The Land Tool Box is Full

Enemark, Stig

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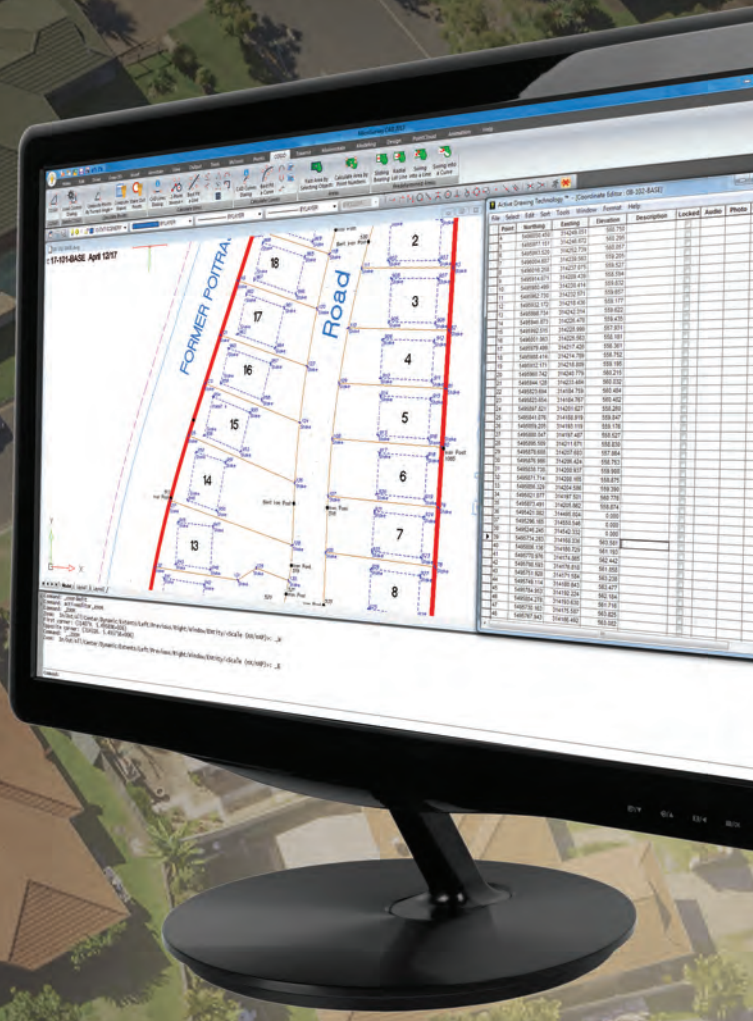

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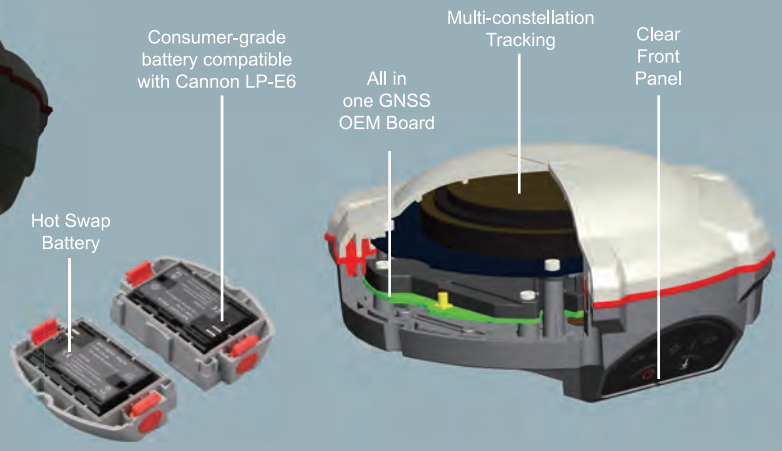
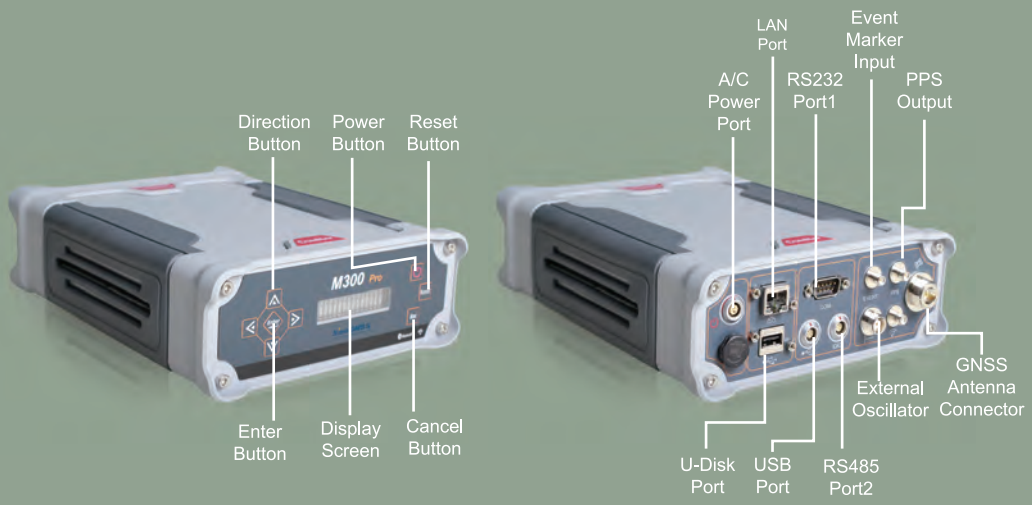
The front cover of this issue of *GIM International* shows the challenging task of surveying a tunnel. Switzerland-based company Amberg Technologies supports tunnelling in all construction phases. The company combines precise measuring instruments with task-specific software. In this issue we focus on the very latest technologies used in professional land surveying.
(Image courtesy: Amberg Technologies)

GNSS RECEIVER T300

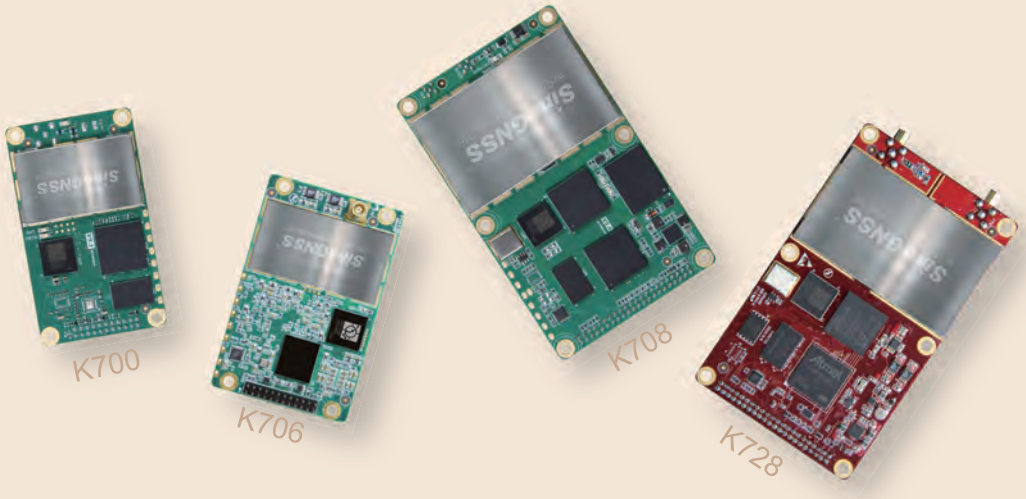


THE NEXT LEVEL RTK

GNSS RECEIVER M300 Pro



THE NEXT GENERATION CORS RECEIVER



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The Netherlands
T: +31 (0) 514-56 18 54
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Good mapmaking for small and big

Maps are making the world a better place! This was the motto of Professor Menno-Jan Kraak during his keynote at the opening of the 28th International Cartographic Conference (ICC) in Washington, DC. The conference, held from 2-7 July in the national capital of the United States, brought close to a 1,000 cartographers together from all over the world. In the midst of summer, Washington is a hot place and the fact that 4 July, the national holiday, fell in this week, made it a happening place as well. The conference was centred around numerous themes that were all highlighted in a great number of presentations. The themes included big data, remotely-sensed data for mapping and feature extraction from Lidar, open source mapping, cadastral mapping, geospatial intel, geo-visualisation, spatial analysis, 3D mapping and design of maps.

The beauty of maps has always amazed me. In my office I am surrounded by maps, although I have to admit they're all old, but still… I am always looking at maps on the internet, in magazines and newspapers, because one map can say more than a thousand words. I am always aware though that every map could have been designed in another way or projection and that colour, size or scale has an effect on how the map is perceived. That effect, which is indeed very big, is an effect which is taken very seriously by the cartographic community. Rightfully so. The number of errors in maps can increase dramatically if cartographers are no longer well educated or don't understand the basics of geography, geodesy, visualisation, maybe even psychology and user design. Needless to say, this makes good cartographic education necessary also in the future, but also complex. Surely the cartographer-to-be needs to be educated in all those fields, will need to gather skills to be able to combine the factors and absolutely needs to be trained in his position as gatekeeper when it comes to quality of maps.

Throughout the week, the whole ICC conference emphasised the importance of all this and the higher goal it serves. Because when it comes to establishing higher goals, the fair distribution of resources, food security, welfare, yes even securement of democracy (when maps can no longer be trusted, what does that say about the governments who issue them?) even the most insignificant map published needs to be correct. Every visualisation of demographics in newspapers or online such as the prevalence of certain conditions or ageing of population or the outcome of elections, for instance, is required to give the right impression of the facts. Monitoring the progress in reaching the Sustainable Development Goals set by the United Nations, is an example of where good mapmaking will come into place. Giving policymakers all over the globe insight into how they are doing, implementing new policy to meet the goals as soon as possible, and helping them to adjust where necessary. There's no big or small in the necessity of good mapmaking, every good map will make the world a better place.

▲ *Durk Haarsma, publishing director.*

The Land Toolbox Is Full

Within the land sector, we all know the stories about ambitious land administration projects that have generally failed … they were too costly, too time consuming and too demanding in terms of capacity. It was not possible to keep up the political momentum, and the push for change to existing legal and institutional arrangements eventually faded. Barriers also relate to vested interests from land professionals.

However, we are facing new times. Over the last ten years a whole range of new land tools have emerged, and technology developments have fostered opportunities for quick and affordable land parcel mapping as well as easy management of large-scale land information.

Today we have reached a global consensus around the continuum of land rights as promoted by GLTN/UN-Habitat, and the Social Tenure Domain Model (and other similar tools) enables registration of informal and legitimate land rights at local level that can eventually be recognised and registered as formal and legal rights. Furthermore, the Gender Evaluation Criteria offer a flexible tool to improve the rights of women and other vulnerable groups.

The UN Committee on World Food Security, through FAO, has developed and promoted the Voluntary Guidelines on Responsible Governance of Tenure that provide internationally accepted standards and best practices for dealing with rights in land, land value, land use, and land development. The Guidelines are globally recognised and set the scene for building sound and sustainable land institutions.

▲ *Stig Enemark.*

Mapping techniques, whether photogrammetry, satellite, drones, or hand-held GPS, are developed to a stage where traditional land parcel surveys are no longer a constraint in large-scale land projects. Time as well as costs have been seriously reduced. Furthermore, the Open Geospatial Consortium is taking the lead in creating new standards for comprehensive land information management in support of sustainable land administration.

The World Bank has developed a framework for assessing national land administration systems as a basis for innovation, improvement and capacity development.

Finally, a comprehensive 'Fit-For-Purpose' tool has emerged that provides an overall framework for quickly delivering affordable, nationwide land administration solutions. The tool was developed by FIG and the World Bank and further unfolded by the recent publication from GLTN / UN-Habitat providing advisory guidelines for country implementation. This comprehensive tool looks at applying the spatial, legal and institutional methodologies that are most fit for the purpose of providing secure tenure for all by addressing the current constraints and allowing for incremental improvement over time.

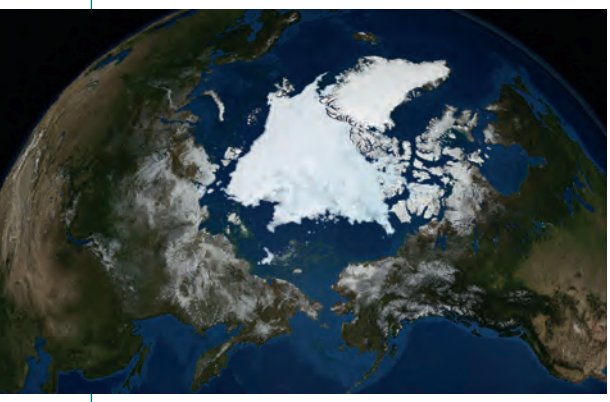
Against this backdrop, it looks like the land toolbox is full and ready for use – and the timing is apt. The 2030 Global Agenda, the Sustainable Development Goals, have highlighted the key role of secure land rights in achieving many of the global objectives. Land issues are currently high on the political agendas. Therefore, the timing appears to be right to initiate a global campaign to close the security of tenure gap.

Let's get to work.

OGC Publishes Results of International Arctic Spatial Data Pilot

The Open Geospatial Consortium has published the results from the Arctic Spatial Data Pilot (Arctic SDP). The results, including reports, demonstration videos and interviews, are available at the consortium's website. Additionally, the OGC is now exploring options for the next phase of the Pilot. The Arctic SDP, an 18 - month project, was initiated to demonstrate the diversity, richness and value of providing geospatial data using international standards in support of seamless spatial data exchange with application to a range of Arctic topics. Eight scenarios were used to demonstrate a solution to a key aspect of environmental and resource management in the Arctic: from permafrost melt, to shipping routes, from search & rescue, to food security, and more.

▸ **http://bit.ly/2ugvNSf**



Arctic seen from space (Courtesy: NASA).

Bluesky Launches Nationwide Map of Building Heights

Aerial mapping company Bluesky has launched the first UK nationwide map providing accurate height measurements for around 40 million buildings. Created from a combination of remote sensing surveys, including data from aircraft mounted lasers (Lidar), the Bluesky Heighted Building dataset covers the whole of England, Wales and Scotland, and will help to change the way we visualise and understand the built environment. By applying height values to 41,083,111 buildings, Bluesky is giving planners, developers, local government, utility companies and the emergency services a brand new perspective. Including multiple values for every residential, leisure, retail, commercial and industrial structure in mainland UK, the Bluesky Heighted Building dataset will provide new intelligence to underpin decision making and service delivery.

▸ **http://bit.ly/2uP8d1M**

Bluesky Heighted Building dataset.

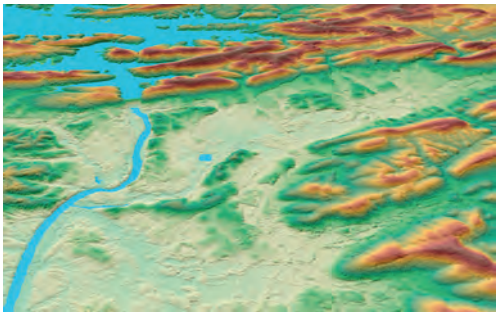
Esri and Microsoft Join Forces on Artificial Intelligence

Land cover mapping is a critical part of conservation planning, but current methods for collecting detailed geographic data are highly labour-intensive. Advanced technologies like artificial intelligence (AI) can help but are not yet widely accessible to those on the front lines of conservation and mapping. That is why Esri announced a collaboration with Microsoft to provide greater access to these technologies through a newly aligned grant process. Spatial analytics is a crucial part of conservation, because it is an inherently geographic field, said Jack Dangermond, Esri founder and president. Understanding environmental data in the context of location is necessary when making decisions about protecting fragile ecosystems. The ability to analyse the vast quantities of data present in our environment is critical, and this collaboration allows conservationists to do their job more accurately than ever before on a wider scale.

▸ **http://bit.ly/2taB4xl**

Microsoft will deliver AI technology to Esri.

Airbus Releases Elevation Model for Global Orthorectification



WorldDEM imagery.

Airbus Defence and Space has expanded its WorldDEM portfolio with the launch of WorldDEM4Ortho. Tailored for orthorectification of high and very high - resolution optical and radar satellite data, WorldDEM4Ortho will enable corrections of all distortions induced by the topographical variations of the Earth's surface and satellite orientation when acquiring an image. WorldDEM4Ortho covers the Earth's entire land surface and is one of the most consistent and accurate elevation models for orthorectification on a global scale. Without these geometrical corrections, satellite images cannot be used in Geographical Information Systems or for any mapping related applications. With the huge development of new geolocated applications like business analytics, location-based services or tourism, the needs for such a consistent and precise elevation model are exploding.

▸ **http://bit.ly/2uFyr6v**

Another Eight Satellites for Galileo Constellation

Europe's Galileo navigation constellation will gain an additional eight satellites, bringing it to completion, thanks to a contract signed today at the Paris Air and Space Show. The contract to build and test another eight Galileo satellites was awarded to a consortium led by prime contractor OHB, with Surrey Satellite Technology overseeing their navigation platforms. This is the third such satellite signing: the first four In Orbit Validation satellites were built by a consortium led by Airbus Defence and Space, while production of the next 22 Full Operational Capability (FOC) satellites was led by OHB. These new batch satellites are based on the already qualified design of the previous Galileo FOC satellites, except for changes on the unit level – such as improvements based on lessons learned and reacting to obsolescence of parts.

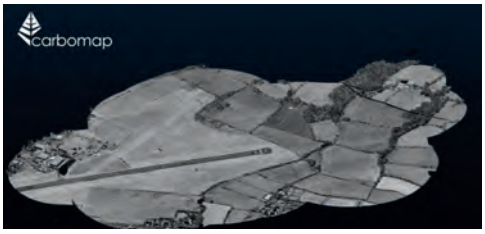
▸ **http://bit.ly/2tvwMRi**

Galileo satellites.

Carbomap to Map with Advanced Lidar UAS Solution

Carbomap, an environmental survey company, in collaboration with high-performance Lidar manufacturer RIEGL, UAVE and the University of Edinburgh, have announced the first successful demonstration flight of a RIEGL VUX-1LR survey-grade waveform laser scanner on a fixed wing, long range unmanned aerial vehicle (UAV). This is likely the first time that such a high-performance scanner has ever flown on a fixed wing UAV with such an advanced specification for long duration (8 hrs) and long range (1,000km). With centimeter-scale 3-dimensional accuracy, this breakthrough development will greatly increase the worldwide accessibility to high-quality laser scanning. Throughout the world, Lidar data is used for mapping infrastructure, conducting forest inventory, and determining flood risk in river basins, for example. However, obtaining such high-quality 3D data can be very expensive to obtain using conventional airborne surveys. It is difficult to process without specialised software, and as a consequence, it is rarely available in most developing nations. By bringing such instruments together into a single UAV system (named Forest-Lux or F-Lux, for short), together with its own solution-focused software, it is now possible to get a system that can be a local asset, under local stakeholder control, and be operated at an affordable price in any country in the world.

▸ http://bit.ly/2uFH6FZ



Overview of the data collected in Wales.

On-Demand Positioning-as-a-Service with Trimble Catalyst

Trimble has announced that its Trimble Catalyst software-defined Global Navigation Satellite System (GNSS) receiver for Android devices is now available through Trimble's global distribution network. Customers can now access Positioning-as-a-Service to collect geo-location data with Trimble or third-party apps on smartphones, tablets and mobile handhelds. When combined with a small, lightweight, plug-and-play digital antenna and subscription to the Catalyst service, the receiver provides on-demand GNSS positioning capabilities to transform consumer devices into centimeter-accurate mobile data collection systems. Catalyst extends the accessibility of Trimble's high-accuracy positioning to a broader base of users easily and with only a few components, which include any location-enabled mobile app, a Catalyst subscription, with accuracy options ranging from one-metre to centimeter level and Trimble's small, lightweight DA1 antenna that plugs directly into Android smartphones and tablets.

▸ http://bit.ly/2ugwUTi

Trimble Catalyst application.

World's Densest Urban Aerial Lidar Dataset Released

New York University's Center for Urban Science and Progress (NYU CUSP) Professor Debra F. Laefer has released the world's densest urban aerial laser scanning (Lidar) dataset. At over 300 points per square metre, this is more than 30 times denser than typical Lidar data and is an order of magnitude denser than any other aerial Lidar dataset. The dataset also includes the first ever urban scan with the full-wave form version of the data, as well as affiliated imagery and video. The unprecedented comprehensiveness of this multi-layered dataset enables new opportunities in exploration and modelling. It also sets a new standard for what can be collected and used by cities around the world. The data and affiliated information is now publicly available through New York University's Spatial Data Repository (SDR) for both personal and commercial use.

▸ http://bit.ly/2uHOyjI

UrtheCast and Esri Bring Satellite Imagery to Life in ArcGIS

UrtheCast and its subsidiary, the Earth Observation company Deimos Imaging, have entered a broad partnership with Esri, starting with a new UrtheCast imagery service that is powered by Esri: Kanvas. The service will enable all Esri users to access timely, reliable and quality assured imagery, directly into their apps and desktops. The on-the-fly imagery service curated by Deimos imaging, is a precursor to the upcoming UrtheDaily constellation, which is expected to image the entire Earth daily at 5m resolution, complimenting Sentinel-2 and Landsat applications. From now on, anyone with the ArcGIS platform will have free access for three months to the multi-season time series of medium and veryhigh - resolution satellite imagery, over the whole of Spain and California. Hosted in Amazon Web Services using ArcGIS, Esri users can utilise the multi-temporal imagery service and start building valuable apps for monitoring, change detection, precision insights and more.

▸ http://bit.ly/2tlgg21

UrtheCast Earth imagery.

senseFly Launches Package to Keep UAV Operators Flying

senseFly, the Switzerland-based producer of mapping drones, has announced Always On, a new service package designed to keep professional UAV operators working and ensure business continuity. Businesses are increasingly professionalising their drone operations, with UAV data acquisition developing in line with this change, marking a move from using drones in pilot projects only to integrating the technology into companies' business models and processes. To address the growing demand for turnkey solutions that come with professional grade service and support, senseFly has developed its Always On service package. Available as a bundle option alongside every new eBee Plus drone purchase, Always On provides operators with an advanced level of professional support and peace of mind. In the event of a drone hardware problem –whether the result of user error, a naturally occurring event or a technical issue – customers can simply contact their local senseFly representative to have their drone replaced for free within 48 hours, no questions asked.

▸ http://bit.ly/2uHKf80

senseFly eBee Plus.

Best Practices to Take Centre Stage at the IASEXPO Forum

From 26 to 28 September 2017, the international UAV sector will be demonstrating its potential at Interaerial Solutions in Berlin. Europe's largest drone show will form part of Intergeo, the world's leading trade fair for geodesy, geoinformation and land management. IASEXPO has the clear aspiration of becoming established as the number one industry gathering for commercial and civil drone applications in Europe. Advance tickets can now be purchased online. The IASEXPO practical forum will cover the very latest topics and feature renowned experts, an international outlook and direct practical relevance. Visitors don't have to walk far to switch back and forth between market overviews and expert presentations on user-group-targeted clusters of topics. The aim is to efficiently combine trade fair and talks. As Germany's drone regulations come into force this year, the legal aspects of using and operating this kind of equipment forms a key focus of the IASEXPO practical forum. First-hand reports will also abound at the forum – providing examples of best practice in using drones for surveying and inspecting buildings and industrial complexes, above all.

▸ http://bit.ly/2uHYv08

Interaerial Solutions.

Cadastral Boundaries or Legal Boundaries

I am sure that most of the readers of *GIM International* know what the word 'boundary' means. I'm not a native English speaker, but, in everyday terms, the usual understanding of the word 'boundary' is related to international borders rather than private property borders. However, if we add the adjective 'cadastral' to the word 'boundary', perhaps it will help us get into the topic a little bit more. In my country, Spain, the word cadastre is related to real estate tax and once again this can create confusion.

A generally accepted definition for 'boundary' is: An imaginary line which marks the mutual extent and limits of two adjacent parcels of land. This definition clarifies the way in which the main characteristic of a boundary becomes, 'the legal line where the ownership rights of one person meets those of another'.

Because of the inherent legal and non-physical characteristic, intensive surveying data capture is not really the best way to ensure security of ownership. Furthermore, the legal boundary may be delineated on the ground by physical features such as boundary marker-stones, fences, walls, ditches, etc.

It is important, in the first instance, to have a look at where the boundary lines originate:

- As a result of an agreement between adjacent neighbours, it could be clearly stated where the boundary line lies. That is known as an 'agreed boundary' and shall then be registered at the proper real estate registry.

- Because of a parcel subdivision, in which case we must firstly have administrative permission, and then the real estate must be legally divided, as a division or segregation and the precise location of that sub-division must be recorded for future reference.

In both cases, there is a technical act that determines the precise location of the boundary, but if this boundary is described in the title deeds or any other kind of legal document, the physical feature could well have disappeared but the recording of that boundary as a clear legal aspect remains the sole aim.

Once the boundary has been recorded on the legal document, i.e. title deeds, and then by the land registry, the land owner needs to physically fence the property (although, occasionally, due to the topographic nature of the land, a fence may be built as an offset from the true line). At other times, transit purposes require a gap to be left between the boundary and roads, rivers, railways, etc.

There are several circumstances that do not require erecting a fence, because there is a natural boundary feature (a riverbed, a watershed, etc). These kinds of boundary features are not easy to determine with a flat orthophoto, and would ideally require a digital terrain model (DTM) as well. Nevertheless, the most important aspect is that the DTM shall represent/capture the date that the boundary definition took place if it differs from the survey date.

In order to represent the boundaries in a map or a geospatial database, there is one critical aspect, namely, the liability on this data. It should be remembered that there are three main parties involved in this issue; the land owner, the land surveyor, and the Authority in charge of recognising the overall legality of the process.

In some countries, the Land Surveyor and the Authority are merged into the same entity, which is an advantage in terms of security, economic agility and finally, the overall responsibility. It should be borne in mind that a GIS operator (interpreting the captured data), will not, and should not, be responsible for any misinformation or mistakes caused by the boundary interpretation.

Those involved in the above process should never forget that the object of the exercise is to ensure certainty for property owners in the future. ◀

Pedro J. Ortiz is a geometry expert and real estate geo-consultant, who has his own company, GeoPropiedad in Marbella, Spain, with more than 20 years of experience in the surveying industry.

www.twitter.com/ortiz_pedroj

▲ *Pedro J. Ortiz.*

GIM INTERNATIONAL INTERVIEWS DAVE LOVELL

Maximising the Benefit of Geospatial Information

The Global Spatial Data Infrastructure (GSDI) Association was formed in 2004 as an inclusive networking organisation of academic and research institutions, government agencies, commercial geomatics firms, national and regional geographic information associations and individuals from around the world. What are the latest trends and developments when it comes to spatial data? *GIM International* talked with Dave Lovell, president of the GSDI, about topics ranging from knowledge sharing and capacity building to big data.

The GSDI Association's vision is a world where everyone can readily discover, access and apply geographic information to improve their daily lives. Where do we stand now?

The simple answer is that, at the moment, no one truly knows, that's why we are working on a new approach to creating a global index of National Spatial Data Infrastructure (NSDI) implementation. It's an approach which will allow all actors, users, suppliers, consultants and the academic community to contribute. The index consolidates and condenses a large body of scholarship and experience of NSDIs into a set of key components that can be assessed and benchmarked using six indicators. The index will provide a top-level assessment and ultimately the scoring will support investment and decision making to be directed towards any weak or problematic areas of NSDI development.

After testing in the coming weeks, the index will be made available in an online platform where the results, without weighting, analysis or conclusions being drawn, will be made available dynamically by sector and as an overall averaged score from all responders to give the index value for each country. To maximise contributions to scoring we will be seeking support from the UN-GGIM thematic networks and Regions.

As an added value we believe that the process and results will promote collaboration and motivation between government departments and other stakeholders to improve their spatial data quality, management and availability. There is also the potential for the Index to raise awareness of potential barriers to a country effectively reporting spatial data evidence to the Sustainable Development Goals and other international agreements.

Your Association is also on a mission, namely to advance geo-information best practices, knowledge sharing and capacity building. Are you satisfied with where you are today?

GSDI has achieved a great deal since its inception; nearly USD300,000 has been granted to support 117 completed projects which advanced the understanding, implementation, development and use of Spatial Data Infrastructures across the world. 15 global conferences have been organised which have been attended by thousands of delegates, a 'how to' SDI Cookbook has been published, updated and translated into multiple languages, and a wealth of other resources made available at our website. We've funded a number of development projects, attended many conferences, supported GEO and CEOS and contributed to establishing the UN Committee of Experts on Global Geospatial Information Management. In fact, I think that we can claim that the pioneering work of GSDI and its members has contributed significantly to this development. But until a job is done or an outcome is delivered, I'm not satisfied. A great deal has been achieved by GSDI, and others of course, to advance understanding of the role and benefits of applying geospatial information and technologies to real world challenges and problems be they in the environment, the economy or wherever, but there is still much more that needs to be done in order to realise the full potential of geospatial information and technologies.

You have been making Small Grants Programme awards available since 2003. How can a grant of USD2,500 make a difference in geospatial data infrastructure?

If you'll forgive me for saying so, the question embodies a very developed world perspective. In many countries in the world, USD2,500 is a significant sum of money and the appetite for receiving a grant continues unabated. Since 2004 GSDI has supported 117 projects. This year's call for proposals stimulated 31 applications from 27 countries in Africa, Asia-Pacific, Europe, North and South America, covering a wide range of SDI and GI/GIS related project work. In addition to cash awards, some of the proposals also requested support from the GISCorps of URISA's volunteer network.

Supported projects this year include: Unlocking Government Environmental Data in Kenya, Support for Working Group on Formulating the SDI Act in Mongolia, SDI to Support Sustainable Energy Planning in West Africa, Translating the GSDI SDI Cookbook and a number of SDI promotion and training projects.

This year, the cash awards are made from GSDI's own reserve funds. I'm disappointed that we can't provide more funding so that others of the more deserving proposals can be funded in 2017. If readers wish to

contribute they can do so, without becoming a member of GSDI if they so wish, by sending an email to smallgrants@gsdi.org.

Spatial data infrastructure allows nations to better address social, economic, and environmental issues of pressing importance, including sustainable development. Can you give some eye-catching examples?

I find it impossible to select just two, as there are already many thousands of case studies that address these issues, where 'location' is a key aspect of the challenges being faced. Another challenge is one faced by all stakeholders who engage in pre- and post-SDI implementation cost-benefit studies. That is, are you measuring the societal benefit achieved by the specific application(s) or the additional benefit achieved due to having a robust spatial data infrastructure in place, i.e. one in which the required data can be created, managed, publicised, accessed, shared, used and re-used with greatest efficiency and at least cost. Research has been ongoing for over two decades now, and the challenges are well described in 'Assessing the impacts of SDIs: A report of the international workshop on spatial data infrastructures' cost-benefit / return on investment' held at the EC's Joint Research Centre in 2006 – see http://cordis.europa.eu/publication/rcn/200718878_en.pdf. Research carried out by our Secretary General has identified cost benefit ratios ranging from 1.8:1 to as high as 27:1 for different sectors and applications in nations across the globe, in areas such as cadastre, land management, remote sensing, census statistics, managing local government, and many, many more.

Geospatial big data is a hot topic in the geomatics industry. Which developments do you foresee when it comes to managing the data?

I'm not really the right person to ask given my interests are principally in association management and articulating the benefit of the use of geospatial information, but from the many things that I've recently been exposed to the following two stand out:

1. Blockchain - which allows for records between different parties to be recorded and managed in an efficient, verifiable and permanent way with records held in a database distributed across multiple computers, has I think real potential in land registry and land information systems;

2. Machine learning – which gives computers the ability to learn without being explicitly programmed, particularly within the field of data and predictive analytics, has the potential I believe to help us move from a spatial data infrastructure to the more powerful spatial knowledge infrastructure which is envisioned in the Australia and New Zealand Cooperative Research Centre for Spatial Information's white paper www.crcsi.com.au/spatial-knowledge-infrastructure-white-paper/.

The European Union has its INSPIRE Directive, which establishes an infrastructure for spatial information in Europe to support Community environmental policies. Is the GSDI Association involved?

GSDI members, particularly EuroGeographics, National Land Survey of Finland, Kadaster (The Netherlands), KU Leuven, TU Delft and others have contributed immensely since its inception, and continue to do so. The recently completed European Location Framework and current transitional programme towards European Location Services project provide excellent examples of their practical work to provide the single access point for international users of harmonised, pan-European, authoritative geospatial information and services; and enable national mapping, cadastral and land registry authorities to be recognised in their international effort to contribute to the wider public good.

Members have also contributed at a number of INSPIRE Conferences and will do so again this year. For example, Abi Page, chair of the Association for Geographic Information (AGI) and Technical Product Development Manager at EuroGeographics, presents on the role of open data in the journey to operational European Location Services. Our Secretary General, Roger Longhorn, will present one of our current projects in the Marine SDI, INSPIRE and the EU Marine Directives Workshop and will report on Multiple Agency Cooperation for Implementing the EU Maritime Spatial Planning Directive. One of our key founding members, the Open Geospatial Consortium, has also been directly involved in several projects relating to INSPIRE implementation.

You organise GSDI World Conferences – and other events – around the globe. What makes these conferences/events so relevant?

For me, the sheer variety of topics covered and the diversity of presenters and

▲ *Dave Lovell.*

presentations differentiates GSDI Global Conferences from the rest. Our conferences aren't stage-managed platforms for global companies to promote themselves and their products, but rather a platform for everyone from early career professionals to people with decades of experience to present their latest research, report new and exciting uses of geospatial information and technologies or project achievements. At our fifteenth and most recent conference in Taipei in December 2016, simultaneously in different streams, our member PSMA Australia Ltd with Digital Globe delivered a workshop on the development of the 'ground breaking' Geoscape product whilst in another room an assessment of building evacuation scenarios considering panic and knowledge of exits using a 3D GIS agent-based model was presented.

By choosing a different location around the globe for each conference, we provide opportunities to people and companies unable to travel to 'far flung' international destinations to showcase their work and receive feedback from the expert knowledge our delegates represent.

The Proceedings of the GSDI 15 World Conference are available for downloading from the GSDI website.

GSDI has signed several Memorandums of Understanding with partner organisations such as FIG, ICA and ISPRS. What are the benefits of these partnerships?

GSDI has MoUs with FIG, ISPRS, ICA, ISDE (International Society for Digital Earth), and CDMPS (the Centre for Disaster Management and Public Safety) of our member Univ. of Melbourne, the earliest dating back to 2010. The main benefits are sharing geo-related news and ensuring participation on themes related directly or indirectly to SDI at multiple international conferences and workshops of our MoU Partners. As well as joint promotion, over the years we have seen an SDI focus appearing in the structures of the organisations, such as ISPRS Commission 4, Working Group WG IV/6 - SDI: Internet of Things and Spatial Decision Support, the ICA Commission on SDI and Standards and FIG Commission 3 – Spatial Information Management.

A good example of how all the MoU Partners work together is demonstrated by the International Workshop on the Role of Land Professionals and SDI in Disaster Risk Reduction in the context of Post 2015 Nepal Earthquake held in Kathmandu, Nepal, 25 – 27 November 2015, directly supported by our Nepal member, NGIID (National Geospatial Information Infrastructure Department, Nepal) and jointly organised by FIG Commission 2 (Professional Education) and ISPRS Technical Commission IV (Spatial Information Science), supported also by FIG Commission 7 (Cadastre and Management). This level of cross pollination of skills and expertise would be much more difficult to achieve without the existence of the MoUs – and we wish to thank all of our MoU Partners for their continued work with GSDI.

You are also involved with education focused on SDI development and implementation, and related geomatics technologies. Can you give some examples?

The joint GSDI / FIG / ISPRS workshop mentioned above is one good example. Many different GSDI members have also been directly involved in implementing SDIs nationally and at trans-national level, such as for INSPIRE in Europe. Our members include not only the Open Geospatial Consortium (OGC), whose international geo specifications work is crucial to implementing SDIs, but also eight universities in Europe, North America and Australia, plus UNIGIS, the global GI Science distance learning network that boasts 9 university partners, 15 study centres, 4,000 active students and over 10,000 alumni. We have also been implementing an expanded Capacity Building Programme since 2016, which includes many webinars relating to the work of our Strategic Projects, such a Marine SDI Best Practice and developing the global index of National Spatial Data Infrastructure (NSDI) mentioned earlier. In 2017, we are delivering specific webinars focusing on SDI issues that are often not covered by others in the geo sector, such as data policy, IPR and licensing practices, open data and big data challenges. GSDI also maintains a major online resource of open access publications directly related to SDI implementation, best practice, case studies, webinars, cookbooks, etc. at our website.

How do you foresee the future when we zoom in on the geospatial sector? Are there any developments that will change the industry in the coming years?

We can be sure that there are developments that will change the industry in the coming years; only time and hindsight will tell us if we were able to predict them!

It seems that everybody I meet professionally at the moment is talking about the potential of Geospatial Platforms. When I looked for a definition, I found the one from FGDC the simplest to consume - 'The Geospatial Platform will be a portfolio of common geospatial data, services, and applications, managed, contributed and administered by authoritative sources and hosted on a shared infrastructure'. What struck me was that this was in a document published in June 2011. If this is the future, it's a long time coming!

Most recently I've been struck by the conversations about the future of national mapping authorities, and given the first forty years of my career were happily spent in a variety of roles with Ordnance Survey (GB), I guess that's inevitable. Nowhere is this better covered than in an output from the recently held Cambridge Conference. I recommend reading the story 'Mainstreaming geospatial data: an exercise in market satisfaction' from the CEO of one of our members.

So, fundamentally, I see the biggest need and the biggest change coming from the greater integration of information and technologies driven by people with similar ambition, foresight and passion to maximise the benefit of geospatial (location) information as was the vision of those who founded GSDI in the first place. ◀

ABOUT DAVE LOVELL

Dave Lovell is currently president of the Global Spatial Data Infrastructure Association, chair of UN-GGIM Geospatial Societies, a member of the UN-GGIM Expanded Bureau, a Board member of the Association for Geographic Information and until 2014 a member of the British Geological Survey advisory committee. Lovell started his career with Ordnance Survey (Great Britain) and spent forty years with them in a variety of roles in Surveying, Sales and Marketing and concluded his time with them as their head of Public Affairs. Between September 2007 and October 2015 he was Secretary General and Executive Director of EuroGeographics the International not-for-profit association now representing 63 National Mapping, Cadastre and Land Registry authorities in 46 countries in Europe.

STATUS AND PROSPECTS OF AUTOMATIC 3D MAPPING OF ROAD OBJECTS

Mobile Laser Scanning Point Clouds

The demand for 3D maps of cities and road networks is steadily increasing and mobile mapping systems are often the preferred geo-data acquisition method for capturing such scenes. Manual processing of point clouds is labour intensive and thus time consuming and expensive. This article focuses on the state of the art of automatic classification and 3D mapping of road objects from point clouds acquired by mobile mapping systems and considers the feasibility of exploiting scene knowledge to increase the robustness of classification.

Management of roads, their maintenance or reconstruction, requires inventories on pavement conditions, road markings and objects in the vicinity of the road including utility poles, traffic signs, lamp posts and speed guidance boards. The high point density of point clouds acquired by mobile mapping systems (MMSs) allows mapping of traffic guidance arrows and road lines painted on the pavement, vertical road objects, cracks and holes in the pavement, cavity and sagging. Vertical road objects are known as pole-like objects (PLOs), because of their profoundly elongated shape usually extending in vertical direction. While carrying out the survey at traffic speed, there is no interference with other road users, which contributes to safety. As a result, MMSs have evolved into an increasingly popular geo-data acquisition technology for conducting road inventories over the last fifteen years.

▲ *Figure 1, Components of the mobile mapping system of Riegl.*

MOBILE MAPPING SYSTEMS

A Mobile Mapping System is usually mounted on a car, van or other vehicle that can move with traffic speed over roads and highways. An MMS consists of a positioning and orientation system (POS), one or more laser scanners, one or more digital cameras and a control unit. The setup of an MMS is schematically shown in Figure 1, depicting the components of the Riegl VMX-1HA. The part of the MMS without cameras is called Mobile Laser Scanning (MLS) system. The POS continuously acquires data for calculating the exterior orientation parameters (three coordinates and three attitude angles) using a GNSS receiver and an Inertial Measurement Unit (IMU), often complemented with a wheel rotation counter. Each laser scanner emits pulses, presently up to one million pulses per second, to capture road surfaces and objects above and alongside the road. From the pulse travel times the distances between sensor and object is calculated. The laser scanner primarily measures: (1) range – that means distance from the sensor to the first surface hit by the laser pulse – (2) scan angle and (3) intensity of the return. Combining these measurements with those from a GNSS receiver, IMU and wheel counter provides 3D coordinates of

millions or even billions of points in a local or national reference system. Usually the sensors are integrated on one rigid platform of which the mutual offsets have to be calibrated. This is usually done by the manufacturer. Vibrations during the survey, shocks due to holes in the pavement and sudden slowdowns will cause mutual displacements of the sensors and other disturbances. To warrant high-precision surveys all the time regular recalibration is required. In addition to the 3D coordinates, one or more attributes may be assigned to each point. The attributes may be directly measured by the sensor, this relates particularly to the intensity of the return, computed from a neighbourhood of points or obtained from other sources. RGB values may be assigned to laser points using the simultaneously recorded digital images or image sources having other time stamps. Attributes act as features for automatic object recognition.

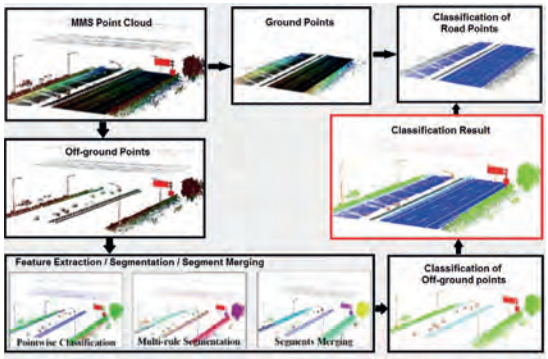
AUTOMATIC OBJECT RECOGNITION

The demand for automated mapping methods has been a great stimulus for research in photogrammetry, remote sensing and computer vision over the last decade. The classification of MLS point clouds is directed towards 3D mapping, that is, the outlining of objects along the road scenes which are of interest for a particular task at hand and the assignment of class labels to these objects. This article focuses particularly on the classification part of the equation. The pipeline of automated classification and mapping of road scenes usually starts with separating ground points from off-ground points. Figure 2 depicts a typical pipeline, which has been recently proposed by Yang et al. (2017). If mapping road surfaces and road markings is not part of the survey, separation of ground points from off-ground points results in a great reduction of points in the classification process. The next steps depend on the type of scene and the preferences of the researchers. The diverse approaches can be categorised into three main groups: point-wise classification, segmentation-based classification and multiscale classification. Point-wise classification exploits the intensity of the return and/or the shape and other geometric properties in the vicinity of each point. The geometric features are assigned to each of the individual points, which then are grouped and classified. Segmentation-based methods fit planes, spheres, cylinders or other geometric primitives through neighbourhoods of points. The descriptive parameters of these segments are used as features for further grouping, classification and mapping. The same type of object may appear in road scenes in different lengths, widths and/or heights. The multiscale approach takes account of size variations of objects through combining features computed at various point densities.

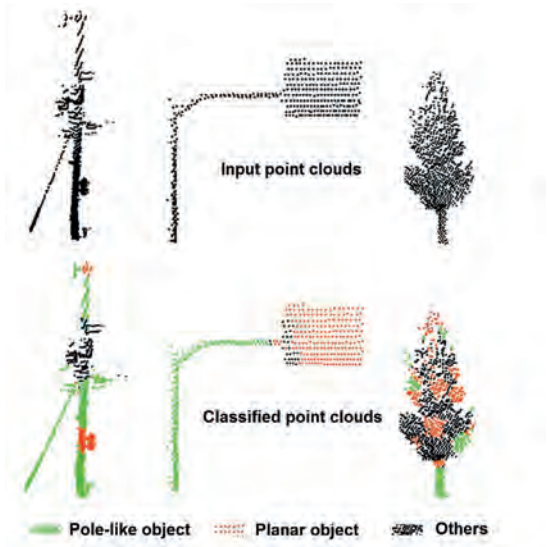
The three categories discussed above heavily rely on the computation of geometric features through exploiting the local geometric structure. Automated classification attempts on MLS point clouds have mainly focused on assigning pre-specified classes to individual points. Point-based approaches are more robust to occlusion and clutter compared to the segmentation-based approaches but the latter are more robust to noise and varying point densities. As a result of their sensitivity to noise and inhomogeneous point densities, point-based approaches may suffer from assigning wrong classes to the individual points (Figure 3). However, segmentation – based methods may also produce erroneous results because of their sensitivity to occlusion and clutter. Occlusion means that a part of an object is not visible from the sensor position due to the presence of another object in the line-of-sight. An example of clutter is the mixing of segments belonging to the one object with segments of another object which is closely attached to the object or overlaps it (Figure 4).

LOCAL GEOMETRIC STRUCTURE

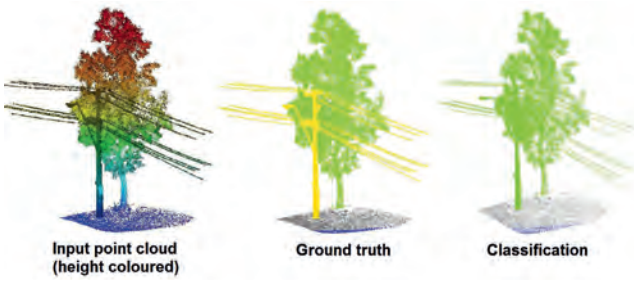
Point clouds acquired by mobile laser scanning systems are attribute poor. In addition to the 3D coordinates in a local, national or regional reference system, usually only the reflectance value of each point – often represented as a digital number in the range from 0 to 255 – is available in a point cloud. As a result, many classification approaches rely on enriching the attribute set with RGB values from imagery, which may not always be available, and on examining the local geometric structure of a set of neighbouring points. The suitability of the local geometric structure is based on the observation that many objects differ in shape. For example, the majority of buildings can be modelled as an ensemble of planes which – in most cases – intersect perpendicularly at corner lines, while power lines can be modelled as linear elements. There are two basic descriptors to express the shape of a surface: normal vectors and eigenvalues. Both are assigned to individual points by examining the configuration of the point under consideration and its adjacent points. So, the computation of normal vectors and eigenvalues is done by examining the 3D coordinates of a neighbourhood of points. If the normal vectors of neighbouring points point in the same direction, the local neighbourhood likely form a plane. If they diverge in a systematic manner they likely form a sphere or a cylinder. When no systematics in directions are present, the points may be reflected on a fuzzy surface, such as foliage.



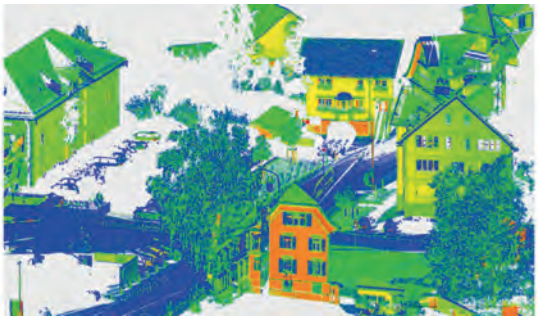
▲ *Figure 2, A typical proposal of an automated mobile laser scanning point cloud classification approach (courtesy: Yang et al. (2017), modified by author).*



▲ *Figure 3, Point-wise classification may be error-prone (source: Yokoyama et al., 2013, modified by author).*



▲ *Figure 4,The segments of a utility pole partly attached to and overlapping a tree are mixed up with tree segments and misclassified as tree (source: Yang et al. 2017, modified by author).*



▲ *Figure 5, Point cloud of an urban scene in the Semantic3d.net benchmark dataset, intensity coloured.*

Also eigenvalues of the 3x3 covariance matrix of the three coordinates of neighbouring points indicate shape. If one eigenvalue is large and the other two close to zero, the neighbourhood forms a line. A plane is indicated by two eigenvalues which have approximately the same value and one eigenvalue close to zero. Spherical and fuzzy surfaces will have three large eigenvalues. It is common practice to derive measures from the eigenvalues which indicate the type of local structure. Examples of such measures are: linearity, planarity, sphericity, anisotropy, eigenentropy and local surface variation.

DEEP LEARNING

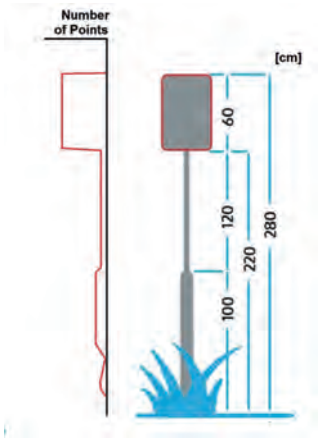
Recent innovations in computer vision and artificial intelligence include the development of deep learning algorithms based on Convolutional Neural Networks (CNNs). The development of this type of machine learning methods have been inspired by the working of the human brain. In the popular science literature it is often suggested that a CNN simulates the brain but that is not true in the same way as it is false to state that an aeroplane would simulate the flight of birds. CNNs have been successfully applied in self-driving cars, robotics and object recognition from images. However, classification of point clouds appears to be a hard issue because of the sheer amount of points and the complexity of outdoor scenes. Added to this the points are not inherently structured as on an image raster while the distribution of points over space is irregular and non-homogenous. By feeding a CNN with data of an abundance of prototype objects, the algorithm can recognise objects across a broad variety of scenes. However, the training data has to be manually selected, which is more time-costly for 3D models than for 2D models. Recently, ETH Zurich, Switzerland, has released a large-scale point cloud classification benchmark with over four billion manually labelled points, acquired with terrestrial laser scanners (semantic3d.net). The benchmark contains urban and rural scenes, captured in Central Europe, depicting typical European architecture including town halls, churches, railway stations, market squares, sport fields and farms (Figure 5). The benchmark is freely available and is a valuable source for testing the performance of existing or proposed classification pipelines.

HEIGHT COMPONENT

Indeed, because point clouds are limited in the number of attributes, which are directly observed during the survey, it is inevitable to explore a local neighbourhood in the class assignment process of individual points. In the case of 3D mapping of outdoor scenes, the heights above a reference surface, e.g. ground surface, are the most important asset of a point cloud and this information should by fully exploited. Of course, it is not feasible to explore the height above ground level itself as height component. Many points reflected on traffic signs, façades, lamp posts, cars, pedestrians and trees all may have the same height. So, height above ground level weakly discriminates among the different classes and thus is not well-suited for classification. An approach which may work is based on the observation that off-ground points of urban scenes collected by a MLS system are usually part of objects which extend in the vertical direction. One of the characteristics of these objects is that they have different heights. For example, a building facade varies in range which may start at seven metres, or higher, depending on the urban area, while the height of a traffic sign mounted on a pole from ground level upwards usually does not exceed three metres. The exploitation of the height component is subject of on-going research, see Zheng et al. (2017). Furthermore, scene knowledge can be exploited for checking and improving classification results.

SCENE KNOWLEDGE

Different types of objects may have similar geometric features. As a consequence, when only using this type of feature the result may be prone to confusion in the class assignment process. To avoid the classification only depending on the use of the 3D coordinates of a local neighbourhood of points, a priori scene knowledge can be introduced in the classification pipeline. Therefore, to improve classification results we can introduce



▲ *Figure 6, One of the features to exploit a priori scene knowledge are height diagrams; depending on the point density and incident angle, i.e. the angle under which the sensor 'views' the traffic sign, the height histogram may look as indicated (left) (courtesy: M. Lemmens).*

FURTHER READING

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scene-specific rule number one: roads and their vicinity are man-made, meaning that the placing of objects, their shape, size and orientation, have to obey road traffic regulations, master plans and other official restrictions. As a result road objects, such as guardrails and traffic signs, appear in zones which are approximately parallel to the main direction of the road, while the distance to the road only varies within a certain range. Added to this, the orientation of traffic signs mounted on poles is usually perpendicular to the road direction. A second useful rule is that everything is connected to something else and ultimately to the surface of the Earth. This generic rule can be further specified in the form of a geometric constraint, reading: road objects usually expand in the vertical direction, while their height lies within a specific range. Furthermore, the distribution of the number of returns from a traffic sign depends on its shape and size. Figure 6 depicts schematically how the height constraint and the distribution of points along the height of the object can be exploited for classifying a traffic sign. Road objects are often placed in regular patterns. This knowledge can be used for improving assignment of classes. For example, along the road lamp posts are placed at regular distances. Recently, Yang et al. (2017) used scene knowledge together with combining the point-based approach with the segment-based approach as described above and found that their classification pipeline resulted in an improved class label assignment compared to other methods.

CONCLUDING REMARKS

Around the year 2003 mobile laser scanning systems became operational for surveying and 3D mapping of road scenes. Today MLS systems are used for capturing roads and their vicinity aimed at road inventories on a regular basis. In the meantime, interesting innovations are ongoing, one of these is increasing awareness that point clouds should be treated as a third type of data model along raster and vector representations. The point acquisition rate as well as the number of commercial MLS systems in operation are steadily increasing. However, data is not yet information – the conversion of data to information requires careful processing of which the specifications of the various steps depend on the application domain as well as scene type. Before the sheer amount of points can be mapped fully automatically a long and winding road still lies ahead of us. ◀

ACKNOWLEDGEMENTS

Thanks are due to Prof Konrad Schindler, ETH Zurich, Switzerland, for allowing the presentation of the semantic3d.net benchmark and providing valuable input for the Deep Learning paragraph.

BIOGRAPHY OF THE AUTHOR

Mathias Lemmens gained a PhD degree from Delft University of Technology, The Netherlands. He is an international consultant and is the author of the book *Geo-information – Technologies, Applications and the Environment* published by Springer in 2011. Currently he is working on a book on Point Clouds, provisionally entitled: *An Introduction to Pointcloudmetry.*

✉ m.j.p.m.lemmens@tudelft.nl

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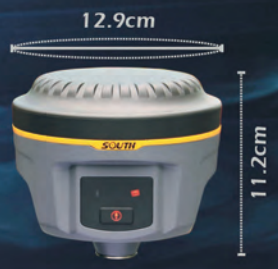

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SIMULTANEOUS GEO-DATA CAPTURE FROM THE GROUND AND FROM THE AIR

Tandem for 3D Corridor Mapping

3D Mapping of roads, pipelines and other linear structures – often called corridors – is an important geomatics activity. Geo-data acquisition technologies, which are increasingly used for corridor mapping and also for 3D mapping of urban areas, are mobile mapping systems and unmanned airborne systems. Can these two technologies be combined for simultaneously capturing corridors from the ground and from the air to improve efficiency, completeness and accuracy? This was the leading question in the mapKITE project. The authors explain the concepts underlying the project and prove their feasibility through pilot studies.

MapKITE – developed within the Horizon2020 R&D programme of the European Commission – integrates an Unmanned Aerial System (UAS) and a Mobile Mapping System (MMS) for simultaneous capture of geo-data from the air and from the ground (Figure 1). The UAS consists of a Spyro-4 quadcopter from UAVision equipped with a Sony NEX-5R camera with 20mm camera constant and a high-precision GNSS receiver. The MMS consists of a van equipped with dual-Lidar Lynx from Optech, operated by TopScan GmbH. The UAS is operated and controlled from a ground control station (GCS) onboard of the MMS.

TANDEM

To enable the UAS and MMS to operate in tandem a number of innovations had to be developed and implemented. One of the keys of the concept consists of the 'virtual tether' software which runs on the GCS installed in the MMS. Based on the 3D coordinates generated by the real-time navigation system of the MMS, UAS waypoints are computed and next transmitted to the UAS (Figure 2). In this way the virtual tether forces the UAS to follow the MMS allowing the operation in tandem. The UAS is always in line-of-sight of the MMS. Another key concept is the use of Kinematic Ground Control Points (KGCPs). The implementation of the KGCP concept consists of a target mounted on the rooftop of the van (Figure 3). The target is designed such that it can be automatically identified and accurately located in the UAS images. KGCPs enable tremendous reduction in placing and measuring of GCPs in the field or even eliminates the need for these, which saves a lot of time and costs, especially in corridor surveys, and speeds-up the workflow. The target also acts as an additional tracking facility, which adds to safety when the computation or transmission of waypoints fails. The target and the real-time target-tracking facility were designed by EPFL.

MAPKITE ENABLES CORRIDOR SURVEYS AT A LOWER COST WHILE MAINTAINING HIGH ACCURACY

TEST

Ten teams from six countries have been working on developing, constructing and validating the first prototype since March

Figure 1, The tandem of UAS and MMS used in the Horizon2020 mapKITE project.

Figure 2, Schema of the virtual tether.

	Conventional UAS Survey			mapKITE Survey		
	East [mm]	North [mm]	Height [mm]	East [mm]	North [mm]	Height [mm]
Max	164	110	245	103	76	212
Min	-59	-71	-103	-4	-64	-122
Mean	3	14	31	0	-5	7
Std. Dev	49	48	87	32	36	86
RMS	49	50	92	32	36	87
RMS (px)	2.46	2.52	4.61	1.61	1.82	4.33

Table 1, Accuracy statistics obtained from confronting the computed coordinates of check points with the reference values.

2015. In June 2016, several test surveys were conducted at the BCN Drone Centre in Moià, Barcelona, Spain. This UAS testing facility covers 2,500 hectares of segregated airspace. A non-paved road through a rural landscape was captured over a length of 2.3km. The height of the UAS varied from 80 to 90m above ground resulting in a ground sampling distance (GSD) of 2cm. The images were captured with an along-track overlap of 80% yielding a base-to-height ratio of 0.156. This guarantees good geometric precision and robustness even when there are gusts of wind or large terrain variations. As the test aimed at validation of components rather than on testing performance under full operational condition, the survey was conducted at low speed, ranging from 10 to 30 km/h. The next section focuses on the accuracy assessment of the test.

ACCURACY

To assess the potential of KGCPs as input in the triangulation and geo-referencing of the images, 37 GCPs were evenly distributed along the corridor. To simulate a conventional UAS corridor survey a one-way strip consisting of 149 images was selected. Using tie points, the GNSS coordinates of the UAS trajectory and 19 evenly distributed GCPs the interior and exterior orientation parameters of the 149 images were calculated. The same images were also geo-referenced using 136 KGCPs complemented with two GCPs at each end of the strip, i.e. four GCPs in total. Figure 4 shows the distribution of GCPs and KGCPs over the test area. Using the remaining part of the GCPs, 18 in total, as checkpoints, the accuracy of both the conventional UAS survey and the mapKITE survey have been calculated. The accuracy statistics show that the accuracy of the mapKITE survey slightly outperforms the conventional UAS survey (Table 1). The accuracy of the conventional approach can be improved at the cost of adding GCPs. So, the mapKITE concept enables corridor surveys at a lower cost while maintaining high accuracy standards.

BUSINESS OPPORTUNITIES

MapKITE focuses on corridor mapping, which appears to be a growth market. Indeed, there is an increasing demand for 3D mapping of roads, railways and waterways; inspection of powerlines and oil and gas pipelines; and coastal monitoring. Geo-data simultaneously collected from ground and airborne viewpoints complement each other. Roofs not visible in an MMS dataset and occluded objects are captured from an airborne perspective (Figure 5). Line-of-sight limitations between GCS and UAS usually dictated by regulations disappear within the mapKITE concept as it is kept continuously within standard specifications. Of course, there are constraints on the survey duration particularly introduced by the need to change

Figure 3, Coded optical target mounted on the vehicle roof (left) and real-time target-tracking.

Figure 5, Point clouds derived from the MMS data only (top) and from the tandem datasets.

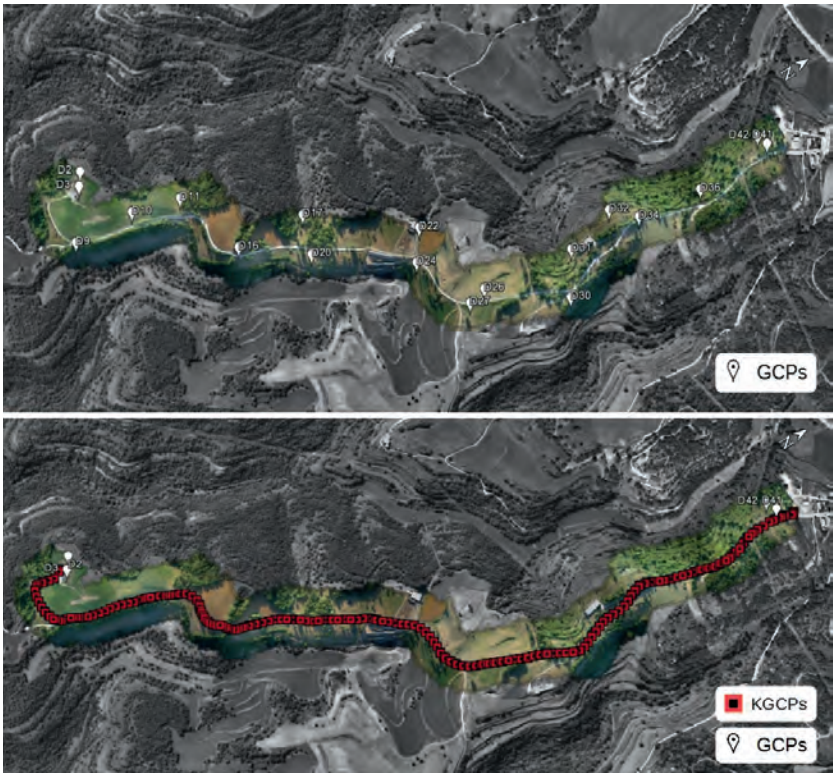

Figure 4, Distribution of 19 GCPs (white pins) used in the conventional UAS test survey (top) and the four GCPs and 136 KGCPs (red squares) used in the mapKITE test survey.

batteries and the limitations of UAS speed, which is lower than for MMS.

FUTURE

The navigation systems onboard the UAS and MMS collect redundant data, the capability of which is not yet fully exploited. Although the MMS navigation system is more accurate than the UAS system, data from the latter may be beneficially exploited in case of blocking or multipath of GNSS signals. Also here the target mounted on the van plays a key role. Laser scanners, digital cameras and other sensors continue to become smaller and lighter, which enables their combined use in one and the same UAS. The UAS developments concern fixed-wings with Vertical Take-Off and Landing (VTOL) capability, operation in swarms and longer battery charge endurance. Together with global regulations relief these developments will trigger more efficient and robust UAS operations. When EU's Galileo and the Chinese Beidou GNSS become fully deployed, around 100 GNSS satellites will be available by 2020. With new wideband signals, improved multipath mitigation and more precise code-based ranging the precision of the KGCPs will steadily increase supporting the feasibility of our approach.

CONCLUDING REMARKS

Now our concept has proven its feasibility, we are working on making it operational for corridor mapping by cooperating with system integrators and survey companies who aim to extend their portfolios. The concept and prototype were presented at a workshop held in June 2016. The event was attended by the world's leading mapping service companies and technology integrators. On the MapKITE concept GeoNumerics holds patents in Spain (ES2394540) and United States (14/417,435) while patents are pending in Europe and Brazil. ◀

MORE INFORMATION

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Video: https://vimeo.com/181634599

BIOGRAPHIES OF THE AUTHORS


Pere Molina is manager of advanced applications at GeoNumerics, based in Castelldefels, Spain. He is an expert in trajectory determination, remote sensing and unmanned aircraft applications and leads the mapKITE project.
✉ pere.molina@geonumerics.com


Dr **Ismael Colomina** is chief scientist at GeoNumerics, and holds over 30 years of experience in geomatics specialised in sensor orientation and calibration and trajectory determination.
✉ ismael.colomina@geonumerics.com


Prof **Jan Skaloud** is an expert in sensor integration for navigation and mobile mapping. He teaches and researches at École Polytéchnique Fédéral de Lausanne (EPFL), Switzerland, on satellite positioning, inertial navigation, sensor calibration and photogrammetry.
✉ jan.skaloud@epfl.ch

YELLOWSCAN INTERNATIONAL USER CONFERENCE 2017

Turning **UAV and Lidar** into Something Beautiful

Mounting Lidar on an unmanned airborne vehicle (UAV) is called the next geospatial frontier but gradually the barriers are levelled. Scientists and Lidar and UAV adopters from surveying companies gathered at the second YellowScan User Conference in Montpellier, France, to discuss the future of this novel and promising geo-data acquisition technology. The diverse backgrounds of the over 80 attendees reflect the potential of equipping UAVs with Lidar sensors, resulting in what may be called UAS-Lidar.

The venue – Château de Flaugergues, built between 1696 and 1730 – added an extra dimension to the two-day conference, held on 29 and 30 June. The conference included demonstrations, workshops and presentations on geo-data collection with UAS-Lidar as well as the processing and analysis of the acquired point clouds. Various challenging case studies were presented. The participants were also provided with an update on what's new and what's forthcoming at YellowScan.

YELLOWSCAN

The conference was kicked off by Pierre d'Hauteville, head of sales and marketing at the company. Next, Michel Assenbaum, president of YellowScan and its mother company L'Avion Jaune, highlighted the history of the company. L'Avion Jaune was founded in 2005, with the aim of developing aerial high-end imaging services in France. Having observed a market for UAS geo-data acquisition technologies Assenbaum together with Tristan Allouis, both engineers holding a PhD degree, started YellowScan in 2012. In 2013, a first prototype of an airborne Lidar system mounted on a UAS was tested resulting in the commercial launch of the YellowScan Mapper in 2014 and followed by the Surveyor UAS-Lidar system in 2016. This was also the year in which the first international user conference was held. YellowScan aims at designing, developing and producing unmanned airborne Lidar systems for professionals across the world.

KEYNOTE AND WORKSHOP

Omar-Pierre Soubra, director of marketing communications for Trimble, delivered a keynote entitled 'The Future of Geospatial', bringing us from the history of Lidar, via self-driving cars, data processing with artificial intelligence to new infrastructures and the hyperloop. The latter is a proposed solution for transporting people and freight in a pod-like vehicle propelled through a reduced-pressure tube at airliner speed. He ended with looking at geomatics companies that will survey the planet Mars. A workshop by Arttu Soininen of Terrasolid was one of the highlights. Mr Soininen focused on the capabilities of TerraScan for automatic classification of roof, roof structures, walls, wall structures, trees, vegetation, poles and cars. The underlying method is based on grouping of points to segments and objects through exploring the local geometric structure. In this way adjacent points lying on a planar surface are grouped as

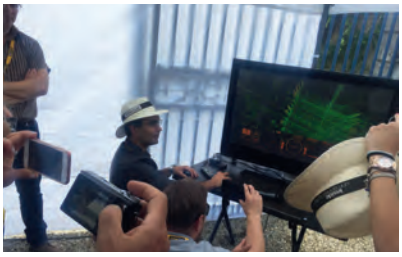
▲ *The conference was packed with presentations on geo-data collection with UAS-Lidar.*

▲ *The Château de Flaugergues added an extra dimension to the conference.*

belonging to a wall or a roof. Also the spacing between points and the appearance as a pole-like object are used in the classification process. An important application is the mapping of individual trees, which enables the calculation of the height and canopy width of each tree and to count the trees. Adding multispectral data to the points allows automatic recognition of tree species. These capabilities help managers to maintain a tree database of a city and to decide which trees in a forest need to be cut.

DEMOS

During a live demonstration on the first day the château and garden were captured with a YellowScan Surveyor Lidar system (weight: 1.6kg, dimensions: 100mm x 150mm x 140mm) mounted on the Six3 from Escadrone, a rotary wing with six rotors. Since the system is equipped with a parachute and weighs less than 6.5kg, flights in urban areas are permitted according to the French drone regulation. The operational speed of the Surveyor Lidar system is typically 15 to 75km/h, its flying height 10 to 60m and its swath width 30 to 120m. The Lidar sensor emits 300,000 laser pulses per second. These pulses have a wavelength of 905nm, which lies in the near infrared part of the electromagnetic spectrum and are thus invisible for the human eye. The onboard GNSS receiver can trace 220 GNSS channels from three operational constellations including GPS, GLONASS and BeiDou. The acquired point clouds were visualised in real-time on a TV screen with the YellowScan LiveStation software, and processed and classified using Trimble RealWorks. Point clouds from three different sources were mixed: the YellowScan Surveyor, the Trimble SX10 scanning total station, and the GeoSlam handheld scanner, which made it possible to show the interior of the château. The second day started with a field trip to the prehistoric site of Cambous, where humans settled as early as 2,500 years BC. This site was more challenging than the one the day before, as there was lots of vegetation covering the ground surface, buildings and other objects. Again the Surveyor Lidar system was used, but now mounted on the OnyxStar FOXC8 HD from AltiGator, as the Six3 also a rotary wing but with eight rotors rotors. A point cloud of the site captured a few weeks before the start of the conference was processed by Martin Isenburg of rapidlasso, the creator of LAStools and LASzip. Since he never visited the site before, Isenburg had to analyse the point cloud without scene knowledge. A challenging job, particularly because some surfaces did not deliver returns, such as the roof of a small cabin, covered with wire netting. The post-processing resulted in a Digital Surface Model, and a ground-filtered Digital Elevation Model (DEM) for forestry applications.

▲ *Live demonstrations at the château and in the garden (top), and at the prehistoric site of Cambous.*

CASE STUDIES

Several case studies were presented during parallel sessions. Isabelle Heitz (AIRD'ECO) discussed a survey with the YellowScan Mapper aimed at mapping a hillfort. The Roman site Camp de César, located near Paris, France, is covered by a dense boxwood, ruling out a terrestrial survey. The UAS-Lidar survey resulted in 28 million points (140 points/m²) with a height accuracy better than 20cm. From the point cloud a DEM was generated which acted as a source for derived products such as a contour map with 1m interval and profiles.

Dr Akira Kato, Chiba University, Japan, placed UAS-Lidar in the broader context of various geo-data acquisition technologies, including airborne Lidar and terrestrial laser scanning for forest monitoring purposes in general and the determination of tree growth in particular. He concluded that UAS-Lidar has the capability to improve the accuracy of forest monitoring. UAS-Lidar also contributes to better risk management of forest fires.

Doyle McKey, University of Montpellier, and Cédric Krasnopolski, L'Avion Jaune, discussed the mapping of pre-Columbian raised fields in Bolivia using UAS-Lidar. The aim of the mapping was to find out how abandoned mounds – artificial hills created centuries back by indigenous people – could survive the fires during the dry season and the three to four metres of heavy rain falls during the annual rainy season. Lidar enabled the collection of data of the ground surface of the wooded area. From the DEM created using the Lidar point cloud, slope, surface, diameter and height of the mounds, could be computed – all being information which helps to resolve the puzzle.

PANEL DISCUSSION

The attendees appreciated the ample opportunities for discussion and exchanging ideas and prospects. At the end of the first day Tim Roorda, director of solutions engineering at Juniper Unmanned, led a panel discussion. The panellists consisted of Omar-Pierre Soubra, Michel Assenbaum, Dr Akira Kato and Wim van Wegen. The discussion focused on the present status quo, the upcoming challenges to make a success of UAS-Lidar and the seemingly limitless number of applications that are coming into sight. The questions and discussions underlined the high commitment for UAS-Lidar of the participants. Indeed, UAS-Lidar is a truly promising surveying technique and only time will tell which applications will be most successful. ◀

FURTHER INFORMATION

A demonstration of the YellowScan Surveyor Lidar system mounted on the Six3 from Escadrone in operation and the resulting point cloud and products can be viewed at: https://www.youtube.com/watch?v=vnyZjfYSL7I

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BY **FRÉDÉRIQUE COUMANS**, CONTRIBUTING EDITOR, GIM INTERNATIONAL

IBM SHOWS A MAINSTREAM DIRECTION FOR SPATIAL IT

'Location' Forms Ubiquitous Part of **Big Data Analytics**

As some of the core infrastructure challenges have been solved, the application layer of Big Data is rapidly building up. And therefore, the major GIS players have recently been focusing their attention on their added 'intelligence' value. The geomatics and GIS sector will benefit greatly from the innovation brought by Big Data companies like IBM, so how does IBM see its future in this regard? The combination of Big Data with artificial intelligence, hybrid cloud, security, Internet of Things etc. has already brought IBM USD33 billion in revenue, and next year it will probably be USD40 billion.

'Spatial intelligence' in the context of Big Data means a new era. The data volumes are enormous, of very heterogeneous sources, a combination of structured and unstructured data, and (almost) real-time analytics and distribution are demanded. Big Data gives a boost to the geomatics and GIS sector. The leading actors in this play are the IT companies, like IBM, who are the real masters in Big Data and cognitive analysis. Geodata and GIS-functionality are inside many of their solutions – under the hood - to get a view on the 'where' in the issues they are helping to solve. However, IBM still has no special organisational entity for the spatial component. In 2016, IBM took over 15 companies, adding to their capabilities in the high-growth areas of cognitive, cloud and security. So they are probably looking to buy a GIS company, we tried to find out in contrary to our better judgment. In an IBM Center of Excellence Christophe De Melio, Executive Analytics Architect, makes sure to respond with only a smile.

GEODATA AND GIS FUNCTIONALITY ARE INSIDE – UNDER THE HOOD

Christophe De Melio: "There will be a lot of sensors and location data as input for the logic reasoning. But the value only arises when combined with other data sources." (Photo: Jeroen van Berkel)

OVER TIME..

The history is short. Big Data is, basically, enterprise technology in the back office: databases, analytics, etc. It started with the large Internet companies (Google, Yahoo, Facebook, Twitter, etc), which were faced with unprecedented volumes of data, and had no infrastructure to profit from them. They started building Big Data technologies. The ethos of open source was rapidly accelerating and a lot of those new technologies were shared with the broader world. The demand grew. Big Data success proved not to be

▲ *The new Watson IoT Global Headquarters in Munich. It represents IBM's largest investment in Europe in more than two decades.*

about implementing one piece of technology, but required the entire company to commit to building a data-driven culture. Over time, the more forward-thinking large companies such as banks, crime-fighters, airlines and Telcos, started experimentation with Big Data technologies. A lot of the infrastructural work has now been done, and the phase where applications are deployed on top of the core architecture is starting. The Big Data firms offer more mature products, including the tech giants - Amazon, Google and IBM in particular. The trend in Big Data analytics is the focus on Artificial Intelligence (AI) to help analyse huge amounts of data and derive predictive insights. The algorithms behind deep learning can now be applied to massive amounts of data cheaply and quickly. Increasingly, machine intelligence is assisting data scientists: just by crunching the data, emerging products can extract mathematical formulas or automatically build the data science model that is most likely to yield the best results. Big productivity gains are the result, also from the real-time intelligence capabilities. Many of those applications are (partly) in the cloud; customers can leverage Big Data without having to deploy underlying Big Data technologies in their data centres. "Within the new solutions, geodata and geographic analyses are ubiquitous. Location data are one of the most interesting data for various industries", says Christophe De Melio. That makes that not only the GIS sector but also the photogrammetry sector is heading for new markets where data from diverse image sources are used to identify changes in scenes and patterns by cognitive systems. Images, more and more from sensors from the Internet of Things, drones and satellites are now being evaluated in automated processes with the utmost precision at near-real-time speed.

WATSON

IBM is now a global cloud platform and cognitive solutions company, which has continually evolved over the past century to remain at the forefront of technological innovation. Last year, USD6 billion went into R&D and 8000 patents were granted. "The mission is to help organisations unlock new insights and usher in a new era of cognitive business", De Melio points out. Cognitive computing or Artificial Intelligence represents a new class of systems. Rather than being explicitly programmed, they learn (to reason) from their interactions with people and from their experiences with their environment.

NOT ONLY THE GIS SECTOR BUT ALSO THE PHOTOGRAMMETRY SECTOR IS HEADING FOR NEW MARKETS

"Cognitive systems can make sense of the 80 percent of the world's data that computer scientists call unstructured, to provide more context and details on the data and define trends in a more automatic way." Over the last five years IBM invested heavily in integration of (secure) cloud computing, big data and cognitive analysis. Now these contribute USD33 billion or 41 percent of the annual revenue. It is expected to be USD 40 billion next year. The central stage is for their Artificial Intelligence core engine called Watson, trained for specific enterprise / sector solutions. Watson is used in all the cloud platforms that IBM offers. De Melio: "We help clients to take advantage of our cloud platforms with industry-focused use cases and applications, using IBM but also other components. The platforms are hybrid: you can deploy modules on your own premises in combination with your legacy applications, mainframes, etc., and not everybody wants to have all data in the cloud. The architecture is set explicitly for data analytics and cognitive capabilities." The global IBM platforms work on 50 IBM cloud data centres in 20 countries. The company is world market leader in cloud computing.

AUGMENTED REALITY

"An important difference with competitors like Google and Amazon is that we do not monetise the value of the data of our customers, i.e the benefit of the analytics is for them", sketches Christophe De Melio. This is an important IBM business ethic. Also crucial for him is that the Watson cognitive engine is defined as a help to users, not that it takes over. "It augments the clients reality. If you want, you can follow the reasoning, ask Watson questions and it might respond with additional questions for you." An often used dataset to augment the clients reality is about weather. In 2016, IBM bought The Weather Company, not only for their data, but also for their high volume, high performing platform for doing analysis. Vestas, Denmark, is using these to define where to put windmills on the sea. The oil and gas companies use sea streams, iceberg-movements and temperature to know where to place their drilling platforms. The capital of Ireland, Dublin, close to the sea, predicts traffic by combining weather data and other data on the IBM smart city platform. The sources are not only data about weather and tides, but also data from cars, traffic lights and the municipal wastewater systems. They know now where the sewer system would react less

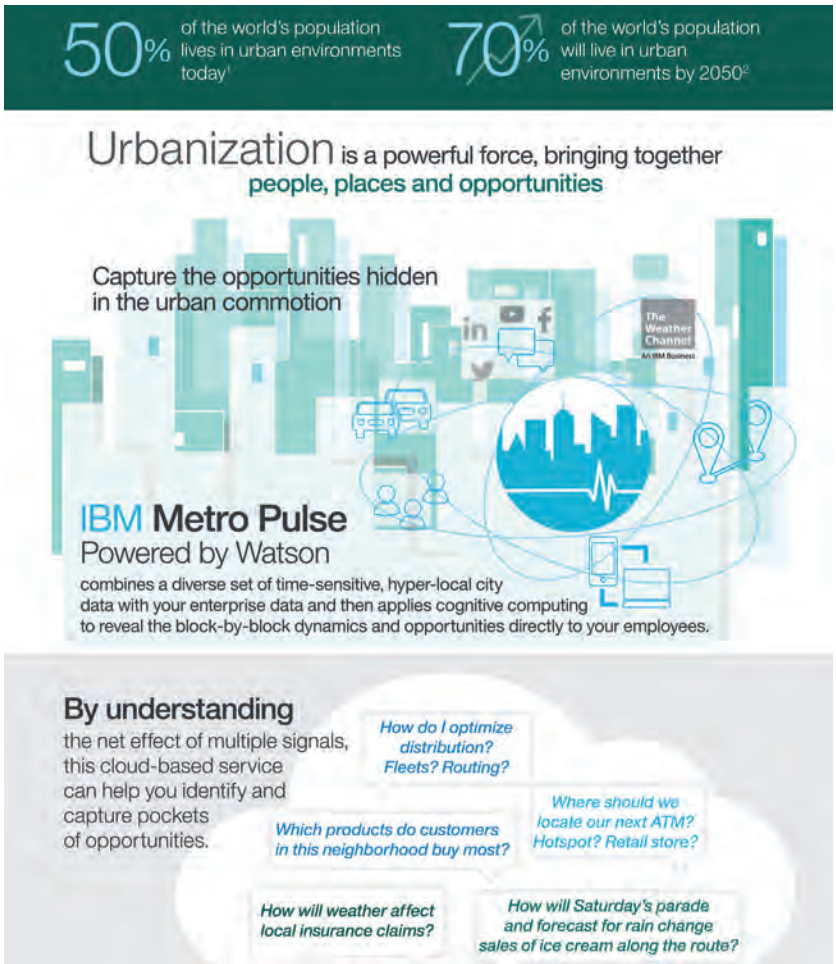
well when more rain is forecasted while the tide is high (so the rainwater is not pumped easily into the sea). Traffic could then be hindered. They combine that with events happening in the city such as a football match and with knowledge about the way people behave then. All this is transformed into alert messages to the citizens.

IBM HAS NO SPECIAL ORGANISATIONAL ENTITY FOR THE SPATIAL COMPONENT

Esri is inside the Weather platform that IBM took over. Esri communicates: "The Weather Company integrated Esri basemaps, demographic and business data, and deep proximity analytic tools to provide powerful location-based insights that spur cognitive thinking and event-specific action." Esri ArcGIS is integrated with many Watson platforms providing location analytics functionality, proximity search tools, and map visualisation as well as integration of clients' spatial data. It is used, for example, to support link analysis, fraud detection, and identity determination for government public-safety agencies as well as banking, insurance, and retail organisations. In addition to being in cognitive computing platforms, Esri is also in IBM business intelligence & reporting products like Cognos – as are others. Since last year, World Boundaries Data from Pitney Bowes are embedded directly in Cognos and Watson. They are used to examine the financial services of various branches, for example, and to frame a list of under-performing ones to enable ATM locators at such places. The global spatial data provider looks ahead: "It is the first step for a deeper analytics partnership with IBM."

INTERNET OF THINGS

The new investment zone is the combination of Artificial Intelligence and the Internet of Things (IoT). "IoT analytics will have a lot of value in the same areas where GIS companies are playing", confirms De Melio, such as supply-chain optimalisation, energy optimisation in smart grids, location-based commercial services and precision farming. There are more than 9 billion connected devices operating in the world today, generating 2.5 quintillion bytes of new data daily. Making sense of data embedded in intelligent devices, in real-time, is creating a significant market opportunity that is expected to reach USD1.7 trillion by 2020. IBM opened the global headquarters for its new Watson IoT unit, as well as its first European Watson Innovation Center in Munich, Germany in December 2015. Now 1,500 people focus on this exploding stream of information and build new solutions at the intersection of cognitive computing and the IoT. "An issue with IoT devices is that they function in very decentralised infrastructures while the need for local analytics and local decisions is important", which he sees as a challenge. "So we have to put 'the analytics on the edge'. That means that as much context information and logic has to be put as close as possible to the IoT devise to make the wanted big data analysis on the spot." He gives an example of a large retail client who uses IoT data from the clothes tags, social media data, location data, but also behavioural data and others for his in-store marketing. "A girl is testing her new outfit. She sends a text message from the fitting room to her mother to ask if she could buy it. The mother goes online to see if the shop gives a discount. There is no discount, so she says no to her daughter. The girl leaves, but as she passes the cash desk she is offered a push message on her cellphone with a discount offer. To give one more example, now from the smart city and energy platforms: IoT / Watson / cloud combinations monitor the energy balance of individual buildings, and can regulate lighting, shading, electricity storage and distribution depending on the position of one building or part of a building amidst others. "There will be a lot of sensors and location data as input for the logic reasoning. But the value only arises if you combine them very fast with other data sources – at best in our cognitive platforms." Which we, of course, answer only with a smile. ◂



▲ *Location data are everywhere, certainly in smart city solutions. But GIS companies will have a hard job keeping themselves visible to end-users.*

ROMANIAN GEOPORTAL TO SERVE MULTIPLE USERS

Thriving Bucharest Presents Mapping Challenges

The applications for up-to-date digital orthophotos and digital surface models (DSM) over areas with rapid change are numerous, however, logistics for collecting aerial imagery over a major city like Bucharest can present challenges due to military and altitude restrictions on overflights. As Romania continues to experience high economic growth and development, the boundaries of the Bucharest Metropolitan Area and its environs are being reviewed and expanded, generating a demand for high-resolution mapping, 3D modelling and detailed GIS data for the entire area.

Bucharest is Romania's capital city and commercial centre. The city proper has a current size of 228 sq km, however, revised boundaries have been proposed that include Ilfov County in a new metropolitan zone that brings the size to 1,800 sq km. Eventually the zone could include over 5,000 sq km and six other cities. These planned changes require up-to-date geospatial information to support informed decision making.

METROPOLITAN AREAS DRIVE GROWTH

Coordinated urban planning is the motivation behind redefining the boundaries of Romania's primary cities. A variety of issues, such as inadequate public transportation and roadways, are hindering growth and development in individual municipalities and reducing quality of life for the population. Supporters of the initiative believe that creating a unified metropolitan zone run by a council of representatives from across the region will reduce the occurrence of duplication and inefficiency, resulting in sustainable growth and improved infrastructure for everyone.

▲ *Dambovita river with a new suspension bridge being built (44°26'48.09"N, 26° 2'30.00"E).*

ROMANIAN MAPPING FIRM SUPPORTS PLANNING

Primul Meridian provides professional services including photogrammetric surveying, cadastral mapping, topographical mapping, Lidar scanning, bathymetry and geodesy. With headquarters in Slatina, Romania, and offices in Bucharest, Caracal, and Craiova, Romania, its 100 employees complete projects for public and private customers.

To meet anticipated demand for high-resolution aerial imagery and other derived products, Primul Meridian started collecting data over Bucharest and Ilfov County (total 2,276 sq km) at 11cm GSD with 60% / 30% overlap. The resulting deliverables include high-quality digital orthophotos, digital surface models (DSM) and infrared imagery. The NIR channel facilitates the classification of vegetation and water surface in derived products, which will be useful for updating local greenspace registers. Field crews are also collecting feature data, such as addresses, to offer complete GIS/imagery packages.

All potential customers will have access to the data via a geoportal, similar to the Republic of Moldova's geoportal that features a 30,000

▲ *Mogosoaia Lake and part of Mogosoaia commune (44°31'16.15"N, 26° 0'21.41"E).*

▲ *Cosmopolis residential compound (44°32'10.01"N, 26°10'21.03"E).*

sq km orthophoto map produced by Primul Meridian. Derived products will be available as custom orders, and 3D vectoring will be completed in the future as needed.

FLYING OVER BUCHAREST

Restrictions on overflights over densely populated areas or facilities that are sensitive from a military perspective are typical, however, it does complicate efforts to map the areas. Unless digital aerial data can be collected from a high altitude, high-resolution geospatial information might be unobtainable. To successfully collect the Bucharest/Ilfov County area, Primul Meridian needed permission to fly over the city and required equipment that could quickly gather the necessary data at a high resolution. The mapping company operates two digital aerial systems — an UltraCamLp digital camera suitable for small to mid-size projects, and an UltraCam Eagle Mark 2 ultra-large format camera ideal for high-resolution mapping with a footprint of 23,010 x 14,790 pixels. The UltraCam Eagle is the only photogrammetric digital aerial sensor that features a user-exchangeable lens system along with R, G, B, and NIR channels.

Primul Meridian was granted permission to fly over the city but had to schedule the image capture for two days when there was a gap in another project. On 10 and 11 April 2017, 2,423 images were collected at 2,500m altitude in 7 ½ hours of flying time with the UltraCam Eagle Mark 2. The extra-wide footprint and powerful 100mm lens allowed the operators to easily meet the time and image quality requirements.

The UltraMap processing suite provides full end-to-end workflow software with automated processing capabilities that require just a few employees to manage the production process. All that is needed are powerful central processing units (CPU), graphics processing units (GPU) and adequate storage space. Vexcel Imaging is continuing to expand the software capabilities based on individual client requests. Using UltraMap, Primul Meridian processed the Bucharest/Ilfov County area in about two weeks.

COMPETING ON LARGE PROJECTS

Due to its large footprint, the UltraCam Eagle Mark 2 is highly efficient for large-scale photogrammetric projects, high-resolution (true) orthophoto production, DSM production, ortho mapping and 3D technical vector mapping. The system may be operated with four different focal lengths — 80mm, 100mm, 120mm, and 210mm. The 210mm lens is effective up to 7,000m in altitude, while the 100mm lens collects imagery at up to 5,000m.

The UltraCam Eagle Mark 2 allows Primul Meridian to successfully compete on very large area projects. The firm is currently collecting 50,000 sq km — about 25% of Romania — for the Romanian National Agency for Cadastre and Land Registration. This project includes processing DTMOrthos, Lidar scanning and 3D vectoring. The flight planning software indicates 60 hours of collection time will be needed with the UltraCam Eagle compared to 116 hours with the UltraCamLp, a 48% time savings. The UltraCam Eagle also produces fewer images over the same area, so processing goes faster. Faster collection and processing reduces project costs and timelines for Primul Meridian.

GEOSPATIAL INFORMATION SUPPORTS ECONOMIC GROWTH

As the capabilities of digital aerial sensors continue to improve, it becomes more feasible to successfully complete complex and challenging mapping projects at a high level of accuracy and quality. The new high-resolution dataset for Bucharest and Ilfov County, collected in just 7 ½ hours with an UltraCam Eagle Mark 2, is useful for multiple applications, including urban development, transportation network planning and utility management. Achieving an effective long-term strategy for economic growth throughout the region relies on up-to-date geospatial information. ◀

ABOUT THE AUTHOR:

Vicentiu Eftimie joined Primul Meridian as an engineer in 2002. He gained experience at smaller firms like SC GEOTOP SRL and has over 10 years' experience as a remote sensing specialist. He is responsible for implementing digital aerial mapping and surveying projects, as well as coordinating the execution of Lidar projects and quality assurance. In addition to office work, Eftimie has participated as a sensor operator for aerial data acquisition involving both imagery and Lidar measurements using different surveying platforms.

✉ office.slatina@primulmeridian.ro
+4 0733 598 658

3D LASER SCANNING AND MODELLING OF EXISTING CONDITIONS

Scan-to-BIM in the Pre-design Phase

The high demand for energy-efficiency of buildings nowadays has triggered the need for gathering documentation on existing construction conditions. This information is then used to design buildings with high consideration to the site or to allow the renovation of old buildings that can no longer meet the requirements for energy performance or comfortable living. The documentation required for this type of situation is often outdated or missing, and to create an optimal design the existing conditions need to be registered and analysed using advanced technological methods, such as Building Information Modelling (BIM) and 3D laser scanning.

Effective planning, coordination and sharing of expert knowledge and relevant project information are essential to architects, engineers and contractors in any type of construction project and at any stage of the project life cycle. Sustainability and energy-efficiency, on the other hand, are demands that can no longer be met using traditional architectural design methodologies. Thus, BIM and 3D laser scanning together play an important role in the creation of reliable models of existing conditions for further development of projects; intelligent parametric building models that can be used to perform various types of simulations early in the design process and ensure compliance with energy demands and other regulations, and are a strong platform for communication with the rest of the project team.

▲ *Figure 1, Point cloud of the former cemetery and the existing building (Autodesk ReCap Pro).*

COPENHAGEN CASE

On the main shopping street in Copenhagen (Denmark) a construction site has been hidden behind plastic covers for about 10 years. At the location of the cemetery of the oldest church in Copenhagen, Saint Clements Church (built in 1192), in a building dating back to more than 400 years ago, the first Shawarma restaurant and the famous disco Absalon opened its doors. When this building was demolished in 2008 to make room for a new one, construction workers started digging into the basement of the former disco and came across hundreds of skeletons of children from the Middle Ages. This was followed by archaeologists investigating the place and due to the financial crisis, no new construction processes have been initiated since.

Now, a new commercial building is to be built at the location of the former cemetery, while the existing construction will be renovated and converted into an office building by Zeso Architects – a renowned Danish architectural

company. BIM, an intelligent model-based process, and 3D laser scanning were used to register the existing conditions, design the project faster, more economically and with less environmental impact.

PRE-DESIGN STAGE

As a starting point in the pre-design stage, terrain, roads, building data and imagery were automatically generated using the Model Builder feature in Autodesk InfraWorks 360 (data sources:

- Terrain – USGS 10 and 30m DEMs from the National Elevation Dataset (NED) used for the United States, SRTMGL1 30m DEM used for latitudes between -60 and +60 degrees, ASTER GDEM v2 30m DEM used for latitudes between +60 and +83 degrees;
- Roads – OpenStreetMap's Highway and Railway datasets;
- Buildings – OpenStreetMap Building data,
- Imagery – Satellite imagery from Microsoft Bing Maps).

The data was then converted into .dwg format and linked into Autodesk Revit for the performance of shadow and solar radiation studies. As some of the generated data seemed outdated or was not accurate enough, the incorporation of 3D laser scanning was deemed necessary.
Thus, the existing building, the inner court yard (the former cemetery) and the surrounding streets were scanned to form a reliable basis for further development of the project. A FARO Focus 3D x330 laser scanner was used. This scanner has a range up to 330m, an accuracy of +/- 2mm and can measure up to 976,000 points/second. The scanner not only captures laser data, but also has an integrated colour camera with up to 70 million pixels and a positioning system comprising of a GPS, a compass, a height sensor and a dual axis compensator allowing immediate positioning of the scans.

As the specific applications of the point cloud data in a building project define the needed level of detail and time required to perform the actual 3D laser scanning, careful planning was necessary prior to scanning the objects of interest. With medium resolution of the images and medium quality settings (defining the intensity of averaging), well-planned scanning sequence and an overlap of at least 30-40% between the different scanning positions, both the indoor and outdoor environments were captured in approximately 10 hours providing data with very high relative accuracy. Results that no other registration method that we have used in the past achieved, including 360 degrees coloured pictures from each scanning position.

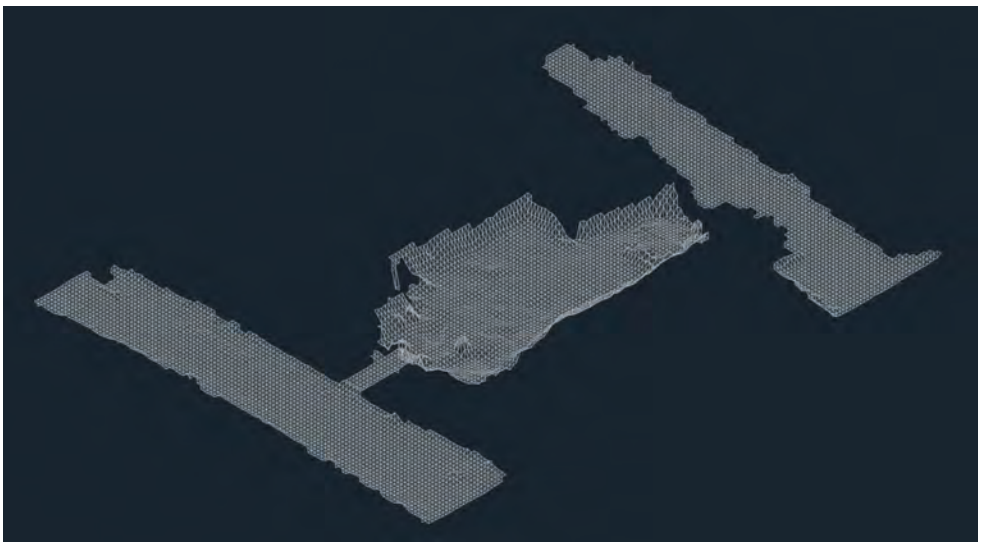


Figure 2, Terrain data generated from the point cloud to .dwg format (Autodesk InfraWorks 360).

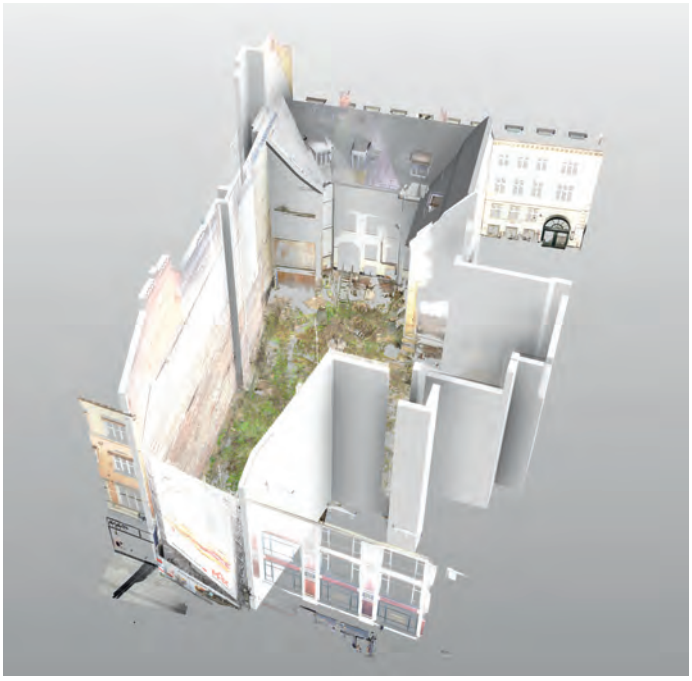


Figure 3, Modelling of the existing building and surroundings based on point cloud (Autodesk Revit and FARO PointSense for Revit).

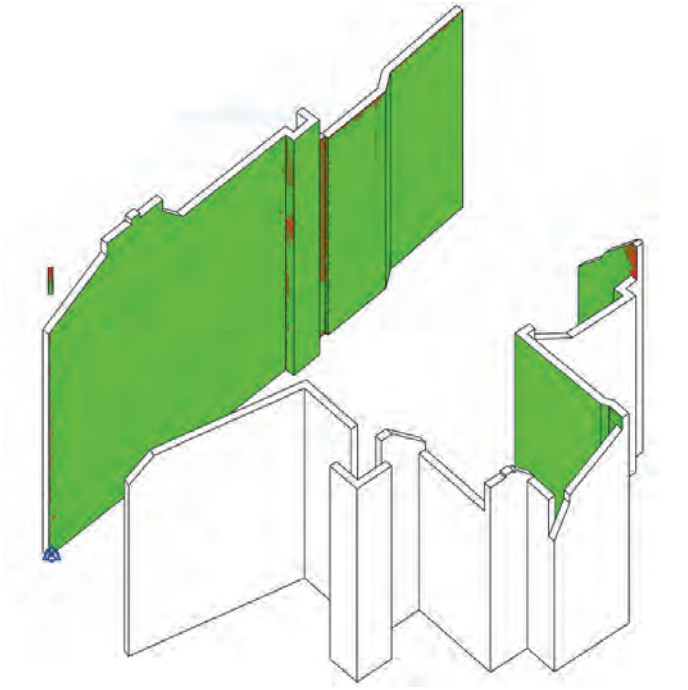
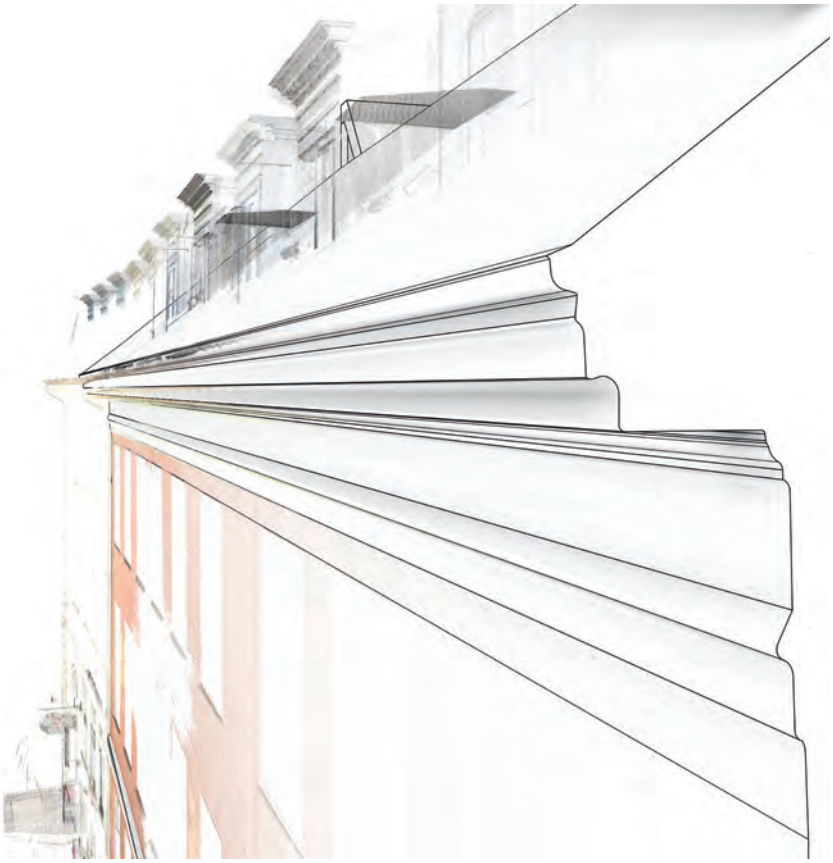
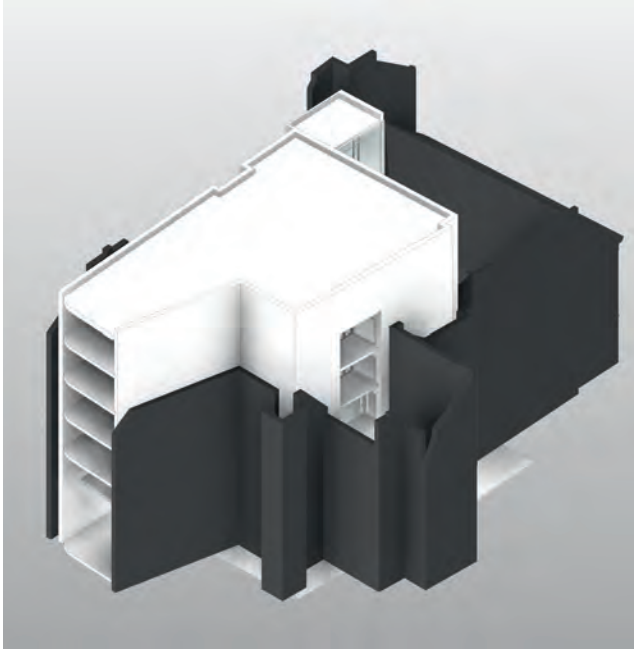


Figure 4, Calculation of the deviation of the modelled surfaces from the point cloud (Autodesk Revit and FARO PointSense for Revit).



▲ *Figure 5, Modelling façade details based on the point cloud (Autodesk Revit and FARO PointSense for Revit).*



▲ *Figure 6, Designing the new building in the inner court yard (Autodesk Revit).*

Moreover, after post-processing the data, it was made available to the whole project team as a single point cloud file that could be opened and viewed in Autodesk ReCap or directly linked into Autodesk Revit. This, furthermore, eliminated the need for future visits to the site and thus generated both time and cost savings for the whole project team.

POST-PROCESSING

Post-processing of the point cloud files generated from the various scanning positions was done using Autodesk ReCap Pro. A copy of the original file was cleaned up from all unnecessary points and only the terrain points were left intact. This file was then linked in Autodesk InfraWorks 360 and accurate terrain data of the inner court yard was automatically generated from the point cloud data. This model was exported to .dwg format to create the design proposals and do the excavation planning. Furthermore, by linking the terrain and building data from Autodesk InfraWorks 360 and the point cloud from the laser scanner into Autodesk Revit a reliable basis for the modelling of the existing buildings and their surroundings was created.

Using FARO PointSense for Revit, accurate building levels were generated from the scans. This also allowed the walls surrounding the inner court yard and the existing buildings to be roughly modelled. The deviation of the modelled surfaces from the measured point cloud was then calculated and visualised with colours indicating the distance between the two. This ensured acceptable tolerances prior to the initiation of the design.

Using FARO PointSense for Revit a detailed model of the existing building's façade elements was made so that the existing façade could be analysed to allow preservation and restoration of the 'old' view of the building.

CONCLUSION

The generation of reliable data of the current situation for the further development of the Copenhagen case seemed a challenging and time-consuming task prior to the incorporation of 3D laser scanning. Thanks to the advance of technology, this process turned out to be much faster, more seamless and transparent to the whole project team. BIM and 3D laser scanning were applied together as an integrated process and methodology that brought multiple benefits in the pre-design stage of the project by generating more reliable and precise data achieved more quickly than with any other method used before. What is more, these technologies will continue adding value in every aspect throughout the rest of the building's life cycle and thus, they will generate time and cost savings and ensure high-quality and well-informed decisions. ◀

BIOGRAPHY OF THE AUTHOR

Galina Slavova was educated as an Architectural Technologist and is currently involved in a Master's degree in Building Energy Design at the Technical University of Denmark (DTU). In the past 5 years, she has gained vast experience in the field of Building Information Modelling (BIM) whilst working at several architectural companies and as a Consultant in BIM and Sustainability at the Danish Technological Institute (DTI). In 2015, she took over NEWBIM ApS and started the development of BIM Project Models to support the needs of the AEC industry in relation to BIM implementation.

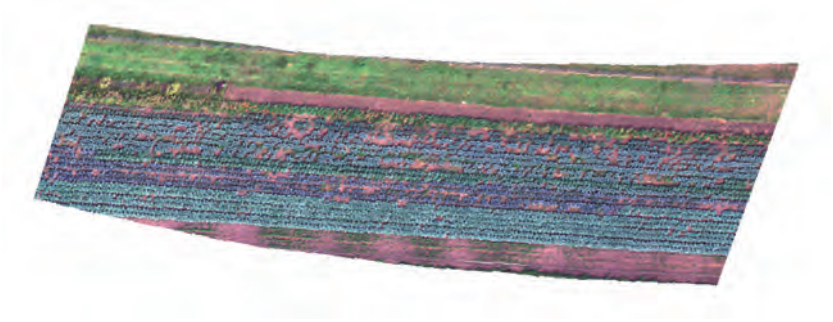
RESONON, INC.

Hyperspectral Remote Sensing: **From Aviris to Everyone**

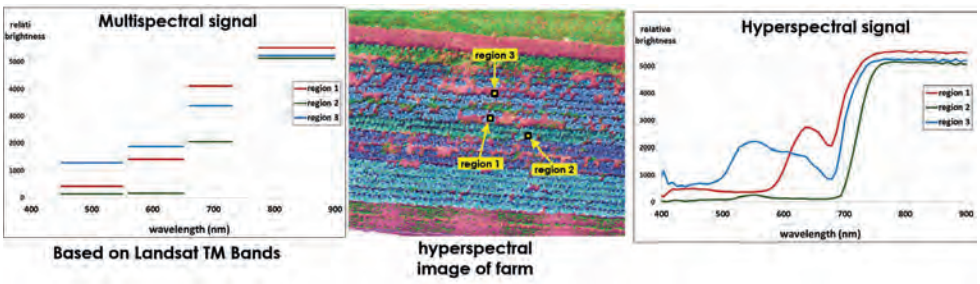
Hyperspectral imaging (HSI) has the potential to transform the way computers see, enabling them to think much more powerfully. When obtained from an aerial platform such as an airplane or satellite, hyperspectral (HS) remote sensing data can make existing tools more useful. Whether used for early detection of crop stress, determining forest composition and health, monitoring algae blooms in lakes and oceans, or examining mineralogical properties of mountain ranges, HSI is rapidly becoming an integral component of precision remote sensing. Furthermore, recent developments in HS technology and the aerial drone market has lowered prices and enabled broad access to this exciting technology.

HS datasets are 2D images where every pixel contains a complete spectrum. A standard colour camera provides three spectral data points at each pixel: red, green, and blue (commonly known as 'RGB'). The viewer's brain interprets the mixture of these three colours as a unique colour in the visible spectral range. However, HS data typically has between 100 to 500 spectral data points, essentially providing a continuous reflectance spectrum. Furthermore, HS cameras often scan beyond the visible spectral range, penetrating into the ultraviolet and infrared.

HSI is useful because different materials have different reflectance spectra; different plant species have different spectra, and even the same species of plant will have a different spectra under different health conditions. So, to use a very popular example, HSI has the potential for early detection of crop stress. Importantly, HSI data is quantitative data (and 'big data' at that), amenable to automated statistical classification, so detection can be automated by computer.



▲ *False-colour rendering of hyperspectral data of crops, obtained with Resonon's Pika L hyperspectral system. This dataset, along with their free analysis software, is available for download at www.resonon.com.*



▲ *Graphs showing the difference between hyperspectral and multispectral data. Data shown is a farm in Bozeman Montana, and was acquired from a drone.*

Multispectr al cameras provide yet another form of spectral imaging, albeit with only a few spectral bands, typically four to twelve. Often multispectral data is adequate for many applications, and these cameras can be both lighter and cheaper than HS cameras. However, the precision and detail available in HS data makes it indispensable for detecting subtle changes and weak signals. The figure below shows the difference between multispectral and HS data obtained from HS data of a farm in Bozeman Montana:

HISTORICAL PERSPECTIVE

Historically HS remote sensing was available only to special researchers, using very large, expensive instruments on large military and government platforms. The instruments weighed 40 kg or more, cost half a million dollars or more (up to many millions of dollars), and were difficult to operate and maintain. Some well-known spectral imaging systems include LANDSAT, AVIRIS, and HYPERION.

In the last five years or so the explosion in the unmanned drone market, combined with the availability of small, fast and cheap computers, has enabled HSI technology to become accessible to almost everyone. HS sensors themselves are now relatively small

▲ *Resonon's Pika L hyperspectral system, ready for mounting in a UAV.*

▲ *Resonon's Pika L hyperspectral system, ready for mounting in a UAV.*

(< 1kg) and inexpensive (USD10-20k), and there are quite a few commercial packages specifically designed for drones. For example, the entire system we manufacture at Resonon weighs 1.6kg and costs less than USD35,000. Assuming the price of a high-quality multicopter is about USD20-USD30k (with gimbal and controller), a researcher or consultant can acquire HS remote sensing data for under USD70k, which fits many research and development budgets.

BUSINESS ENVIRONMENT

Not only is producing HS cameras a strong technical challenge, but incorporating the camera into a complete autonomous remote sensing system is a strong business challenge. In the case of our airborne system, a small computer flies with the system and operates the imager, GPS/IMU, and point spectrometer that measures solar illumination. After flight, the raw data is geocorrected for the GPS/IMU and solar information, and the final output is georegistered HS data. Integrating the components into a user-friendly tool requires specialised knowledge of spectral imaging and remote sensing, lots of software development, and familiarity with customer needs.

The importance of agriculture and environmental monitoring is driving strong demand for HSI across the world, particularly in Asia. These topics address persistent critical global issues and the use of HS data to solve these problems is expected to grow. Additional HSI applications include animal science, food science, plant science and geology. This growing demand is fueling an increase in the number of companies supplying HS equipment along with advances in HS technology itself.

FUTURE CHALLENGES

However, despite a vast array of scientific studies showing potential benefits, HS remote sensing is still largely a research topic, and the analytical techniques required to transform this technology to commercially viable products remain to be developed. To revisit the example of precision agriculture, while there is much published research correlating HS signals to specific crop stresses, it is currently unclear how to deploy HS cameras on commercial tractors and sprayers. The hope is that HSI will eventually lead to precise and location-specific applications of pesticides, herbicides and fertilisers. These tools will likely be available to commercial farmers in the next five to ten years, but at this time it remains an outstanding problem.

COMPANY PROFILE

Founded in 2002, Resonon, Inc. is a high-tech optics company located in Bozeman Montana and specialising in HSI systems. Over the last four years we have transitioned from a grant-based research company to a market-driven enterprise supplying products to customers worldwide.

Resonon is a vertically integrated company, including optical design, engineering, machining and software development capabilities, currently employing 13 individuals. We design, manufacture and integrate the HS systems entirely in our own facility. Our strengths are high-precision user-friendly products, affordable pricing and excellent customer support.

"We have designed our systems for users that wants to focus on their research – they do not have to be experts in HS imaging or remote sensing," says Rand Swanson, president of Resonon. "Because they are turnkey systems, the user can literally pull it out of the box and begin collecting data right away."

"Research funds are difficult to come by, and researchers do not have any money to waste, so our customers are very price-sensitive," continues Swanson. "We at Resonon have worked diligently to keep costs down so our sensor packages can be available to everyone." ◀

More information

Resonon, Inc.
Bozeman, MT 59047 USA
+1 (406) 586-3356 x116
stern@resonon.com
www.resonon.com

Volunteer Community Surveyor Programme

Together with Global Land Tool Network (GLTN), the FIG Young Surveyors Network (FIG YSN) established a competence based volunteer programme for young surveyors also known as Volunteer Community Surveyor Programme (VCSP). VCSP is an innovative volunteer programme that intends to be a powerful driver for both social impact and professional development. The VCSP leverages on the skills, experience, talents and education of young surveyors, matches this competence with the needs of GLTN, particularly in GLTN's county level implementation plans and programmes. VCSP represents opportunities for young surveyors to touch a particular cause, or bring surveying skills and knowledge to contribute and impact communities through one's volunteered capacity. VCSP is about matching the right person with the right skills and knowledge, at the right time, to the right opportunity through GLTN with the overriding aim to achieve greater impact.

The VCSP is inspired by the conviction that volunteerism is a powerful means of engaging people in tackling development challenges worldwide. Every young surveyor can be a VCS by contributing their time, skills and knowledge through volunteerism, and their combined efforts can be a significant force for achieving development on the ground. The young surveyor will be challenged to transfer useful knowledge and contribute at the community level while gaining a greater understanding of the issues affecting these communities that are often marginalised and vulnerable.
The Volunteer Community Surveyor Programme is a pilot programme. It is a small-scale, short-term pilot that helps GLTN/UN-Habitat and FIG YSN to learn how a large-scale programme might work in practice. It provides a platform for all stakeholders to test logistics, prove value and reveal benefits. "

Eva-Maria Unger, Chair Young Surveyors Network

More information
www.fig.net

Arctic Spatial Data Pilot

Natural Resources Canada (NRCan) and the United States Geological Survey (USGS) co-sponsored a recently completed Arctic Spatial Data Pilot, executed by the Open Geospatial Consortium (OGC). The objective of the Pilot was to show how geospatial data can be used as a tool for making more informed decisions and providing more efficient administration of the Arctic region. The Pilot tested interoperability of standards, increased access to Arctic data, and demonstrated the diverse, rich and valuable potential of providing geospatial data using standards.

The idea behind the Arctic Spatial Data Infrastructure (Arctic SDI) is to bring together data and information – the most authoritative information available – to aid in our understanding of what is happening in the Arctic environment and to allow smart decisions to be made as a result. The Arctic SDI is an invaluable opportunity to bring together geospatial experts and scientists in a voluntary cooperation between the eight national mapping agencies of the Arctic countries (Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden, and the United States) in direct support of the priorities of the Arctic Council and other important stakeholders.

GSDI commends both NRCan and USGS for providing financial resources to influence and support international geospatial initiatives and the formation of compatible spatial data infrastructures. The Arctic Spatial Data Pilot had a North American focus, yet is scalable to the circumpolar community. The Arctic region is of increasing interest to the whole world as a result of its linkage to global climate systems, opportunities for economic development, geo-political strategic importance, and its environmental importance as homes to indigenous populations and other residents and sensitive ecosystems. To be successful, the Arctic Spatial Data Pilot took particular requirements into account, including responding to priorities of Northerners and Aboriginal Communities, working in zero/low bandwidth regions, and considering the realities of frontier economies.

The final demonstration of the Arctic Spatial Data Pilot, held in March 2017, showcased data intensive scenarios including sea ice evolution, caribou migration analysis, effects of new shipping routes, food security and landslide susceptibility mapping. Videos and the Final Engineering Report, which will be evaluated by Arctic SDI to inform ongoing strategic priorities, can be found online.

More information
www.gsdiassociation.org
www.opengeospatial.org/pub/ArcticSDP/index.html
https://arctic-sdi.org

The Onsala Twin Telescopes

The Onsala Space Observatory, Chalmers University of Technology, and the International VLBI Service for Geodesy and Astrometry (IVS) are proud to announce the inauguration of a new pair of twin telescopes for geodetic and astrometric VLBI. More than 200 international and national guests, including veterans of the first transatlantic VLBI observations in 1968, as well as the regional governors and representatives of Chalmers, participated in the inauguration ceremony on 18 May 2017.

The two new telescopes have dishes of 13.2m diameter, and follow the design specifications for the VLBI Global Observing System – the next generation geodetic VLBI network with ultra-fast telescopes and wide bandwidth recording. The telescopes will allow continuous observations by at least one of them, but will also permit exploitation of innovative observing scenarios with other stations, so offering new opportunities for VLBI research.
The new telescopes join a number of other co-located VLBI instruments at Onsala. Together with the exisiting 25m and 20m radio telescopes they are part of the Onsala Telescope Cluster. The 25m radio telescope was installed in 1964 and is the first European telescope to be involved in VLBI, with observations commencing in 1968. The 20m radio telescope was installed in 1976 and has been used with the MarkIII geodetic VLBI system since 1979. Today it has one of the longest time series in the IVS database.

OTHER CO-LOCATED INSTRUMENTS

The GNSS station ONSA was established in 1987 as part of the CIGNET network, several years before the International GNSS Service (IGS) was founded. ONSA has had a pioneering role in the early days of GNSS, and has the longest continuous time series in the IGS network. There is also a gravimeter laboratory with a superconducting gravimeter, and a tide gauge site with several independent sensors. The observatory is one of the small number of fundamental space geodetic sites that have direct access to sea level and have co-located VLBI, GNSS, and gravimetry instrumentation. Onsala is therefore a very important co-location site for IAG's Global Geodetic Observing System.

More information
www.ggos.org

National Societies and Worldwide Experiences

The 28th International Cartographic Conference took place last month in the impressive surroundings of the Wardman Hotel in Washington DC. The next ICA GIM International column will reflect on the conference as a whole, and its impact on the cartographic community worldwide. One of the many fringe meetings, including gatherings of ICA Commissions across Washington in the preceding days, was an inaugural meeting of a 'World Cartographic Forum'. This initiative, promoted by Alex Kent, president of the British Cartographic Society, is intended to collect the experiences and practices of national cartographic societies from around the world to address common problems of purpose, governance, services, membership retention, establishment and relations with kindred organisations.
In introductory remarks, the ICA president reflected on the nature of membership of an organisation (such as a national cartographic society): previously membership used to be taken as a firm, long-term commitment; today with the rise of social media, making it very easy to 'unfriend' or withdraw from engagement, the concept of belonging to a society is much more fluid, and the commitment to such a society is much more irregular. Many societies have an ageing profile, and difficulty in recruiting younger cartographers: membership is not perceived as important by young people.
It was agreed that the attracting, retaining and offering of benefits to members is crucial. Here, publications have a particular importance, with formal journals of record and informal newsletters being equally valued. In some cases, differing membership categories can be created with variable access to materials of direct interest. The monitoring of membership, characteristics of members, events and their impact, are also critical to meet expectations and assess impact.
Conferences are regarded as important information conduits, but are also vitally important for networking and maintaining an engagement with the society. One society's experience was to insist on membership as a pre-requisite for conference attendance. For another society, a lot of work goes into ensuring the conference goes well, student discount is large, the conference recognises professional/commercial sectors, travel awards go to members from across the field, the conference is open to all, and is abstract-based only. In this case, the representative suggested that >50% of the conference effort was devoted to non-academic activities.
Focusing on young people with alternative, less formal, models of conference activity such as 'hackathons' (with pizza and beer supplied) was considered as the way forward.
It was pointed out that some conferences only succeed due to sponsorship by engaged commercial companies: this is a vital component for some, but others experienced conferences as being a source of funds rather than a drain on resources.
Other experiences presented were less generic, and covered experiences in recruitment, accreditation, maintaining quality in outputs, and jointly working with national sister societies.
Summarising, Dr Kent solicited thoughts on the future for the Forum, an online presence, the role of the Forum in future ICA conferences, and initiatives for getting young people engaged.

More information
www.icaci.org

The Prepublication of Papers in Public Archives

THE ISSUE

There is a growing tendency in neighbouring disciplines to post manuscripts in public repositories such as arXiv or on the authors' home page while submitting the manuscript for publication to a conference and/or scientific journal. The reasons are not exactly clear, but certainly include:
(a) authors want to prove that they are the originator of a certain idea,
(b) the formal reviewing process is at times too long, in particular for some PhD students,
(c) public repositories are part of the open-access publication policy.
This policy is encouraged (and sometimes enforced) by many donors and universities, partly due to the high price of scientific journals, partly with the argument that research results which are obtained with public money need to be available to the public for free, while at the same time authors need publications with a high impact factor.

ISPRS POLICY ON PRE-PRINTS IN PUBLIC REPOSITORIES

ISPRS recognises the increase in popularity of publishing technical reports in public, non-commercial repositories. As a result, a paper submitted to an ISPRS Journal or an ISPRS scientific meeting may already be available to the community, and during the review process the authors of a paper may be known to the reviewer. The ISPRS policy is that papers posted in such repositories, including the home page of the authors, are not considered prior work. As a consequence, authors are not required to declare whether or not they have posted a paper in such repositories.
A reviewer should review such a paper as if the paper in the repository did not exist. Citations to papers in the repository are not required and failing to cite them or beat the performance of algorithms etc. described therein are not grounds for rejection.
Reviewers should make every effort to treat papers fairly whether or not they know (or suspect) who wrote them, while at the same time not giving away their own identity.
More information on this important topic and a rationale for the ISPRS policy decisions can be found in the July edition of the ISPRS eBulletin at www.isprs.org/news/newsletter/2017-03/index.html.

Christian Heipke, President ISPRS

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

AGENDA

2017

SEPTEMBER

UAV-G 2017
Bonn, Germany
from 4-7 September
For more information:
uavg17.ipb.uni-bonn.de

CMRT17 - CITY MODELS, ROADS AND TRAFFIC
Hannover, Germany
from 6-9 september
For more information:
www.ipi.uni-hannover.de/hrigi17

ISPRS GEOSPATIAL WEEK
Wuhan, China
from 18-22 September
For more information:
zhuanti.3snews.net/2016/ISPRS

2ND GEOINT AND OPEN SOURCE ANALYTICS SUMMIT
Alexandria, Virginia, USA
from 19-20 September
For more information:
geoint.dsigroup.org

INTERGEO
Berlin, Germany
from 26-28 September
For more information:
www.intergeo.de

I3S 2017 - 5TH INTERNATIONAL SYMPOSIUM ON SENSOR SCIENCE
Barcelona, Spain
from 27-29 September
For more information:
sciforum.net/conference/i3s2017Barcelona

OCTOBER

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

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

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

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

CALENDAR NOTICES
Please send notices at least 3 months before the event date to: Trea Fledderus, marketing assistant, email: trea.fledderus@geomares.nl

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