photogrammetry, unmanned aerial systems (UASs), satellite imagery. Besides this, software forms an essential part of the mining surveying profession nowadays. After all, the captured data needs to be processed in order for it to be of any use.

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

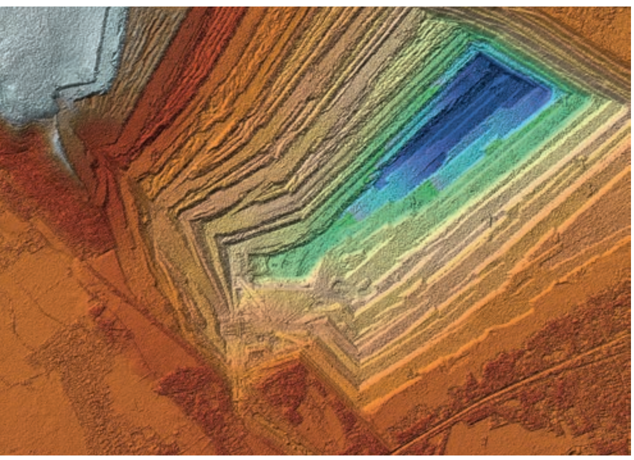
▲ *Aguas Teñidas copper-lead-zinc mine in Andalusia, Spain.*

▲ *Mapping a mine site with a UAV (Courtesy: Aibotix).*

TERRESTRIAL LASER SCANNING

Surveying in the mining industry, both in open-pit and underground mines, often goes hand in hand with terrestrial laser scanning (TLS), which is deployed to verify the spatial changes of mining works. Thanks to its high point density and high accuracy, TLS is a very suitable surveying technique for monitoring movements and deformations.

By obtaining a highly detailed set or 'point cloud' of three-dimensional vectors to target points relative to the scanner location, TLS technology collects a large amount of valuable geospatial information in an automated manner. By combining TLS with GNSS, it is possible to obtain a fully geospatially referenced dataset, which opens up opportunities for changes to be directly measured and monitored over time. In mining specifically, TLS has the potential to be used for a wide range of applications: monitoring and documenting the progress of underground mining works, assessing the stability and hence worker health & safety at mining sites, monitoring deformation and convergence, calculating volumes, providing supplementary evidence (e.g. in the case of accidents or damage), aiding security and protection of mining sites, etc. Hence, laser scanning in the mining industry represents a significant growth market. The technology is already used for the documentation of corridors and infrastructure by room-and-pillar mining methods, although it has not yet gained a substantial foothold in the case of long-wall mining, for example: a form of underground coal mining whereby a long wall of coal is mined in a single 'slice'. Manufacturers of laser scanners – such as RIEGL and Maptek – often not only produce the hardware, but also offer a software solution with a streamlined survey workflow. With the purchase price of the device and the corresponding software amounting to roughly EUR100,000, the required level of investment is a key factor affecting the adoption of this technology in the mining industry.



▲ *TanDEM-X digital elevation model of a coal mine (Hambach, Germany) with ground spacing of 12m (Courtesy: DLR).*

AIRBORNE LASER SCANNING

Another method of capturing the mining environment is airborne laser scanning, also known as 'airborne Lidar'. Utilising high-end manned or unmanned airborne platforms makes it possible to obtain data in challenging circumstances. Airborne Lidar offers great opportunities for the mining sector, as it is able to acquire millions of points per square kilometre. This density creates a robust dataset in the form of a digital terrain model (DTM) or digital elevation model (DEM) that can be used for mining applications such as volume calculations, geomorphology and structural geology, slope analysis and surface run-off modelling for feasibility studies and environmental impact studies. Volumetric mapping or time-sequenced topographic modelling to facilitate subsidence monitoring is also a service that can be provided when using airborne Lidar.

AERIAL PHOTOGRAMMETRY

Over the past few decades, aerial surveying has changed the overall face of mining operations and has revolutionised exploration. The application of aerial photogrammetry is a proven method of pit mapping and stockpile volume measurement, with a particular emphasis on 3D modelling and monitoring. The spatial data acquired in this way is used, for example, to create digital terrain models, orthorectified georeferenced imagery and topographic maps. The imagery derived from an aerial survey can also be used in automated processing for the production of DEMs.
Nowadays, aerial photogrammetry is often combined with Lidar technology and is increasingly being obtained using UAVs. The successful use of aerial photogrammetry is dependent on factors such as the expertise and delivery speed of the aerial survey company, the level of ground support from mine site survey staff and, not unimportantly, favourable weather conditions.

UNMANNED AERIAL VEHICLES

Reflecting the trend in the entire geospatial profession over the past five years, a growing number of mining companies are working with UAVs. These are equipped with digital cameras to provide high-resolution aerial imagery, which is then further processed to produce highly precise orthophotos, point clouds and 3D models. This data can be used for forecasting the development of the mine, monitoring changes and calculating volumes. UAVs can also play a role in improving the safety of workers underground by providing information about the above-ground situation.

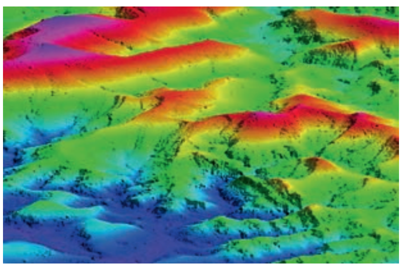
A new disruptive technology in the broader geospatial industry that can bring benefits for the mining sector too is the combination of UAV and Lidar. This may have the potential to replace many existing options. Several companies, such as YellowScan, have launched ultra-compact and lightweight unmanned Lidar systems. The demanding environmental circumstances and sometimes dangerous conditions make UAV surveying the ideal solution in terms of producing GIS data for DEMs and DTMs.

SATELLITE IMAGERY

A lot of powerful information for the mining industry is obtained from space. Satellite imagery is an essential tool in support of mineral exploration projects, for example. Thanks to the detail-rich satellite imagery, the presence and patterns of pathfinding minerals can be mapped, providing valuable insights for mining companies before they decide whether to invest in field deployments. Due to its global coverage, satellite-derived imagery is a safe and cost-effective method for obtaining information regardless of local constraints, even in remote regions. Satellite imagery also makes it possible to monitor elevation changes in an open-pit mine. Image processing, orthorectification, georeferencing, feature extraction, and mosaicking are all techniques that guarantee tailor-made image data for numerous different mining and geological applications. One technique especially worth mentioning is short-wave infrared (SWIR) wavelength bands which offer unique remote sensing capabilities, such as material detection, which are often impossible with other technologies. The SPOT satellites (SPOT 4 and 5) are equipped with SWIR, for example, while DigitalGlobe is an experienced provider of high-resolution SWIR imagery.

PROCESSING SOFTWARE

Over recent years a broad variety of innovative software solutions for mine planning and surveying have emerged. Bentley's mine surveying solution brings together mine site survey data, surface terrain models, digital



▲ *3D surface model for a mining project in Gunung Bayan, Kalimantan, Indonesia. (Courtesy: Airborne Informatics, Malaysia)*

images and point clouds. The solution enables mining engineers to develop a comprehensive 3D model of the mining site compliant with company standards. One company that offers the whole geospatial workflow associated with mining is Maptek. This Australian-based company bridges the gaps between the geological, spatial design, execution and measurement details of a mining operation. Other renowned companies in the geomatics industry such as Leica Geosystems (integrated with Hexagon Mining), Topcon and Trimble (Trimble Connected Mine) also offer a complete product suite for mining engineers. Their solutions include aerial, terrestrial and underground scanning and imaging, positioning infrastructure, planning software, visualisation software, GIS and more. In fact, they comprise all the tools a mining surveyor needs.

THE FUTURE OF MINE SURVEYING

In view of such completeness of the surveying solutions for mining professionals that are now available, one could be inclined to rest on one's laurels. What else is left to wish for, when so many state-of-the-art solutions are making surveying relatively easy? Nevertheless, a couple of exciting broader technological developments deserve a mention here as being set to make mining even more productive: virtual reality (VR) and augmented reality (AR). In fact, the global mining industry has been an early adopter of both of these technologies. One of the industry's pioneers when it comes to VR is Brazil-based Vale, the world's largest producer of iron ore and nickel. Since 2000, Vale has been assembling geographic databases of its fields, by investing in very-high-resolution images. The company conducts 3D aerial surveys with laser geotechnology and assembles 3D digital models. In 2013, Vale entered into a partnership with the British Geological Survey, which has played a major role in the use of virtual reality in mining. Vale now uses VR to aid decision-making in several aspects of its operations and projects: from defining the mining area to environmental licensing scenarios and even closure of a mining site. Geological, geotechnical and environmental studies are carried out with VR.

Likewise AR – which superimposes a layer of interactive digital information over images of the physical world – offers significant opportunities for the mining industry in terms of improved productivity, reduced equipment maintenance costs and employee safety.

▲ *Virtual Reality Room of Brazilian mining giant Vale, located in Minas Gerais. (Courtesy: Vale)*

Microsoft's HoloLens AR headset is already transforming businesses in architecture, the automotive industry, engineering and education, to name but a few, and the potential of 'mixed-reality' technology to revolutionise the mining industry is already being widely recognised.

So 'complete' solutions are already being supplied by the leading companies in the field, but the definition of 'complete' seems likely to expand further in the near future. If our own minds sometimes boggle at these science-fiction-like advancements, just what would a Roman surveyor of the ancient Rio Tinto mine make of such innovations? ◀

BIOGRAPHY OF THE AUTHOR

Wim van Wegen is content manager of *GIM International*. In his role, he is responsible for the print and online publications of one of the world's leading geomatics trade media brands. He is also a contributor of columns and feature articles, and often interviews renowned experts in the geospatial industry. Van Wegen has a bachelor degree in European studies from the NHL University of Applied Sciences in Leeuwarden, The Netherlands.

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After three years of rapid growth, in 2015 ComNav Technology was the first domestic company dedicated to developing core technology and manufacturing OEM boards to be listed on the National Equities Exchange and Quotations (NEEQ). The company currently employs over 200 people, and that figure is increasing all the time. As an R&D-driven company, more than half of the employees have extensive experience in high-precision GNSS or engineering. In addition, ComNav Technology invests at least 10% of its annual revenue into R&D every year. ComNav Technology is committed to maintaining its leading position as game rule-breaker to delight engineers and users looking for the ultimate high-precision multi-constellation and multi-frequency GNSS technologies.

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Geo-allen Co. Ltd. was founded in 2002, in Suzhou, Jiangsu Province, 80km away from Shanghai. Suzhou is a beautiful city, nicknamed 'heaven on earth', with more than 2,500 years of history. In May 2017, Geo-allen will celebrate its 15th anniversary. Over the past 15 years, Geo-allen has grown to be a world-famous company with an R&D team, a trading department, manufacturing workshops and an after-sales service team.

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HI-TARGET has established 13 subsidiaries and 28 branch offices, and currently employs more than 2,000 people including over 500 engineers. Every year, the company keeps innovating by investing more than 10% of its overall turnover into R&D and working with renowned universities to develop solutions through scientific research.

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Leica Geosystems is part of Hexagon (Nasdaq Stockholm: HEXA B; hexagon.com), a leading global provider of information technologies that drive quality and productivity improvements across geospatial and industrial enterprise applications.

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MicroSurvey

MicroSurvey has been creating software solutions for land surveyors, accident reconstructionists, forensic specialists, engineers and construction professionals for over 30 years. The company's software solutions are helping provide industry professionals with the tools they need, in over 120 countries around the world.

Recognised worldwide as the best least squares adjustment software on the market, STAR*NET sets the standard as the easiest, most widely used and respected least squares software with the most understandable results. MicroSurvey FieldGenius® is the most powerful graphics-based surveying data collection software available. Multi-brand instrument drivers ensure support for the latest hardware from the most popular global manufacturers of GPS and total stations. Code-free line work, easy pick-up and stake-out workflows allow users to do more work in less time. Multiple platform support allows users to take advantage of the latest high-power, high-definition display devices and tablets. MicroSurvey CAD offers a complete, cost-effective desktop survey and design program designed for surveyors, enabling them to perform standard surveying calculations and create high-quality 2D and 3D deliverables more quickly and easily than those using more complex, non-survey-centric applications. It is even possible to work with point clouds, Lidar and photogrammetric data.

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Phase One Industrial

Phase One Industrial is a world-leading provider of medium-format cameras and imaging solutions for aerial and industrial applications. Phase One 100 MP medium-format aerial cameras combine high resolution (11,608 pixels), wide ISO range (100 to 6,400) and fast capture speed.

The iXU-RS aerial camera series takes performance to the next level – it features a breakthrough central lens shutter design that enhances exposure speed to 1/2500s and presents a record-breaking capture rate of 500,000 exposures, offering exceptional accuracy, image quality and coverage that rival large-format cameras.
With a product line of aerial cameras, an impressive array of Rodenstock and Schneider-Kreuznach fast-sync lenses, a powerful controller complete with software, compatible with leading flight management systems and GPS receivers, Phase One offers solutions that streamline the entire capture and processing workflow and meet the exact needs of aerial imaging. Phase One products and solutions are easily integrated into existing or new set-ups and offer maximum connectivity with systems for a wide range of applications, such as 3D cities, Lidar integration, UAV solutions for surveying and inspection, 4-band multi-spectral solutions for agriculture, forestry, environmental monitoring & research and more.

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Racurs

Racurs has a history of 20 years of success on the Russian and worldwide geoinformatics markets. Since its foundation in 1993, the company has been developing innovative digital mapping software for processing aerial, space and terrestrial imagery. The flagship product, PHOTOMOD, was one of the first digital photogrammetric systems on the market that was designed for working on off-the-shelf PCs. Today, PHOTOMOD is the most popular digital photogrammetric software in Russia and well known all over the world.

The PHOTOMOD software family comprises a wide range of products for remote sensing data photogrammetric processing. This state-of-the-art software allows the extraction of geometrically accurate spatial information from almost all commercially available types of imagery, whether obtained by film or digital cameras, UASs, high-resolution satellite scanners or synthetic aperture radars.
An international dealer network helps to market, sell and support Racurs' products in 70 countries. Racurs' main business activities are:

- PHOTOMOD development and further integration into Russian and international markets.
- Photogrammetric production services using both airborne and satellite imagery.
- R&D in the field of RSD processing software, methods and algorithms.
- Remote-sensing data distribution in Russia and the CIS countries.

Racurs has been an ISPRS Sustaining Member since 1998 and a member of Special Committee I2AC since 2016. Racurs organises the well-known International Scientific and Technical Conference 'From imagery to map: digital photogrammetric technologies', which annually brings together the best specialists from dozens of countries and provides them with excellent opportunities for professional communication and discussion.

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RIEGL

RIEGL Laser Measurement Systems specialises in the research, development and production of laser scanners and scanning systems for a variety of applications in surveying. In terrestrial scanning, the RIEGL VZ-400i combines a future-oriented, innovative new processing architecture and internet connectivity with RIEGL's latest waveform processing Lidar technology. The scanner offers ultra-high speed, high-accuracy data acquisition with up to 500,000 measurements per second at up to 800m measurement range. In mobile scanning, RIEGL provides application-specific solutions: from the 360-degree field of view kinematic Lidar sensor VUX-1HA ready for integration into customised mapping solutions to user-friendly turnkey mobile mapping systems like the VMQ-1HA and the VMX-1HA with IMU/GNSS system, control unit and optional cameras fully integrated.

In airborne scanning, RIEGL's broad product portfolio has now been further expanded by the ultra-high performance dual-channel airborne mapping system VQ-1560i for aerial survey of wide areas and complex urban environment. The system offers up to 1.33 million measurements per second on the ground and an operating flight altitude of up to 15,500ft AGL. It is capable of online waveform processing as well as full or smart waveform recording. In unmanned scanning, RIEGL has added the entry-level, survey-grade miniVUX-1UAV Lidar sensor with only 1.6kg weight to its portfolio. With the RiCOPTER, a high-performance X-8 array foldable octocopter equipped with the fully integrated miniaturised airborne laser scanning system VUX-SYS, and the BathyCopter, an sUAV-based surveying system for hydrographic applications with the bathymetric depth finder RIEGL BDF-1 fully integrated, RIEGL provides turnkey Lidar system solutions for professional UAS surveying missions from one manufacturer.

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Teledyne Optech

With over 40 years of experience, Teledyne Optech is dedicated to developing and refining advanced Lidar survey instruments. Teledyne Optech strives to democratise Lidar with fast, accurate and cost-effective solutions for airborne mapping, airborne Lidar bathymetry, mobile mapping and terrestrial laser scanning. And now Teledyne Optech also has access to the deep remote-sensing expertise of the entire Teledyne Technologies family. Teledyne Optech's airborne Lidar systems are complete sensing solutions with integrated cameras and an end-to-end LMS workflow for Lidar/camera processing and third-party output. Requiring no operator, the highly automated Optech Eclipse reduces capital and operating costs, while the Optech Galaxy uses SwathTRAK™ technology to survey variable-elevation terrain economically. Finally, the multispectral Optech Titan improves target identification and enables simultaneous topo/bathy collection.

For surveying the crucial near-shore marine environment, the CZMIL Nova airborne Lidar bathymeter maps water depths even in turbid conditions and fuses Lidar, RGB and hyperspectral data into unprecedented deliverables. The CZMIL is already in use by multiple government agencies, and smaller groups can now deploy it via the CZMIL Project Program. The Lynx family of mobile survey solutions uses its industry-leading scanner speed to deliver usable point spacing, even at highway speeds, and leverages the same automated LMS workflow used for airborne operations. Meanwhile, the Optech Maverick is so light that users can wear it on a backpack, opening new applications for mobile Lidar. The Optech Polaris terrestrial laser scanner makes high-quality Lidar surveying affordable for the average surveyor, with a user-friendly workflow and long-range performance at an unprecedented price.

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Trimble Geospatial

Trimble's Geospatial Division provides solutions that facilitate high-quality, productive workflows and information exchange, driving value for a global and diverse customer base of surveyors, engineering and GIS service companies, governments, utilities and transportation authorities. Trimble's innovative technologies include integrated sensors, field applications, real-time communications, field-to-office processing and software for modelling and data analytics. Using Trimble solutions, organisations capture the most accurate spatial data and transform it into intelligence to deliver increased productivity and improved decision-making.

As elements of everyday living continue to evolve and shift, so too does the decision-making process – as well as the technology used to guide decision-making. These technological changes require geospatial information to not only be specialised, but also readily available and cost-effective for a wide variety of applications. Trimble understands that there will always be a need for both – integration of technology to streamline the workflow, and specialisation for particular applications pertaining to specific industries. Trimble places a great deal of emphasis on developing technology and solutions to seamlessly connect workflow processes with software applications. Whether it's more efficient use of natural resources or extending the life of civil infrastructure, reliable information is at the core of Trimble's solutions to transform the way work is done.

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Vexcel Imaging

VEXCEL IMAGING

Vexcel Imaging, based in Graz (Austria), taps into more than two decades of photogrammetry expertise to offer its successful line of UltraCam systems together with the UltraMap workflow software solution. For the last 10 years, the company was owned by Microsoft, contributing to the success of one of the world's biggest technology companies. Since March 2016, Vexcel Imaging is a private company again, continuing its story of success with even greater flexibility and agility.
The comprehensive digital aerial camera portfolio provides a range of imaging capabilities starting with the photogrammetric nadir camera systems, namely the UltraCam Falcon and the ultra-large UltraCam Eagle systems. The UltraCam Osprey camera systems can be used for combined nadir and oblique image capture. In March 2016, the latest addition to the UltraCam family was announced: the UltraCam Condor. This is designed for collection of 5-band imagery for wide-area, high-altitude mapping at high aircraft speeds while still serving photogrammetric projects. On the terrestrial side, the car-based mobile mapping system UltraCam Mustang allows the world to be captured from a street-level perspective. For off-road collection, it can be complemented with the UltraCam Panther portable 3D reality system (currently under redesign). Rounding out the UltraCam offering is the fully integrated workflow processing software UltraMap, providing a straightforward workflow and constantly updated feature sets. UltraMap delivers exceptionally high-quality point clouds, DSMs, ortho imagery and 3D-textured TINs leading to an optimal output in all of the numerous areas of applications of the UltraCam product family.

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Zoller + Fröhlich

Zoller+Fröhlich

In 2016, Zoller + Fröhlich presented a new generation of laser scanners which allows beginners and expert professionals alike to reach new levels in their projects. The IMAGER 5016 has been given a fresh, new design, becoming 30% smaller and 30% lighter than the Z+F IMAGER® 5010X. The ergonomic streamline design features a passive cooling system, IP54 rating and two handles for better grip while carrying and during set-up, plus much easier mounting of the scanner on high tripods and overhead applications. The maximum range of the new Z+F IMAGER® 5016 has been extended to up to 360m (1,180ft), thus establishing new opportunities and applications. The maximum measurement rate of more than 1 million points/second guarantees highly accurate results even across long distances. Due to 50% less range noise, the scanner can now scan faster than before without compromising quality and accuracy of the resulting point cloud.

The new Z+F IMAGER® 5016 series includes all the powerful features of the 5010 series, including an integrated high-definition HDR camera which has been extended with four bright LED spots to shed light into the darkest scenes for perfect colour imagery. It also features the unique Z+F scan positioning system, which allows real-time registration of scan data directly in the field to guarantee a complete and successful project. Even though the system has an implemented GPS receiver, the scan positioning system also works indoors, independent of satellite coverage. The scanner is classified as 'eye-safe' according to laser class 1 and can therefore be used in public areas without any restrictions.

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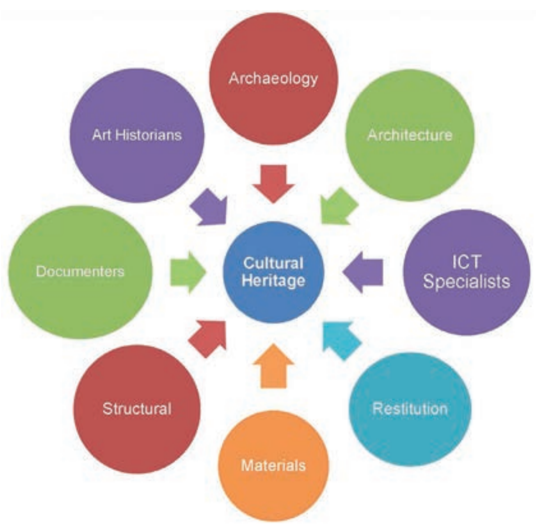
THE IMPACT OF MODERN MAPPING TECHNOLOGIES FOR CULTURAL HERITAGE

Preserving the Past Using Geomatics

Over the past decades, the tremendous progress in information and communication technologies (ICT) has totally changed the way we live, communicate and indeed measure and model the world around us. The author maintains that this progress has influenced the traditional land surveying profession more than any other in the engineering business. Geomatics and geoinformatics are a consequence of this technological advancement and today's professionals should feel privileged to have experienced this radical change first-hand. But how has the progress influenced specific parts of the profession and related applications such as the 3D documentation and modelling of cultural heritage? This article aims to examine the beneficial impact.

Monuments and other cultural heritage objects are valuable assets of world history. The thorough study, preservation and protection of them is an obligation of our era to mankind's past and future. However, these records of human history are greatly endangered, both by natural and manmade factors, as various incidences have painfully demonstrated recently. Over the past few decades, international bodies and agencies have passed resolutions concerning obligations for protection, conservation and restoration of monuments. UNESCO and the Council of Europe have formed specialised organisations for taking care of mankind's cultural heritage. The International Council for Monuments and Sites (ICOMOS) is the most important one, but also CIPA Heritage Documentation, the International Society for Photogrammetry & Remote Sensing (ISPRS) and the International Union of Architects (UIA), among others, are all involved in this task. Today the traditionally involved experts, like archaeologists and architects, tend to accept and recognise the contribution of geomatics to the cultural heritage agenda. Hence the geometric documentation, preservation and conservation of cultural heritage are rapidly becoming interdisciplinary and intercultural issues (Figure 1).



▲ *Figure 1, The interdisciplinary contribution to cultural heritage.*

It was in the Venice Charter (1964) that the necessity of the geometric documentation of cultural heritage was set as a prerequisite for the first time. In Article 16 it states "… In all works of preservation, restoration or excavation, there should always be precise documentation in the form of analytical and critical reports, illustrated with drawings and photographs…". It should however be stressed that, since there is as yet no generally acceptable framework for specifying the level of detail and the accuracy requirements for the various kinds of geometric recording of monuments, every single monument is geometrically documented based on its own accuracy and cost specifications. Therefore, it is imperative that all disciplines involved should cooperate closely, exchange ideas and jointly formulate the geometric documentation requirements, while deeply understanding the monument itself and each other's needs.

CONTRIBUTION OF GEOMATICS

The rapid ICT advancements have provided today's scientists with powerful new tools. We are now able to acquire, store, process, manage and present any kind of information in digital form. This can be done faster and more completely than before, and it can ensure that the information is easily available for a larger base of interested individuals. Those digital tools include instrumentation for data acquisition, such as scanners, digital cameras, digital total stations etc., software for processing and managing the collected data and – of course – computer hardware for running the software, storing the data and presenting it in various forms.

The introduction of digital recording technologies for geomatics applications can contribute to all steps of traditional archaeological practice, although the extent of ICT's contribution differs in the various stages and in the various cases. Modern technologies

Figure 2, Examples of contemporary data acquisition instrumentation (digital single-lens reflex [DSLR] cameras, the FARO Focus 3D and the ZScanner 700 CX).

of remote sensing and archaeological prospection assist the touchless and rapid detection of objects of interest even before digging. Spectroradiometers or ground penetrating radar, or even the simple processing of multispectral satellite images, may easily lead to the rapid location of underground or submerged objects of interest. Contemporary non-contact survey technologies, such as photogrammetry, terrestrial laser scanning and digital imaging, can be used to produce accurate base maps for further study, or 3D virtual renderings and visualisations. The collected data may be stored in interactive databases, either georeferenced or not, and be managed according to the experts' needs. Last but not least, ICT can assist in the presentation stage, by producing virtual models that may be displayed in museums or be included in an educational gamification application or enable disabled people to admire the treasures of the world's cultural heritage, for example. Since 2003 UNESCO mandates the use of digital technologies in the preservation and curation of cultural heritage. With its Charter on the Preservation of the Digital Cultural Heritage, this global organisation proclaims the basic principles of digital cultural heritage for all civilised countries of the world. At the same time, numerous international efforts are underway with the scope to digitise all aspects of cultural heritage, whether large monuments, tangible artefacts or even intangible articles of the world's legacy (Stylianidis & Remondino 2016).

The instrumentation necessary to support heritage conservation activities should always be at the cutting edge of technology. Modern instrumentation includes data acquisition instruments (Figure 2), processing software and powerful computers. Data acquisition instruments should include devices which are capable of digitally collecting (i) images or image sequences, (ii) points in 3D space and (iii) other pieces of information related to cultural heritage objects.

The impact of digital geoinformation technologies on the cultural heritage domain has increased the speed, objectivity and automation of the procedures which involve processing of the digital data and presentation of the results. At the same time, accuracy and reliability have been substantially enhanced. However, most important is the ability to provide users with new and alternative products, which include two-dimensional and three-dimensional products, such as orthophotos and 3D models. The use of 3D models is becoming increasingly common nowadays in many aspects of everyday life (cinema, advertisements, games, museums, healthcare, etc.). Overall, the tangible and intangible digitisation of the world's cultural heritage is now possible.

DATA ACQUISITION & PROCESSING

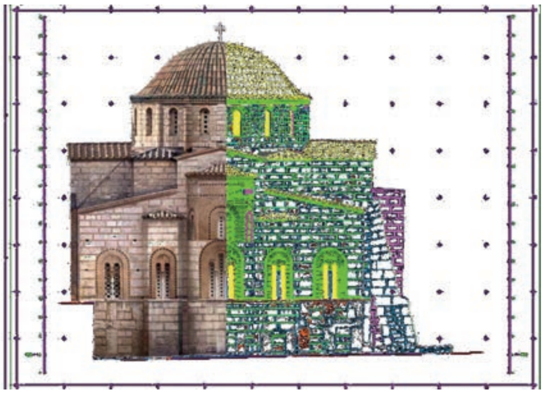
Recording techniques are based on devices and sensors which perform the necessary measurements, either directly on the object or indirectly by recording energy reflected from the object. In the latter category, one can broadly distinguish between active and passive sensors. Active sensors send their own radiation to the object and record the reflectance, while passive ones rely on the radiation sent to the object from some other source. Usually, the latter are image-based sensors which record the visible light reflected from the objects of interest. Rapid technological progress has provided scientists with sophisticated instrumentation including calibrated high-resolution digital cameras, digital high-resolution video recorders, accurate angle and distance measuring devices, GNSS receivers, terrestrial laser scanners, 3D non-laser scanners for small artefacts, film scanners and printed document scanners. Moreover, instrumentation such as thermal and range cameras, material sampling devices and ultrasonic non-destructive inspecting instruments are also contributing to data acquisition. Terrestrial image-based surveying comprises all those methods, techniques and technologies that use images to extract metric and thematic information from the object in question. The main focus nowadays is on digital cameras and sensors, the contribution of the unmanned aerial vehicles (UAVs), remotely piloted aircraft systems (RPASs) or unmanned aerial systems (UASs), and also the useful role that image-assisted total station (IATS) technologies are playing in the recording, monitoring and documentation of cultural heritage (Figure 3).

Figure 3, A typical UAS carrying a DSLR camera.

Processing of all acquired multi-source data includes positioning calculations, processing of the digital images or image sequences and working with point clouds. For these actions, related software has been developed to cover all possible needs. The processing stage is supported by powerful computing units that are available today. Processing usually aims to store, archive, manage, visualise, present and publish the collected data and the information derived. In recent years, many research efforts have been directed towards multi-image matching techniques, thus complementing terrestrial laser scanning technology.

▲ *Figure 4, Lost heritage retrieved from crowdsourced data. (RecoVR Mosul Exhibition, courtesy: Nichon Glerum)*

Common image-based 3D modelling of the current state of a monument requires data acquisition in the field. Surveying, photogrammetry and laser scanning techniques can be combined to produce a full and accurate 3D model of the object. Modern photogrammetry and computer vision techniques manage to create realistic and accurate 3D models of objects of almost any size and shape by combining robust algorithms and powerful computers. Multiple images depicting the object from different viewpoints are needed and the so-called structure from motion (SfM) and multi view stereo (MVS) procedures are implemented (Figure 4). However, these images do not necessarily have to be captured by calibrated cameras; compact or even smartphone cameras can also be used. A variety of recent studies examine the creation of 3D models of cultural heritage objects and sites with the use of SfM algorithms (Remondino et al. 2012). The lack of images or other surveying data, especially in cases of lost cultural heritage objects, has led to the use of random, unordered images acquired from the web. Some recent studies deal with the 4D (space-time) virtual reconstruction of cultural heritage objects using web-retrieved images (Stathopoulou et al. 2015).



▲ *Figure 5, Combination of traditional 2D line drawing and orthoimage (Georgopoulos et al. 2004).*

▲ *Figure 6, Textured 3D model (Tryfona & Georgopoulos 2016).*

This interrelation between heritage objects and their geographic location is extremely important nowadays and has bridged the gap between geoinformatics and monument preservation. A geographic information system (GIS) is the scientific tool with which monuments and related information can be connected to a place, and this has led to the evolution of monument information systems (MISs). However, the connection of intangible information to tangible cultural heritage is highly important and definitely required. Hence intangible cultural heritage can also be 3D digitised and may also be linked to location, while important attributes of both forms of cultural heritage are preserved and interrelated at the same time.

ALTERNATIVE PRODUCTS

Contemporary digital technologies have made alternative documentation products possible. Initially the conventional line drawings were enriched with orthophotos (Figure 5), carriers of rich qualitative and quantitative information. The interpretation of the necessary information can be carried out on these products by any interested experts at will. The virtual environment of computers has opened new horizons in terms of alternative products. Realistic 3D textured models (Figure 6) are common nowadays and can be used for visualisations, for virtual visits and for development of serious games (Kontogianni et al. 2016) which push cultural heritage documentation into the realm of 'edutainment'. Moreover, virtual restorations (Valanis et al. 2009) and virtual reconstructions can be used to help experts to reach the correct decisions

FURTHER READING

A. Georgopoulos, C. Ioannidis, A. Daskalopoulos and E. Demiridi. 3D Reconstruction and Rendering for a Virtual Visit, International Congress of ISPRS, Istanbul, July 2004. http://www.isprs.org/proceedings/XXXV/congress/comm5/papers/629.pdf

Kontogianni, G., Koutsaftis, Ch., Skamantzari, M., Georgopoulos, A., Chrysanthopoulou, Ch., 2016. Developing and Exploiting 3D Textured Models for a Serious Game Application. VS-Games 2016, IEEE conference, Barcelona.

Remondino, F., Del Pizzo, S., Kersten, T. P., Troisi, S. (2012). Low-cost and open-source solutions for automated image orientation – A critical overview. In *Progress in cultural heritage preservation* (pp. 40-54). Springer Berlin Heidelberg.

Stathopoulou, E. K., Georgopoulos, A., Panagiotopoulos, G., Kaliampakos, D., 2015. 3D Visualisation of Lost Cultural Heritage Objects Using Crowdsourcing. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-5/W7, 2015 25th International CIPA Symposium 2015, 31 August - 4 September 2015, Taipei, Taiwan.

Stylianidis, E., Remondino, F. (eds.), 2016. *3D Recording, Documentation and Management of Cultural Heritage*. Whittles Publishing, ISBN 978-184995-168-5, 388pp.

Tryfona, M.S. and Georgopoulos, A., 2016. 3D Image Based Geometric Documentation of the Tower of Winds. ISPRS-International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, pp.969-975.

Valanis, A., Tapinaki, S., Georgopoulos, A. C. Ioannidis, 2009. High Resolution Textured Models for Engineering Applications. Proceedings XXII CIPA Symposium, 11-15 October 2009, Kyoto, Japan. http://cipa.icomos.org/text%20files/KYOTO/164.pdf.

after examining numerous alternative solutions in the virtual environment. Finally, augmented reality and virtual reality implementations help visitors to 'see' cultural heritage ruins in their original state, thus increasing their appeal, especially among younger generations.

CONCLUDING REMARKS

It has been shown that digital contemporary technologies can contribute decisively to the conservation of cultural heritage. The final products are 3D models and virtual restorations or reconstructions of monuments that either no longer exist today or are at risk. Consequently, digital technologies and interdisciplinary synergies are of utmost importance. Equally important are the discussions and suggestions of scientists who have studied the monuments from a historical and archaeological point of view, proving once again that such interventions are a multidisciplinary process.

On the other hand, virtual reconstructions, virtual restorations, monitoring and 3D models support many other disciplines involved in cultural heritage. They help architects and structural engineers in their work for monuments especially in cases of restoration, anastylosis, etc. Archaeologists and conservationists have a very good tool at their disposal for their studies. Many applications can be generated from a virtual reconstruction, such as virtual video tours of the monument for educational and other purposes for use by schools, museums and other organisations, for incorporation into a GIS for archaeological sites, for the design of virtual museums and for the creation of numerous applications for mobile devices (e.g. smartphones, tablets, etc.).

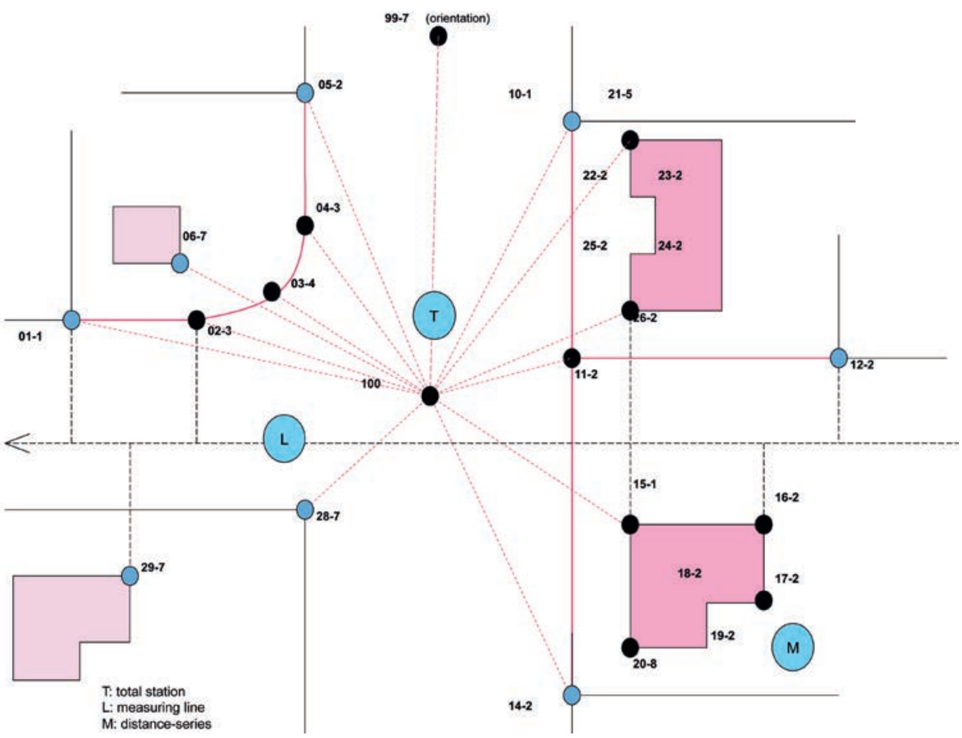
ANDREAS GEORGOPOULOS

Dr Andreas Georgopoulos is professor of photogrammetry in the School of Rural & Surveying Engineering (R&S Eng) at the National Technical University of Athens (NTUA) in Greece. He graduated from the School of R&S Eng (1976) and obtained a diploma (1977) and an MSc and later a PhD (1981) in photogrammetry from University College London (University of London). Since 1985 he has been a faculty member of NTUA and teaches photogrammetry and courses on metrology, photographic data acquisition, monument surveys, etc. He has been director of the Laboratory of Photogrammetry since 1996 and has served as vice-head (1998-2002) and head (2002-2006) of the School and vice-president of the NTUA Research Committee (2006-2010 and 2014 to date). Since 2005 he has been an executive board member of CIPA Heritage Documentation; he served as secretary general (2011-2014) and has been president since 2015. Since 1985 he has participated in all research projects of the Laboratory of Photogrammetry concerned with photogrammetry, architectural photogrammetry and monument recording, digital and analytical photogrammetry and cadastral applications. Since 2010 he has been teaching in the ARCHDOC workshop in the RLICC at KU Leuven for the postgraduate course for monument preservation, and has been a visiting professor to the Cyprus Institute (STARC) and CUT (2010-11). He has published more than 200 scientific articles in conference proceedings and peer-reviewed journals on subjects concerned with photogrammetry, geometric recording of monuments, digital photogrammetry and automation techniques. His research interests focus mainly on geometric recording of monuments using contemporary techniques.

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. Here, the authors investigate 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.



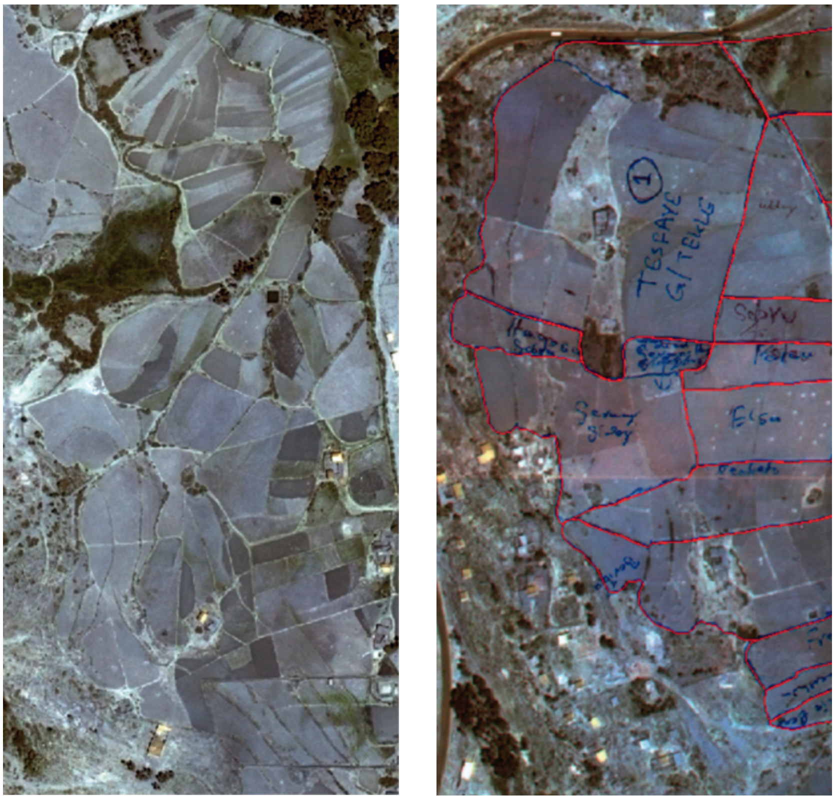
▲ *Figure 1, Results from a conventional cadastral survey - with total station and measuring line (courtesy Berry van Osch).*

USING IMAGERY

In the last few years, there has been considerable buzz surrounding 'fit-for-purpose land administration'. The approach argues for cost-effective, time-efficient, transparent, scalable and participatory systems. The philosophy is driven by the idea that, in many situations, it is sufficient to identify visual boundaries based on imagery. This means making use of photographs, images or topographic maps in the boundary adjudication and mapping activities. Alternatively, apps on mobile devices can be combined with imagery to identify plots, thus avoiding misinterpretation of visual boundaries on the image. Images can be collected from satellites, traditional aircraft or unmanned aerial vehicles (UAVs). In cases of high land values or intensive land use, the field surveys can be conventional land surveys using high-precision total stations or GNSS (Figure 1).

STANDARDISING MODELS

Alongside the push for the increased use of imagery, global standards such as the Land Administration Domain Model (LADM) focus on standardised modelling of information at the conceptual level. The model does not include processes for initial data acquisition, data maintenance and data publication. This is because those processes were considered to be country-specific when the first edition of LADM was prepared; a generic and global approach was likely to be difficult to model. This view now needs reconsideration, however. The fit-for-purpose land administration approach arguably allows for identification of more generic process-related modules in data acquisition and data handling (Figure 2). Standardisation can also make it easier to monitor the progress of global indicators relating to land tenure security.



▲ Figure 2, Imagery supports participatory and fit-for-purpose approaches for collecting evidence on the location of boundaries in the field.

FOCUSING ON PROCESSES

So what are some of these processes that might be supported? Examples include initial data acquisition, georeferencing (based on elevation models), identification of boundaries, surveying (based on imagery, conventional surveys, UAVs, digital pens for imagery and handwriting, feature extraction/data cleaning, radar), area management, linking rights, restrictions and responsibilities (RRRs) to spatial units, linking (groups of) persons to (shares in) RRRs, public inspection, publication of land data, formalisation, map renovation and quality improvement and digital archiving. Computerising large sets of legacy data (maps and archives) requires analogue-to-digital conversion, georeferencing and linking to digital data from other sources. Data may be used for taxation, tenure security purposes, slum upgrading, city management and so on. This also includes land use and zoning plans implemented by land consolidation and land readjustment processes. Statistical information such as fragmentation index and price index may need to be derived from the land administration. Imagery may be available on paper or on mobile devices in the field, or both.

CREATING A TENURE ATLAS

Another challenge in many countries is that several authorities may play a role in the process of recognising, recording, registering and managing the land tenure, and they may each maintain their own land information sets. Therefore, at national level, coordination is needed; a Land Tenure Atlas could be developed to provide an overview of the spatial distribution of legitimate tenure types throughout a country – be they customary, informal, private, public or otherwise. The Atlas may further include a layer for national and administrative boundaries and potentially a layer for planned and ongoing projects in land administration. The Atlas should be able to be aggregated to global level, enabling linkage to proposals for international data exchange representing the different RRRs in use within countries.

UTILISING DEVICES

Surveyors and geoprofessionals focus on geometric accuracy, and this focus should result in quality labels identifying the relative and absolute accuracy of geometric data. This is relevant for later adjustment and integration of data from different sources collected with different instruments and tools in different approaches. But land administration is not only about geometric data. Talking about quality in land administration means not only talking about geometric accuracy, but also about 'linking' between polygons (spatial units) and people (right-holders). It would be nice if functionalities could be combined in one single device, i.e. linking functionalities for image-based data acquisition to handheld GPS, biometric data (fingerprint identification and facial recognition) and voice/video recording in support of object identification (Figure 3). Such devices would also be useful for inspections, for fieldwork related to building and construction permits, for cadastral maintenance, etc. Land data collected on many devices could deliver results in formats based on operational standards.

INTEGRATING WITH OGC

The Open Geospatial Consortium (OGC) recognises that worldwide, effective and efficient land administration is an ongoing concern, inhibiting economic growth and property tenure. Existing approaches are at significant risk of data loss and failure due to disasters and lack of interoperability. The charter members of an established OGC Land Administration Domain Working Group are seeking to identify enabling standards and best practices to guide countries in a programmatic way towards establishing more cost-effective, efficient and interoperable land administration capabilities. Attention will be paid to upgrading currently manual processes to semi-automated ones, and to suggesting ▸

▲ *Figure 3, Handheld devices allow cadastral data collection with sub-metre accuracy providing correction signals can be accessed.*

new approaches for data acquisition that are more automated and flexible. These challenges are faced today in 'developing' and 'developed' countries alike.

DEVELOPING COOPERATION

Enabling standards are also being developed with other domain working groups within OGC, such as LandInfra. Partnerships and liaisons with other associations and standards developing organisations (SDOs) will be developed to address interoperability issues that span the land administration community of practice, geographic information systems and the broader IT environment. Examples include linkages with ISO TC 211 regarding the LADM as well as those SDOs responsible for IT standards related to topics such as security, the internet and mobile services. Further, the DWG will be open to participation by any interested organisations and individuals.

INDUSTRIALISING APPROACHES

The geospatial industry provides tools, products and services in support of a number of important processes required in fit-for-purpose land administration. Image-based acquisition of cadastral boundaries needs access to huge image libraries – including historic imagery – to support large-scale implementations. Detection and selection of cloud-free imagery is needed to create cloud-free compositions, possibly from different sensors. By using orthophotos to produce spatial frameworks, the imagery is typically linked to the national geodetic reference frame through GNSS in space/on the aircraft and on the ground. Furthermore, automated feature extraction and feature classification appear to be very promising developments for the generation of coordinates of visual objects from imagery, and Lidar and radar technologies can also be used for this purpose. 'Pre-defined' boundaries resulting from feature extraction may be plotted on paper or visualised in interfaces, and can then be declared identical to cadastral boundaries in the field.

MODERNISING DEMARCATION

In general, fixing boundaries should be avoided in the preliminary stages. It has been shown that demarcation with monuments or beacons often takes 80 to 90% of the surveyor's time. If demarcation is an absolute requirement, let people place the beacons themselves. Otherwise, it is a good idea to explore modern demarcation methods – smart markers could provide a good alternative. Modern markers like the traceable 3D radio frequency identification (RFID) markers can be detected and identified from a distance of several metres using a simple smartphone. The RFID in the marker can store administrative and positional data. It eliminates all known drawbacks of traditional markers. They could be used as main markers or georeferenced markers, supplemented by locally surveyed points demarcated with low-cost materials. RFID boundary marker strips cost less than EUR1 to produce – although that does not necessarily make it affordable in some countries, of course.

UTILISING UAVS

UAV or 'drone' technology is rapidly developing, although autogyro platforms may represent another possible solution for aerial image capturing. Such platforms can operate at low to medium heights, thus largely eliminating the risk of images being obscured by cloud. In some cases, walking can be an alternative to low-altitude flying, e.g. using a portable 3D laser scanning device, the surveyor can map a strip extending 200 metres to each side of the trajectory on foot.

HANDLING THE LOGISTICS

Processes such as initial data acquisition may concern millions of spatial units (parcels) for which people-to-land relationships have to be determined. The organisation of this process requires geospatial support in logistics and case/task management based on geoinformation. This starts with gaining an overview of the density of information. This is about estimating the amount of spatial units in a project area for planning purposes. Provision of materials and tools to data collectors can involve paper-based or digital approaches.

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A paper-based approach entails using plotted images in the field. This means that the collected field-boundary evidence can be left with the local people, providing a scan is available for the land administration authority. However, even paper-based approaches require a comprehensive range of geospatial technologies. Logistics activities include the processes of creating awareness of and announcing participatory approaches, agreeing on citizens' roles in the land administration process, and publishing status information online/offline, as well as performing checks on completeness before leaving a location. Collecting copies of people's ID, photos, signatures, fingerprints and video/voice recording requires field devices and battery power/electricity.

HANDLING MAINTENANCE

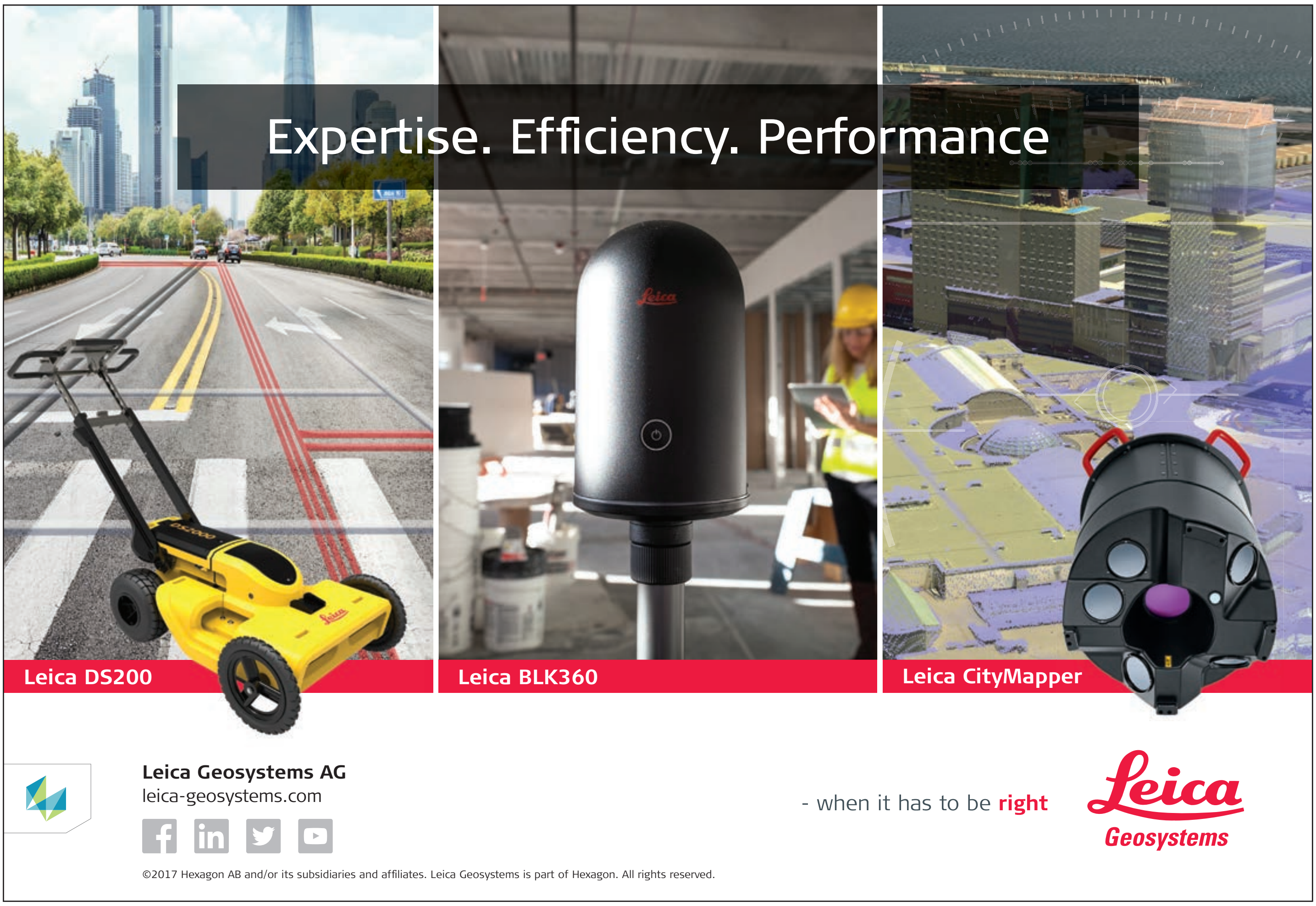
Data maintenance can be 'programme driven' (systematic) or 'sporadic'. 'Programme driven' means a complete and systematic new acquisition after some time. 'Sporadic' means case by case in a 'transaction-driven' way and relates to transactions in the land market (buying/selling, mortgaging, etc.). Quality upgrading can be part of the maintenance process. This may be required after digitisation of legacy data or in the case of urbanisation or urban planning. It is crucial that data collected using survey approaches based on different accuracies can be integrated together. This may require adjustment of new observations to existing coordinates in the field or within GIS. Quality upgrading may also entail integration of 3D cadastral data (this includes integration with standards such as IndoorGML, InfraGML, LandXML, CityGML, BIM/IFC) and marine cadastre.

CONCLUDING REMARKS

Implementation of all the processes presented here is currently undertaken in different places based on customisation from available databases and GIS technology. This is a time-consuming activity which demands GIS and ICT development expertise. Standardisation is required for those processes and needed in order to bring scalable approaches – ones which can be easily implemented based on the defined purposes of each land administration project. ◂

FURTHER READING

- Enemark, Stig, McLaren, Robin, Lemmen, Christiaan, 2015: Fit-For-Purpose Land Administration – Guiding Principles. UN-HABITAT/GLTN, Nairobi, Kenya
- *GIM International*, 2016. Special Issue on Fit-for-purpose Land Administration for Sustainable Development. Geomares Publishing, Lemmer, The Netherlands
- OGC, 2016, Domain Working Group (DWG) Charter Land Administration. Open Geospatial Consortium. http://www.opengeospatial.org/projects/groups/landadmin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Advancing Smart Farming Thanks to Geospatial Technologies

Tractor working in a farmer's field using GNSS.

The Netherlands' agricultural exports have hit a new high. In 2016, a record EUR85 billion worth of farming products were shipped around the globe, making the country (with an area of only 41,543km^2!) the second-largest exporting nation in the world. Precision agriculture, also known as 'smart farming', is likely to further boost these export activities significantly in the coming years, as geospatial technologies help farmers to continue to increase their production.

▸ **http://bit.ly/2kPCCnV**

Cadastral Boundaries from Point Clouds?

Overview of automated extraction results overlaid on imagery from a sample region.

Proponents of the new era for land administration argue that countries must explore alternatives to accelerate land administration completion. As an example, fit-for-purpose land administration is based on the use of printed imagery, community participation and hand-drawn boundaries. Digital solutions then convert the generated analogue data into useful digital information. However, the approach is manually intensive, and simple automation processes are continually being sought to cut time and costs. One approach gaining traction is the idea of using image processing and machine learning techniques to automatically extract boundary features from imagery – or point cloud data – prior to even entering the field. The approach could speed up activities both in the field and in the office. Read on for insight into the ongoing developments.

▸ **http://bit.ly/2jQPA4m**

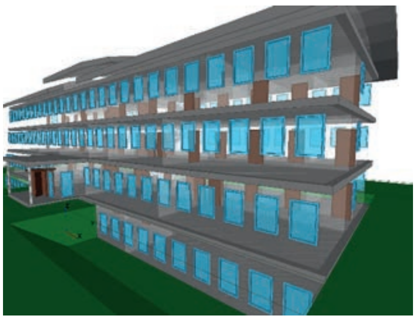
Investigation of 3D Modelling Techniques

Photorealistic modelling.

The rapid developments in the fields of photogrammetry, laser scanning, computer vision and robotics provide highly accurate 3D data. 3D models that can be created from such types of data are extremely effective and intuitive for present-day users who have stringent requirements and high expectations. Depending on the complexity of the objects for the specific case, various technological methods can be applied. Read on for a comparison of three technologies, based on real projects, including an assessment of their suitability for web-based visualisation of numerous objects of interest.

▸ **http://bit.ly/2jyxdR3**

The Need to Integrate BIM and Geoinformation



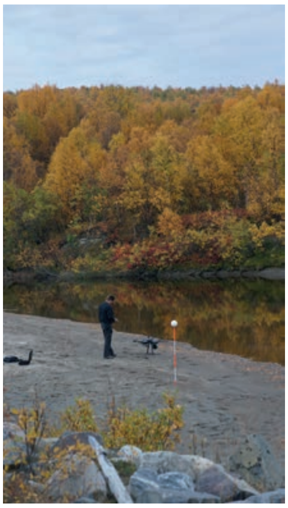
Semantic selection of windows from a BIM.

In the construction industry, business relationships are often short term and one-off. There are many unique processes and activities. The resulting complexity and fragmentation may obstruct quick and effective exchange and integration of information and thus hamper project progress. Building information modelling (BIM) is aimed at preventing mismatches in information exchange between the many stakeholders. Although BIM has come a long way in this respect, there are still challenges to overcome.

▸ **http://bit.ly/2kLOmKD**

The Current State of the Art in UAS-based Laser Scanning

Airborne laser scanning (ALS) offers a range of opportunities for mapping and change detection. However, due to the large costs typically associated with traditional ALS, multi-temporal laser surveys are still rarely studied and applied. Unmanned aerial systems (UASs) offer new ways to perform laser scanning surveys in a more cost-effective way, which opens doors to many new change-detection applications. What are the differences in suitability between the two main types of UAS platforms – fixed-wing systems and rotorcraft – and what is the current state of the art in UAS-compatible laser scanning systems? Read this article to find out.



Launching a UAS for a topographic laser scanning mission.

▸ **http://bit.ly/2kmuJJQ**

Future Trends in Geospatial Information Management

The most significant changes in the geospatial industry in the next decade will come not through a single technology, but rather from linking multiple technologies together. Especially the development of big data analytics will boost smart use of the location component to integrate data from many sources. The United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) sees precise location information forming a core part of tomorrow's all-connecting IT infrastructure. Read this article for UN-GGIM's insights into the trends over the next five to ten years.

The UN-GGIM report.

▸ **http://bit.ly/2kc8Pqj**

Geomatics Provides Truth about the Physical World

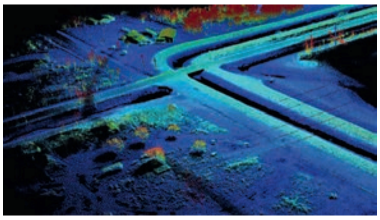
New digital technologies are changing our industry. Or is it the other way round? Is the future of geomatics a virtual one? Will surveying soon be done in digital realities? Future opportunities may be beyond the realms of our current geospatial imagination, but what's in it for the geomatics industry? Read this interview with renowned futurist Tom Cheesewright to find out what he foresees for the digital era and how disruptive those changes will be.

Tom Cheesewright.

▸ **http://bit.ly/2jQzNTg**

9 Revolutionary Lidar Survey Projects

The history of Lidar goes back to the 1960s. In 1969, a laser rangefinder and a target mounted on the Apollo-11 spacecraft were used to measure the distance from Earth to the moon. Now, more than four decades later, Lidar has become a fundamental technology in the geospatial sector. *GIM International* has compiled a list of nine inspiring and spectacular Lidar projects that show the almost unlimited possibilities Lidar offers the geomatics world.



Airborne Lidar.

▸ **http://bit.ly/2hpSZch**

UAS-based Lidar: A Market Update

One of the most eye-catching developments in the surveying profession is the integration of unmanned aerial systems (UASs) and Lidar. Airborne laser mapping is no longer restricted to traditional aircraft only, but is now also available for unmanned aerial vehicles. UAS-based Lidar is particularly interesting for surveys carried out over relatively small areas. The quality of the captured data – i.e. point clouds – depends on the sensor performance and the flight-path accuracy. *GIM International* has selected some examples of available solutions for UASs and Lidar.

Lidar system mounted on a UAS.

▸ **http://bit.ly/2ilz5Gw**

Solving Societal Problems with Smart Cities

The world population is growing rapidly, putting urban planning under increasing pressure. Cities are facing challenges such as how to improve the environment and how to reduce the impact of congestion. The smart city concept seems to offer a solution. Reflecting the fact that smart cities are built on geospatial foundations, Intergeo – the world's largest annual trade show for the geomatics industry – chose smart city as its key theme this year. To gain insights from an urban planning insider, *GIM International* interviewed Martin Powell, head of urban development at Siemens.

Martin Powell.

▸ **http://bit.ly/2jqrRvN**

UAVs: The Deceptive Rise to Disruption in the Geospatial Industry

The period where exponential growth remains unnoticed following the inception of innovation is classified as 'deception'. The year 1849 inaugurated the birth of the unmanned aerial vehicle (UAV or 'drone'), producing a deceptive impact on the industry. Today, the use of consumer UAVs for data acquisition is quickly approaching its zenith, allowing for a broader scale of applications.

The early use of consumer UAVs typically included videography. The move towards a photogrammetric approach occurred with the influx of mapping software, aimed at small-scale photogrammetry. These applications allowed for an autonomous, easy-to-use alternative to the survey-grade photogrammetry software suites, while maintaining an acceptable accuracy. Start-up companies, including Pix4D and DroneDeploy, brought a foreseeable disruption to the industry. The result was the birth of a new market, threatening the existence of conventional photogrammetric techniques.

The impact that drones will have on the industry is yet to be fully realised. A surge in the amount of applications for consumer UAVs is predicted. Yes, start-ups have done an exceptional job in tackling the photogrammetric aspect of geomatics. However, there is still progression to be achieved, including in terms of:

• SMALL-FORMAT TOPOGRAPHIC AND BATHYMETRIC LIDAR SYSTEMS

The production of small-format Lidar scanners will allow for a fast, easy-to-use alternative to the conventional methods of hydrographic and topographic surveys. Currently, point clouds are extractable from aerial imagery using some of the aforementioned applications allowing for easy representation, but one can argue that the accuracy of these methods cannot compare to that of a Lidar scanner. With the production of bathymetric Lidar systems on the rise, it is easy to see a smaller form factor being an asset to geospatial professionals. The need for boat and echosounder rentals will be fully eliminated for small-scale hydrographic purposes.

• 360° CAMERAS

The use of 360° cameras will greatly assist the evolution of spatial representation. As the industry moves towards other outlets of spatial representation, UAVs paired with these full-field-of-view cameras will give the geospatial professional a new way of acquiring data. Consumer UAVs equipped with 360° cameras will allow for a much more realistic representation of the area being surveyed or the area to be surveyed.

• ARTIFICIAL INTELLIGENCE (AI)

UAVs integrated with AI will open up a whole new world of possibilities. The ability to command a drone to perform certain technical tasks or, in the event of a malfunction, to simply say "return to home" – and all from a remote location – will provide an added layer of versatility during the survey.

• 3D-PRINTED UAVS

The inception of 3D-printed drones will allow for a much more affordable and accessible UAV. Any mounts or gimbals needed for upcoming technologies can easily be printed and malfunctioning parts can easily be reprinted, thus eliminating the need for a new purchase and ultimately saving money for the end user.

There are a myriad of other applications that can be addressed here. However, I believe that one can now see the important role that disruption plays in the progression of an industry. The applications for drones will continue to grow as new, innovative drone and spatial acquisition technologies continue to emerge. As a community, it is our duty to embrace these new approaches as they will allow for the continuous growth of our industry.

Jonathan McCollin is a final-year student at the University of the West Indies, St. Augustine Campus, pursuing a bachelor of science in geomatics engineering. He is currently working towards being an inimitable catalyst of exponential technologies in the geomatics industry.
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