GIM INTERNATIONAL

THE GLOBAL MAGAZINE FOR GEOMATICS
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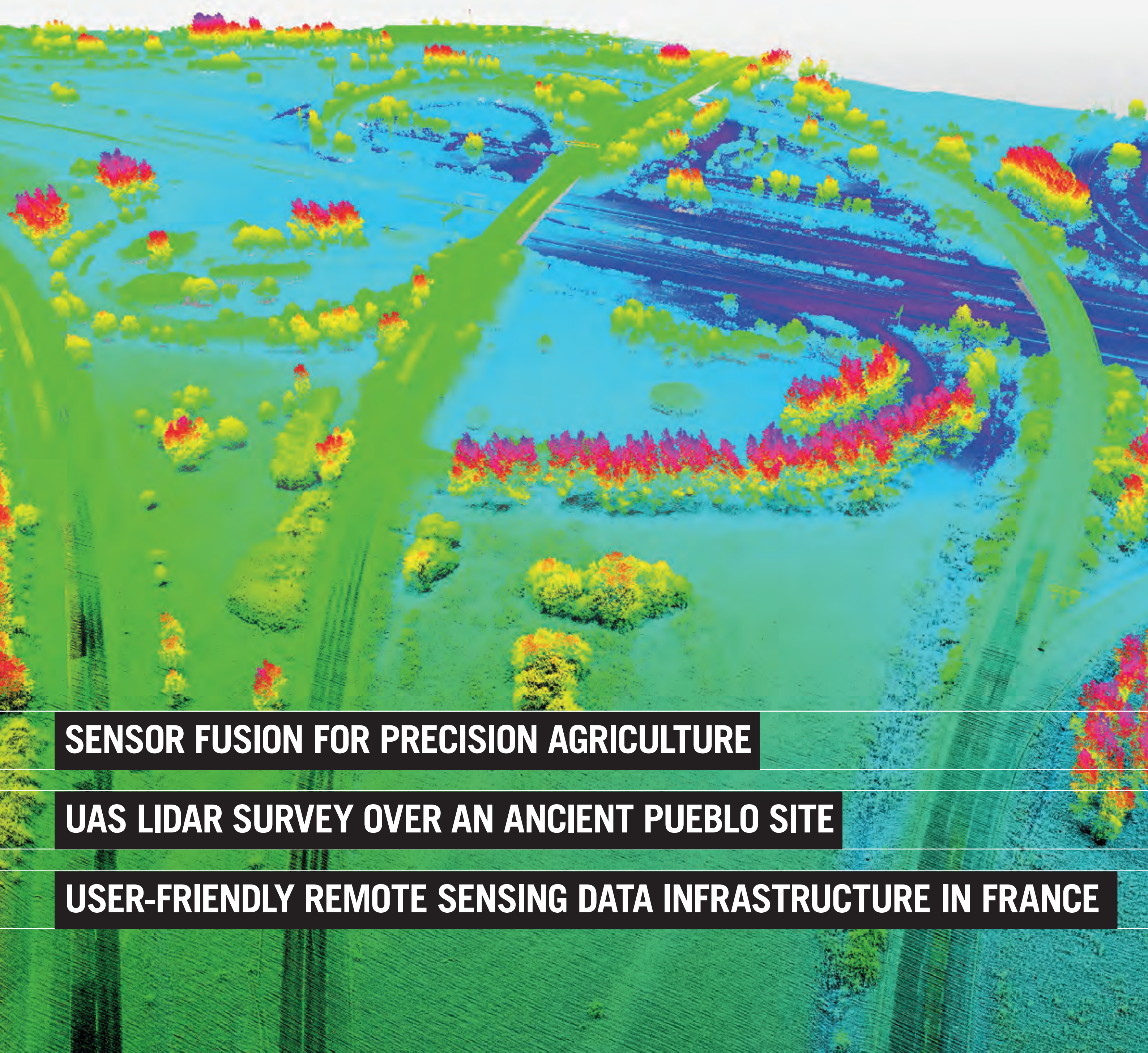
geomares

ISSUE 4 • VOLUME 33 • JULY/AUGUST 2019

Lidar Point Cloud Segmentation

A Novel Framework for Processing Terrestrial Lidar Data



SENSOR FUSION FOR PRECISION AGRICULTURE

UAS LIDAR SURVEY OVER AN ANCIENT PUEBLO SITE

USER-FRIENDLY REMOTE SENSING DATA INFRASTRUCTURE IN FRANCE

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 ISSN 1566-9076

COVER STORY

This issue of *GIM International* has a special focus on Lidar technology, with applications ranging from agriculture to archaeology. The cover image shows very detailed 3D Lidar data that accurately depicts the landscape. The survey was conducted along a 47-kilometre stretch of the M1 motorway in northwestern Hungary. (Courtesy: YellowScan)

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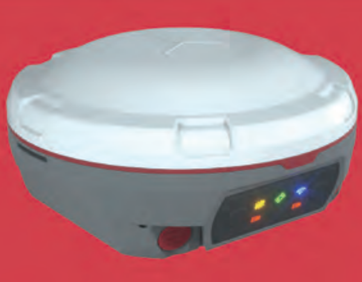

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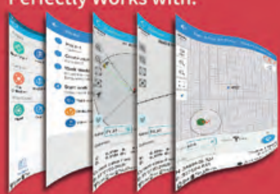

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Taking the Stage at Intergeo

GIM International has been serving a worldwide audience of mapping and surveying professionals for more than 30 years. Over the decades, we have published countless features about state-of-the-art technical developments in our industry, shared challenging case studies employing the latest survey methods, zoomed in on the advancing capabilities of sensors, reported the rise of new technologies to capture our environment and provided context for how our readers can benefit from it all. We have always done our utmost to bring you the latest product-related and business news covering the entire geospatial spectrum – first by distributing our magazines across the globe, and subsequently also through our website, weekly e-newsletter and more recently our social media channels. In view of the growing challenges facing our planet, the need for us to continue in our mission is greater than ever. Although the landscape for media and publishing companies has changed considerably over the years, we are determined to remain your number-one source of information about the comprehensive field of geomatics.

We are also always on the lookout for other ways of highlighting all the innovation going on in the geospatial industry which is why we are pleased to have been invited to put together the conference programme at the Forum on the third day of this year's Intergeo (Thursday 19 September). We have managed to secure two renowned keynote speakers from the mapping industry, as well as nine other high-profile experts from research institutions and pioneering companies in our business. The *GIM International* conference track is divided into two sessions: the morning and the afternoon. The morning session, titled 'Geomatics in the Next Decade', will give you a realistic yet enthralling glimpse into the geospatial future. Meanwhile the afternoon session, titled 'The Many Faces of Mobile Mapping', will cover all the advancements in mobile mapping, whether the system is mounted on a car, on a train, on a drone or on your back. I hope you will come and see *GIM International* take the stage on this inspiring day at the world's leading trade fair for geodesy, geoinformation and land management, which this year is being held in Stuttgart. You won't regret it!

Wim van Wegen, content manager

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Huge Variety

The ISPRS Geospatial Week is a unique combination of workshops aiming to promote international cooperation and knowledge exchange in the field of geospatial science and technology. This year, the event was held from 10-14 June in Enschede, The Netherlands. It was organized by the Faculty ITC, University of Twente, on the university campus, which is a pleasant environment with modern facilities and green surroundings suitable for indoor and outdoor discussions. *GIM International* was the media partner of the event, where around 750 experts, scholars and users gathered, originating from all around the world. I had the pleasure to be part of the local organizing committee led by Prof George Vosselman. The preparation was done in a highly professional manner; the collaboration between everyone involved was smooth, structured and very well organized. Personally, I heard very positive feedback from many participants during the event. Some of the tutorials held just before the event, such as those on deep learning using point clouds and images, were fully booked very early on. The 13 workshops jointly organized with the members of the ISPRS working groups ran in parallel, but there was quite an even distribution of people in the rooms. They covered a huge variety of topics, starting with classical photogrammetry and remote sensing using images and point clouds obtained from different platforms and sensors, and ending with the very trendy use of machine learning and deep learning techniques. The fact that the fifth edition of UAV-g was also part of the Geospatial Week significantly contributed to the number of participants, since there is very high interest in unmanned systems and their applications. Judging from the participants' feedback, the exhibition, lunches and dinners were also highly appreciated. A Q&A on the ISPRS Geospatial Week can be found on pages 16 and 17 of this magazine.

Mila Koeva, assistant professor, University of Twente

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THE RIGHT INGREDIENTS TO TACKLE CLIMATE CHANGE

Low Lands, High Potential

Earlier this year, Esri CEO and founder Jack Dangermond paid a visit to Zwolle, a city of about 130,000 inhabitants in the eastern part of the Netherlands. He described the country as a centre of excellence when it comes to knowledge, technology and innovation, which puts it in a strong position to lead the international response to the challenges of climate change. Geoinformation is a core ingredient in protecting us from the threats of global warming. So which other ingredients do the Dutch – and especially the country's geospatial professionals – have to offer?

Firstly, knowledge of cartography can play a key role in tackling climate change. After all, skilled map-making ensures that maps can be interpreted quickly and can serve their purpose. Interactive maps, such as those provided by Esri, help us to get a better understanding of the potential hazards posed by global warming. By clearly visualizing the threats that our world's ecosystem faces at every level, such maps are crucial in enabling governmental authorities to act to mitigate climate change, and to obtain the social and professional support required.

The Dutch and the Flemish have an impressive history when it comes to cartography. Joan Blaeu, Gerard Mercator, Abraham Ortelius, Jodocus Hondius, Lucas Janszoon Waghenaer and Petrus Plancius were all some of the most prominent cartographers of the 16th century. Without such highly skilled map-making, the Netherlands – which at that time was still known as the Republic of the Seven United Netherlands – would never have been able to achieve its status as such a powerful seafaring nation in the late 16th and throughout the 17th century. The maps that were drawn around that time are considered to be remarkable milestones in cartographic history, with Mercator and Ortelius from the Southern Netherlands (which is now situated in Belgium) regarded as key founders of the Golden Age of Dutch cartography.

Let's fast-forward to the 21st century. The Netherlands lost its status as a major world power long ago and is now a small (40,000km^2), densely populated (17 million inhabitants) country on the shores of the North Sea. Having seen their geopolitical power become eroded, the Dutch are keen to prevent the same thing happening geographically. Large parts of the physical land are situated below sea level, which has forced the nation to develop engineering skills to protect itself against the sea. As a result, the Dutch count among the leaders in coastal protection and land reclamation, and Dutch engineering companies are contracted for major infrastructure projects worldwide, such as to build colossal dams and advanced storm surge barriers to protect major cities against the sea.

As Jack Dangermond observed, the Netherlands – with its history of maritime and engineering innovations – is also in a strong position to become a front runner in the sustainable production of energy. The truth is that the necessary technology is already available. But although Dutch companies are involved in projects all over the world, the country itself still is lagging behind in its progress to reduce greenhouse gas emissions by 49% by 2030 (compared with 1990)

▲ *Wim van Wegen.*

and to become practically carbon neutral by 2050. The Dutch government hopes that its national climate agreement will enable the country to achieve these climate goals, while also strengthening the Dutch economy.

Futhermore, the Netherlands excels in land administration, which is an important pillar in the prevention of and response to natural disasters. Kadaster International is widely recognized for its work in this field of expertise, as too are institutions such as Delft University of Technology, University of Twente and Wageningen University and Research. So I echo Dangermond's observation: the Netherlands has great potential to accelerate the transition towards a smart and sustainable economy and to tackle climate change. What are the core ingredients? Geospatial data combined with broad social, professional and political support! ◀

Taking Full Advantage of the Benefits of UAS Technology

UAS technology is an important tool for Geosyntec.

Leveraging unmanned aerial system (UAS) technology across surveying and engineering sectors is demanding. The expectations in terms of accuracy and accountability call for the best in expertise, methodology and equipment. Using the latest UAS photogrammetric hardware and software, surveyors are now capturing millions of survey measurements on the ground, where they would previously have measured only hundreds. It is essential to have the best-quality equipment, software and workflows to ensure this data is accurate, robust and defensible for professional use. Consulting and engineering firm Geosyntec works with private and public-sector clients to address new ventures and complex problems involving the environment, natural resources and civil infrastructure. UAS technology is becoming a key complement to the innovative technical solutions Geosyntec provides to its clients. From initial site inspections, engineering design and analysis to improving construction quality assurance and project earthwork productivity assessments, leveraging in-house high-accuracy UAS mapping capabilities is proving to be invaluable in countless projects.

▸ **https://bit.ly/2RzDdeR**

SimActive Introduces New Drone Processing Service

SimActive's new drone processing service.

The Canadian photogrammetry software manufacturer SimActive has launched a new unmanned aerial vehicle (UAV or 'drone') data processing service based on Correlator3D. Clients can now upload full projects and have SimActive experts generate optimal results from their imagery, including DSMs, DTMs, 3D models and orthomosaics. As opposed to common cloud-based solutions where outputs are generated automatically and delivered as-is, the new offering includes quality control by photogrammetry specialists. Manual tagging of ground control points is also performed as part of the service.

▸ **https://bit.ly/2KDyOXA**

Intergeo Places People at the Heart of Digitalization

Intergeo celebrates its 25th anniversary this year.

Intergeo is celebrating its 25th anniversary this year, providing the perfect occasion for a brief review of what it has achieved so far. Even more importantly, it's an appropriate juncture for looking ahead – to the leading international trade fair for geodesy, geoinformation and land management, with its focus on digital topics. Industry experts from the realms of business and science gathered in Stuttgart at the end of May for a Round Table to share their experiences and expertise, true to Intergeo's motto: 'Knowledge and action for planet Earth'. Reviewing how Intergeo has evolved over time, Christiane Salbach, managing director of the German Society for Geodesy, Geoinformation and Land Management (DVW), observes that "Intergeo has become far broader and more interdisciplinary, international and even dynamic in recent years." She adds: "We have been able to reflect trends at Intergeo much faster than before in recent years and have also become more data-driven." All in all, Salbach says the leading trade fair has become far more important, not only in Germany, but even more so on the international stage.

▸ **https://bit.ly/2LmKfT5**

Leica Geosystems Streamlines Workflow with New Point Cloud Software

Leica Geosystems, part of Hexagon, has announced Leica Cyclone 3DR: new reality capture software that fuses technology for centralized, full-scale point cloud management from Leica Cyclone with advanced, automated point cloud analysis and modelling from 3DReshaper. The new software delivers a simplified platform for surveying, architecture, engineering and construction (AEC) and tank inspection applications. With industry-centric guided workflows, Cyclone 3DR includes a range of adaptable features for automating cleaning, modelling, meshing, extraction, inspection and reporting. An assortment of 3D deliverables can be created to meet the unique needs of reality capture professionals across a wide spectrum of fields. Specialized workflows such as construction monitoring, tunnelling surveying and tank inspecting (based on the API 650/653 standard) are also available. Cyclone 3DR further connects the use of reality capture into multiple industries through its wide support of data formats, including IFC, STL, OBJ, VRML, DXF, STEP, IGES and more.

▸ **https://bit.ly/2KBD1uV**

Leica Cyclone 3DR.

Multi-sensor UAV Project Secures Digital Preservation of Indian Landmark

Terra Drone India scanned and surveyed the damaged minaret using multiple technologies.

Terra Drone India has recently successfully completed a multi-sensor, multi-platform scanning project of the internationally recognized landmark Charminar. Built in 1591, the monument, which is often called the 'Arc de Triomphe of the East', suffered significant damage in May 2019 when a huge chunk of lime plaster from its south-west minaret broke and fell off. This incident made the digital preservation of Charminar extremely time-sensitive and important for the Indian government. The IT department of Telangana state government invited Terra Drone India to provide innovative technological solutions for the digital preservation of Charminar.

▸ https://bit.ly/2NaHM06

Plowman Craven Awarded Network Rail UAV Contract

Plowman Craven's Vogel R3D system.

Plowman Craven has been awarded a national framework agreement with the UK's Network Rail for the provision of unmanned aerial vehicle (UAV or 'drone') services. The survey measurement and consultancy firm was one of just four companies to be awarded the contract, which covers the inspection and surveying of railway infrastructure throughout the UK as well as overhead line equipment, structures, bridges and embankments. The award also includes condition inspections following adverse weather or incidents. David Norris, technical director at Plowman Craven, said: "We're very proud to have been awarded a place on the framework – it's great recognition of the value of the services we provide to Network Rail and our expertise in surveying the UK's rail network. We have already carried out a significant amount of work for clients and contractors using our state-of-the-art Vogel R3D system. Being a main framework holder will enable us to accelerate the provision of these services and help Network Rail solve some of the many challenges across its network."

▸ https://bit.ly/2FzNBi1

New Association to Promote Aerial Surveying in Europe

Some of the leading names in European aerial mapping have come together to create a new association promoting the benefits of aerial surveying to the wider commercial and government sectors. Similar in concept to the USA's MAPPS (the national association of firms in the surveying, spatial data and geographic information systems fields), the European Association of Aerial Surveying Industries (EAASI) was incorporated on 6 June. This was immediately followed by the association's first board meeting. Simon Musäus (COWI), president of the newly fledged alliance, sees the founding of EAASI as an important chapter in the history of aerial surveying. "By working together across geographical boundaries, political divides and commercial opportunities, we can create a platform from which our industry can develop the strong future it deserves," he commented.

▸ https://bit.ly/31VpjIM

Founding members of EAASI.

Ecometrica Uses UAV-Lidar to Map Vegetation in Scottish Forests

Lidar-UAV being prepared for flight near Lochgilphead, Scotland.

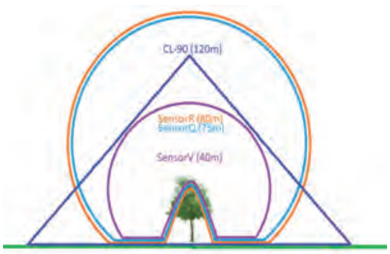
Soaring over Scotland's majestic landscape and beautiful forests, unmanned aerial vehicles (UAVs or 'drones') are helping to map the species growing under the upper canopy of the trees thanks to advanced laser technology. Downstream space information company Ecometrica, which is headquartered in Edinburgh, UK, is the developer of the award-winning Ecometrica Platform, which enables businesses and governments to turn the vast and growing streams of observation data from space, air and land into actionable insights. Sarah Middlemiss, space programme manager at Ecometrica, said: "This is a great opportunity to address some of the challenges facing our own environment, with innovative technologies, such as drones equipped with Lidar sensors. A number of native plant species are facing a growing threat from land use change, development and climate change and this initiative will help identify, for example, the spread and impact of invasive rhododendron in key areas of Scotland."

▸ https://bit.ly/2QwZhpP

Teledyne Optech Introduces UAV-Lidar Solution

The Optech CL-90 is the first in a new family of compact Lidar (CL) products designed specifically for the unmanned aerial vehicle (UAV or 'drone') market drawing on Teledyne Optech's 45-year Lidar heritage. The CL-90, which is infused with Teledyne Optech's survey-grade Lidar technology, will be available for integration with third-party inertial navigation system (INS) solutions, imaging sensors and UAV platforms. Any camera-equipped UAV can make a basic 3D map of bare terrain using photogrammetric techniques, but forested terrain requires a Lidar to punch through the foliage and map the bare earth below. Modern UAV-based Lidar systems struggle with this task due to their wide beam divergence and low-powered lasers, leaving holes in the user data. The CL-90 uses Teledyne Optech's high-power, low-divergence Lidar technology to achieve foliage penetration that is – according to the company – unparalleled at its price point. Whether they are surveying an obscured ruin in dense jungle or doing a pipeline easement assessment that requires a detailed ground model, CL-90 users can be sure that it will minimize data holes and collect the best bare-earth model possible.

▸ https://bit.ly/2FxlgJO



Forested terrain requires a Lidar to punch through the foliage and map the bare earth below.

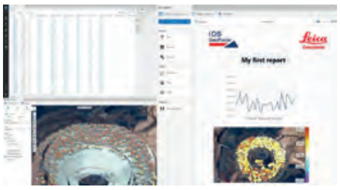
Mobile Mapping Helps Italian Railways Inspection Project

The Rail-SIT software application.

On behalf of the Emilia Romagna Railways (Ferrovie Emilia Romagna/FER), Siteco is carrying out a verification project of the clearance outlines of the railways in this region of Italy. For the railway inspection, Siteco used the Road-Scanner 4 mobile mapping system associated with the Rail-SIT software application, expressly developed to optimize the analysis and inspection activities typical of this sector. The combination of hardware and software allowed Siteco to provide the regional body with a complete solution. Mobile mapping systems (MMSs), which are increasingly implemented and exploited in the railway sector with success, allow track detection in a short time with minimum effort and unimaginable efficiency compared with the use of traditional tools. Starting from the point clouds and the trajectories produced by the MMS, with Rail-SIT it was possible to automatically process the collected data and extract the geometry of tracks and catenaries, dynamically generate the clearance outlines, and calculate the interference. The first phase of the FER project included three railroad lines: Bologna-Portomaggiore, Parma-Suzzara and Bologna-Vignola.

▸ **https://bit.ly/2XxqsH8**

Hexagon Unveils Monitoring Platform for Mining



Hexagon's monitoring platform for mining.

Hexagon's Geosystems division has released HxGN GeoMonitoring Hub, an integrated visualization and analysis platform bringing all sensor technology together in one holistic view of a mining environment. The new platform uses advanced software to show highly accurate information, thus accelerating decision-making and improving safety. HxGN GeoMonitoring Hub combines total station, GNSS, radar and other monitoring sensor data from a mining project into one simple-to-understand view. HxGN GeoMonitoring Hub fully integrates the IDS GeoRadar Guardian and Leica GeoMoS Monitor systems. This provides a comprehensive view of all information aggregated by different sensors, including third-party information, without cumbersome manual importation or manipulation of data. The interface can further be customized to provide the best-suited information for individual projects that need monitoring operations.

▸ **https://bit.ly/2RCrg8o**

René Worms Joins Atmos UAV as Head of Global Sales

René Worms (left) with Sander Hulsman, CEO of Atmos UAV.

Atmos UAV has appointed René Worms, former managing director of Topcon Positioning Europe, as head of global sales. The well-known strategist and geospatial expert will work towards the international expansion of Marlyn, the company's professional vertical take-off and landing (VTOL) mapping and surveying (fixed-wing) drone, which is designed to assure surveyors of the right accuracy, maximum ease of use and highest wind resistance in its class. René Worms' skills in international sales, sales management and building business strategies were recognized by the Topcon Positioning Group where he previously worked as the managing director. Additionally, his past professional positions – as regional director at Leica Geosystems, amongst others – are a testament to his passion and show extensive experience in the industry. Atmos UAV states: "Worms is a results-driven, exceedingly knowledgeable and very well-connected individual. He promises to be a charismatic business leader and a great asset for Atmos UAV."

▸ **https://bit.ly/2Xyqpe2**

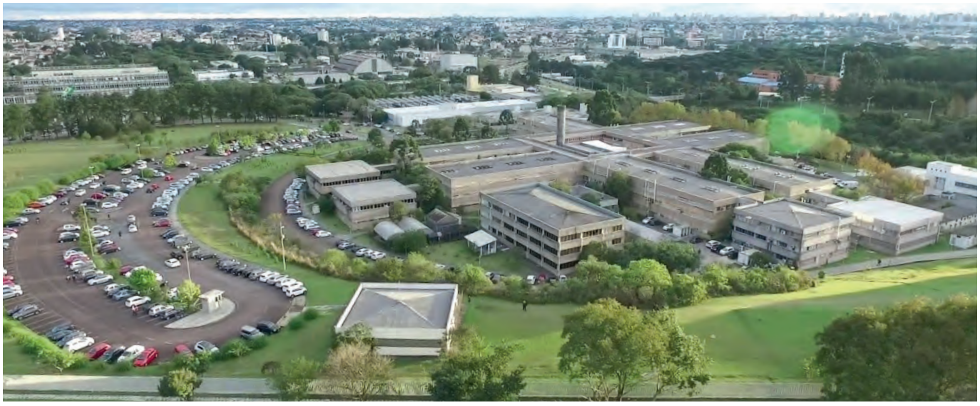
BY **LUCIENE STAMATO DELAZARI** AND **LEONARDO ERCOLIN FILHO**, FEDERAL UNIVERSITY OF PARANÁ, BRAZIL

CREATING INDOOR AND OUTDOOR MAPS FOR A ROUTING APPLICATION

Mapping a **University Campus** in Brazil

At universities, facility managers and other support staff need easy access to data, including geodata, for maintenance, safety measures or routing of students, staff and visitors. A responsive geodatabase containing detailed and up-to-date information on roads, the interior and exterior of buildings and other objects is a key tool in that context. The authors of this article describe a pilot project conducted at a university campus in Curitiba, Brazil, aimed at creating outdoor maps using unmanned aerial system (UAS) photogrammetry as well as indoor floor plans, and demonstrate the possibilities of the database with a routing application.

The Federal University of Paraná (UFPR) is headquartered in Curitiba, but it has a total of 26 campuses distributed throughout the entire state of Paraná in southern Brazil. Together the campuses comprise 1,100 hectares, of which 50 hectares are taken up by 316 buildings. In 2014, an ambitious pilot project called 'UFPR CampusMap' was launched, aimed at developing an enterprise GIS or 'smart geodatabase' for the university administration. To start with, an indoor and outdoor geodatabase of the Centro Politécnico campus in Curitiba was created (Figure 1). Within this pilot, the floor plans were obtained from facility managers, while the outdoor part of the database was created using UAS photogrammetry.



▲ *Figure 1: Bird's-eye view of the Centro Politécnico campus in Curitiba, southern Brazil.*

UAS PHOTOGRAMMETRY

The base map was created from images captured with a Phantom 4 from DJI. For small areas, UAS photogrammetry is faster and cheaper than traditional photogrammetry. The campus was captured by 1,438 images with a ground sample distance (GSD) of 2.5cm and georeferenced using 50 control points measured with GNSS (Figure 2). Tie point extraction and bundle block adjustment with self-calibration was conducted using Agisoft Photoscan. The exterior orientation parameters and 3D object coordinates of the tie points were calculated simultaneously with focal length, principal point and lens distortion coefficients, i.e. the parameters of the interior orientation. Using dense image matching, 516 million points

▲ *Figure 2: Flight lines and exposure centres of the UAS survey (left) and the distribution of control and check points over the campus.*

▲ *Figure 3: Digital surface model of the campus (left) and detail, generated by dense image matching.*

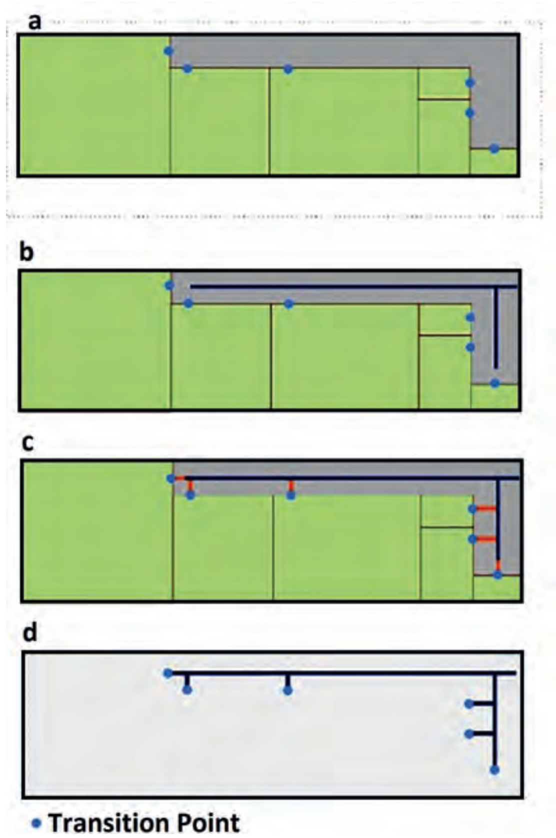
were generated with a point density of 600 points/m². A digital surface model (see Figure 3) and orthomosaics were generated from the point cloud and the images. Next, the outlines of buildings and other objects were manually extracted through stereo compilation according to the standards of the Brazilian Mapping Agency (Figure 4). The layers storing the different types of objects were edited in QGIS, the topology was built and a spatial database was created using Postgres/PostGIS.

The 3D coordinates of 35 check points, measured with GNSS, were compared against the 3D coordinates extracted directly from the digital surface model and through 3D viewing. The planimetric root mean square error (RMSE) was 4cm (1.6px) and the height RMSE was 1cm (0.4px). The 3D RMSE was 4cm (1.6px). These mapping accuracies are better than the requirements for 1:1,000 maps as defined by the Brazilian Mapping Accuracy Standards.

INDOORS

The 2D outlines of buildings, rooms, doors, exits, corridors, stairs and elevators for each floor were represented on maps (Figure 5a). Transition points were defined for routing purposes. These points are essential for finding the shortest path between two spaces using Dijkstra's algorithm. Doors and corridors enable horizontal transportation between spaces on the same floor. Stairs and elevators enable transportation in the vertical direction. Exits enable transportation between indoor and outdoor spaces. In the case of doors, the transition point was manually placed in the middle of the threshold and for corridors it was placed at the intersection of the centre lines of two corridors. The transition points and their connections resulted in a skeleton map (Figure 5). The centre lines of the corridors were created manually (Figure 5b). Next, the link between the transition points and the central corridor

▲ *Figure 4: Outlines of buildings and other objects manually extracted by stereo compilation, superimposed on the orthomosaic of the campus.*



▲ *Figure 5: Floor plan with transition points (a) to corridor centre lines (b), transition points connected to centre lines (c) and final skeleton map with the floor plan removed (d).*

were created using the PostGIS function ST-ShortestLine (Figure 5c).

ROUTING

To find the shortest route between two locations Dijkstra's algorithm assigns costs to the length of trajectories. For this purpose, the skeleton map was transferred to a graph by first generating nodes at the ends of line segments using the PostGIS function topology. CreateTopology. Disconnected, adjacent line segments were automatically snapped by defining a tolerance of 10cm. Once connected, the line segments became the edges of the graph. The number of stories per building varies from two to five, and all floors have the same floor plan. Applying the topology. CreateTopology function without caution would have connected line segments of different floors. Therefore, subgraphs were created per floor, except for the ground floor where OpenStreetMap data was combined with the skeleton map. If the routing entailed multiple floors, the subgraphs were joined by creating edges linking the transition points with the start and end points of the subgraphs. Within the cost function the Euclidean distance between the two floors was taken. In practice this meant max. 2m, which is a small distance compared to the total length of the routing.

LOOKING AHEAD

This routing algorithm allows the determination of the shortest path between two indoor points or between indoor/outdoor points. The next step is to differentiate according to mode of transport, such as on foot, by bicycle or on a moped. Using QGIS, PostGIS and Python, the creation of the skeleton map will be able to be fully automated, including the determination of edges and nodes. Similar indoor/outdoor databases will be created for the other UFPR campuses and these databases, in turn, will form the core of an enterprise GIS. ◂

MAPPING ACCURACIES ARE BETTER THAN THE REQUIREMENTS FOR 1:1,000 MAPS

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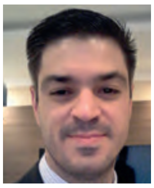

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5 Questions to... Sander Oude Elberink, GSW2019

In June this year, the Dutch city of Enschede welcomed the photogrammetry and remote sensing community for the ISPRS Geospatial Week 2019 (GSW2019). Whether to attend presentations, such as on 'Façade Reconstruction for Textured LOD2 CityGML Models Based on Deep Learning and Mixed Integer Linear Programming', or to meet up with fellow Lidar specialists from around the world, numerous delegates travelled to Enschede for a thorough update on what is going on in their area of expertise. We asked Sander Oude Elberink, programme chair of GSW2019, five questions in order to get an impression of this high-level event.

How would you sum up the event?

In five words: it was a fantastic week! The event itself is only one (although also the most important) part of the ISPRS Geospatial Week. So, when looking back as an organizer, I also see the activities which started sometime in 2018. Agreeing on the number of workshops and the various scopes, discussing the schedules and the scientific papers – these are just some of the activities that are done in the months beforehand by a team of about ten people. The preparations form the basis for a successful week, and during the Geospatial Week itself we just need to give it the finishing touch. Thanks to the hard work of all the volunteers, caterers, technicians and organizers, everything ran smoothly. So, looking back, it was a fantastic week after a long period of preparation.

What were the key themes discussed during the conference?

There were 13 different workshops running in parallel during the week, each with a different focus, so unfortunately I can't mention them all here. Of course, deep learning for data processing was prominently present during the conference, and not only in the workshop on Semantics3D where the main focus was on retrieving semantic information from images and point clouds. In fact, ten papers spread over five workshops included the term 'deep learning' in their title, and a keynote presentation was given on deep learning for processing hyperspectral imagery. In other words, deep learning is 'hot', and I expect it to remain so for a while.

Geomatics is a very dynamic profession. What would you consider as the most striking developments in photogrammetry and remote sensing that were presented at the Geospatial Week?

This is another hard question to answer here, but I'd say the insights that very long-range remote sensing, e.g. planetary mapping, and very close-range remote sensing (UAVs and indoor mapping) are really close to each other in terms of sensor integration and data processing techniques. 2D and 3D image information is everywhere, and sensors and algorithms are increasingly being used to cover the whole range from long to short-range remote sensing. Another slightly less striking ongoing development is the integration of computer vision and photogrammetry. Performing scene understanding in 3D has many advantages over 2D, so it is logical that some advances are bringing photogrammetry and computer vision closer together.

How would you describe the synergy between business and science that was visible at the event?

There was indeed a clear connection between industry and science. The industry presentations were well attended, with many scientists interacting with the presenters representing the companies. Likewise, many delegates from private companies attended the scientific sessions. On the sensor side, new insights were presented into Lidar sensors like the single photon Lidar (SPL) systems. This illustrates that business and science need each other in order to make progress. Vendors are opening up parts of their data processing to gain more insights from scientists. It will be interesting to see what the SPL data from IceSat-2, which has been available since 10 June, will bring us.

Markus Gerke presenting at ISPRS Geospatial Week 2019.

The next edition of the ISPRS Geospatial Week will take place in Dubai in 2021. What's your advice for the organizing committee?
My advice is to make sure that the programme contains a collection of workshops which complement each other. This ensures the cross-pollination of ideas between disciplines and communities. The organizing committee may even consider facilitating this in conjunction with sister events outside the ISPRS, such as CIPA on cultural heritage or Silvilaser on forestry applications.

The next issue of *GIM International* (September/October) will include an extensive review of the ISPRS Geospatial Week, written by Ian Dowman and Wim van Wegen.

2D AND 3D IMAGE INFORMATION IS EVERYWHERE, AND SENSORS AND ALGORITHMS ARE INCREASINGLY BEING USED TO COVER THE WHOLE RANGE FROM LONG TO SHORT-RANGE REMOTE SENSING

ISPRS Geospatial Week 2019 programme book.

BY **ERZHUO CHE** AND **MICHAEL J. OLSEN**, OREGON STATE UNIVERSITY, USA

A NOVEL FRAMEWORK FOR PROCESSING TERRESTRIAL LIDAR DATA

Automatic Lidar Point Cloud Segmentation

Terrestrial Lidar data has great potential to produce measurements for as-built building information modelling (BIM). Unfortunately, processing hundreds of millions of points, often contaminated by substantial noise, can be tedious and time-consuming. This article describes normal variation analysis (Norvana) segmentation – an automatic method that can segment large terrestrial Lidar point clouds containing hundreds of millions of points within minutes.

Thanks to the high speed, point density and accuracy of modern terrestrial laser scanning (TLS), as-built BIM can be conducted with a high level of detail. But TLS captures not only useful geometric information but also unwanted objects, such as people, animals or vehicles moving across the scene (Figure 1). These unwanted points have to be removed and the data cleaning can be a tedious and time-consuming process, not least because of the use of 2D interfaces to interact with 3D data and the high point density. One of the most fundamental challenges is the discreteness of the points, because each point is an independent data record with limited information by itself. A point does not directly contain semantic information (i.e. what it is) or topological information (i.e. who its neighbours are). A common solution to reduce point cloud complexity is 'segmentation', i.e. the grouping together of neighbouring points into segments, because it is less complex to model and analyse segments than it is to process individual points.

SEGMENTATION ISSUES

Point cloud segmentation can be straightforward as long as the assumptions can be mathematically modelled. For example, a flat floor can simply be extracted by using an elevation threshold. However, it is not always possible to make such simple assumptions, and the more assumptions

▲ *Figure 1: Dense TLS indoor point cloud of a building at Oregon State University (typical point spacing is around 3mm).*

▲ *Figure 2: Detected segments coloured randomly.*

that are made, the less generally applicable the approach becomes. Moreover, complex analysis can be time-consuming or the computation can even crash when large datasets of hundreds of millions of points are involved. In this case, the research goal was to come up with a solution that can serve as a general pre-processing framework without specific assumptions so that the approach can be applied more widely.

NORVANA SEGMENTATION

Many algorithms and software packages are able to segment point clouds reasonably well. In many of these approaches, however, processing several million TLS points can be very time-consuming. Norvana exploits the scan pattern for organizing the data and performing analysis. In the implementation, the time required to traverse the data is limited while the program has also been optimized to be more cache-friendly by aligning the data storage in the memory (RAM) with the search order for the processing and analysis. The Norvana segmentation method consists of two steps. First, the edges between objects are extracted based on a rapid change in surface orientation. This is done by performing an evaluation of the variance in normal vectors observed between the point and eight surrounding neighbours on the scan pattern grid. Then the points enclosed by these edges are grouped into single segments (Figure 2). Because the algorithm is designed as a pre-processing step, only the segments smaller than 10cm in any dimension have been removed to demonstrate the effectiveness in Figure 2. Because all of the points belonging to one segment can be processed as a single object, the following process and analysis can be performed in an object-based manner, which leads to higher efficiency and robustness. For example, for those points captured on any people walking across the scene, one can select the corresponding segments manually and delete or mask them without having to tediously

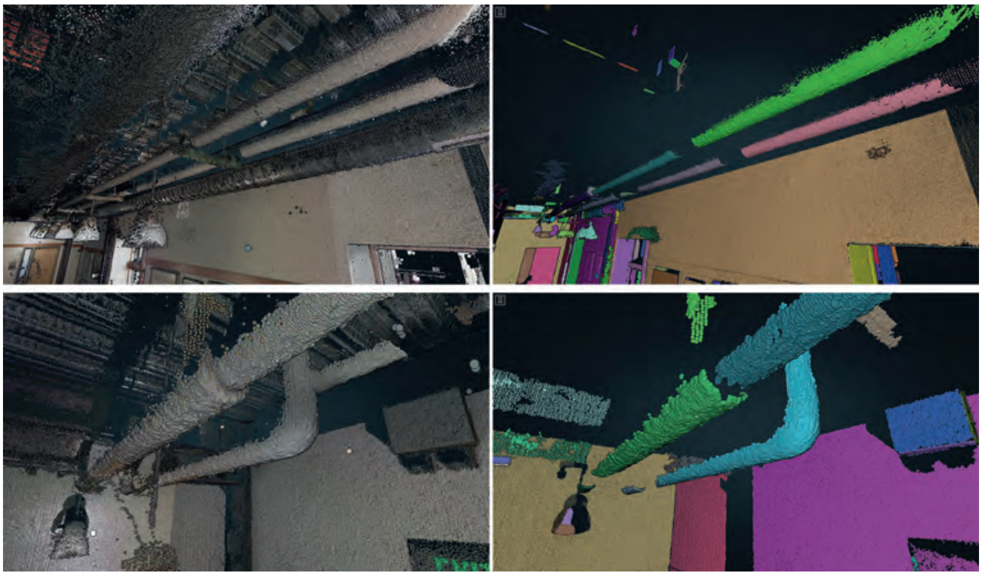
STRUCTURING OF THE DATA IN THE SCAN PATTERN GRID ENABLES THE USE OF PARALLEL PROGRAMMING

▲ *Figure 3: TLS scans (left) and extracted planar surfaces.*

draw a fence to remove each unwanted object in the scene. Technical details can be found in Che and Olsen (2018).

SEGMENTATION EXAMPLE

In Figure 2, the floor and walls are segmented appropriately and the ceiling is segmented into the individual panels. The top of Figure 3 shows a close-up of a display case embedded in the wall containing objects of different shapes, orientations and sizes that are segmented with a very high level of detail. A frame and a chair, both on the left of the display case, are correctly separated from the wall and floor, respectively. On the right of the display case, a vertical wide-flange column is segmented into different parts (web and flanges). Because Norvana considers the scanner location when estimating the normals, each side of the same flange is isolated as an individual segment instead of being merged into a single plane, even when the flanges are thin (which is a common failing of many existing algorithms). This robust approach to thin objects enables solid models to be generated for a wide variety of objects. The staircase is another important structure. The stairs are properly segmented into treads and risers (Figure 3, bottom). Compared with a planar surface, cylindrical objects require a more complex mathematical model. Regular and irregular-shaped smooth surfaces are readily segmented (Figure 4) because the normals still vary evenly across the surface. In the example, the points on the straight pipe have been correctly extracted and could subsequently be modelled as a cylinder. Also, complex objects such as the elbow have been segmented. Notably, pipes of different sizes and orientations are extracted using the same parameters.

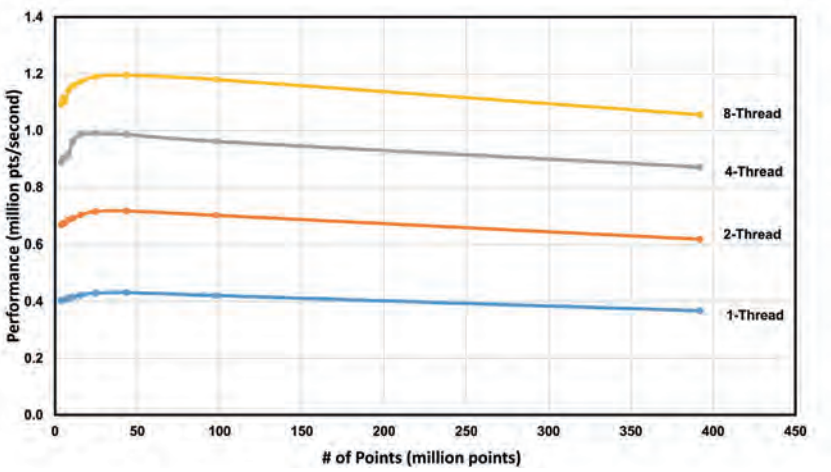


▲ *Figure 4: TLS scans (left) and extracted pipes.*

However, a limitation of this algorithm is that very rough surfaces cannot be extracted as a single segment.

COMPUTATIONAL CONSIDERATIONS

Structuring of the data in the scan pattern grid enables the use of parallel programming so that multiple threads on the CPU can process different portions simultaneously. The approach was benchmarked on an outdoor dataset down-sampled at different rates with a different number of threads using a desktop computer with a low-end CPU (Intel Xeon CPU E5620 @ 2.40GHz, released in 2010). Efficiency is not significantly affected by the number of points at the scales tested (Figure 5). The performance is consistent at over one million points per second using eight threads during the processing of nearly 400 million points.



▲ *Figure 5: Computation performance.*

CONCLUDING REMARKS

In the future, the plan is to increase the functionality of Norvana by including classification, modelling and other modules. ◀

FURTHER READING

- Che, E., Olsen, M.J., 2018. Multi-scan segmentation of terrestrial laser scanning data based on normal variation analysis. *ISPRS Journal of Photogrammetry and Remote Sensing*. 143, pp. 233-248.
- http://research.engr.oregonstate.edu/lidar/pointcloud/OSUCampus/Kearney_Norvana_2018/index.html

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CREATING AN ACCURATE AND DENSE DIGITAL TERRAIN MODEL REQUIRES EXPERTISE

UAS Lidar Survey over an Ancient Pueblo Site

Archaeologists have been studying the Sand Canyon Pueblo in Colorado, USA, for decades. Today, painstaking traditional mapping and visualizations no longer suffice for detailed studies. A survey combining an unmanned aerial system (UAS) with Lidar has shown how accurate and dense point clouds enable the discovery of previously undocumented structures. However, conducting a UAS Lidar survey requires thorough knowledge and skills, as the author of this article convincingly demonstrates.

The Canyons of the Ancients National Monument in Colorado, USA, is an archaeologically significant landscape containing a wealth of historical and environmental resources. It is now a recreational hotspot, but around AD 1240 the area was occupied by the Pueblo community, which constructed over 70 villages housing approximately 30,000 residents. In Sand Canyon alone, over 90 subterranean structures known as 'kivas' were used by families as dwellings. Between 1984 and 1995, the site was studied, mapped and excavated using traditional survey techniques. To further accurately map this culturally rich site, which is managed by the Bureau of Land Management, Routescene Inc. worked in partnership with Caddis Aerial to create an accurate bare-ground digital terrain model (DTM). The approach was based on a Lidar system – which can penetrate dense vegetation and produce high point densities – mounted on an unmanned aerial vehicle (UAV or 'drone').

▲ *Figure 1: Preparing for take-off.*

▲ *Figure 2: Lidar target positioned on top of a GCP (left), measured with GNSS.*

UAV DETAILS

The DJI M600 Pro was chosen as the platform for its stability and high lift capacity. This UAV can sustain a flight duration of 15-20 minutes, depending on wind and other weather conditions, and captures an area of at least 400 x 400m in a single flight, enabling users to survey areas of over two square kilometres per day. Designed in 2013 for use on UAVs, Routescene's LidarPod comprises a carefully selected array of sensors including the Velodyne HDL32. With a scan rate of up to 1.4 million points per second from 32 different lasers angled in a 40-degree field of view, this enables high vegetation penetration. The in-built radio modem not only enables command and control but also, and more importantly, allows operations – complete with real-time quality assurance (QA) monitoring – over a distance of more than 2 kilometres.

SETTING THE OVERLAP AT 100% MEANT A HIGHER POINT DENSITY AND MORE LASER POINTS HITTING THE GROUND

TAKE-OFF AND SURVEY

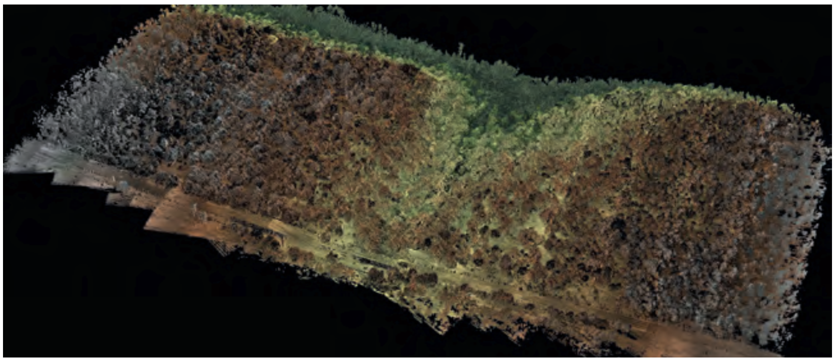
The take-off point on the main dirt road in the north of the area allowed sufficient line of sight up to the outer edges of the area (Figure 1). The UAV was flown at 40m altitude relative to the take-off point. The altitude was 20m at the west and east boundaries due to the undulating terrain, and 60m in the south due to steep cliffs. To achieve a very high DTM point density, the UAV was flown as low as was safely possible, flying at a speed of 5m/s. Setting the overlap between adjacent flight lines at 100% meant each piece of land was surveyed twice, resulting in a higher point density and more laser points hitting the ground. The flight plan was uploaded to the UAV from DJI's GS Pro app. The M600 Pro was flown manually to the start of the mission and the flight plan was executed from within the GS Pro app. For accurate georeferencing purposes, eight ground control points (GCPs) were measured with GNSS, and 60cm-diameter Lidar targets mounted on tripods were placed over them (Figure 2). Thanks to their highly retroreflective material, the targets were easily identifiable in the point cloud. After every mission, the data was downloaded from the LidarPod and inspected using LidarViewer Pro. This proprietary software enables the user to build a Lidar processing workflow, using the Filter Development Toolkit to develop and apply filters.

FLIGHT CONDITIONS

The survey was undertaken in October 2018. The temperature was 15-20°C in the early morning, increasing by five degrees at sunrise. The UAV mission planning had to take account of the altitude of 2,100m because the aircraft's performance reduces with increasing flight height as well as due to atmospheric conditions such as temperature and humidity. Flight height and atmospheric conditions are combined in the so-called density altitude. The cooler morning air resulted in a density altitude of 2,750 to 3,050m. In addition to the density altitude, other challenges included the piloting of a newly purchased aircraft and the payload. 40% of the battery capacity was left after the current flight line had been completed and the UAV then flew back to the take-off site, typically landing with 30% capacity still remaining. This generous safety margin was deemed to be a sensible approach. The wind tended to increase mid-morning making the flying conditions even more challenging. Even so, four flights were successfully completed and the last flight line was finished just before the wind further strengthened to beyond operational limits.

PITFALLS

Since there is always a possibility that additional data will need to be collected at a later date – either planned or unplanned – it is standard practice to anticipate this by marking all GCPs using a permanent peg driven into the ground. The resurvey was conducted in the middle of winter, when the GCPs were buried under 30cm of snow cover. The data analysis revealed



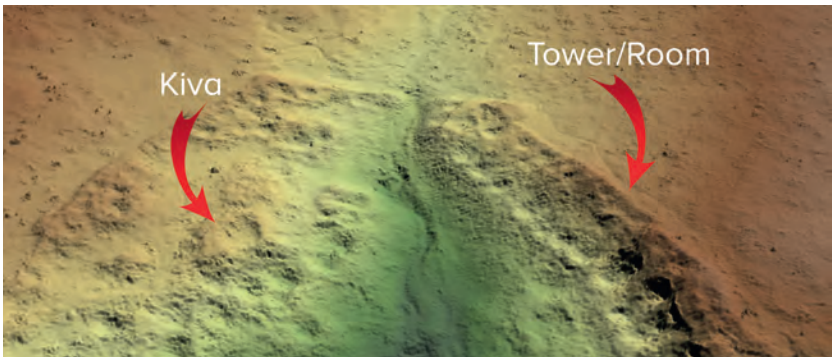
▲ *Figure 3: UAS Lidar point cloud consisting of over 3.2 billion points.*

a discrepancy in the position of the GCPs relative to the point cloud. Extensive further analysis revealed that the errors were caused by the storage of the GCP coordinates in Microsoft Excel, which rounds all numbers to six decimal places. For geographical coordinates this introduced an inaccuracy of up to 4m. So a word of caution: beware of how survey data is captured and stored! Reloading the original raw data into another format solved the issue, but the ground surveyors were rather displeased. A lesson learned!

RESULTS

Over 3.2 billion points were collected and processed (Figure 3). The filters used in an automated sequence were sector reduction, laser ID reduction, coordinate conversion, grid creation, the purpose-built 'bare-earth tool', a skim grid and lastly the LAS export filter. This process virtually removed all the vegetation from the point cloud, to expose in detail the structures that the archaeologists were interested in. The point density of the final DTM was 400 points/m^2 and enabled the archaeologists – much to their surprise – to discover previously undocumented kivas and other structures (Figure 4). These results, gained without painstaking ground surveys, proved to be accurate and will allow the archaeologists to focus their future work on the newly found structures.

BEWARE OF HOW SURVEY DATA IS CAPTURED AND STORED!



▲ *Figure 4: Bare-earth DTM revealed previously undocumented structures.*

ABOUT THE AUTHOR

Gert Riemersma, CTO of Routescene, has 20 years' experience as a hydrographic surveyor. He has been a private pilot since 1986 and has working with Lidar since 2008 and with UAS Lidar since 2013.

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LOW-COST LIDAR CAMERA SYSTEM WITHOUT GNSS

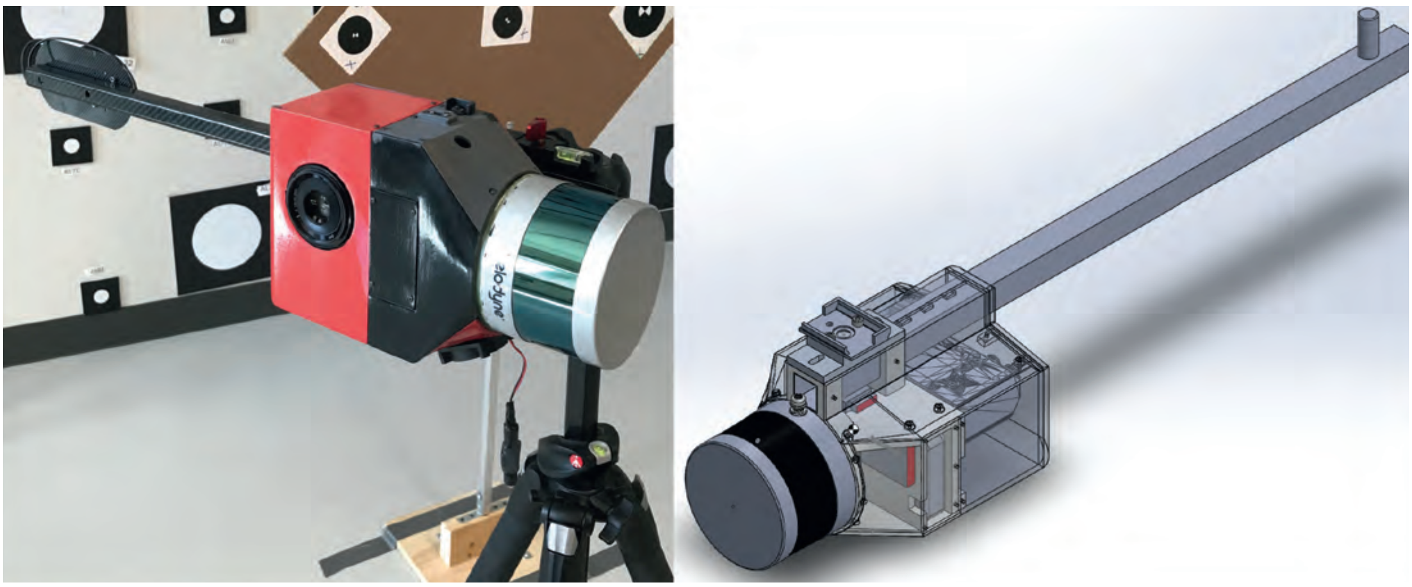
Sensor Fusion for **Precision Agriculture**

Precision agriculture has considerably benefited from the use of unmanned aerial vehicles, often combined with active ranging sensors like Lidar to gather information from underneath the crops, but existing systems are relatively expensive for the farming sector. In this project, researchers in Canada have used an integrated sensor orientation method for the local referencing of Lidar measurements. Their approach is based on loosely coupled, image-aided inertial navigation in which the pose of the camera replaces the GNSS measurements. The result is a low-cost solution that is useful for capturing topographic data of inaccessible areas as well as in GNSS-denied environments.

One of the major components of agricultural automation is formed by sensors, which are required for both monitoring the condition of productions (precision agriculture) and facilitating the navigation and deployment of farming machinery (agricultural robotics). Precision agriculture has considerably benefited from the use of unmanned aerial vehicles (UAVs or 'drones') to address a variety of fine-scale mapping problems such as monitoring crop health, modelling field biophysical attributes and studying soil characteristics including soil micro-topography. Micro-topography defines topographic variability and describes soil surface variations. This attribute plays a significant role in many agricultural phenomena, such as run-off, erosion, aggregate stability, surface storage, infiltration capacity and vegetation dynamics. The primary challenge for quantifying soil micro-topography at plot scale includes access to accurate and complete elevation measurements from the bare soil at high horizontal resolution (1-3cm). Passive imaging such as in UAV photogrammetry acquired at low altitudes is a suitable solution to address this challenge. The use of structure from motion (SfM) techniques and multi-view stereo reconstruction allows the creation of high-resolution, high-accuracy and high-precision 3D point clouds of the environment from unmanned aerial imagery.

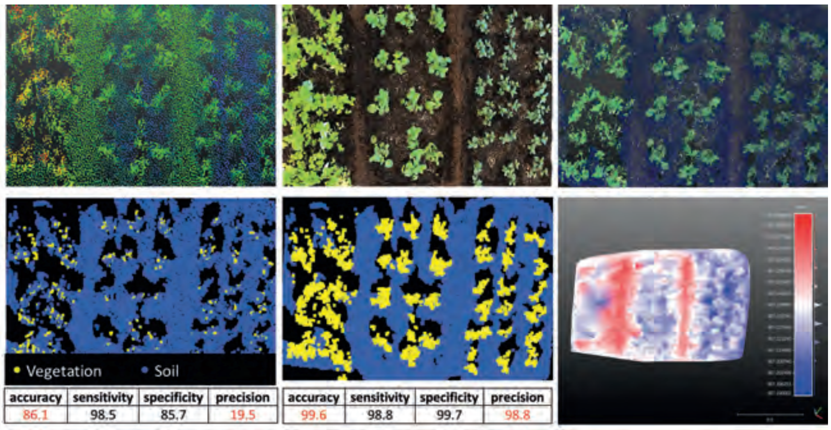
SOIL MICRO-TOPOGRAPHY SENSORS

However, sensitivity to environmental conditions as well as the inability of passive imaging to gather information from underneath the crops necessitates the



▲ *Figure 1: The CAD model and the in-house-built multi-sensor system.*

(additional) use of active ranging sensors, like Lidar. Photogrammetric 3D point clouds can be complemented by Lidar point clouds to include additional geometric information. For example, a distinction can be made if the Lidar sensor provides multiple returns: one from the top of the vegetation and, possibly, one from lower elevations, e.g. bare soil. Several studies have compared the pros and cons of 3D reconstruction of agricultural attributes using photogrammetry versus laser scanning. The briefest conclusion is that there is no technology which is thoroughly robust against all sources of error and noise caused by the sensors and/or the environment. Examples are brightness variations, shadows, weather conditions, reflectivity variations, dynamic objects (vegetation moving in the wind), partial and total occlusions and perspective distortions (oblique versus nadir imagery). Therefore, integrating a digital camera and a Lidar sensor on board a UAV is a practical solution for measuring soil micro-topography. Figure 2 shows an example of integrating Lidar data with colour information from imagery and densifying the data by photogrammetric point clouds. 3D points corresponding to vegetation are automatically separated from soil points (a.k.a. ground filtering) using supervised classification via support vector machines, and a highly detailed digital terrain model (DTM) is reconstructed.



▲ *Figure 2: Lidar 3D point cloud (top left), image (top middle), densified and coloured point cloud (top right), results of ground filtering only based on colour information (bottom left), results of ground filtering based on fused geometric and spectral information (bottom middle), and soil-level DTM (bottom right).*

SENSOR INTEGRATION AND DATA FUSION

Therefore, a system was developed that integrates passive imaging and active ranging sensors. The total cost of building this integrated system is under CAD15,000, including an optical digital camera (a6000, Sony), a 3D Lidar capable of obtaining two returns (VLP-16, Velodyne LiDAR Inc), an inertial navigation system (VN-200, VectorNav Technologies), a compact processor, electronic components and the casing.
To measure georeferencing accuracy, one needs ground checkpoints, i.e. points with known 3D coordinates not participating in the bundle adjustment process as a ground control point (GCP). GCP errors are the residuals of the bundle adjustment and are not representative of the reconstruction accuracy nor the georeferencing accuracy; they merely show how well the mathematical photogrammetric equations are fit to the observations. In this project, the researchers did not test the georeferencing accuracy as the data was positioned relatively in space. What is important for soil micro-topography is the internal consistency of the positions obtained at various moments during the survey. The sensors and the system were geometrically calibrated and, with an integrated sensor orientation solution, the georeferencing accuracy achieved is better than 1cm within a local coordinate system.

IMAGE POSITIONING WITHOUT GNSS

Since Lidar performs range and bearing measurements in its local body frame and with high frequency, GNSS-aided inertial navigation sensor (GNSS/INS) data is required to directly georeference the measurements taken from the moving Lidar in an object-fixed coordinate system, e.g. an earth-centered-earth-fixed one. High accuracy such as required for micro-topography calls for high-quality inertial navigation sensors enabled with dual-frequency real-time-kinematic GNSS receivers. This also necessitates having access to local or national base stations and proper post-processing software. As a result, existing systems are relatively expensive for the farming sector. The approach taken in this research project was to use an integrated sensor orientation method for the local referencing of Lidar measurements based on loosely coupled, image-aided inertial navigation. Put simply, the pose (position and orientation) of the camera replaces the external measurements (position and velocity) from the GNSS. This solution compensates for time-variant INS errors (accelerometer and gyroscope biases) using the image measurements and eliminates the need for accurate GNSS measurements. This solution references the Lidar point cloud in the same object-fixed local coordinate system in which the photogrammetric point cloud is also being generated. This local coordinate system does not need to be a geocoordinate system unless adequate landmarks known

Integration method	Horizontal mean error (m)	Vertical mean error (m)	Roll and Pitch mean error (sec)	Heading mean error (sec)	Velocity mean error (m/s)
Image-aided INS	0.004±0.003	0.005±0.003	0.2±0.3	2.3±4.6	0.002±0.002
GNSS-aided INS (manufacturer specs)	2.000	2.500	360.0	1080.0	0.05

▲ *Figure 3: Results of 69 seconds trajectory estimation. The estimation uses the authors' image-aided inertial navigation and is compared to the INS GNSS/barometer-aided solution. The camera pose replaces the external GNSS measurements every second, although imagery is captured at 2Hz. Therefore, the other epochs at which the camera pose is available are used as check measurements to validate the accuracy of the image-aided inertial solution. The errors are represented as absolute mean plus/minus one standard deviation for this solution.*

in a geocoordinate system are observable in images (optional availability of GCPs). Therefore, this solution is useful for capturing topographic data of inaccessible areas as well as in GNSS-denied environments.

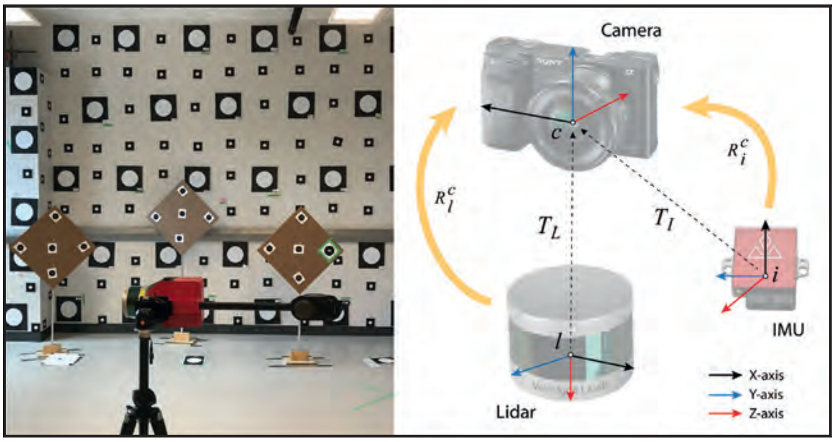
Three basic types of geometric calibration are performed: intrinsic camera calibration, intrinsic Lidar calibration and extrinsic system calibration. Intrinsic camera calibration involves modelling the lens radial distortions, lens decentering distortions, affinity/nonorthogonality of sensor and interior orientation parameters (principal point offsets and focal length). Intrinsic Lidar calibration involves modelling the systematic effects of range zero error, horizontal circle scale error and vertical circle zero index error for all the 16 laser beams in the VLP-16. System calibration, also known as 'platform calibration' or 'calibration of mounting parameters', involves measuring the rotational transformation matrix (bore-sight matrix) and a translation vector (lever arm) between the local coordinate systems of the scanner and the camera. Since the georeferencing approach also requires the INS raw measurements, the system calibration should be extended to establish the relation between the local coordinate systems of the camera and the INS as well (Figure 4, right). A software solution has been developed to enable all these calibrations to be performed simultaneously in an indoor environment (Figure 4, left).

To measure the accuracy of calibration, the laser-scanner points were considered on two verification features (planes not entered in the self-calibration) from one station. Planes were fitted to these points before and after applying the intrinsic calibration parameters. The residuals from the planes before calibration were 0.008±0.006m. This was reduced to 0.005±0.003m after calibration.

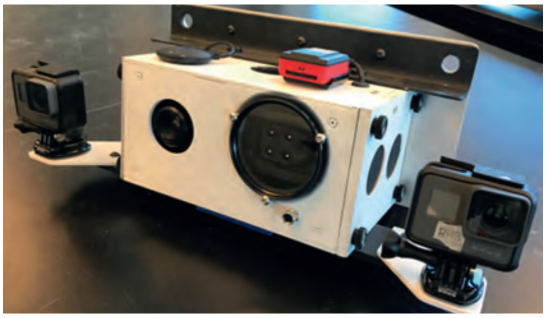
CONCLUSION

Integration of a low-cost 3D Lidar sensor with a DSLR camera and an industrial-grade INS allows the creation of high-resolution and complete point clouds of agricultural plots and the automatic generation of a terrain model to measure soil micro-topography. The quality of the data is assured via integrated calibration that solves for all system and Lidar parameters simultaneously. The accuracy of Lidar observations can be improved by 37% via this calibration approach. A critical challenge with this system is georeferencing the Lidar point clouds with an accuracy comparable to the georeferencing accuracy of image-based point clouds. High accuracy cannot be achieved via direct georeferencing using an industrial-grade GNSS-aided INS. Thus, the authors propose an image-aided inertial georeferencing approach that can considerably improve the results, eliminating the need for expensive, tactical-grade GNSS-inertial systems at the cost of giving the results in a local arbitrary coordinate system unless accurate GCPs can be identified for georeferencing.

The next step will be to test the system under real conditions. Furthermore, the system will be extended with the integration of the low-cost in-house-built multi-spectral solution in Figure 5. This system is composed of a thermal infrared, a near-infrared, a red, a red-edge, a green and three RGB cameras. Using additional spectral bands, various vegetation-index 3D maps can be generated that can be used to analyse biophysical attributes of plants, e.g. Leaf Chlorophyll Index, Normalized Difference Vegetation Index, Water Stress Index, etc. ◀



▲ *Figure 4: Calibration test field at the University of Calgary (left) and system calibration parameters (right).*



▲ *Figure 5: Low-cost, multi-spectral, multi-camera system with the potential for 3D Lidar integration.*

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BY LOUISE FRIIS-HANSEN AND CHRISTIAAN LEMMEN

FIG WORKING WEEK IN HANOI, VIETNAM, 22-26 APRIL 2019

Land Surveying: Towards a Smarter Life

Surveyors and land professionals from all over the world came together in April in the heat of Hanoi to take part in the FIG 2019 Working Week. This year's theme was 'Geospatial information for a smarter life and environmental resilience'. The conference had a strong focus on tackling climate change by working towards a smarter life, both through the development of smart cities and also in rural areas. Spatial information, big data, surveying, BIM, land administration and much more are recognized as being essential factors in this development. There is a strong awareness that Sustainable Development Goals (SDGs) are directly linked to surveyors' activities and that surveyors should contribute to achieving them.

The old city of Hanoi with its temples and historical architecture is a unique experience. One feels surrounded by friendliness. The traffic is very busy with millions of mopeds on the roads, but everything flows very organically based on collective cooperation: a miracle. Around a thousand participants were welcomed to the Working Week during the opening session featuring a spectacular cultural performance which proudly presented the country's rural roots from many regions.

DIGITAL PUBLIC GOODS

Hanoi was the first event under Prof Rudolf Staiger's leadership. As FIG president, he shared his vision of the surveying profession in a world where maps and spatial data are digital public goods – free of charge, up to date, high quality and with almost no blind spots. Against this backdrop, he positioned surveying as a modern profession acting worldwide for better infrastructure, both for society and for planet Earth. Land administration can make a key contribution to social and civil security, reducing conflict and bringing peace and economic benefits. He highlighted that classic cadastral approaches are too time-consuming and expensive; faster solutions are needed. The fit-for-purpose principle is an interesting general approach which needs to be adapted to each individual case. It should be seen as an extension to the classic cadastre rather than as a replacement. His statements were the subject of heated and sometimes fiery debate during the conference. It is clear that changes are afoot with the availability of the latest innovations in data acquisition that facilitate participatory approaches.

LAND TENURE SECURITY

Mika-Petteri Törhönen, lead land administration specialist at the World Bank and keynote speaker at the opening session, provided a fascinating overview of secure tenure for all – men and women – in the context of the World Bank's land and geospatial programme with a special reference to achieving the SDGs. He highlighted that land tenure security is key to ending poverty, eliminating hunger, achieving gender equality and sharing prosperity. The profession has to deliver comprehensive land records in modern systems based on cadastral intelligence.

For the first time, the FIG Young Surveyors held a keynote presentation and they gave delegates a sense of the community feeling that they are establishing around the globe. The council motto for this term, which President Rudolf Staiger presented at the General Assembly, is 'Volunteering for the Future' and it was in this spirit that the president gave the floor to the future of surveying and the future of FIG.

The local organizers were pleased to show the ancient history and recent development of Vietnam. In his presentation, Prof Dr Pham Van Cu, former vice-minister of the Vietnam Ministry of Natural Resources and Environment, pointed out the opportunities and challenges in Vietnam's current transition from the 'electronic' era to the 'smart' era. As a special treat, the local organizers also arranged for all participants to visit the opera for a special performance held especially for this occasion.

The conference was organized in cooperation with FIG and the Vietnamese Association of Geodesy Cartography and Remote Sensing. Thanks go to the whole team for this well-organized Working Week, and also to the sponsors – Esri, Trimble, Leica, LX Korea, Ripro, Geo-Plus, South, Bels+ and Chinese Federation of Surveying and Mapping (Taiwan) – as well as all exhibitors and the partners for the technical programme: World Bank, UN-Habitat/GLTN, FAO and UN-GGIM. ◄

▲ *Opening ceremony of the FIG 2019 Working Week in Hanoi.*

NEW SERVICES WILL STIMULATE MARKET GROWTH

Setting up a User-friendly **Remote Sensing Data** Infrastructure in France

Over the past decade, Geosud has contributed to successfully mitigating the various obstacles to the operational use of satellite imagery for environmental management and territorial development. Geosud's role in the project will soon come to an end but the services will continue, embedded in an even better infrastructure: Dinamis. As of next year, Dinamis will provide satellite images of land, sea, air or underground, and even online image processing, for organizations related to the public sector in France.

As you approach the Maison de la Télédétection in Montpellier, France, the first sight that greets you is a 5.5m-tall receiving station on an 8m-high platform. The centre employs around 175 people, all of whom are in some way involved in research and development, training and putting GIS and remote sensing to good use for France's ecosystems. A substantial part of the budget over the past decade was linked to the Equipex Geosud project, to which the country's Ministry of Research donated €11 million ('Investments for the Future' programme), with a further €10 million coming from the 13 project partners. "We started Geosud because we realized that France was not making sufficient use of satellite data. We wanted to help overcome limitations like knowledge, skills and costs. The project will end next year, but Geosud has changed the landscape for good," comments Pierre Maurel, coordinator of Geosud. He is proud of the results: the market growing from just a few companies offering commercial services to an open-innovation community with 540 member organizations.

The main service currently rendered is the free and easy distribution of satellite images from different suppliers to state agencies, regional GIS centres, local authorities, research laboratories, training centres and so on, all in the public sector. Private companies working for a public body can also have free access to the images for the job at hand. Small private companies are allowed to use the facilities on their own for R&D activities, e.g. the development of a new application. When the product is ready to be marketed, the free flow stops and the company has to negotiate the licence conditions with the provider of the images.

GEOSUD MEMBERS CAN REQUEST THAT A SATELLITE OBTAINS ADDITIONAL IMAGES FOR FREE, WORLDWIDE

IMAGES ON REQUEST

When Geosud started, French satellites – owned by the national space agency CNES – were already in orbit and delivering images known as SPOT (1 to 5). Nowadays, SPOT 6 and 7 are distributed by Airbus, which operates private satellites, while CNES owns the public Pleiades satellites. Maurel: "We can choose to buy for our members whatever images are available on the market, whether they are from French satellites or not. In the beginning we concentrated on improving the access to very-high-resolution (VHR) imagery so that the use of satellite images improved. Landsat and Sentinel decametric images are available for free, but our users need additional resolutions, combinations of satellite images and combinations of data sources. We have annual national coverage, the French overseas territories included. Nowadays, that means 1.5m panchromatic and 6m multispectral SPOT images. The main urban regions and sensitive areas (new infrastructures, coastlines, etc.) are covered by Pleiades at the 50cm and 2m level. Our Geosud archives now contain 13,000 VHR images."

Geosud members are allowed to access images that have already been archived. They can also request that a satellite obtains additional images for free, anywhere in the world. The user simply completes the online form to indicate the desired area, resolution, time slot, number of images, mono, colour, purpose, etc. If users lack sufficient expertise, they can receive advice

▲ *Pierre Maurel: "We work in an open innovation chain where every link is clear and respected." Image courtesy: VBB, Jeroen van Berkel*

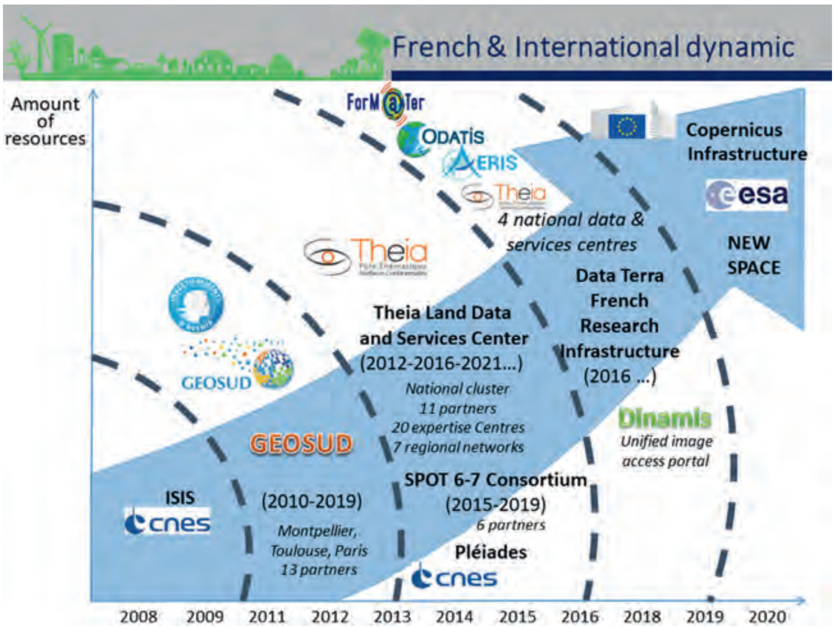
on the most suitable type of images or the most adequate combination. After checking whether the data is already available in the Geosud and/or Airbus archive, the request is validated and the satellites are programmed to acquire the images. After a quality check by an expert, users can then download the requested images. "Sentinel or Landsat satellites cannot be programmed. The other, more agile satellites can shift their place in orbit or take images of the same area from different angles. Mostly, the extra images are needed because of the resolution or a specific period. If they go directly to the supplier, they will have to pay full price; from us, they get the images for free or at a very low rate," says Maurel with respect to another bonus of membership. Members get to see the commercial cost of the images, so they are aware of what the service is worth.

ONLINE PROCESSING WILL HELP THE REGIONAL GIS PLATFORMS TO INTRODUCE SATELLITE IMAGERY FOR THE LOCAL WORKFLOWS

ONLINE IMAGE PROCESSING

As of the end of this year, a new free service will be provided: online image processing. "You select an image and indicate what you want to do with it. The matching algorithms, developed by French scientific experts, are then tried out on a small part of the image. If this is satisfactory, the same algorithms are applied to the whole image and you can

▲ *Searching in the Geosud catalogue of nearly 13,000 VHR images.*



▲ *Next year, satellite images from all four remote sensing clusters will be accessed through a single portal: Dinamis. Cooperation will be intensified under the umbrella of Data Terra.*

download the result. It is another step to democratization of remote sensing for people who are not equipped or lack the means to use it," continues Maurel.

That same thought is behind the new national remote sensing data infrastructure, Data Terra, which is currently under development. It will include four remote sensing clusters; in addition to Theia for land services – which comprises the Maison de la Télédétection, CNES, the Institut Géographique National and other institutes – the clusters for oceans (Odatis), for underground (Form@Ter) and for air (Aeris) will participate. The users of all four clusters will obtain their satellite images through a single unified portal: Dinamis. A meta-catalogue service will help users to extract the right images from a variety of sources. Then, if needed, the online image processing services will be provided by the Theia infrastructure.

Now that the Geosud project is nearing the end, Maurel is rethinking his funding. Perhaps there will be a Geosud 2.0, to improve the services provided by Dinamis and Theia. Perhaps the main users, especially the Ministries of Agriculture, Research and the Environment, and also the regions – who are responsible for economic development and land planning – will donate more. If that is not enough, members could be asked to pay a membership fee or make a financial contribution after a certain amount of free on-request satellite images. Geosud has conducted a survey to investigate members' willingness to pay, but no decisions have been made yet.

MARKET GROWTH THROUGH NETWORKING

There are many new users joining each year as new products open up new market segments. Maurel: "Over the past two years we've grown from 700 to 1,000 individual users within the Geosud Theia community. Archaeology is one new up-and-coming market and another is insurance – companies use our images to see where drought or flooding are becoming fundamental problems. We're also seeing new users in the field of forest management, to detect diseases faster. Talking of diseases: the Ministry of Health is now researching the risk of tiger mosquitoes – initially in our overseas territories but now also in mainland France." The growth in membership is particularly being stimulated by the many new applications created within the large national community of developers. In Theia alone, there are 25 research groups, 55 laboratories and 6 regional groups that can use the satellite images for free. In exchange, they have to prove fitness for use, mostly in close contact with potential user communities and their IT consultants. The groups write user guides, organize training sessions and suchlike.

Private companies do not complain about 'unfair competition', as far as Maurel is aware. "We work in an open innovation chain with private, public and academic players where every link is clear and respected. Companies, most of which are not specialized in remote sensing, can use our maps to support their added-value applications. We're helping to develop the market, not ruin it." Once the online processing service is available, he hopes to grow much more, especially at the local level. "By law, each region has a GIS platform where the local partners exchange experiences. We will work with them to introduce satellite imagery for their workflows."

IMPACT STUDIES

Its knowledge of the possible impact of such images at a micro-level – i.e. on workflows –

is another of Geosud's specialities. The return on investment in satellite imaging is measured everywhere in the world. That mostly only leads to macro-economic studies, but not so in Montpellier: "With funding support from CNES, several students are working on a methodology for impact studies. We not only look at the macro level, but also at which changes satellite imaging has brought about in offices – both quantitatively and qualitatively." In 2015 Geosud started with a methodology to measure the impact of the French regional GIS platforms. It is now so mature that most of those platforms use it. It can lead to an aggregated indicator: from savings at several layers, to extra revenues, to better decisions. So what are the overall efficiency results? Maurel explains: "Every euro invested in a regional GIS platform saves or generates at least three euros. In forestry, to manage clearcutting in woodlands through satellite imagery, the ratio is between 1:20 and 1:30 euros. For the updating of land-use maps, the impact is 1:12 or 1:13 euros. We're using these studies to show how it can change a workflow and the management of certain public policies." And of course there has also been an overall study of the impact on the public budget of the images from Geosud and its receiving station: the savings for image acquisition amounted to €80 million between 2011 and 2017 (a ratio of approximately 1:4), and this figure will be even higher for 2017-2019.

IN TERMS OF IMAGE ACQUISITION COSTS, GEOSUD AND ITS RECEIVING STATION HAVE SAVED THE PUBLIC BUDGET AT LEAST FOUR EUROS FOR EACH EURO INVESTED

The existence of public remote sensing data centres is not disputed in France. "It helps in the independence of the public sector and to develop private business. You can use Google Earth or other platforms, of course. But all these things are run by private companies with their own business logic to make the highest profit, either directly or indirectly. That is not always in the interest of the public sector, even though such companies can be very helpful. For example, if the Americans get angry with Europe for political reasons, they could decide to impose tax measures or even close the service to all European users. Therefore, we advise our users not to do everything on those toolboxes. We also need independent, autonomous institutions in France to guarantee strategic public services." ◂

FROM LICENSING TO SUBSCRIPTION

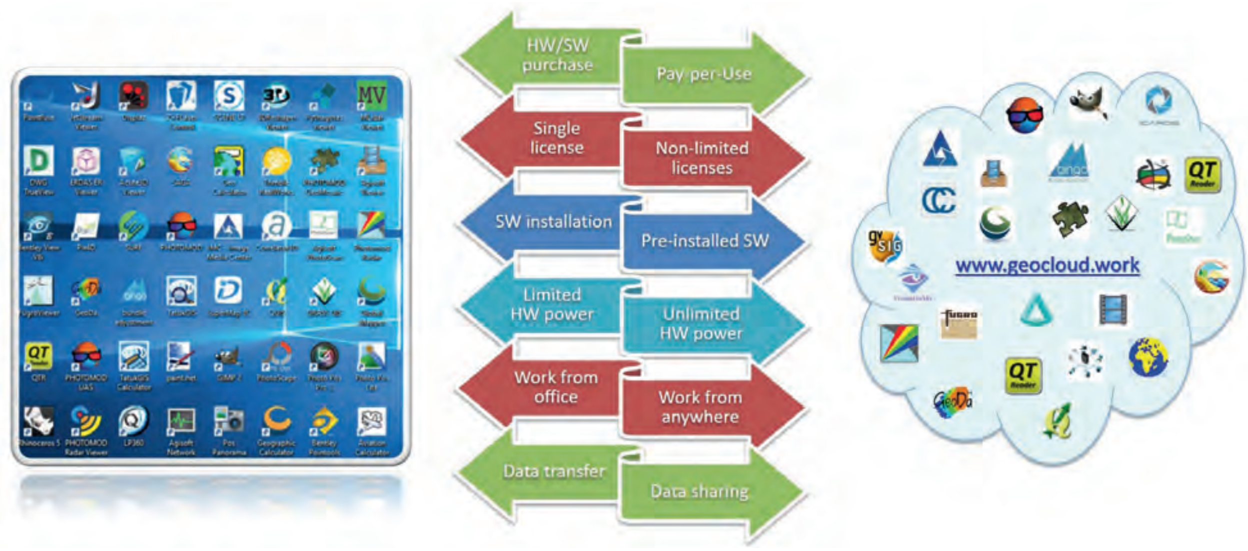
Geoinformation Software as a Service

Accurate geoinformation about urban areas, public buildings or historical sites is in great demand. It has become astonishingly easy to capture these scenes through cameras or laser scanning or to acquire open data from a diversity of sources. Professionals without a surveying background can do the job, but such professionals require reliable, robust, easy-to-use and affordable processing tools. Today, cloud computing can meet that need, enabling users to work with software packages running on remote servers on either a pay-per-use or a subscription basis. This article presents a cloud computing service dedicated to geoinformation software.

Storing data in the cloud has become increasingly popular among companies and the general public alike over recent years. The next logical development is to exploit remote servers for data processing and to deliver the end product via the internet. The sustained rise of cloud computing is fuelled by the exponential growth in computational power, ever-faster access to storage devices and high-speed data transport over the internet resulting from broadband networks. These three technological developments are allowing new business opportunities to flourish. The growing popularity of cloud services in recent years has been further boosted by the ease of internet access from almost any location across the globe.

CLOUD SERVICES

Cloud services can be divided into three main models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). IaaS creates a virtual desktop environment in which all data and all applications, including the operating system, are in the cloud. To process data and perform other IT tasks, the user can choose from a broad spectrum of software running on remote servers. In contrast, PaaS allows the user to deploy self-developed or self-purchased software using the hardware, programming languages, libraries and tools offered by the platform provider. The provider manages and controls the cloud infrastructure, but users have control over their applications. Meanwhile, SaaS goes a step further than PaaS: users rent the software supplied by the provider to process their own data and run it in a cloud infrastructure. Then, the data and the end product are safely returned to the user or shared with the user's customer via

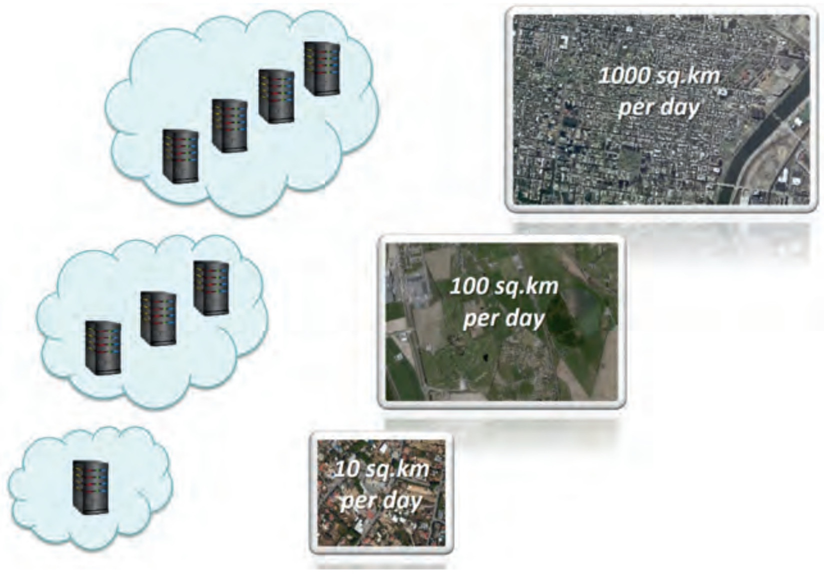


▲ *Figure 1: Software on a desktop versus cloud infrastructure.*

the internet. The provider hosts application software which can be accessed by users via the internet on either a subscription basis or a pay-per-use basis. Figure 1 compares the main features of licensed software installed on a desktop against software offered as a service in a cloud infrastructure.

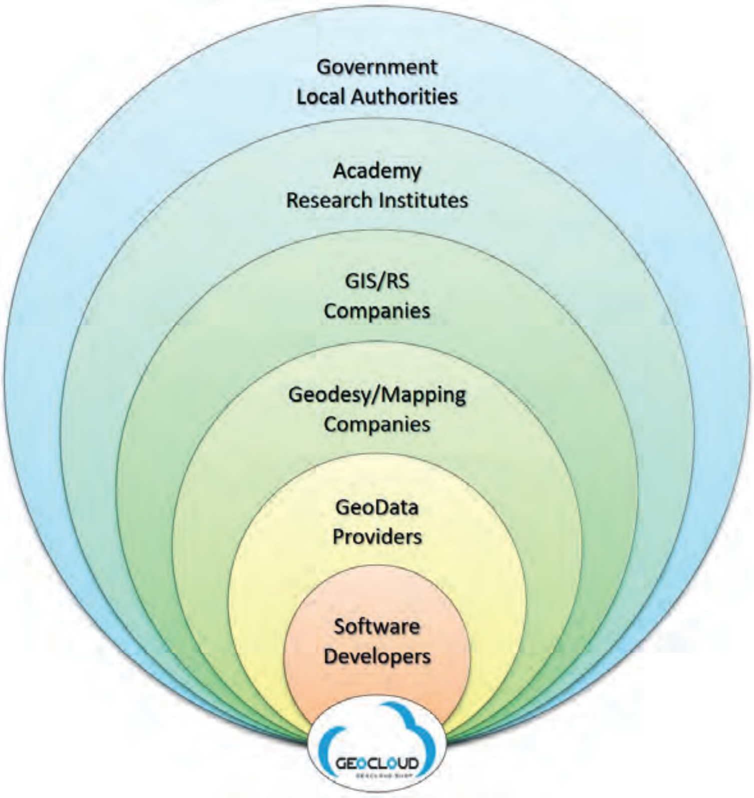
OPPORTUNITIES

The capabilities of today's geodata acquisition technologies – with at the forefront laser scanning and photogrammetry in the broadest sense – are tremendous. As a result of the advancements in smart software and miniaturization of electronics, relatively small devices can capture a variety of sites, both indoors and outdoors, at high levels of detail and accuracy. This means that the focus of geomatics specialists is increasingly shifting from the exploration of geodata for certain applications, to the acquisition and processing of geodata itself and the development of software to support automated processing. This shift in focus has also been reflected in the geomatics curriculum at many universities over the past decade. Besides this, professionals such as architects, constructors, cultural heritage conservators and urban green-space managers are becoming incidental users of geodata acquisition technologies.



▲ *Figure 2: Scalable and 'always available' computer environment.*

They lack the time and/or the inclination to get to grips with the nitty gritty of these technologies. Instead, they merely want to be able to process the geodata – which they may have acquired using a handheld device or by pushing a trolley – into a file and format suitable for use in their BIM or CAD software. These casual users welcome services which make their jobs easier. They regard geomatics end products as raw material for their own applications. It is simply a matter of uploading the data and indicating the desired processing steps on a digital form. Then, a little while later, the processed data becomes available to them in the desired format and the user can focus on utilizing it to create their actual product or service. Such users represent tremendous opportunities for providers who offer cloud-based geomatics software.



▲ *Figure 3: Shared use of software and data fosters collaboration among organizations and companies.*

GEOCLOUD

One recent example of a cloud computing service for geomatics software is GeoCloud. Launched in July 2018, the platform enables software vendors to host their geomatics software. "Users benefit from unlimited remote access to fully licensed, preinstalled and ready-for-use dedicated software," says Dr Yuri Raizman, CEO of GeoCloud Ltd. "Our cloud computing services cover all geomatics fields, including geodesy, photogrammetry, mapping, cartography, remote sensing, GIS, CAD, image processing, 3D city modelling, point cloud processing and automatic object recognition. We started less than a year ago, and the platform already supports over 50 geomatics software products."

The platform has been built on Amazon Web Services (AWS), which is the world's largest cloud service infrastructure, and has inherited all its advantages. By installing their software on the platform, vendors benefit from doing business round the clock at lower marketing, pre-sale and support costs. After installation, vendors can test how well their software works. Small software producers,

Figure 4: Unified and easy access to many software packages and data.

start-ups and other firms with limited financial resources can offer their software packages to a worldwide audience without high and risky investment. Established firms with a large consumer base also benefit from the platform since it enables them to extend their coverage globally and also to build awareness of their services and solutions among professionals outside of the geomatics field. After all, a single platform bringing together a variety of software is more likely to be found by smaller firms or casual users. "The potential is huge since today over 180 geoinformation software vendors are serving hundreds of thousands of geomatics and GIS professionals worldwide," continues Raizman. Users do not need to invest in computers with powerful processors; a fast internet connection suffices. A cloud infrastructure is very flexible for both users and software vendors since cloud computing provides a scalable and 'always available' computer environment (Figure 2).

Can GeoCloud's business model be compared with how an intermediate or broker operates? "Today, we are an intermediate between software vendors and customers," Raizman confirms. 'Soon we will bring together producers of imagery and maps, and other data providers with data users followed by connecting mapping service providers and their customers. What is important and new with us is the pay-per-use model." (Figure 3).

SUBSCRIPTION

When a user signs up for a subscription, an account is created which provides access for all employees within the user's organization. The accountholder pays for the total amount of time the software, computer and storage facilities have been used within their company or organization. The usage hours per account are added together every month and billed – at a predefined price per hour – at the beginning of the next month. Incidental users can subscribe for a limited period, e.g. one quarter, one month or even one week.

ONE HAS TO RELY ON THE SERVICE PROVIDER, WHICH MEANS RELINQUISHING AUTONOMY

Periodic subscriptions can be prolonged at any time. The main difference with a continuous subscription is that the user pays in advance for the selected software licence. The payments for the computer and storage are calculated on a pay-per-use basis. After gaining access to the platform, the customer first selects the relevant apps and storage units for uploading and processing their data. The storage volume should be sufficient to hold the customer's data, temporary files and end products. The volume of standard storage ranges from 1GB to 10TB, but can be extended on request. The next step is to sign up, including selection of the payment method. After finalizing this administrative procedure, customers can upload their data and start the selected apps (each of which runs independently of the other apps). In the case of software vendors, after signing up and selecting a payment method they then select one or more computer configurations from the choice of nine. Lastly, the software vendor uploads their software and can start doing tests.

RELIANCE AND SECURITY

Cloud computing provides unified and easy access to a variety of geoinformation software packages and data (Figure 4). While this is beneficial, the other side of the coin is that one has to rely on the service provider, which means relinquishing autonomy. One also depends on the security features with which the provider has surrounded his platform, and this is where trust comes in. Behind any digital service, there are not just robots, machines or computers but also an organization run by people. These people want to grow their business, which requires customers to keep coming back and recommend the organization's services to others. This is a powerful driver for companies to do their upmost to satisfy customers. On the other hand, it is very conceivable that organizations that work with sensitive information will be reluctant to use cloud computing services, instead preferring to establish their own secure data-processing environment.

CONCLUDING REMARKS

The ongoing developments in information and communication technology (ICT) continue to ignite new business opportunities and ideas. One relatively new business model is to offer software as a cloud computing service rather than on a licence basis. This encourages the shared use of software and data, thus fostering collaboration among organizations and companies. It is highly likely that these ICT advancements will further boost the use of geomatics tools and create greater public awareness of the benefits of geomatics.

FURTHER READING

www.geocloud.work

Communicating the Economic Impact of Climate Change with **Satellite Imagery**

Geospatial intelligence can play a fundamental role in communicating the economic cost of climate change in the 21st century. With more availability of spatial resolution, the environmental effects of global warming are becoming more noticeable from remote sensing techniques. Earth observation satellites increase the transparency between industry, policyholders and environmentalists, providing high-quality ammunition for environmental activists.

We see melting glaciers, sea level rise and extreme weather as tears the Earth is shedding due to climate change, but this is actually inadequate. Although we may not realize it, climate change has a far greater influence on our daily lives.

IMAGING SATELLITES

Imaging satellites help mitigate the effects of climate change through more environmental accountability. As surface temperatures rise and fall, patterns emerge in human activity, natural resource use and environmental degradation. With the mobilization of near-real-time sub-30cm resolution and machine learning capabilities, climate change can be monitored with unprecedented insight.

As humans welcome more heatwaves, the geospatial industry can begin correlating incremental surface temperature fluctuations with the financial and economic impact as symptoms of global warming. Satellite-derived artificial intelligence helps assess the impact of climate change on costs relating to parking, construction, traffic delays, the price of and demand for fuel, water, the environment and much more. For every single-digit rise or fall in extreme temperature levels, machine learning algorithms extract caveats invisible to the naked eye underneath ones and zeros of pixelated imagery. By observing the movement of machines and cars in near real time, we build and partition extreme weather databases to correlate anomalistic patterns of activity in geospatial datasets. Data analytics companies can assess the effects of climate change on the costs of courier delivery systems, national tourism, mining and agriculture. As commercial operations run at a loss of hundreds of billions of dollars, geospatial intelligence (GEOINT) can reveal the cost burden from reduced consumer demand in restaurants, malls, shops, event management and more.

While global warming contributes to more volatile health effects and imbalanced circadian rhythms of ecosystems, industries and business that are affected by heatwaves due to working outdoors may prefer to operate in cooler conditions during the evening and overnight. With rising daily temperature changes above 20°C (36°F) in surface temperature, analysts may correlate night-time construction and activity with urbanization and development. However, it is also a manifestation of rising temperatures. Synthetic aperture radar (SAR) may be one of the most scalable methods to monitor communities that are diverting operations to more optimal temperature ranges in order to mitigate unnecessary financial expenditures due to heat and cold. It may provide insight into the adoption of night-time activity trends, outdated vehicles and more heat-tolerant machinery.

MONITORING THE COST OF GREENHOUSE EMISSIONS

GEOINT helps monitor the costs of greenhouse emissions on coral reefs, forest health ecosystems, and the spread of disease. As homo sapiens become more affected by abnormal weather, nocturnal routines and less outdoor activity, geospatial communities can aid health industries in forecasting the time estimations, health influence and disease tolerance.

It is important to share inefficient uses of time and money emanating from rising temperatures and extreme weather. This knowledge can help us to establish industry standards that require companies to share the economic impact of climate change.

Predictive analytics and enhanced availability of GEOINT can more accurately predict the damage and costs of the greenhouse effect. By incentivizing and incorporating climate data science positions, companies can begin democratizing the costly outcome from periods of extreme heat and cold. For it is the responsibility of each of us to share how climate change is influencing our passion, industry and future. With this knowledge, the intelligence community is challenged to take on a larger role in the preservation of planet Earth.

19th General Assembly of the World Earthquake Geodesy Network for Environmental Hazard Research

The 19th General Assembly (GA) of the World Earthquake Geodesy Network for Environmental Hazard Research (WEGENER) was held at the Site Bergès – CRAYA Amphitheatre at Grenoble University in Grenoble, France, from 10-13 September 2018. Since being established in the early 1980s, WEGENER has primarily focused on the application of space geodetic and other disciplines to the study of geodynamics. Since 2012 WEGENER has been IAG Sub-commission 3.5: 'Tectonics and Earthquake Geodesy'. This GA was organized around seven thematic sessions:

- Active faults: reconciling short- and long-term observations
- The seismic cycle: from transient and precursory deformation to seismic rupture
- Technical and methodological developments
- Intracontinental deformation and slowly deforming areas
- Multi-timescale glacier and landslide processes
- Improving understanding of magmatic and volcanic process
- Vertical movements of the Earth surface, sea level and potential fields

A total of 170 scientists from 27 countries attended over four days, and the programme featured seven keynote speeches, 72 oral presentations and more than 100 poster presentations. All details of the GA including information about presentations and many photographs can be found on the WEGENER 2018 website.

More information
https://wegener2018.sciencesconf.org/

WEGENER participants outside the conference venue in Grenoble. (Photo credit: Haluk Ozener)

Two New FIG Task Forces: on SDGs and on FIG Governance

The FIG Council has established two new task forces for 2019-2022.

The first task force will focus on FIG and the Sustainable Development Goals (SDGs). This task force is chaired by Ms Paula Dijkstra from the Netherlands. The Task Force on SDGs organized a session in the technical programme at the Working Week in Hanoi in April 2019. The SDGs and related land indicators will reshape and influence our profession profoundly in the decade to come. It is considered to be of crucial importance that FIG member organizations and surveyors are aware of and prepared for how their (daily) work contributes to the achievement of the SDGs and vice versa. The aim of this task force is to:
- identify relevant SDGs for FIG and its Commissions
- assess needs, requirements and opportunities for FIG
- explore solutions, approaches, curricula and tools to boost the achievement of the SDGs
- align with other FIG and global initiatives (GLII, WB, UN-GGIM)

A final report is scheduled to be available in 2022 and will be in support of FIG's future workplans.
The second task force is an internal one focusing on an evaluation and proposal of potential changes in the current governance of FIG. This Task Force on FIG Governance is chaired by vice-president Diane Dumashie from the UK. This task force will investigate and evaluate the current structure of FIG.

More information
http://www.fig.net/

LAGIRS 2020: Another Opportunity for Cooperation between ISPRS and GRSS

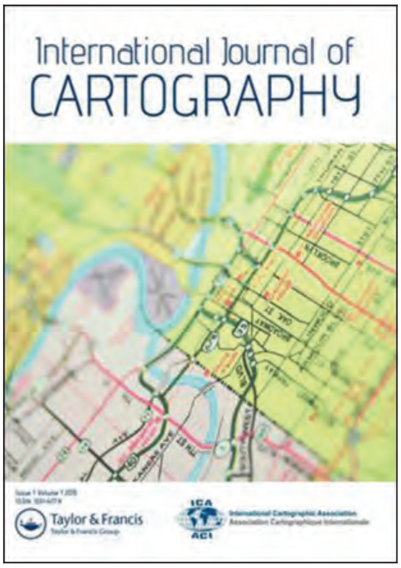
The Latin America GRSS & ISPRS Remote Sensing Conference (LAGIRS 2020) is the latest scientific meeting which ISPRS and GRSS are organizing together to better serve the remote sensing community around the world. Hosted by Universidad de Chile and Universidad de Magallanes, LAGIRS 2020 will be held in Santiago de Chile from 22-27 March 2020 and will attract remote sensing experts working in research and applications from all over Latin America. Based on a Memorandum of Understanding signed by the two societies in October 2018, LAGIRS 2020 is expected to be the first event in a series of regional Latin-American conferences on geoscience, remote sensing and related topics organized jointly by GRSS and ISPRS. LAGIRS 2020 follows a series of common workshops and tutorials successfully held across the continent over the last few years, as well as common meetings in other parts of the world such as the Joint Urban Remote Sensing Event (JURSE) series (since 2001) and the joint multi-sensor fusion and remote sensing workshop held in conjunction with CVPR and ICCV (since 2011).

LAGIRS 2020 will cover several key areas including sustainable developments and the contribution of remote sensing to the United Nations' Sustainable Development Goals (SDGs) relating to agriculture and forestry monitoring and radar remote sensing, as well as artificial intelligence for Earth observation (AI4EO) and 'New Space'. The deadline for submissions (in English only) is 31 October 2019. Accepted papers will be published in the proceedings in the ISPRS Annals and Archives as well as in IEEEXplore.
We cordially invite you to attend LAGIRS 2020 and to learn about specific remote sensing issues relating to the Latin American continent, to make new friends across the two societies and to experience the unique hospitality of our Chilean hosts.
We are looking forward to seeing you in Santiago de Chile in March 2020.

By Christian Heipke (ISPRS president) and Paolo Gamba (GRSS president).

More information
https://2020.lagirs.org

Ten Years Older



International Journal of Cartography.

A decade ago, the International Cartographic Association (ICA) celebrated its 50th birthday in style in Bern, Switzerland (where it was founded on 9 June 1959). Ten years on, arithmetic dictates that ICA is now 60 years old. Our reflections in 2009 considered, in detail, the founding and development of this important international association addressing all aspects of the vital work and fascinating activities of mapping. Today we can look back on ten more years of progress in the mission of ICA: "To promote the disciplines and professions of cartography and GIScience in an international context".

The ICA organization has followed the vision of its founders: a focused Executive Committee (EC), made up of eminent and dedicated cartographers from around the world; research and investigative work of practising cartographers channelled through subject-specific Commissions; awareness-raising and documentation of accomplishments through newsletters and in online arenas; promotion of cartography through engagement with member organizations around the world; publications pushing the boundaries of our discipline through journals; international meetings of cartographers in workshops, symposia and full conferences; and engagement with sister societies and international bodies.

Addressing these since 2009, ICA has organized two quadrennial General Assemblies (GA, the main decision-making body, with all member nations); the next one is taking place this July. The GA has elected a current EC somewhat different to a decade ago, with three females (out of ten), and representation from three continents. The GA also approves Commissions and has requested research into both long-standing and newer topics. Hence, current Commissions address topics that were not even considered ten years ago (e.g. sensor-driven mapping, or geoinformation management). ICA's web presence has benefited from the enthusiasm and technical expertise of individuals primarily based in Vienna, whilst the regular *ICA News* is a highly informative and attractive publication, produced in New Zealand. The international reach of ICA involves engagement by EC members, notably the president and secretary-general, ensuring presence and influence throughout the world. Since 2009, ICA has established the influential *International Journal of Cartography* and initiated a formalized publications policy allowing successive conference presentations to be made accessible. A host of meetings related to Commissions have been organized in the past decade, and the biennial International Cartographic Conferences (ICC) have been globally successful in Santiago (2009), Paris (2011), Dresden (2013), Rio de Janeiro (2015) and Washington DC (2017). Finally, the UN-GGIM has had significant ICA input since being established in 2011.

The international cartographic community meets in Tokyo this month at the 29th ICC. This is an opportunity to confirm and implement the goals and working practices described here. The field of geomatics demonstrates the vitality and value of a range of organizations – reported on these pages – which share ICA's characteristics.

More information
https://icaci.org/
https://icaci.org/commissions/
https://icaci.org/ica-news/
https://icaci.org/publications/
http://www.icc2019.org/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