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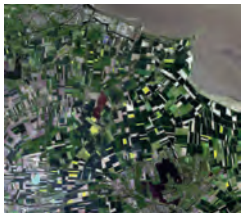

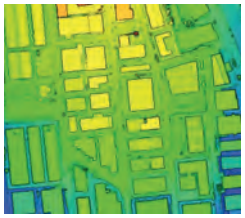

The focus of this last issue of 2017 is on Earth observation (EO) and satellite imagery. The front cover shows images of Dutch tulip fields as captured by satellite, provided by DigitalGlobe. In this magazine you will find an article on The National Satellite Data Portal, managed by The Netherlands Space Office. Despite existing for just five years, its user base and their usage patterns have become so diverse that its level of success is already beyond quantification.

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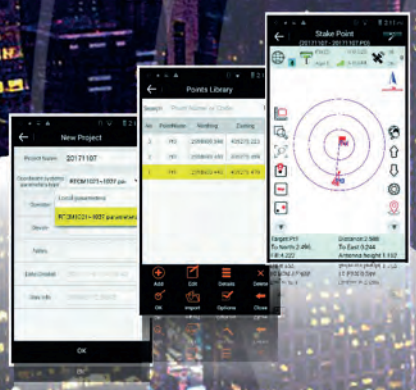

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Virtues

The year is almost at an end. In our region, December is the darkest month of the year which means it's still dark on the way into work in the morning and it's already dark again when you head home – so it's not the best time of year for those of us who like daylight and sunshine. It is traditionally also the time to reflect on the past year and to look ahead to the new one. I don't want to spend too long reflecting on 2017. Some indicators for a good year were on green: growth in world trade and more activity in building and construction. On the other hand, some indicators stayed on red: in Europe there's still much uncertainty surrounding Brexit, and in the USA President Trump and his plans are still causing considerable commotion. Furthermore, some parts of Africa and Asia remain very unstable. So is it all doom and gloom? No, of course not! As a historian by origin, and a journalist and editor by profession, I always ask myself: is it really worse than it used to be? Probably not. Are we hearing more about the 'doom and gloom' than before? Probably so. Could things be better? Yes, of course.

I visited the Austrian company RIEGL recently, which – as everybody knows – specialises in laser measurement systems for terrestrial, airborne, unmanned and mobile applications. I was inspired and pleasantly surprised by the innovative spirit displayed by this manufacturer of very high-accuracy technology. Loyal employees, sometimes working for the company for decades, are entrusted to develop new technology such as unmanned aerial vehicles, which RIEGL subsequently markets with confidence. The firm has had proven success in the last few years, and RIEGL now sells complete Lidar surveying systems including UAVs. Over lunch we discussed the deployment possibilities of these systems and concluded that those possibilities were almost endless, often in seemingly unlikely fields. Are there any challenges standing in the way of ever-increasing sales? Again, yes, of course there are. But the hopes are high and the expectations are realistic in Horn, where RIEGL is based.

I can't be sure that the four characteristics I saw in Austria when visiting RIEGL – innovation, loyalty, trust and realistic expectations – are a guarantee for business success in our industry, but I think they come close. At this time of reflection, at the end of the year, I believe that these four characteristics – or virtues – should form the basis of any good strategy. Maybe a few more need to be added to ensure success, but I'll wait until 2018 to think about that. I am sure there will be a lot more circumstances that will shape 2018 as a year for businesses, and specifically for the geomatics sector that we are all active in. *GIM International* will keep an eye on them for you!

▲ *Durk Haarsma, publishing director.*

GIM INTERNATIONAL

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Lidar-based Mobile Mapping for Accurate Documentation of Work Zones along Transportation Corridors

Mobility of people and goods plays an important role in providing economic and social opportunities and benefits. Improving the efficiency and safety of transportation corridors is critical for realising such benefits. Therefore, maintaining and expanding such infrastructure are among the key priorities of federal and state transportation agencies. The availability of digital maps with road characteristics such as lane marking, lane width, signage, curvature and grade is crucial for driver assistance systems, road safety evaluation, risk assessment, traffic accident reduction and infrastructure monitoring. The United States Federal Highway Administration (FHWA) reported that 47,758 injuries occurred in work zone crashes during 2013 (FHWA, 2017). Efficient work zone monitoring and inspection plays a critical role in decreasing traffic accidents and congestion. Lane width and geometry evaluation are important aspects of road safety inspection of work zones. For example, a narrow lane will increase the probability of severe accidents. Narrow shoulders, presence of guardrails, poor signage, short tapers, encroaching construction barrels and/or confusing lane markings can further exacerbate traffic congestion in work zones.

Mobile mapping systems (MMSs) equipped with light detection and ranging (Lidar) units can rapidly collect spatial data in work zone areas without affecting traffic (Figure 1). Geometric and semantic road characteristics can then be derived from the acquired point cloud and images for risk assessment. Acquired Lidar data by wheel-based MMSs can be used for deriving lane width values as well as other characteristics (e.g. shoulder width, signage clearance, construction barrel alignment and encroachment, invisible lane markers, improper lane markers and potential debris/rubble on shoulders). These capabilities can be even enhanced by integrating Lidar data with digital images captured by the MMS.

Integrated global navigation satellite systems and inertial navigation systems (GNSSs/INSs) with laser scanning/ranging units can derive accurate point clouds with high point density along the driven corridors. In addition to the spatial coordinates of the laser beam footprints, the system also provides intensity data that represents the reflectivity of the scanned objects in the waveband associated with the Lidar unit. The intensity data for transportation arteries is quite useful when compared with other Lidar mapping projects (airborne mapping) due to the high reflectivity of several features along the road network such as lane markers, guiding/warning signage, construction barrels, etc. The geometric accuracy and the intensity of acquired point clouds can be used to automatically extract several features such as lane markers, which can be then used to derive the lane width. Lane capacity in terms of vehicles per lane per hour depends on the lane width, shoulder width and truck volume. A short road segment with substandard lane width will significantly reduce the lane capacity. MMSs equipped with Lidar units provide a safe and accurate modality for accurate estimation of lane width without affecting the traffic, especially in work zones where great care should be exercised to enhance traffic flow.

▲ *Figure 1, Lidar-based MMS within a transportation corridor work zone.*

Combining GIS and Agricultural Engineering to Develop Irrigation Solution

Supergeo has announced a collaborative project with the Agricultural Engineering Research Center (AERC), a leading research institute in irrigation study, to develop an irrigation solution based on SuperGIS software. The result of this collaboration is expected to be shared with and promoted to the Southeast Asian countries in the very near future. Established in 1971, AERC is a professional research institute supported by the Taiwanese government. With the goal of promoting modern technologies and scientific management in agriculture, AERC has been dedicated to introducing new technologies in GPS, GIS, remote sensing and ecological engineering to farms in Taiwan.

▸ **http://bit.ly/2jG7ETA**

Agricultural irrigation.

Autodesk and Esri Partner up to Bridge the BIM-GIS Gap

Esri President Dangermond and Autodesk CEO Anagnost.

Autodesk and Esri have announced the start of a new relationship to bridge the gap between BIM and GIS mapping technologies. Together, Autodesk and Esri plan to enable a broad range of industries to gain better context by visualising data of the man-made world, the environment, citizens and the networks that weave it all together. "It is important to consider the needs of future generations during the design and building of projects today," stated Jack Dangermond, president of Esri. "The benefits of partnering with Autodesk will include securing sustainable resources for the growing population, a responsible human footprint on our natural environment, better use of our planet's resources and more resilient cities," he added.

▸ **http://bit.ly/2zUMPYF**

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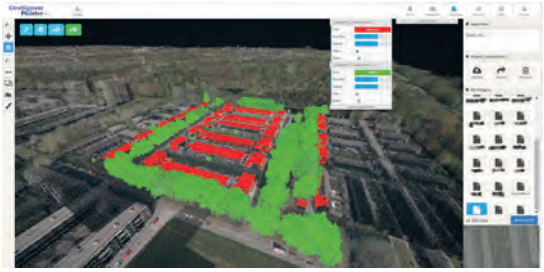
Web-based Lidar Data Processing

The use of 3D laser scanning is growing enormously, and the amount of data is growing accordingly. It is becoming increasingly difficult to acquire the in-house technical capability to store, manage and analyse this massive volume of data. The flood of laser scanning data demands more effective tools that have greater automation, lower cost and more accurate results. With the above requirements in mind, GeoSignum has been developing new tools and technologies for automated analysis and interpretation of huge Lidar datasets which can be accessed through its web-based Pointer platform. Because the Pointer platform is cloud-based, users no longer have to worry about storing, accessing, managing and analysing their huge volumes of Lidar datasets. They simply upload their datasets to the Pointer platform and easily access their data through a web browser.

▸ http://bit.ly/2zV6gm6



Trees and rooftops in a scanned area.

Machine-learning Point Cloud Classification

Pix4Dmapper is an industrial-standard photogrammetry software package that provides accurate 3D reconstruction from overlapping images. Along with the expanding drone market, people are keen to explore new solutions to replace or to complete traditional technologies. Point cloud classification, an iconic feature for Lidar point cloud, is now also being considered by drone surveying professionals. While Lidar provides up to four returns and gives precise and clean 3D points, the quality of photogrammetry points is based mostly on image content. It is more challenging to classify the photogrammetry point cloud than the Lidar point cloud. However, with the advancement of platforms and sensors, image quality has been largely improved and so too have the photogrammetry outputs.

▸ http://bit.ly/2zSYvOs

Accurate 3D reconstruction from overlapping images.

MicaSense Unveils RedEdge Multispectral Sensor

RedEdge-M multispectral sensor.

MicaSense has released RedEdge-M, the evolution of its rugged, built-to-last, professional multispectral sensor, RedEdge. Easily integrated into a wide variety of drones, RedEdge-M enables agricultural enterprises, growers and researchers to optimise management practices, streamline operations, detect stress and disease early, and capture accurate data for scientific analysis. The RedEdge-M captures the spectral bands required for basic crop health indexes, but also those that generate analytics that are anything but basic. With its low weight, low power requirement and multiple integration options, the flexibility of RedEdge-M makes it attractive for farmers.

http://bit.ly/2mJCZWM

Satellite-based Earth Observation Market: Strong Growth and Fierce Competition

According to the 10th edition of Euroconsult's report, titled 'Satellite-Based Earth Observation, Market Prospects to 2026', the Earth observation (EO) data and services market should reach USD8.5 billion by 2026 based on current growth trajectories. An alternative value-added services (VAS) model also presented has a combined market potential of USD15 billion. This upside model considers the implications of new supply solutions being able to open further markets. Additionally, advances in artificial intelligence and deep learning are expected to benefit the sector, acting as enablers for new solutions based on change-detection analytics. Simultaneously, competition is expected to be fierce on the supply side.

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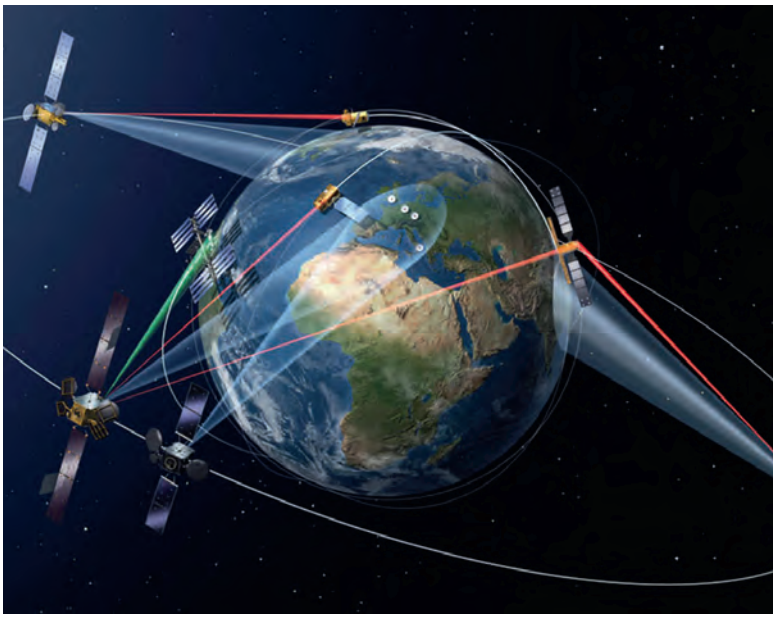

Satellite-based Earth observation.

New Standard to Revolutionise Spatial Information Referencing

The membership of the Open Geospatial Consortium (OGC) has approved the Discrete Global Grid System (DGGS) as OGC Abstract Specification – Topic 21 [OGC 15-104r5]. The goal of DGGS is to enable rapid assembly of spatial data without the difficulties of working with projected coordinate reference systems. The OGC DGGS Abstract Specification standard defines the conceptual model and a set of rules for building highly efficient architectures for spatial data storage, integration and analytics. "DGGS will provide the capability to properly integrate global geospatial, social and economic information. It also allows communities with data attributed to fundamentally different geographies to integrate this information in a single consistent framework," said Dr Stuart Minchin, chief of the Environmental Geoscience Division at Geoscience Australia.

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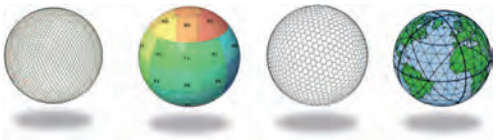

Discrete Global Grid System (DGGS).

ISPRS: Call for Educational and Capacity-building Initiatives in 2018

ISPRS logo.

In accordance with the statutory mission and activities of the International Society for Photogrammetry and Remote Sensing (ISPRS), the society shall provide funds to support educational and capacity-building initiatives. These will further improve its international status in the educational area in the field of the photogrammetry, remote sensing and spatial information sciences, and will therefore benefit all ISPRS members. Future calls for funding shall be made on a two-yearly basis (in odd years), and dependent on the budgetary restrictions at the time of the call for proposals. In view of ISPRS resources, the council is making available up to CHF40,000 to support capacity-building initiatives in 2018.

http://bit.ly/2zSJz2m

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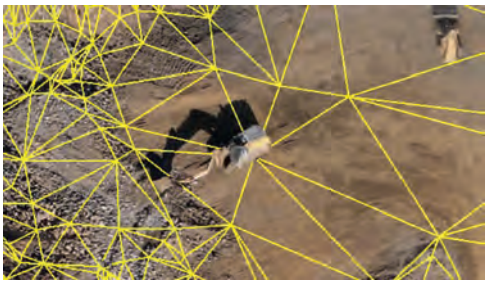
Virtual Surveyor Unveils Productivity Tools in Drone Image Analysis Software



Virtual Surveyor.

Virtual Surveyor, a developer of UAV image visualisation and analysis software, launched a new suite of Productivity Tools at the 2017 Commercial UAV Expo in Las Vegas, USA. The Virtual Surveyor software package enables professional surveyors to generate accurate topographic end products from drone imagery five times faster than traditional field work. Now used in 46 countries, Virtual Surveyor aims to bridge the gap between UAV photogrammetric processing software and engineering design packages. In a typical application, the Virtual Surveyor suite takes the orthophotos and digital surface models (DSMs) extracted from UAV imagery with photogrammetric software like Pix4D or DroneDeploy and generates an interactive virtual environment onscreen where surveyors can apply their core skills to select the survey points and breaklines that define topography.

▸ **http://bit.ly/2mKZnPC**

Gilberto Câmara Announced as New Secretariat Director of Group on Earth Observations

Gilberto Câmara.

The Group on Earth Observations (GEO) has announced the appointment of Gilberto Câmara as its next secretariat director, effective from 1 July 2018. Câmara is a leading researcher in geoinformatics, geographical information science and land use change with Brazil's National Institute for Space Research (INPE). He has been recognised internationally for promoting free access and open-source software for Earth observation data. Under his guidance, as director for Earth observation (2001-2005) and director general (2006-2012), INPE made significant advances in land-change monitoring using remote sensing, which contributed to Brazil achieving an 80% decrease in deforestation in the Amazon rainforest in support of Brazil's commitment made at the UNFCCC COP15. This achievement was hailed as "the biggest environmental success story in a decade" by the scientific journal *Nature*. In support of Brazil's pledge to the 2015 Paris Agreement, Câmara led a team that projected Brazil's future emissions from land use and agriculture.

▸ **http://bit.ly/2zS917Q**

Trimble Tracking Technology Helps Recovery of Stolen Survey Instrumentation

KOREC has reported that, following an investigation carried out by Forest Gate Police in East London, UK, over 30 stolen survey instruments and accessories have been recovered from a lock-up. The success of this recovery operation was assisted by one of the stolen instruments, a KOREC-supplied Trimble S-Series total station, having built-in Trimble Locate to Protect (L2P) tracking technology. The tracked instrument is owned by nationwide survey company Sumo Services and was in use on an East London site during the summer when it was stolen. Following its theft, Paul Williams, director of Sumo Services, was able to log into the L2P portal and monitor the instrument's journey until it finally came to rest. Using Google Maps, he pinpointed its location at a storage centre whilst Google Street View revealed a CCTV camera covering the storage centre's entrance. Sumo immediately informed the police and called KOREC to establish its serial number.

▸ **http://bit.ly/2zSXRQd**

Tracked total station.

INTERVIEW WITH PETER HEDLUND, ORDNANCE SURVEY INTERNATIONAL

Growing Geospatial Capabilities All over the World

Ordnance Survey International (OSI) is a subsidiary of Ordnance Survey (OS), responsible for sharing the British mapping agency's expertise and tradecraft with countries across the globe. In 2016, the international branch appointed Peter Hedlund as its new managing director. Back then, Hedlund stated that location data often reveals the simplest answers to many of our world's most complex questions. In this interview, he zooms in on the geospatial services his organisation provides all over the world.

What attracted you to join OS? And how does your past experience help you in this position?
Ordnance Survey (OS) is well-known and respected the world over; it has an excellent reputation. Geospatial data underpins an increasing number of people, businesses and governments, so it's currently an exciting time for OS and the overall geospatial community. With the emergence of technologies that have the potential to transform our world and the way we live and do business, we are on the verge of something really special. I have been living and working overseas for many years now. My career is technology-focused and my roles have always been to grow teams and businesses across markets and regions. I've worked with small nimble start-ups, as well as large corporations. In general, my experience has been about leading teams, and inspiring people to be innovative and come up with good products and solutions that solve client issues in a clever and efficient way.

How have OS's international activities evolved over the years?
Almost 20 years ago now, OS made the strategic decision to withdraw from international work and concentrate all its efforts on digitising Great Britain's geospatial database – a massive task in those days! This activity was a world first, and the process took around 15 years to complete. Today, Great Britain has 'one true digital source' for all its geospatial information to operate from

and which other government agencies and businesses can confidently use. The digital process enables better decision-making and helps things to happen in Great Britain quickly and with great efficiency. The experience gained from that process has been invaluable, as have the knowledge and skills that have also been amassed, and this supports the international consulting work which we are now doing. We have a lot to offer!

Which particular opportunities do you see for OS's skillset and experience to make a difference globally?

We are taking what we have done for Great Britain to other governments and their national mapping and cadastral agencies, to help them improve what they do and also to provide them with the tools to become more efficient and to make better decisions. We have done a lot of work internationally involving creating strategies and frameworks, data management, data modelling and spatial data infrastructure. Our approach is customer focused and entrepreneurial, and the offering is always expanding as we continue collaborating on groundbreaking smart city, IoT, connected and autonomous vehicle (CAV) and 5G-related projects. It is interesting, because many of these projects are becoming the catalyst for geospatial data.

How would you describe the ideal customer for OSI, and what exactly does OSI offer them?

We are open to any nation that has a need or a problem we can help with. The nation would need to have a clear vision of what it is they want to achieve and be open to learning about the importance of geospatial – if they don't already know – and how it can benefit government, business and citizens. What we offer is very specific geospatial consulting services, and we can broaden that to data capture services and project management services. We are here to enable, to transfer our knowledge and to teach about production capability. Various independent research papers have shown that not only can very large savings be achieved through usage of geospatial data, but also that the spatial information industry and its accumulated impacts are valued at between 0.2 and 0.6% of a country's GDP per annum. So obviously, there are some really large economic benefits to leveraging and using geospatial data.

What type of projects has OSI undertaken recently?

In the past six months OS has won contracts on four continents. The focus of this work has predominantly been on smart cities, climate change, data management, data modelling and improving the capacity of other nations. We are guiding them towards building, maintaining and running a geospatial framework that supports their communities, which creates better government and economic growth.

Which human resources does OSI have at its disposal?

We have a thousand people within OS who are specialised in geospatial consulting and data, and they are based in various locations. In addition to this, we have a huge network of very innovative partners that work with our data and technology and who we also leverage when we deliver on projects.

What role does OS play in UN-GGIM and how does this support the UK's geospatial activities?

From 2011-2015, the UK held one of the co-chair positions within the United Nations Initiative on Global Geospatial Information Management (UN-GGIM) and has helped to establish, grow, shape and develop the Committee of Experts into its current form. Aside from the co-chair position, OS has led the UK delegation to each of the Committee of Expert meetings, and ensures that a balanced delegation attends the meetings. The most recent delegation comprised representatives from OS, Office for National Statistics, HM Land Registry and staff from the UK Mission to the United Nations. But OS's contribution extends further than the leadership of the delegation. Many of the work groups and expert groups have benefited from OS's geospatial expertise, whether regarding the role that international standards play or the benefits that can be realised through having a consistent approach to the Global Geodetic Reference Frame.

The world is increasingly dominated by Google and internet giants, and hard data gathering and processing can be done more economically by Asian countries. How can OSI remain relevant?

Competition is good! It helps drive geospatial usage and raises awareness. The world is big enough for OS and other companies, but on the other hand we are well respected inside and outside the geospatial community. Last year, we marked 225 years of capturing and supplying authoritative geospatial data and location intelligence that is integral to the better prosperity and well-being of Great Britain. We continue to deliver expertise and value at home (across businesses, governments and individuals) while building our international operations with some very interesting offerings to the global market. One of these services is the Geospatial Maturity Review tool, which we've been developing together with our customers over the past few years. The services assess how mature organisations are at collecting, managing and disseminating geospatial information to meet stakeholder requirements and business goals. The review will help customers understand not only how mature they are now, but how mature customers need them to be. We also have a free, light version of the service available online.

Nowadays, for business survival, collaboration is often seen as more important than competition. What is OS's stance on that?

We understand the value of collaboration and partnering to share expertise and deliver customer solutions. We have a huge network of innovative partners in Great Britain and internationally that are from the private sector (non-traditional geospatial information (GI) organisations), GI organisations and government. Our view is that existing partnerships and new ones are essential to our growth strategy. We will continue expanding our partner ecosystem beyond the 380 partners we have in place today. As we expand globally, we will also transform our partnership model to work with global, regional and niche partners. We are therefore constantly on the lookout for new, innovative, best-of-breed partners to help us deliver smart projects across the globe. ◀

The original version of this interview was published in the September/October 2017 issue of *Geomatics World*.

ABOUT PETER HEDLUND

Peter Hedlund leads an Ordnance Survey team that helps national mapping and cadastral agencies and governments around the world develop and grow their geospatial capabilities. Over the past years, Ordnance Survey International has been establishing itself as an internationally recognised thought leader within the global geospatial community. Prior to joining Ordnance Survey as managing director, Peter Hedlund was regional director of Middle East and Africa for Trimble, where he produced and implemented strategies that grew Trimble's international business across continents.

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BY **MOHSEN KALANTARI** AND **ABBAS RAJABIFARD**, UNIVERSITY OF MELBOURNE, AUSTRALIA

Report on **3D Australia** 2017 Conference

The inaugural 3D Australia conference was held at the University of Melbourne from 24-27 October 2017. 3D Australia 2017 comprised the 3D Geoinfo Conference 2017, the first international workshop on BIM and GIS Integration, and 3D cadastre training.

The 3D Geoinfo Conference 2017 brought together 150 international 3D spatial information researchers from academia, industry and government. It provided an interdisciplinary forum in the fields of data collection, advanced modelling approaches, data analysis and visualisation.

The attendees enjoyed excellent keynote lectures on topics related to the national approach for 3D spatial data infrastructures (SDIs), nD systems for cities, the changing role of surveyors and spatial professions driven by 3D technologies, cultural shift to achieve smart cities and the role of standards in nD city systems.

There were 43 scientific papers submitted to the conference. After the double-blind peer review process, 16 papers were accepted and published in the ISPRS Annals (Volume IV-4/W5) and eight papers in the ISPRS Archives (Volume XLII-4/W7), both available online as open access proceedings. The papers covered a range of topics related to 3D geospatial data including drivers of 3D data, reasoning and structuring 3D data, 3D indoor data, several applications of 3D data such as energy analysis, asset management, cadastres and much more. The papers also included some examples of how 3D data is being used by public-sector agencies. There were many promising future research initiatives presented as short papers.

3D Geoinfo 2017 included a pre-conference workshop session on BIM-GIS integration organised by the International Association of Geodesy's BIM Working Group. The workshop provided a platform for researchers to present and discuss their work in various aspects of building information modelling (BIM) and geographic information system (GIS) integration. The focus of the workshop was on the nexus of BIM and GIS to discuss the challenges of integrating BIM and GIS. During the workshop, ten papers were presented which identified several challenges including leadership, advocacy, inter-domain and intra-domain collaboration, best practices, funding models for BIM and GIS integration, BIM and city models data value and IP, standards and scales, BIM to 3D GIS workflow, data models based on concepts and ontologies, cross-domain curriculum development and BIM/GIS issues in the context of current social constructs (public and private sectors). There was also recognition of cross-domain collaborations in this space such as those between OGC, buildingSmart and ISO. The need for more input from the academic community into BIM and GIS standards was strongly highlighted.

▲ *3D Australia 2017 included excellent keynote lectures.*

▲ *Throughout the event, attendees enjoyed Australian hospitality.*

The 3D cadastre training presented the Centre for Spatial Data Infrastructures and Land Administration's previous and current research topics related to 3D cadastre. It also provided training on the implementation of 3D digital cadastral systems. All 40 attendees received a certificate of attendance from the University of Melbourne's Centre for Spatial Data Infrastructure and Land Administration.

Throughout the event, attendees enjoyed Australian hospitality including Melbourne's famous coffee, international food, an Aussie BBQ and Australian Aboriginal music. ◀

The conference presentations are now available at http://3dgeoinfo2017.com.

MARKET GROWTH REQUIRES EFFORT

Free Satellite Data Creates New Commercial Applications

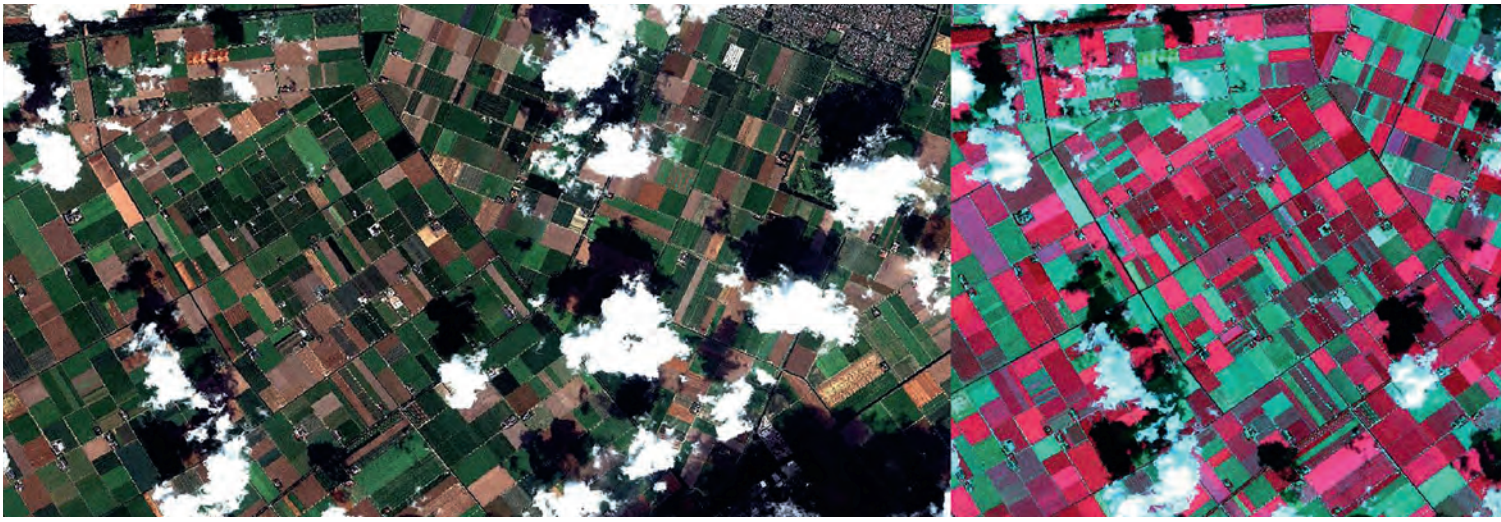
The National Satellite Data Portal, managed by the Netherlands Space Office (NSO), is an interesting phenomenon. Despite existing for just five years, its user base and their usage patterns have become so diverse that its level of success is already beyond quantification – and yet the organisation is convinced that the bulk of the market growth still lies ahead. NSO ensures that its customers and partners in The Netherlands can respond to new opportunities in a timely manner.

Employing 28 people, the Netherlands Space Office is responsible for the execution of the Dutch space policy. 75% of its annual EUR100 million budget goes to the European Space Agency (ESA), and the remaining 25% is spent on realising the national space policy.

DON'T SEE YOURSELF AS THE END SOLUTION, BUT AS PART OF A PRODUCT OR SERVICE

One of the NSO's instruments in particular, the National Satellite Data Portal, is becoming more important every year, even though the team comprises just three people. The number of users of the Satellite Data Portal is rapidly growing and extremely diverse.

Two sorts of images are available: optical and radar. "The Netherlands does not own satellites; in that sense we are an independent agency," explains Dr Jasper van Loon, advisor on science and applications. He is also the National Satellite



▲ *Left: Optical imagery. Centre: NIR multispectral imagery. Right: Radar imagery with no cloud issues. The Dutch National Satellite Data Portal provides access to all sorts of data in various resolutions.*

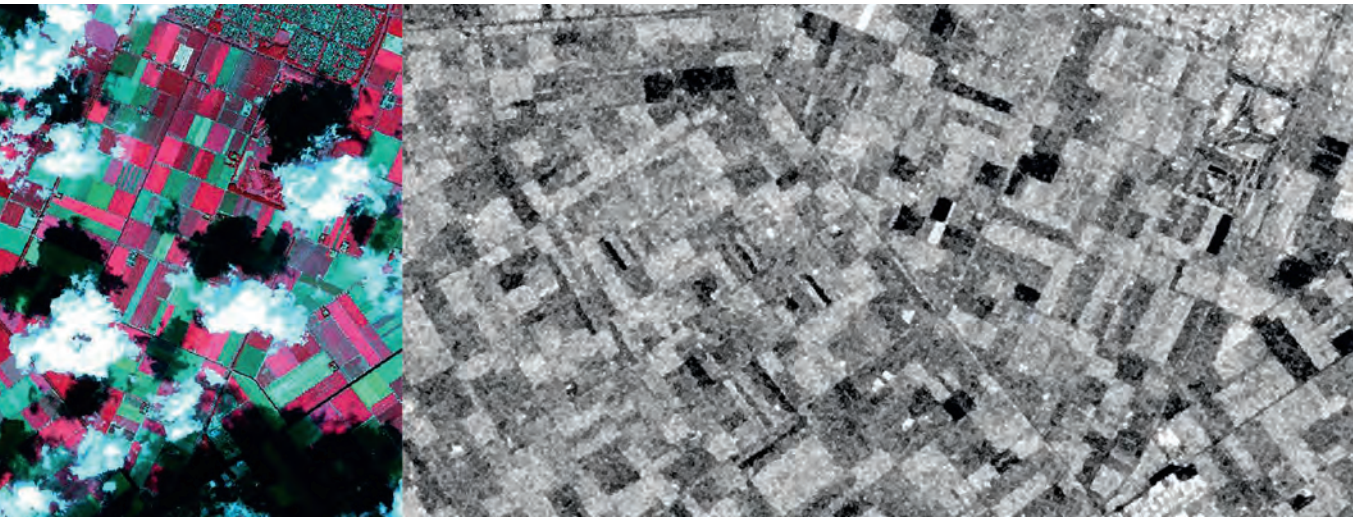
Data Portal project leader and the liaison on satellite data between the Dutch and European governments. "We stimulate the use of satellite data by public and private organisations, and facilitate companies to add value for their clients. With the data portal, we aim to make government processes more efficient and stimulate Dutch trade and industry. Our activities are coordinated by the Dutch Ministry of Economic Affairs and Climate Policy."

MERCANTILE GENES

The implementation of the satellite portal is a good example of the notorious Dutch mercantile genes. The portal was built in 2012 to prepare The Netherlands for the satellite data that would, in a few years' time, become freely available from the Copernicus programme. Thanks to a joint investment programme by the European Commission and ESA, several Sentinel satellites have been providing free data since 2015; in 2018 there will be six satellites in space and several ground stations. Other European countries waited longer to develop such a portal and they are now facing the problem that the benefits of modern satellite data are largely unknown and there are very few companies who can build applications around it. But the Dutch government took care that both the supply side and demand side of the market were ready for Copernicus. NSO bought data similar to the Sentinel data that would later become available for free, invested in a national distribution channel – the National Satellite Data Portal – and organised the contact between potential users and potentially capable added-value companies.

▲ *Agricultural fields in Groningen, northern Netherlands – Triplesat 0.80m image ©21AT (2017), distribution 21AT, all rights reserved.*

This approach worked brilliantly. Many applications are up and running and many other interesting ones are being built, which is already giving Dutch companies an excellent export position. Periodically NSO meets with potential and existing users as well as companies to discuss new possibilities and needs in terms of spectra, frequency, regions and resolution. Van Loon: "As a trained surveyor myself, I know what the geosector thinks about satellite images: low resolution, clouds everywhere, not there when you need them. But that is an outdated idea. You can buy a fresh image of the whole country with



▲ *The satellite data portal enables comparison of two different images, making it easy to spot changes over time – in this case the illegal disposal of soil and waste. Satellite imagery made it possible to quickly assess the situation and the necessary action.*

30cm resolution every day, available within hours. Free Sentinel images in open data format with 10m resolution are available every five days via our portal, either raw or already GIS-friendly." In the crop-growing season (March-October), NSO buys high-resolution (3.1m) images every two weeks and images with a very high resolution (80cm) every two months from commercial data providers.

CO-CREATION

That is one of the reasons why the number of private companies adding value to the NSO satellite data has been picking up speed over the past three years. Whereas in the early days they came from the remote sensing and space sector, now almost every large firm that builds GIS applications is involved. "It is not so much a matter of how to use the continuous dynamic image stream, but rather how to combine the images with other information layers. In the beginning, our mistake was to think that satellite data was the solution to almost every problem – we oversold it. But in those days clouds were a serious problem. Today that is less the case because the satellites pass over The Netherlands every day. And four times a year we put all the mosaics on top of each other and select the cloud-free images to produce a blended 'fair-weather' image. More crucially, we've learned that you have to co-create; you need to involve parties in the whole chain at an earlier stage. Don't see yourself as the end solution, but as part of a product or service," states Van Loon.

He also admits that it is difficult to measure the portal's success. Counting the number of existing and new users, monitoring their revenue or counting downloads says nothing any more. The data is used by a broad range of companies such as engineering firms and industry-specific portals. They might look like one client and they download the data only once, but that data is then actually consulted by thousands of users (e.g. boerenbunder.nl and akkerweb.eu represent 3,600 farmers) who do not even know where the data comes from. "We are certain that we stimulate the economy very effectively, but we can no longer give concrete numbers. More and more links are being added to the chain, including via advisors we do not see or even know about. Nevertheless, if we had more personnel we would be able to bring more parties together, inform more organisations of the benefits, help organisations in their search for a technically suitable solution but also share our experiences with workflow integration. In short, we could stimulate the economy much faster."

IN THE NEAR FUTURE, ALL EUROPEAN FARMERS WILL BE CHECKED BY SATELLITE IMAGES FOR EVERY RULE THAT REQUIRES VISUAL INSPECTION

AGRICULTURE

From the Dutch Ministry of Economic Affairs, the organisation recently received EUR1.4 million extra to invest in high-resolution satellite data for precision farming over the next four years. The agricultural market is the largest at the moment – from precision farming to identifying illegal activities such as marijuana plantations in the middle of cornfields. And on the topic of corn: as of next year, the Dutch authorities will use satellite images to check nationwide whether farmers have sown the right vegetation after harvesting corn to improve the condition of the soil again. In another use case: farmers can receive subsidy if they inundate a certain section of their land for nature conservation purposes and to create a foraging area for birds. Until now, the relevant authority conducted random checks by visiting farmers who were eligible for this regulation. Thanks to satellite images, a first check can be done from the office in order to see if the land really is wet or not. Inspectors can then perform much more targeted field checks. It is not yet common practice to use satellite images in this way to check compliance with the terms for EU subsidies. However, Van Loon expects the EU to change its rules to permit monitoring and inspection using satellite images, and several EU countries are working together to improve such inspection methods. Once the European agricultural policy rules have been adapted from obligatory visual inspections to the use of satellite images in selecting which farms to visit, it is certain that all European farmers will be checked this way for every rule that requires visual inspection. In view of the fact that 40% of the total EU budget is spent on agricultural subsidies (EUR434 billion), the business case in the EU speaks for itself. Thanks to the NSO creating timely awareness of new possibilities on both the demand side and the supply side, Dutch companies can show governments in other countries a solution that already works. This puts them in pole position in international tenders.

EMERGING MARKETS

Emerging markets include homeland security, safety (to prevent mishaps), justice (investigating crimes) and defence. Fire departments are also enthusiastic about using the data for modelling fire scenarios. For example: if a fire breaks out in a particular national park and the wind comes from the west, how will the fire spread and where should the firefighters be deployed? Until now this has been done with a 1:10,000 vector map, but the vegetation detail is often insufficient. Heathland is indicated as sand on the vector map, for example, but – unlike sand – heather does not stop fire; in fact, it spreads it faster. The map is now combined with satellite images, making the predictive models more accurate.

Another trend is the automatic detection of mutations: trees growing into electrical cables, cracks in dikes and dams, ground movement around pipelines, building activities on areas with right-of-way, refugee camps being established high up in the mountains, and suchlike. One good example of commercial use is by port authorities. The data not only helps them to evaluate their own activities but also to look at their competitors in other nations: which activities are growing or declining, whether new infrastructure has been developed, etc.

TIME-CRITICAL

Although the imaging is refreshed much more frequently than before, it is still not done in real time, so that is one area for further development. Time-critical applications are more powerful, of course. In the case of incidents such as pirate attacks, unwanted activities around pipelines or a farmer who is deep ploughing where that is not permitted, the aim is to take action as quickly as possible. The EU recognises that speed is increasingly of the essence. Data is being sent to more ground stations so that the new images are in the national portals within just a few hours. To improve the download process, next year the NSO is implementing a new system in which more and faster computers will be integrated.

In the case of a large-scale emergency, every EU member state can immediately activate measures to ensure that all Sentinel satellites passing over the area capture images which are then automatically transformed into a damage map, among other things. Everyone can use the data and the maps for their action planning. The NSO (together with the Dutch Ministry of Justice and Security) pushed that button when a hurricane hit the Dutch Caribbean island of St. Maarten in September 2017. The Dutch Red Cross was not aware of this possibility and was trying frantically – with amateurs – to map the devastated island, Jasper van Loon recalls: "That was an item on the national news; otherwise we would not have known to call them to say that better options were readily and freely available." ◂

ABOUT THE AUTHOR

Frédérique Coumans lives in Belgium and is contributing editor for *GIM International*. For more than 25 years, she has been covering all aspects of spatial data infrastructures as editor-in-chief of magazines on GIS and on data mining and GIS-in-business.

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A SURVEYOR'S PERSPECTIVE ON BENTLEY'S YEAR IN INFRASTRUCTURE CONFERENCE

The Geospatial Contribution to **Digital Twins**

The digitalisation of our world is in full swing. It is transforming the way we live, work, communicate, entertain and are being governed. Construction and infrastructure are also entering the digital era, although there still is a lot of work to do – the sector is lagging behind compared to some others. Bentley Systems plays an important role in the transition to a digital representation of the built environment. The company's annual Year in Infrastructure Conference, held in Singapore in November of this year, showed that the digital era presents many chances for the geospatial industry.

As Greg Bentley, CEO of Bentley Systems, mentioned at the 2017 event's press conference, the construction industry is conservative. Bearing in mind that 80% of construction and infrastructure projects are either too expensive or finished too late, the sector had better become aware of the benefits of digitalisation – and fast. A huge improvement in efficiency is on the horizon. However, it would be unfair to only blame the construction world for being too slow. Many solutions that will boost digitalisation come from the geospatial field, so companies in this area should be on the front row and have their seatbelts already fastened. The Year in Infrastructure Conference 2017 visualised where the digital road is heading and how geomatics could contribute.

DIGITAL REPRESENTATION

The role for the geospatial sector can be summarised as supporting firms in their 'going digital' strategy. Bentley is obviously doing this, as advancing the construction and infrastructure industry is its core business. However, the solutions delivered by Bentley won't work without the input provided by surveying and mapping professionals. If innovative software is the engine of digitalisation, geospatial data is its fuel. Digitalisation products are often referred to as 'digital twins': 3D reality models that form a digital representation of the built environment, such as construction sites, infrastructure developments, mines, oil & gas fields, power plants, airports and so on. In the same analogy, BIM stores huge amounts of geospatial information, making it the 'digital DNA' of construction projects.

Regular and accurate site surveys are crucial in achieving a well-functioning BIM, and the Year in Infrastructure Conference in Singapore provided an overview of numerous projects with a wide variety of geospatial involvement. A project carried out by Jacobs/Zephyr UAS consisted of mapping approximately 70km of a high-speed rail corridor in California and involved a photogrammetric drone survey; the point clouds derived from it were transformed into a digital terrain model. This project is an example of how Bentley products can be advantageously combined with innovative unmanned aerial vehicle (UAV) technology. The UAV made the acquired data available immediately in the desired resolution (ranging from 5cm to 15cm per pixel). Mapping the rail corridor with a satellite or a manned aircraft would have taken weeks if not months, while terrestrial mapping would have been slow and dependent on the availability of a professional. Carried out with ProjectWise, Microstation and Power RailTrack, the project cost only USD70,000, whereas conventional mapping methods

▲ *The Year in Infrastructure Conference 2017 was held at the amazing Marina Bay Sands venue in Singapore.*

▲ *Be Inspired Awards finalists had the opportunity to present their projects.*

would have cost closer to USD550,000. In other words, UAV mapping achieved a cost reduction of 86%.

MAP FOR SELF-DRIVING CARS

Another intriguing project consisted of feature extraction technology developed by Sanborn. This technology enables the extraction of transportation objects in a semi-automated manner. Both airborne and mobile Lidar data was captured over the project area with existing control and datasets. The highly accurate data was processed with ContextCapture Center, allowing the quick production of 3D mesh models of the urban environment from Sanborn's high-precision oblique imagery. The 3D mesh forms the basis of the Sanborn HD Maps urban datasets for self-driving cars. The combination of aerial Lidar and photogrammetry was labelled as 'Lidargrammetry', and resulted in enormous amounts of point-cloud data which was merged together using TerraScan in Bentley MicroStation. One advantage of merging point clouds collected from different sensor platforms is that it can fill the gaps for each individual technology. Another major benefit is the ability to extract stationary physical objects related to roadways, such as shoulders, traffic signals, paint markings and poles, which leads to a scalable approach for maintaining highly detailed inventories.

REAL-TIME DIGITAL TWIN

A third project that – along with many others – definitely deserves a mention is the development of the Anderson Road Quarry site in Hong Kong, a facility that used to supply the region with aggregate, asphalt, stone and concrete. The vacated quarry is now being transformed into a residential and commercial area, and will accommodate 25,000 citizens. From 2023 onwards, the former quarry will be an urban area that meets all the requirements of the smart city concept. Whereas a traditional survey would have taken more than a month, the quarry was mapped in just one day using a UAV and photogrammetry technology. The reality modelling was carried out with ContextCapture, while the visual animations were done with LumenRT. The result is a real-time, continuously updated digital twin that can be accessed anytime and anywhere, making the reality model available for various stakeholders such as clients, citizens, consultants and contractors. The 3D cadastral boundaries are an interesting geospatial component of the project, which won a Be Inspired Award.

An integrated environment using reality modelling has many advantages; it reduces risks to labourers working on-site, it minimises the time and resources required for planning and monitoring construction progress, and it leads to streamlined workflows which avoid costly reworks.

INFRASTRUCTURE-GEOSPATIAL PARTNERSHIPS

The event was also the ideal occasion to announce significant initiatives that are bringing the geospatial and the building industries closer together. The Bentley-Topcon partnership is a major alliance that will add weight to the integration of geomatics and the construction and infrastructure industry. Topcon and Bentley will collaborate to create the Constructioneering Academy curriculum which will be implemented through existing learning centres located in Livermore, California (Topcon), Houston, Texas, and London, UK (Bentley). These learning centres are aimed at enabling construction industry professionals to learn best practices in constructioneering. The Bentley-Topcon collaboration is set to speed up the digital journey, as is the cooperation between Bentley and Microsoft, with the software giant providing the architecture, engineering & construction (AEC) sector with a vital big data solution.

In 2016, Bentley and Siemens announced a strategic alliance, the goal of which is to jointly develop solutions to accelerate digitalisation of planning, design and operations for power utilities and industrial power customers. The alliance is focusing on shared contributions towards digital workflows and digital cities. At the Year in Infrastructure Conference 2017, the audience was provided with an update on the various joint development projects underway – projects that are built on the continued collaborative work done between Siemens and Bentley, converging Bentley's BIM and reality modelling software with Siemens' product design and production process engineering solutions.

GeoSLAM is the new kid on the block among Bentley's partners. At the conference, it was announced that the British 3D geospatial solution provider and Bentley are joining forces to take mobile reality modelling indoors. The aim is to enable the simple and fast production of hybrid reality models in any environment. It will be interesting to keep an eye on this collaboration to see what is possible with both ContextCapture and ZEB-REVO.

▲ *Ray O'Connor, CEO of Topcon, addressed the audience during the Alliance Partner panel discussion.*

CONCLUSION

In a construction or infrastructure project, a digital twin is very beneficial in terms of saving time and money. Abnormalities, damages and changes will be detected sooner, which means that action can be taken at an earlier stage. This makes it essential for the AEC sector to embrace digitalisation, and that's good news for the mapping and surveying profession. It is clear that BIM and reality modelling open up intriguing opportunities for surveyors. Geospatial information is so strongly connected to BIM that it must feel very familiar and convenient to geospatial professionals. Bearing in mind the recent debate about the future of the surveyor, perhaps we should wonder whether the nature of that discussion hasn't been too negative so far.

For a closer look at the new solutions provided and presented by Bentley Systems, see here: www.bentley.com/news. ◀

BIM

BIM may have been a buzzword for the past couple of years, but some geomatics professionals still seem unsure about what exactly it encompasses. In short, building information modelling (BIM) is a process in which an intelligent 3D model is created and used to make decisions for projects and to communicate them. It is a digital representation of physical and functional characteristics of places. Building information models are being used for planning, design and construction purposes, and for maintaining assets and infrastructure. BIM is increasingly being used by construction firms, but there is still much to improve.

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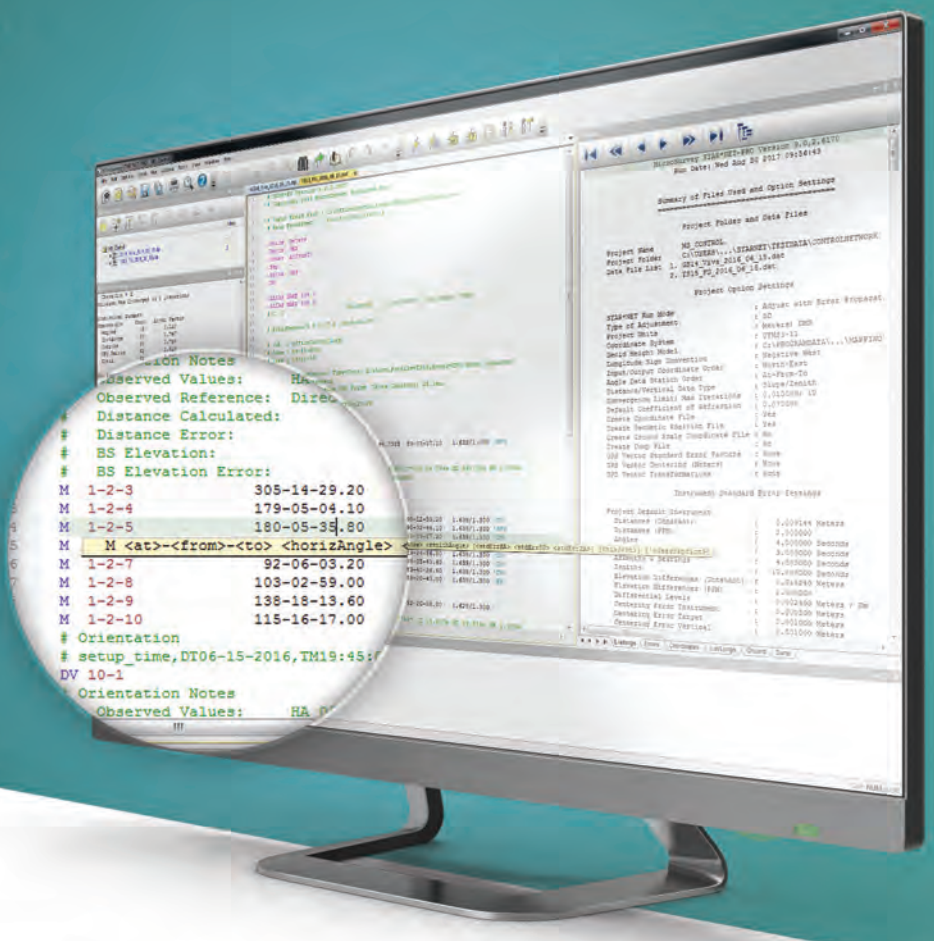

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COMPARISON WITH THE ISPRS LIDAR BENCHMARK DATA

Constructing Very High Resolution **Satellite Data Surface Models**

A digital surface model (DSM) is a common photogrammetric product which is widely applied in the areas of surveying and mapping as well as geographic information systems (GIS). In line with the invention of the semi-global matching (SGM) algorithm by H. Hirschmüller in 2005, stereo pairs are matched pixel-wise, leading to a very dense DSM. Very high resolution satellite (VHRS) imaging sensors provide stereo images at up to 0.3m ground sampling distance (GSD). The major advantage of VHRS data is that the data coverage is much larger than that of classical airborne data. Therefore VHRS imagery is a promising option to generate 3D point clouds and DSMs.

To verify VHRS algorithms, a VHRS benchmark dataset of an area in Catalonia (Spain) is provided by the ISPRS Working Group I/4 on Geometric and Radiometric Modelling of Optical Spaceborne Sensors. The data for the benchmark was laser scanned by the Institut Cartografic de Catalunya (ICC) and functions as a reference dataset.

The University of Stuttgart – Institute for Photogrammetry applied a Worldview-1 (WV-1) dataset at 0.5m GSD to the ISPRS benchmark using their own processing algorithms. The data was acquired on 29 August 2008, with a stereo angle of the pair of 35°. The dataset contains three different regions: La Mola, Terrassa and Canarisses. For each region, the size of the stereo image is approximately 8,000 x 8,000 pixels. These regions cover rural, urban, forest, flat and mountainous areas. All the data is delivered at Level 1B, which provides radiometrically corrected imagery in top-of-atmosphere (TOA) radiance values and in sensor geometry. The data contains the corresponding rational polynomial coefficient (RPC) files, which describe the exterior orientation of the satellite orbits.

PROCESSING VHRS DATA

The algorithms used were implemented as an automatic pipeline to generate both point clouds and DSMs. Normally the first procedure is the RPC-based bundle block adjustment but, because the orientation of the benchmark dataset's RPC files were already available, the actual first step was epipolar resampling. In epipolar resampling, corresponding points are located on the same row in the file so that the calculating time and memory usage is reduced. In a standard aerial camera geometry, the epipolar points are all on a straight line. However, in a VHRS image they are more like hyperbolas.

To approximate the hyperbola, a modified piecewise epipolar resampling method based on J. Oh's research was used (Figure 1). In this resampling method, a number of steps are performed. The first step is to define the coordinate system of the stereo epipolar image. The centre point of the left image is used to calculate the direction of the initial epipolar curve and its orthogonal line. The next step is the determination of the start point for the epipolar curve pair generation from the bottom boundary of the left image. According to the characteristic of a VHRS image's epipolar curve, the local epipolar curves are approximated using the projection-trajectory method. For the epipolar segment inside the image, a pre-defined length of the segment is given and a new epipolar segment

Test site	NMAD [m]	68% [m]	95% [m]	RMSE [m]
Terrassa	0.8	1.0	7.0	2.8
La Mola	1.4	1.8	7.7	3.1
Canarisses	1.4	1.9	8.3	3.4

Table 1, Overview of DSM comparison.

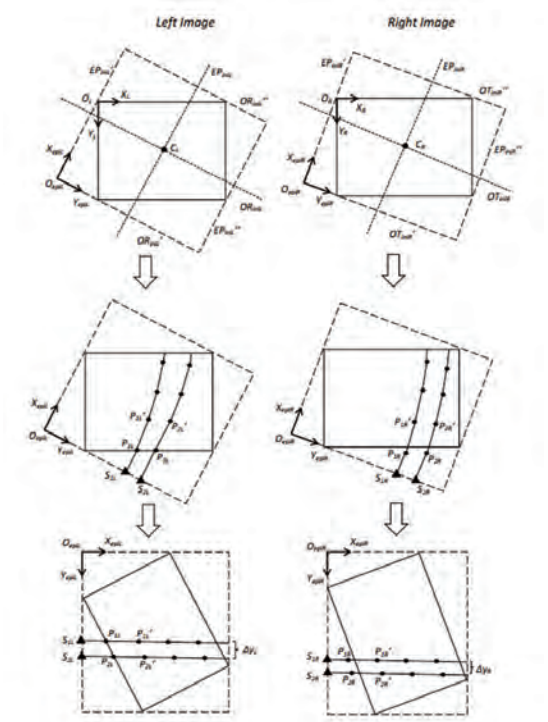
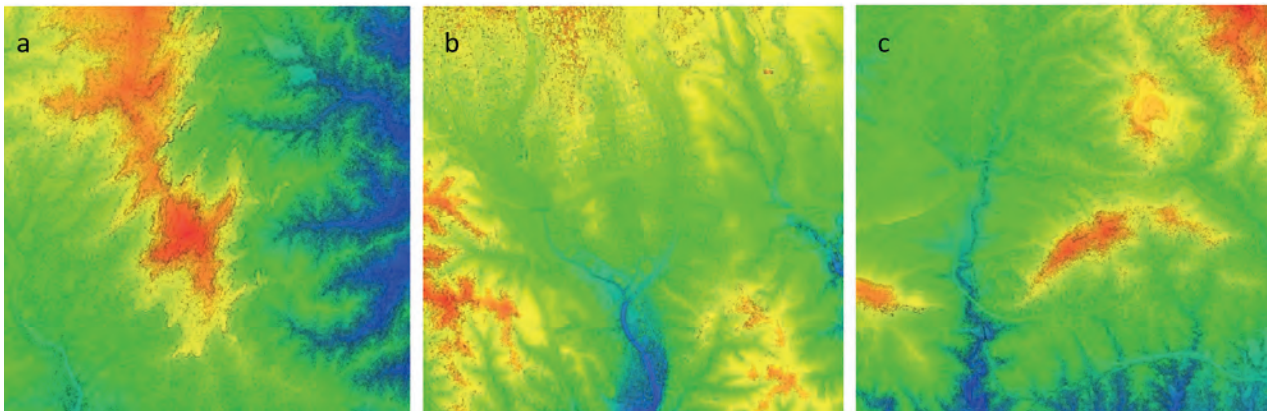


Figure 1, Modified piecewise epipolar resampling method.



▲ *Figure 2, Calculated point clouds: a) La Mola, b) Terrassa, and c) Canarisses.*

will be generated if it reaches the pre-defined length. In the last step, the stereo images are resampled along the epipolar segments.

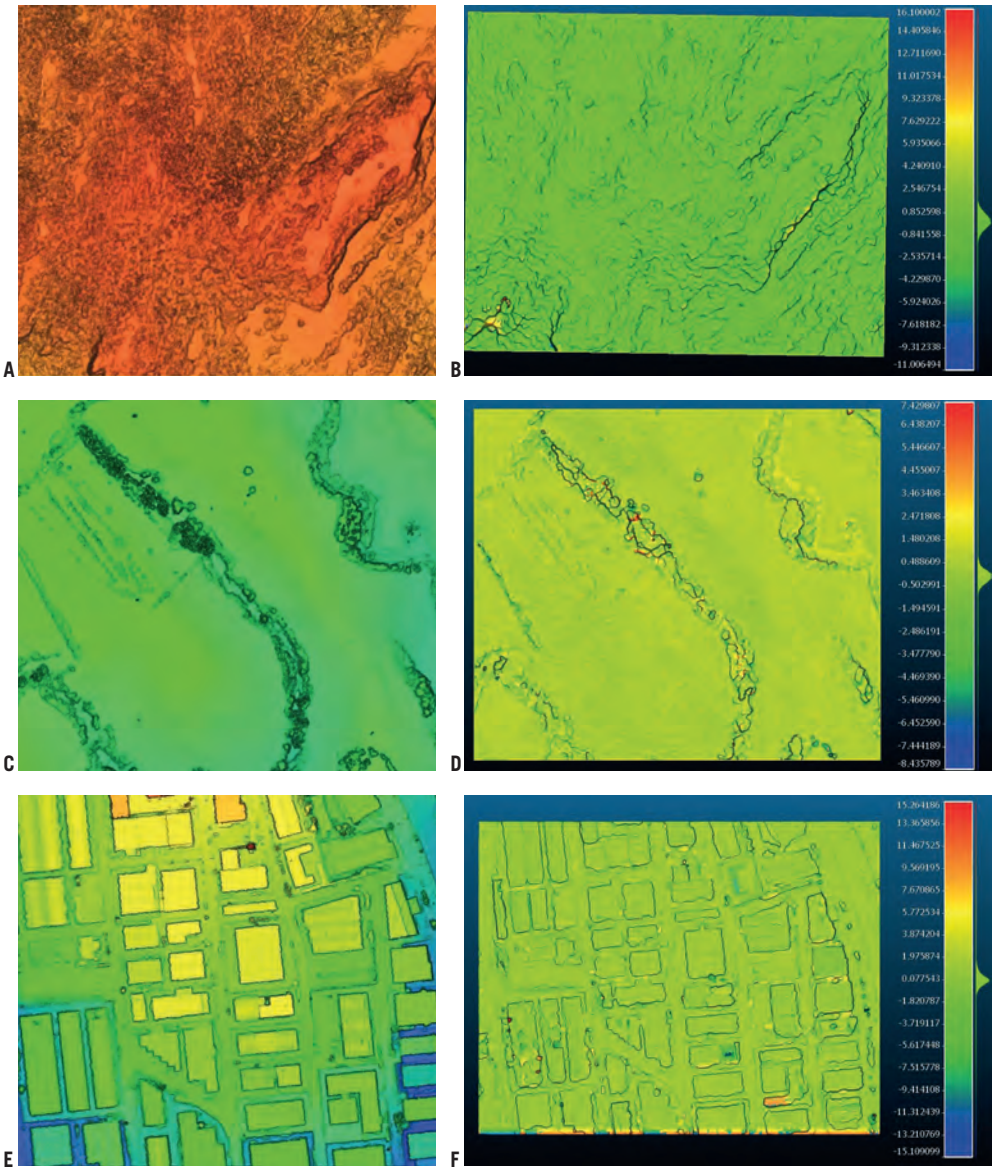
The dense image matching is now based on the resampled epipolar stereo pair. The C/C++ library LibTsgm is applied and integrated in the processing pipeline for pixel-by-pixel matching. LibTsgm implements a modified SGM method and was developed at the University of Stuttgart – Institute for Photogrammetry and then outsourced to nFrames GmbH in Stuttgart in 2013. When the dense image matching is finished, 3D point clouds are calculated; from these point clouds, the DSMs are generated with a GSD of 1m. For better visualisation, the point clouds are meshed by CloudCompare (Figure 2).

POINT CLOUD ACCURACY

In order to investigate the performance of the 3D reconstruction pipeline, three different types of terrain (samples) have been extracted from the point cloud to show more detail (Figure 3): a) mountainous forest area, b) flat rural area, and c) urban area. The point cloud from the VHRS data is in general coarser than that of the reference Lidar point cloud. The extracted DSMs are compared with the reference Lidar point clouds. The height between the processed WV-1 DSM and the Lidar point cloud is compared and, from this comparison, difference charts are created.

The basic terrain of the mountainous forests is reconstructed well in the satellite data, with most height differences less than 2.5m. In the flat rural area, some detailed features are missing in the VHRS point cloud but overall height differences are at the sub-metre level. In the urban area, the buildings in the Lidar point cloud have sharper edges than in the VHRS data and most details are missing, although the WV-1's point cloud can reconstruct some details on the roofs. Most height differences are less than 2m in urban areas.

A further investigation of the accuracy shows that overall accuracy is affected by shadows



▲ *Figure 3, Reconstruction details of Lidar point cloud: a) mountains; c) rural flat; e) urban; b), d) and f) error map for a), c) and e).*

in the scenery. As a result, the accuracy in the flat rural area is the best as there are minimal shadows. The buildings create many shadows that influence their reconstruction and affect the accuracy. The accuracy of the mountainous forest area is affected by the shadow of the trees as well as the steep height changes.

DSM ACCURACY

The Lidar point cloud is processed into a reference DSM in order to compare the DSM from the VHRS. To evaluate the accuracy of the 3D reconstruction, the root mean square error (RMSE) has been calculated according to the height differences of the DSMs. This shows that the RMSE of the La Mola test site is about 3.1m, of the Terrassa test site is 2.8m and of the Canarisses test site is 3.4m. The Terrassa test site has a better RMSE because it has more flat areas.

For a robust estimation, the normalised median deviation (NMAD) between the two DSMs is calculated. The corresponding 68% and 95% quantiles of absolute errors are also taken. The distributions of the height differences are depicted as a histogram for each test site. The NMAD varies between 0.8 and 1.4m with the 68% varying between 1.4 and 1.9m and the 95% varying between 7.0 and 8.3m (Table 1).

CONCLUSION

The automatic 3D reconstruction pipeline of the (V)HRS data has been verified as an accurate and robust method. The generated 3D point clouds and DSMs are very dense, and the main texture information of the test sites is reconstructed. The DSM has some outliers and the edges of buildings are not sharp because of the influence of shadows and low image redundancy. Better results could possibly be obtained if higher resolution data (e.g. 0.3m GSD satellite imagery) and multi-view imagery are applied in future work. ◀

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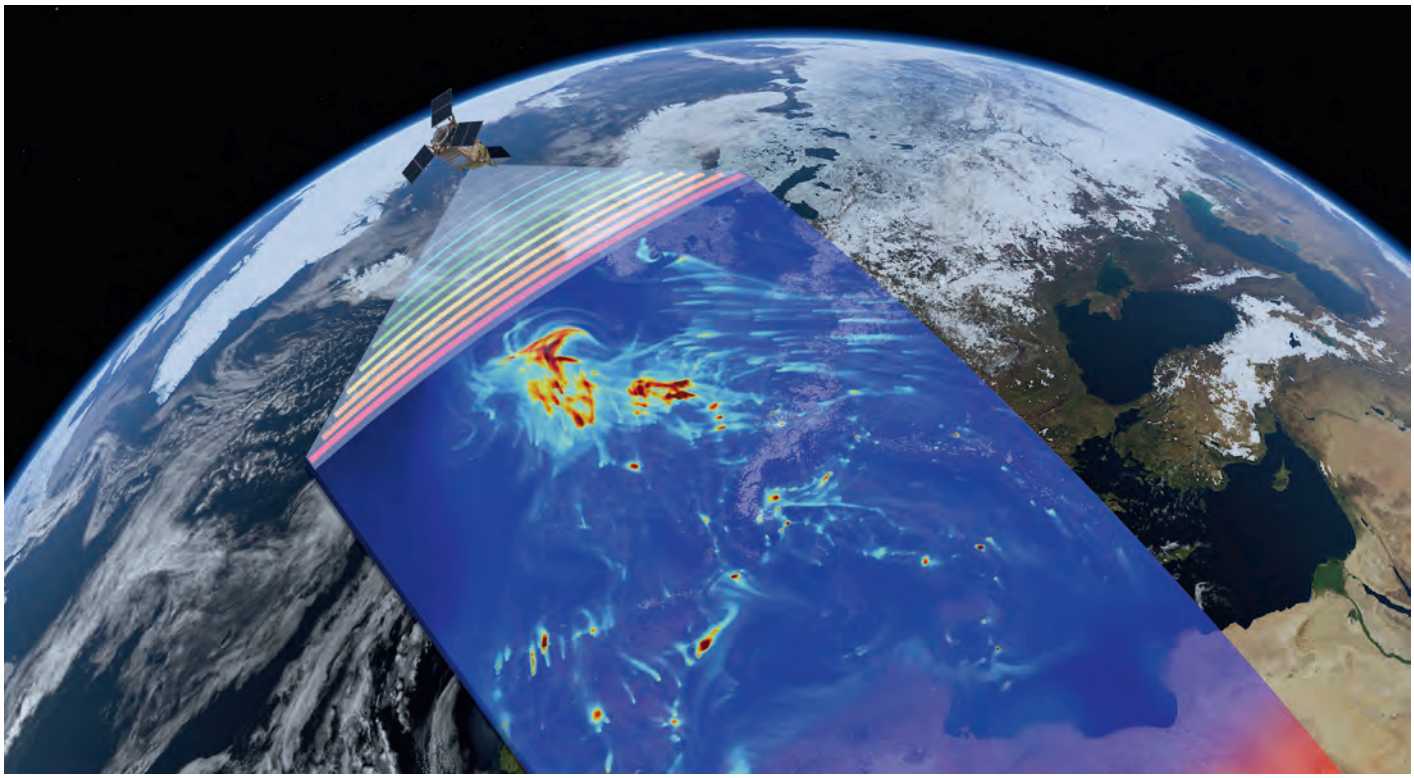
OPTIMISED EXPLOITATION OF SATELLITE OZONE AND UV RADIATION MEASUREMENTS

Real-time Health Advice from Space

Disturbing figures on air quality and UV solar radiation have resulted in a booming interest in environmental public health monitoring. Especially regarding UV radiation and atmospheric composition, real-time health-risk probing tools that rely on satellite observations now feed personalised smartphone apps and global statistics on a daily basis. The Horizon 2020 AURORA project aims at an optimal exploitation of Copernicus Sentinel satellite observations and model data in order to increase the horizontal resolution and surface accuracy of this spaceborne approach. This article explains how this data is enhanced and illustrates how it is used in two health-related apps.

AURORA stands for 'Advanced Ultraviolet Radiation and Ozone Retrieval for Applications'. The term 'retrieval' denotes the derivation of atmospheric constituent densities from remote – mostly satellite – observations. Although the AURORA retrieval concept can indeed be extended to a wider set of atmospheric targets, the project's key scientific aim is to retrieve global atmospheric ozone in an 'advanced' way so that polluting tropospheric ozone and harmful UV radiation can be operationally determined with unprecedented quality. The technological goal of AURORA is to initiate the development of an online real-time data monitoring



▲ *Figure 1, Sentinel-5 Precursor is the first Copernicus mission dedicated to monitoring our atmosphere. With air pollution a major concern, the satellite carries the state-of-the-art Tropomi instrument to map a multitude of trace gases such as nitrogen dioxide, ozone, formaldehyde, sulphur dioxide, methane, carbon monoxide and aerosols – all of which affect the air we breathe and therefore our health and our climate. (Copyright ESA/ATG medialab)*

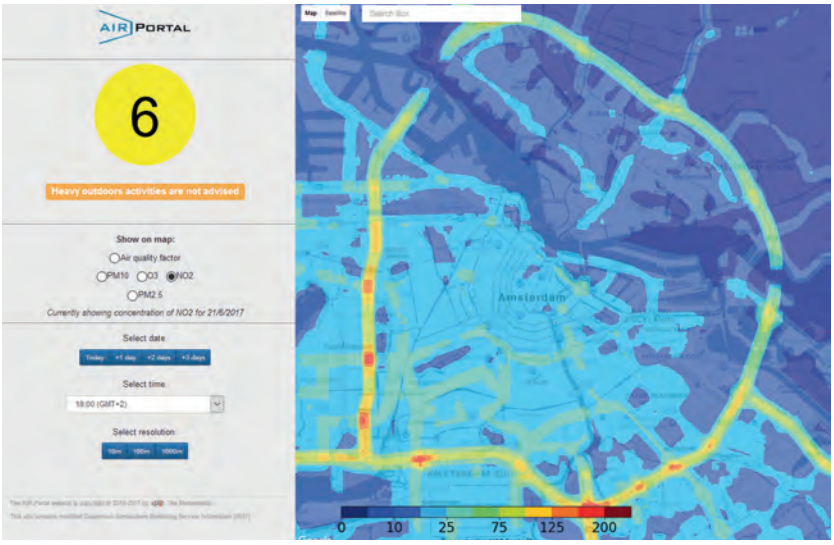
platform and health advice applications that exploit air quality and UV radiation statistics.

SURFACE ACCURACY

Space-based atmospheric composition observations typically suffer from limited horizontal (and temporal) resolutions and strongly reduced surface accuracies in terms of tropospheric bias and precision. The AURORA project intends to address these two shortcomings by means of an optimised exploitation of Copernicus Sentinel satellite data. The relevant Copernicus ozone monitoring missions are the Sentinel-5 Precursor (S5P) launched on 13 October 2017, and the Sentinel-4 (S4) and Sentinel-5 (S5) from 2022 onwards. They will provide a massive amount of atmospheric composition data with unprecedented quality; a major potential strength of these Sentinel satellite observations lies in their complementary information obtained from simultaneous measurements of the same air mass. Measurement observations are fused from three retrieval wavelength ranges (UV, visible and thermal infrared) from both the low-Earth-orbit S5 and S5P platforms with daily global coverage and the geostationary-orbit S4 platform with hourly European coverage. In a later stage, two upcoming non-European geostationary missions called TEMPO (from NASA) and GEMS (from JAXA) will be added to the ozone data fusion input stream. The horizontal resolution of the data fusion output is still in the order of tens of kilometres, but the combined measurement accuracy in terms of bias and precision throughout the whole vertical ozone concentration profile is expected to be significantly improved (see 'Equivalence of Data Fusion and Simultaneous Retrieval' in Further Reading for more details). As not all satellites involved have been launched yet, this improvement is currently demonstrated on simulated data for four months (April-July) in 2012. The retrieval simulation is based on the MERRA-2 global ozone field by the NASA Global Modelling and Assimilation Office (GMAO).

DATA ASSIMILATION

In order to allow for real-time data monitoring and health application development from the fused Sentinel satellite data, the AURORA project integrates the assimilation of all this data in its processing chain. Data assimilation is about finding a weighted average between observations and model data. The resulting average (also called the analysis) is the best estimate of the real atmospheric ozone distribution. Continuous data assimilation of the AURORA fused product allows for near-real-time monitoring and forecasting (up to five days) of atmospheric ozone on a global scale. In AURORA, two state-of-the-art data assimilation systems (DASs) are applied (IFS from ECMWF and TM5 from KNMI). These two DASs serve major stakeholders in the user community, thus facilitating the AURORA outreach to, for example, the Copernicus Atmospheric Monitoring Service (CAMS). Moreover, with each DAS a fixed sequence of assimilation experiments is envisaged. This way, the performance of AURORA's data processing chain can be verified for all processing steps. The resulting ozone analysis and forecasts are then post-processed to derive global fields of tropospheric ozone and surface UV radiation. Data comparisons of both intermediate data and these final products against ground-based reference observations allow demonstration of the improvements of the AURORA approach with respect to the direct exploitation of conventional ozone retrievals. Moreover, ground-based measurements permit horizontal redistribution of the assimilation output, increasing its resolution for health monitoring applications, as demonstrated in the next two sections.



▲ *Figure 2, Screenshot of the AIR-Portal web interface. It shows a high-resolution map of NO_2 concentrations for the city of Amsterdam. The web portal allows users to browse the data in space and time, as well as to select different pollutants. Once a location is selected, air quality-related advice on health and activities can be given.*

STREET-SCALE AIR QUALITY

Increasing urbanisation in combination with intense traffic and industrial activities leads to air quality problems in many cities across the world. Exposure to air pollution is now the fourth-highest risk factor for deaths worldwide. These problems are growing and have a negative impact on local and national economies, ecosystems and people living in urban environments. In order for governments to take effective measures to improve air quality, they need accurate information. This means the data needs to be real time, have a sufficiently high resolution, and provide forecasts. Yet cities now often rely on ground-based sensors to measure air quality. Such sensors are costly, however, and only provide information in a very specific location. Therefore it is difficult to sample an entire urban area at high resolution with ground sensors alone, and a combination with remote sensing is often the best solution. To address this issue, the AIR-Portal application has been developed.

Although Earth observation provides many advantages over ground-based monitoring alone, the spatial resolution that can be obtained is not sufficient to provide information at relevant urban scales, even with major improvements made by AURORA. In order to get the information down to street level, the AIR-Portal combines remote sensing data with additional data, such as ground-based air quality measurements, traffic density, meteorology and land usage information. All this data is combined and then processed using a specially designed scaling algorithm, resulting in air quality forecasts at street level. The data is then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provided to the users via a website and mobile application. The unique combination of forecasting and high resolution, made possible by AURORA, will allow cities and citizens to take action to improve the quality of life.

HEALTHY SUNBATHING

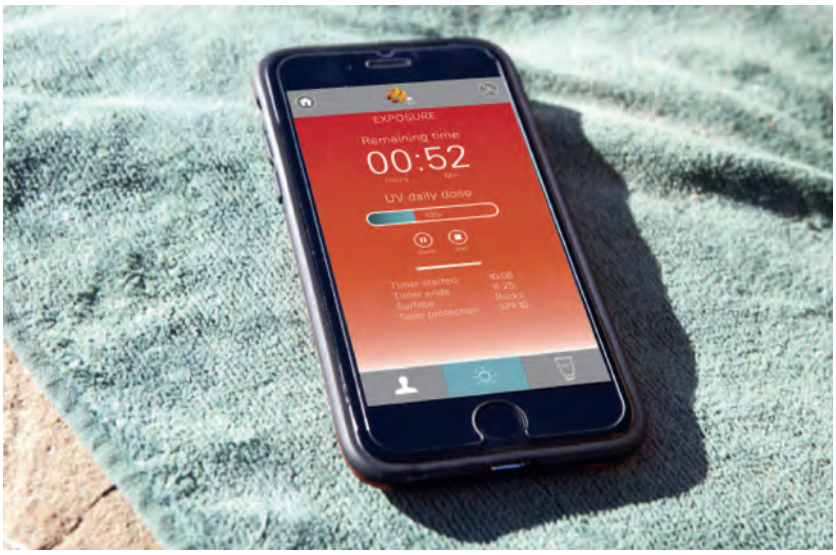
Solar light has a lot of benefits for health and wellbeing. It helps people to relax, activates endorphins and determines the rhythms of body, mind and life. For example, a minimum amount of ultraviolet (UV) light is needed to trigger vitamin D production in the skin, which is essential for calcium absorption, for promoting bone growth and for many other bodily functions. On the other hand, too much sunlight can be harmful; excessive exposure to UV radiation is associated with different types of skin cancer, sunburn, accelerated skin aging as well as cataracts and other eye diseases. People lack an effective decision support system, e.g. a 'digital sunlight healthcare assistant', delivering personalised and actionable information on a daily basis about solar radiation exposure. It should allow a personal solar dosimetry control, maximising the benefits and minimising the health risks related to sun exposure, especially for children. The optimal balance of UV radiation, with respect to vitamin D on the one hand and avoiding sunburn and photo-aging effects on the other, is a challenge for the general public.

HappySun is a satellite-enabled technology answering to this need by measuring the sun's effects on a user's body and recommending how to get the best from its rays. The app uses satellites to take continuous measurements of the UV solar radiation doses the user is exposed to. No smartphone sensors or other external devices are used, so there is no need for the smartphone to be exposed to or positioned towards the sun. HappySun assesses the user's skin type and takes into account the amount of sunscreen already applied as well as the levels of reflection in the surrounding area, all to help the user get the best out of the sun.

The HappySun app represents a new methodology for the personal dosimetry of UV radiation, allowing people to measure their cumulative UV exposure as well as suggesting personalised corrective actions the user can undertake for a healthy lifestyle in terms of daily sun exposure.

CALL FOR IDEAS

In summary, the Horizon 2020 AURORA project is aimed at 'advanced ultraviolet radiation and ozone retrieval for applications' from Copernicus Sentinel satellite data. The project's key scientific aim is to exploit complementary information that originates from simultaneous measurements of the same air mass. This is achieved by data fusion from different retrieval wavelength ranges (UV, visible and infrared) and different satellite platforms. The fused product is assimilated and post-processed to derive global fields of polluting tropospheric ozone and harmful UV radiation in an operational way yet with unprecedented quality in terms of bias and precision. As a proof of concept of the AURORA approach for the health industry, the AIR-Portal and HappySun applications are already under development, addressing city ozone pollution and UV exposure risks, respectively. Additionally, AURORA will organise a call for ideas, primarily addressed to students and spin-offs, for the development of applications based on the project's data platform. The call for ideas will be published in January 2018 and a notice will appear in advance on the AURORA website.



▲ *Figure 3, The HappySun application. UV radiation is measured in real time to provide users with information and advice concerning sun protection.*

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SEMANTIC 3D CITY DATA AS VIRTUAL AND AUGMENTED REALITY

Urban Energy Modelling

The visualisation of results from urban energy modelling and simulation is a crucial part of energy research as it is the main communication tool among scientists, engineers and decision-makers. Energy modelling and simulation results are directly linked to spatial objects and 3D therefore becomes a necessity. Multiple interactive 3D visualisation environments exist, such as Esri's City Engine or CESIUM web globe. However, these applications are mainly targeted as 3D viewers for use on desktop machines and lack immersive components that enable users to truly immerse themselves, explore and interact with the real environment on-site.

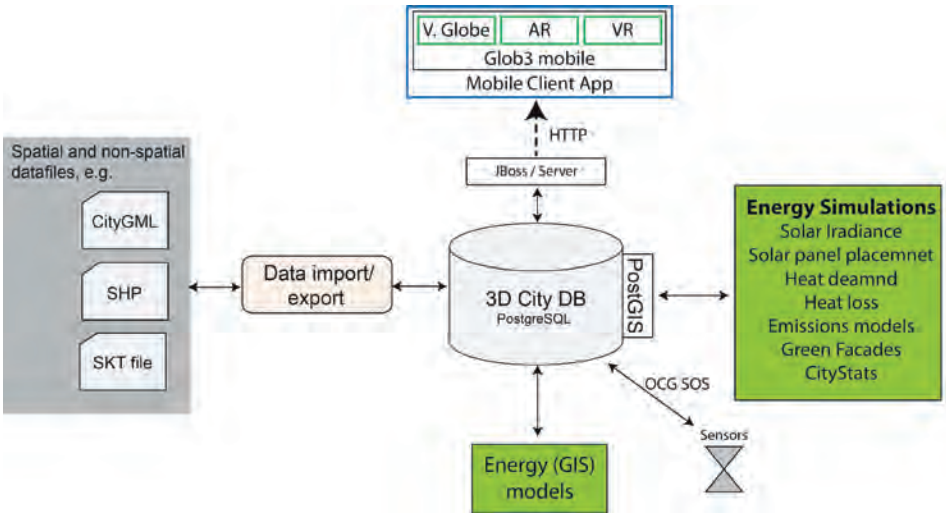
In this study, the team focused on a holistic approach that implements a seamless transition from a traditional virtual map view to virtual reality (VR) and augmented reality (AR) modes in a single mobile application. This is particularly of interest to experts and decision-makers as it provides them with means to explore results on-site through AR or VR. These two visualisation techniques have been combined with traditional maps for a better overview and strategic planning capabilities.

MULTIMODAL VISUALISATION

The multimodal application that has been implemented utilises the Glob3 Mobile framework (Santana et al., 2017). This software development kit (SDK), presented in Suárez et al. (2015), is a mobile-oriented framework for the development of map and 3D globe applications, being highly configurable on the user-navigation and level-of-detail strategies. Thus, the framework is suitable for the present research, having recently demonstrated the possibilities that mobile devices offer for the planning of complex infrastructures and large datasets.

DATA INFRASTRUCTURE REQUIREMENTS

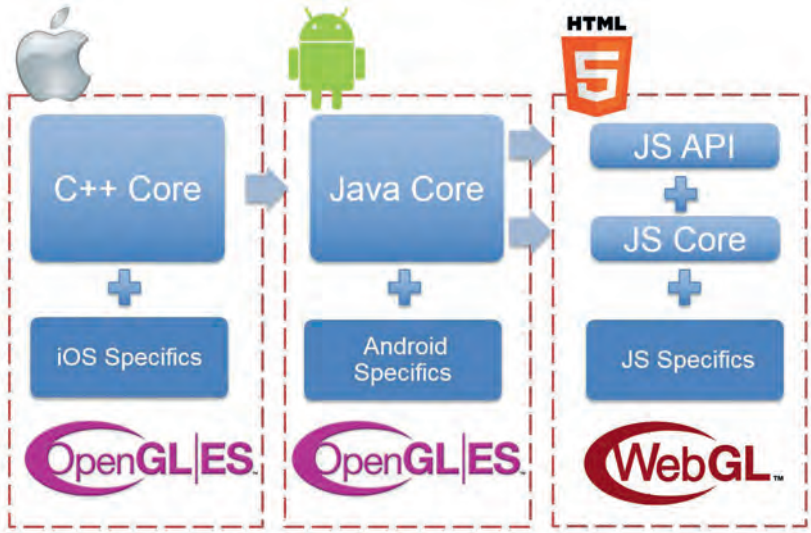
Given the complex nature of multidisciplinary energy-related modelling, datasets commonly differ in spatial and temporal resolution, data structure or storage format that requires an intensive data integration workload. Therefore, in order to maintain flexibility, all datasets are stored in an open-source data infrastructure that is based on a PostgreSQL database and PostGIS, for spatial capabilities. A major requirement of the mobile prototype is its connectivity to a PostgreSQL database and the CityGML data structure in which building information and energy models are stored. A benefit of using the CityGML standard instead of other geospatial data formats is that semantic information about each surface or element of a building can be stored. In addition, object-modelling specifications include different levels of detail (LoDs) (Döllner et al., 2006). Furthermore, the concept of LoDs can be used not only for semantic object abstraction but also for cartographic visualisation purposes. For efficient central data storage of information from diverse energy models and spatial analysis tools, the 3DCityDB – a simplified CityGML database – is used (see Figure 1).



▲ *Figure 1, Open-source data infrastructure for urban energy analysis.*

GLOB3 MOBILE API

The Glob3 Mobile (G3M) API allows the generation of map applications in 2D, 2.5D and 3D following a zero third-party dependencies approach, and provides native performance on its three target platforms (iOS, Android and HTML5). 3D graphics are supported by the Khronos Group APIs, OpenGL ES 2.0 on portable devices and WebGL (web counterpart of OpenGL) on the HTML5 version. Features of this framework include multi-LoD 3D rendering and automatic shading of objects. Due to the multiplatform



▲ *Figure 2, Automated multiplatform development pipeline of the G3M project.*

nature of the G3M API, portability to Android or HTML5 is possible (Figure 2).
A major part of this work was dedicated to the development and integration of new features for supporting seamless VR and AR modes to the G3M application core. From the perspective of the hardware, the location of the device is determined via the GPS system, whereas the orientation of the camera is obtained by processing the readings of the embedded accelerometers.
The different platforms on which G3M runs represent the camera attitude in different ways. These new features, now added to the G3M repository, are aimed at achieving a common description of the device positioning so that VR and AR functionalities and applications could be developed in a multiplatform fashion.
For the AR implementation, a careful mathematic modelling of the camera projection was carried out. In this case, the OpenCV library was used to determine how this projection was applied to an object of reference, determining the internal parameters of the device's camera.

APPLICATION DESIGN

As a proof of concept, a first implementation of the application has been developed and tested on iOS, making it compatible with any iPhone or iPad running versions of iOS 9.0 or newer (Figure 3).

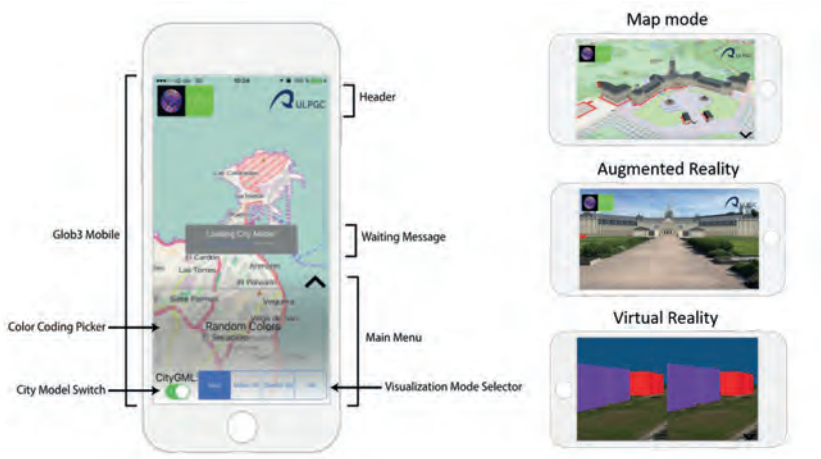
The app is divided into the following viewing modes:

- Classic Map mode, which offers an aerial view of the whole dataset. The user can navigate by using touch commands, exploring the city model in different visualisations and selecting the city structures to manually inspect the assets.
- Mono VR mode, which allows VR visualisation of the urban model in situ by holding the mobile device without the use of a VR headset.
- Stereo VR mode, which implements stereographic rendering. The app must be used inside a VR headset to experience a depth-enriched visualisation.
- AR mode, in which the images captured by the device's camera are merged with the 3D-rendered scenario. This enhances the elements present in the scene with contextual information.

USE CASES FOR MULTIMODAL VISUALISATION IN THE ENERGY DOMAIN

Three different case studies have been applied as proof of concepts for the developed app. In the first use case, the researchers demonstrated the visualisation of energy efficiency values generated by energy models developed in EIFER on LoD1 and LoD2 CityGML building models in Karlsruhe, Germany. The user is able to interactively explore values such as heat demand and CO_2 emissions or energetic properties such as wall-to-surface ratios directly on-site as AR through the lens of the smartphone (Figure 4, left). As a second use case, the visualisation of underground infrastructure such as pipes, electrical wires or telecommunication lines was demonstrated. The underground structures shown in (Figure 4, right) are directly visualised from CityGML. The CityGML Utility Network ADE was used to store and visualise semantic properties such as diameter or flow rate of the pipe directly in CityGML.

The third use case shows the capability of dynamic multimodal data visualisation. Outputs from a vertical solar radiation energy model have been implemented. The solar radiation data model consists of massive sets of points associated to a time series that describe the intensity of the received sunlight at a 1m resolution (Wieland et al., 2015). This form of visualisation is particularly useful in AR mode, as the user can explore solar gains and façade shadowing of potential solar installations as animations on-site.
In order to visualise and animate the time series data, the user selects the building of interest. Once the selection has been made, the user is prompted with a command that triggers the visualisation of the point cloud associated with the selected building (Figure 5). To display this solar radiation model, the geometry model of the building



▲ *Figure 3, Screenshots showing the app layout and the different visualisation modes.*

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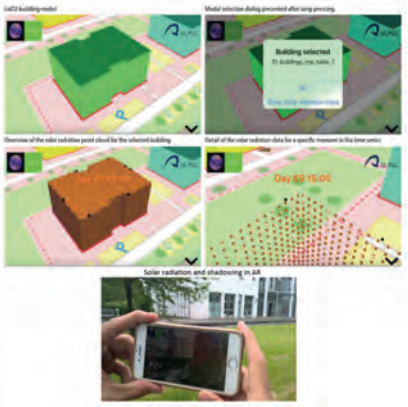


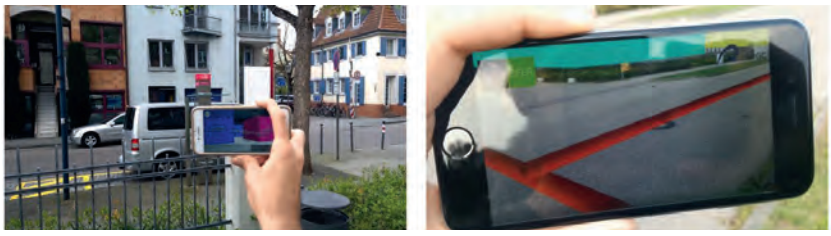
▲ *Figure 5, Dynamic solar radiation point cloud visualisation process (Santana et al., 2017).*

becomes invisible and is replaced by a point cloud. The vertices of such point clouds are stored server-side and retrieved by the client on demand. With the geometry in place, a periodical task scans the data series converting the radiation values into colours using a linear interpolation.

CONCLUSION AND OUTLOOK

The usage of VR and AR for the exploration of urban models and multiple energy simulation outputs has been successfully demonstrated. Likewise, the VR modes have been tested for energy planning purposes where users could explore the heat energy loss and gains model in an immersive environment. However, as only an LoD2 CityGML model was used in this proof of concept, a higher and more detailed abstraction level is necessary in future versions for a more realistic display.
The AR mode was successfully tested for the dynamic visualisation of point clouds generated by a vertical solar radiation model (SolarB). The user was able to select a building and visualise solar gains and the shadowing effect of neighbouring buildings as animations that blend with the environment. This use case sparked great interest, as it is a visual way to communicate the benefits and drawbacks of potential future solar panel installations. Furthermore, the seamless switch from map mode to VR or AR mode was beneficial for users when exploring the study site in the real environment. Without changing from one device or application to another, the user could rapidly change the data visualisation perspective and in consequence could more efficiently analyse the data.

Currently, only GPS and inertial measurements of the smartphone are used for positioning. However, as higher precision is sometimes required (e.g. for underground structures), differential positioning technologies such as the inclusion of Wi-Fi fingerprinting or Bluetooth localisation or the use of visual landmarks are being evaluated. ◀



▲ *Figure 4, Exploring energy efficiency of buildings on-site (left); Underground infrastructure stored as CityGML visualised as AR on-site (right).*

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INTRODUCING AN INTERACTIVE PASS MAP

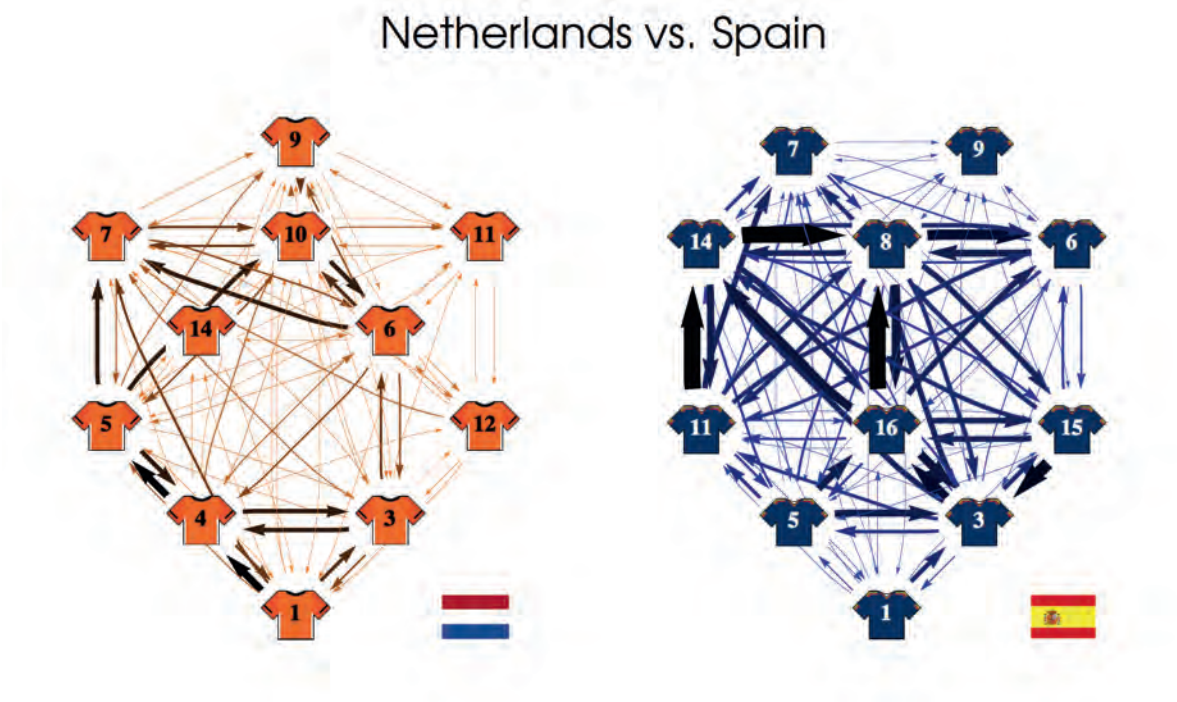
How **Geoinformation** Enhances **Professional Football**

The visual exploration and analysis of passing patterns helps professional football clubs to understand how individual players perform and how their style affects the team performance. However, most clubs lack sufficient knowledge to analyse large and complex datasets themselves. This article presents an interactive pass map that highlights passing patterns in a new and intuitive manner using techniques from geoinformation science with a focus on geovisual analytics.

Recently, the use of spatiotemporal data has strongly increased in various fields of study, including movement ecology, transportation and health informatics. This development has led to large and complex volumes of data. In the domain of football analytics, two complementary types of spatiotemporal data are recognised, namely tracking data and event data. Tracking data refers to the positions of the players and the ball, whereas event data represents the interactions between players and the ball, such as shots, interceptions and passes. Vast amounts of such data are being captured nowadays, and techniques from geoinformation science (GISci) can potentially enhance the analysis by taking the spatiotemporal nature of football into account (Kotzbek & Kainz, 2014). The author of this article has developed an interactive pass map application to aid better understanding of passing patterns in professional football.

LIMITATIONS OF TRADITIONAL PASS MAPS

Understanding the interaction between a team of players, their opponents and the ball is one of the more important and complex problems in sports science today. Capturing these interactions is mostly done using network models, in which players are modelled as nodes and the number of (successful) passes between them as weighted directed edges. In 2012, Peña & Touchette presented a novel method to visually represent these passing



▲ *Figure 1, Passing networks for the 2010 FIFA World Cup final between The Netherlands and Spain. Source: Peña & Touchette (2012)*

networks (Figure 1). Although such a network gives a clear representation of the most used passing lanes, the visualised player positions are fixed and only correspond to the formation given on paper. Today, these networks have evolved into more advanced illustrations known as pass maps (Figure 2). In the GISci domain these maps are commonly referred to as origin-destination flow maps. In these maps, the positions of the origins and the destinations are known, as well as their attributes, but their exact routes remain unknown.

Although these illustrations provide more insight into player locations and pass intensity, there are still some severe limitations that make them difficult to read and use. First, determining the average positions based on event data means that only the interactions between the players and the ball are taken into account. Not knowing exactly how players move through space in the course of a game results in a knowledge gap that remains a critical barrier to further advancements. Second, currently available pass maps do not consider the temporal dimension of passes and thereby fail to provide a temporal account of the players' performances.

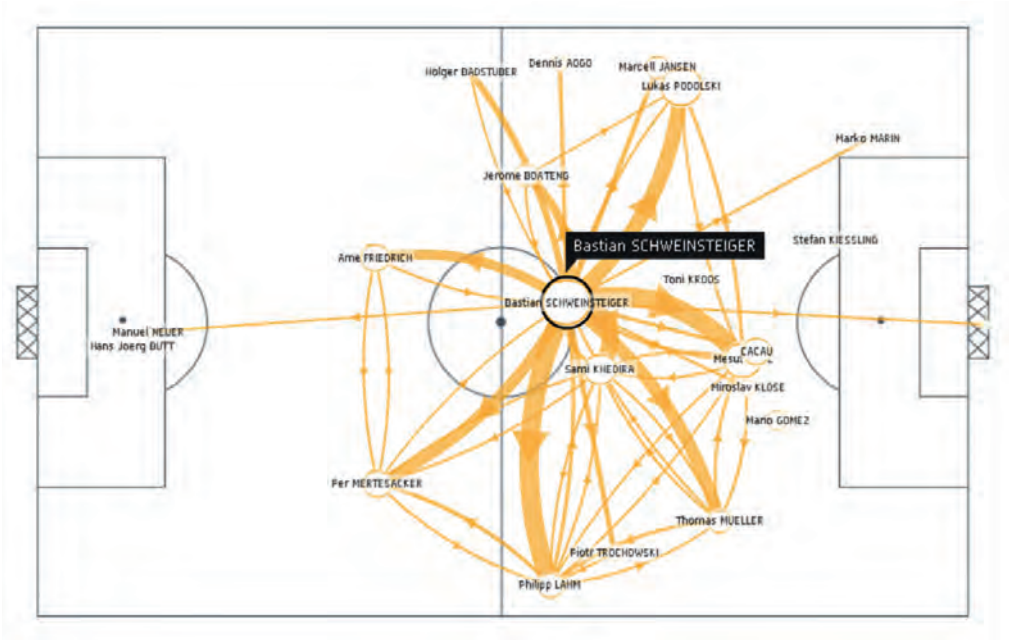


Figure 2, Pass map for the 2010 FIFA World Cup providing a perspective on the morphology of the German team. Source: Near Future Laboratory

DATA HANDLING

Data handling consists of two steps: data cleaning/pre-processing, and data visualisation. First, since it offers suitable libraries for spatial analysis and is supported by most GIS software, Python is used for the necessary data preparation and analysis tasks, including the writing of several scripts that automatically prepare the data and store it either as point or polygon feature classes. The point features are defined by a single pair of coordinates that determines the location of the origin and destination of each pass event. The polygon features are created combining the Python libraries Shapely and Pyshp with the GIS software QGIS. Geometric operations are performed using Shapely and QGIS, whereas the Python Shapefile (Pyshp) library is used to read and write Esri shapefiles in pure Python code.

Second, knowing the exact number of successful passes between any origin and

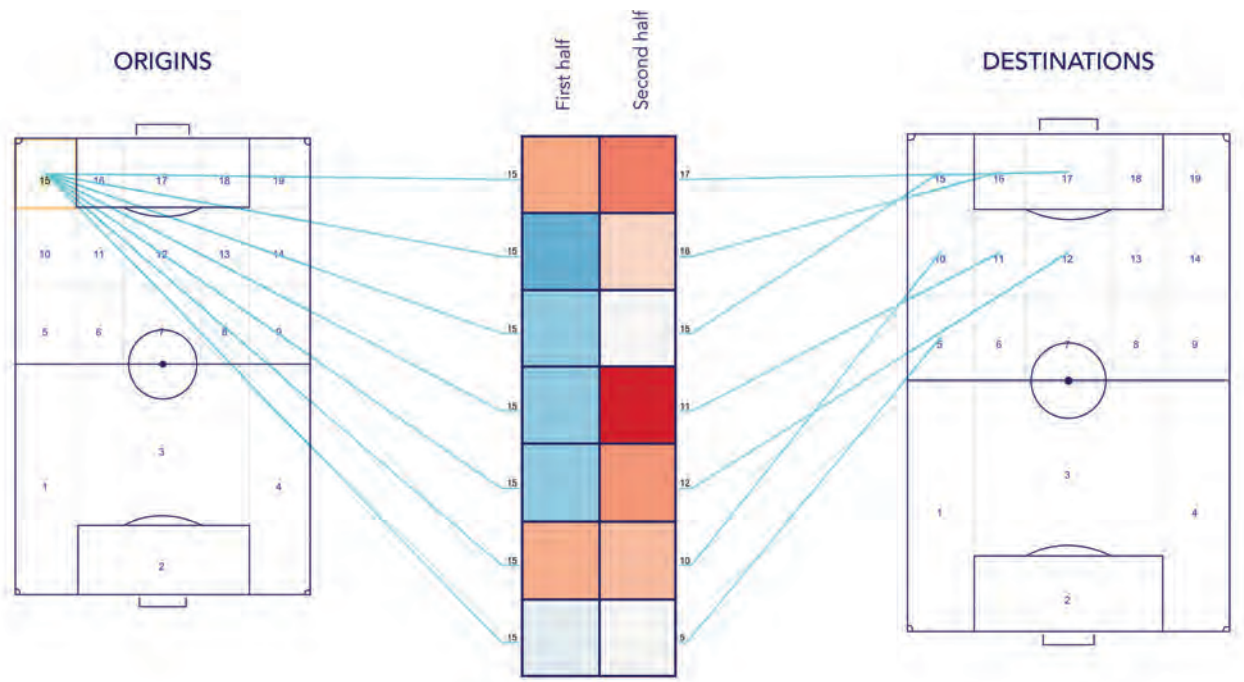
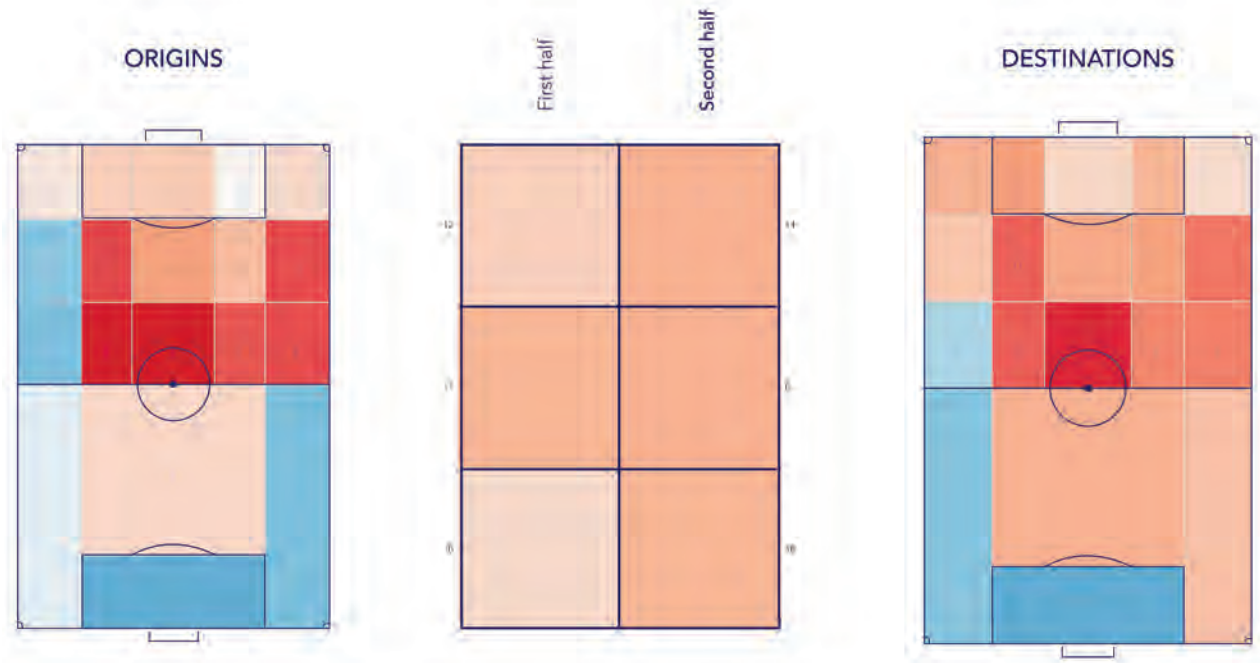
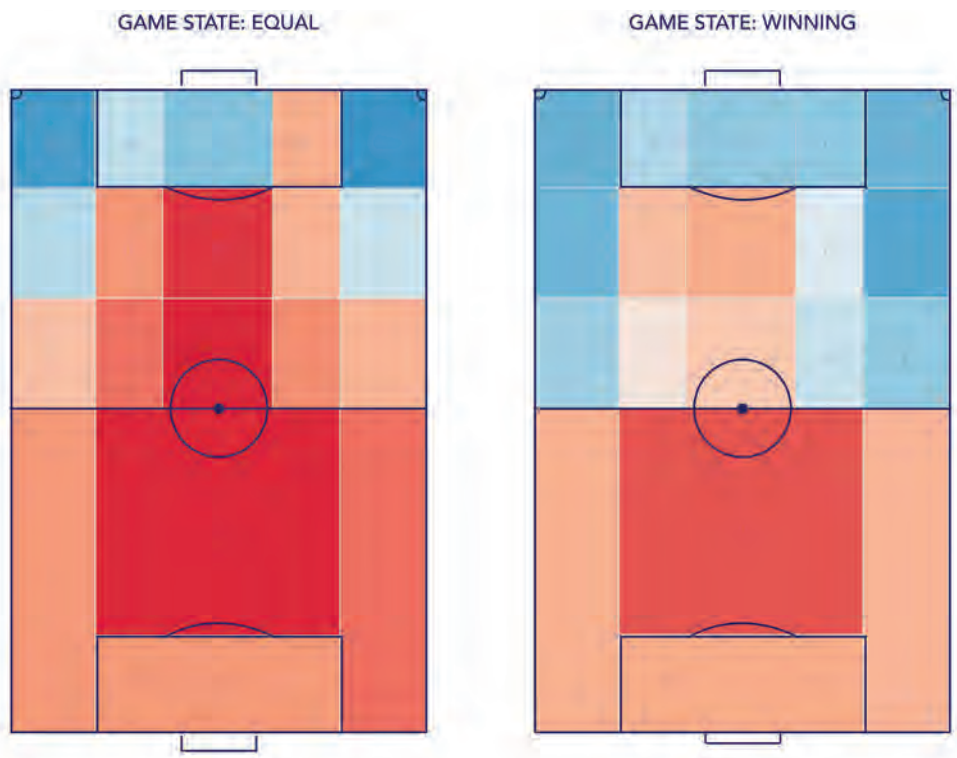


Figure 3, Overview of the interactive pass map showing how flow lines connect the spatial and temporal dimensions. For this image, the data is scaled into a range of -1 to +1. Red indicates more than average, white means equal to and blue refers to less than average.



▲ *Figure 4, The spatial distribution of Borussia Dortmund's successful passes per 45 minutes comparing the home games with away matches based on 16 home games and 17 away matches during the 2016-17 season.*

destination pair makes it possible to calculate changes over time for different periods. Using proper visualisation, this data can become a very rich information source. Due to its complexity, it is almost impossible to produce a single visualisation that shows the data in all its detail without clutter and does not overwhelm the user. Therefore, the open-source visual tool Flowstrates was used to address these challenges (Boyandin, 2011; 2013). This interactive exploratory tool provides means to visually explore and analyse the spatial and the temporal aspects of the data simultaneously using visual links across different views.



▲ *Figure 5, Highlighting different playing styles of OGC Nice based on the game state.*

INTERACTIVE VISUALISATION

In the application that was developed in this project, the flow origins and destinations are presented using two separate maps, whereas the temporal dimension is displayed between both maps to highlight relationships between space and time (Figure 3). Using a heat map in which the columns correspond to the different timestamps allows changes to be visualised over time, while the separate views mean that the visualisation does not have to fit into one map. Being able to see the number of successful passes, between origins and destinations, makes it possible to highlight passing patterns. In order to optimally highlight these patterns, the data was rescaled. Then, using the competition average as frame of reference, each team's relative number of successful passes was calculated. Essentially, this transformation takes those cells containing extreme values and puts them, along with every other cell, into a certain range. This compensates for the skewness between different positions on the pitch and the variation in size between polygons and helps to reveal patterns that would otherwise remain hidden.

Furthermore, this application provides users with various interactive exploration techniques to perform relatively complex visual queries online. For instance, users can compare the temporal changes between two locations, examine changes over time for specific

▲ *Geoinformation helps professional football clubs to improve the team performance. This photo was taken during FC Barcelona-Atlético Madrid, Copa del Rey semi-finals, on 7 February 2017. (Photo: Wim van Wegen)*

locations or search for the largest number of passes for any given origin-destination pair.

REVEALING HIDDEN PATTERNS

Testing of the new application revealed several interesting patterns hidden in the data. Notably, the distribution of the total incoming and outgoing number of successful passes differs between home games and away matches. For instance, Figure 4 clearly illustrates that Borussia Dortmund players send and receive more passes in the centre of the pitch when playing at home. In addition, the zones nearest to the right touchline, vertically between the halfway and 18-yard line, are used more frequently compared to the ones near the left touchline. The same type of analysis is possible when comparing different teams or even different playing styles. These results can, for instance, be incorporated into opponent analysis reports in order to better prepare teams for future matches. The results demonstrate that useful insights can be revealed and hypotheses based on these insights can be tested by football analysts.

Another interesting finding is that most teams adapt their style of play depending on the game state, namely losing, equal and winning. For this application, these differences for one team were compared with the competition average and this identified deviations in passing patterns from an average team in the competition. Figure 5 shows the difference between the game states of losing (left) and winning (right) for the French team OGC Nice. Clearly, Nice changes tactics when leading by one or more goals. Instead of playing attacking football through the middle of the pitch, they adapt their style of play and try to keep possession at the back while taking little risk during their build-up play.

CONCLUDING REMARKS

The proposed interactive pass map provides football clubs with a novel tool to deal with large and complex datasets by giving them the opportunity to look at the data from different perspectives and to make modifications using different interaction techniques. However, tools like these take time to develop and many iterations are needed to combine the technical and football-related components successfully. User and usability research is also highly required. Furthermore, because football is all about the usage of space and time, value can be added by highlighting, generalising and summarising patterns of spatiotemporal dynamics and answering more advanced questions regarding passing through a tool like this. At the same time, in order to fully understand how individual players perform and how their style affects the team performance, tracking data and event data will also have to be combined and analysed. As a consequence, further contributions and efforts are required to establish a new field of application within this scientific discipline and beyond.

ACKNOWLEDGEMENTS

Thanks are due to Dr Corné van Elzakker (assistant professor at the University of Twente) and Bart Aalberts (scientific researcher at SciSports) for their feedback, advice and support. Thanks also go to Ilya Boyandin for help with the source code of Flowstrates.

DATA

The dataset used for this project consists of approximately four million events collected during the 2016/2017 season in five European (male) competitions: the English Championship, the German Bundesliga, the Spanish Primera División, the Italian Serie A and the French Ligue 1. ◀

ABOUT THE AUTHOR

Lars van Hoeve obtained a master of science in geographical information management and applications (GIMA) in 2015. After successfully defending his MSc research project, he continued his interests in geovisual football analytics during an internship at SciSports.

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Smart Solutions for a Secure and Valuable Property

On 14 and 15 September 2017, the FIG Commission 7, 8 and 9 International Symposium GeopreVi 2017 was hosted in Bucharest, Romania, based around the theme of 'Smart Solutions for a Secure and Valuable Property'. More than 200 professionals (from surveying, land administration, spatial planning & development and land valuation) from more than ten different countries came together in Bucharest for professional and scientific debate and dialogue. Through the exchange of knowledge and experience, they aimed to find smart technical solutions for ensuring a more secure and valuable property in today's modern and challenging society.

During her speech in the opening session, FIG President Professor Chryssy Potsiou described it as a great honour to be in Bucharest and represent FIG, appreciating at the same time the presence of the Romanian authorities. In her message, President Potsiou emphasised that it is very important for the surveyors' community to cooperate with governments when implementing land management reforms, to secure not only property rights but also the value of those rights on properties, land and real estate – an issue of significant importance for the well-functioning of property markets and the national economies. She stated: "As we all understand about the global Sustainable Development Agenda for 2030 and the commitment of the 193 UN member states to eradicate extreme poverty by 2030 and undertake reforms to protect the planet, this conference will raise awareness in this field and will help us achieve our goals. Here is FIG and our mission is to develop the profession all over the world and to support governments to achieve reforms successfully."

Opening ceremony with FIG President Chryssy Potsiou.

In Bucharest, three of the FIG commissions were working together: Commission 7 was represented by Chair Ms Gerda Schennach from Austria, Commission 8 was represented by Chair Mr Kwame Tenadu from Ghana, and Commission 9 was represented by Vice Chair Manohar Velpuri. "It was a great initiative to have those three commissions in Bucharest, as all three commissions understand what good land management is," commented President Potsiou.

Two outstanding FIG members, Honorary President Mr Robert W. Foster from the USA and Honorary Member Daniel Steudler from Switzerland, were invited to Bucharest and they stirred the audience's interest with topics such as the universal set of ethics principle and the Land Code.

GeoPrevi Local Organising Committee

More information
www.fig.net

GSDI Capacity-building Webinar Series

The GSDI Association has been hosting a webinar series involving participants from across the globe that runs until January 2018. The webinar series covers a variety of topics to help organisations develop best practices for sharing and using geospatial data across a broad range of stakeholders. This is one of the ways GSDI is expanding the reach of its knowledge dissemination on the challenges, issues and successes in developing Spatial Data Infrastructure (SDI). GSDI webinars are open to all at no cost, limited to the first 100 registrations received.

GSDI hosted the first webinars on Marine SDI in November 2016 and March 2017. The latest webinar on Open Geospatial Data was held on 16 November 2017. Within less than one week of GSDI announcing the webinar, 55 people had registered, which demonstrated to the association that both the subject matter and the webinar format were on target. The webinar presented key issues regarding the use of open data and open geodata, including research and practical applications. Presenters included both senior researchers and policy staff from Delft University of Technology and the Netherlands' Cadastre, Land Registry and Mapping Agency (Kadaster), both valued, long-standing GSDI members.

The next webinar on the role of SDI in Marine Cadastre and Maritime Spatial Planning will be delivered in December 2017. Then, in January 2018, GSDI members will provide a webinar on SDI Data Policies, including various intellectual property rights issues such as data protection, privacy protection, database protection and copyright.

Webinars are an important element of the GSDI Association's Strategic Plan 2015-2020, which places considerable emphasis on capacity building. All of the GSDI's capacity-building resources can be found online, including the recordings of the webinars, as well as workshop results, SDI-related videos, SDI cookbooks, numerous books relating to SDI research and implementation, plus reports and links to national SDI portals, related associations and more. Visit the GSDI Association website for more information or contact the webinar series moderator at secgen@gsdi.org.

Beyond the webinars, GSDI is planning capacity-building activities in support of the UN-GGIM's Academic Network and aligned with SDI themes in the global conferences of GSDI's Memorandum of Understanding partners, i.e. FIG, ISPRS, ICA and ISDE. During 2018, the association is looking for new volunteer support to assist in delivering more capacity-building activities.

More information
http://gsdiassociation.org/index.php/publications.html

UN Subcommittee on Geodesy Established

On 4 August 2017, the 7th session of the UN-GGIM in New York City endorsed the terms of reference and formally established the permanent UN-GGIM Subcommittee on Geodesy (SOG). "The creation of this subcommittee in the United Nations System, the first for UN-GGIM, sends a very clear message to Member States, and other global geodetic entities, that enhancement of geodetic reference frames should be a long-term strategic priority for governments," says Gary Johnston, co-chair of the UN-GGIM SOG.

The Terms of Reference and transition plan were endorsed by the UN-GGIM Committee of

Gary Johnston and Laila Løvhøiden at the 7th session of the UN-GGIM. Photo: Anne Jørgensen.

Experts. The transition phase will end at the inaugural meeting of the subcommittee where co-chairs will be elected. Until then, the subcommittee will continue to be co-chaired by Australia (represented by Geoscience Australia) and Norway (represented by the Norwegian Mapping Authority). The IAG will be an associate member of the SOG. "The International Association of Geodesy, through its geodetic services as well as the Global Geodetic Observing System, will continue its long-standing support of developing a global geodetic reference frame for the benefit of science and society," says Dr Michael Pearlman, who represented the IAG in New York.

The inaugural meeting of the subcommittee is taking place on the margins of the 2017 UN-GGIM High Level Forum in Mexico City in November 2017. The subcommittee is working on the development of the implementation plan for the GGRF roadmap. "The work is progressing and the intention is to present the plan to the UN-GGIM Committee of Experts at its eighth session in August next year," says Laila Løvhøiden, co-chair of the UN-GGIM SOG. The framework for an appropriate governance mechanism is beginning to take shape. The focus group assigned to develop the position paper agrees that, in order to effectively implement the road map for the Global Geodetic Reference Frame, some kind of intergovernmental arrangement must be established.

More information
www.unggrf.org and http://ggim.un.org/UN_GGIM_wg1.html

International Map Year Successfully Comes to a Close

International Map Year (IMY) has previously been the subject of this column, in both July 2015 and July 2016, and its success has been documented throughout the period on the IMY website, through its publications, in ICA News, in numerous local and national publications and, of course, in the rich array of events which took place under its auspices. Officially launched at the 26th ICC in Rio de Janeiro in August 2015, it ran from that time throughout the whole of 2016, and was officially closed by ICA President Menno-Jan Kraak during his concluding speech at the International Cartographic Conference in Washington, DC, in July 2017. The IMY homepage has now been deprecated and access to the IMY e-book, The World of Maps, has been moved to the ICA homepage under the 'Publications' tab.

At ICA, we celebrate the nearly 40 countries that were involved in arranging National Map Days and other types of national events in celebration of IMY. The IMY Working Group is grateful to the writers of the various chapters of The World of Maps, and to the many translation teams who ensured that the book is currently available in six different languages. It also thanks Manuela Schmidt from Technical University of Vienna, webmaster of the IMY website reflecting news and events, and designer of the IMY logo. Members of the ICA Executive Committee, ICA Commission chairpersons as well as members of the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) have also been very supportive. During the UN-GGIM meeting in August 2017, Anthony Milne (current chair of the UN-GGIM Geospatial Societies) highlighted the success of IMY, stating: "The International Cartographic Association ran a very successful campaign on the International Map Year, which was endorsed by the UN-GGIM Geospatial Societies and the UN-GGIM Committee of Experts. This programme aimed to make maps more visible to and understood by decision-makers, citizens and schoolchildren in the global context."

Anthony Milne talked about IMY at the 7th UN-GGIM meeting in New York, August 2017. (Photo Menno-Jan Kraak)

One of the last events led by the ICA in conjunction with IMY was the production of the posters in support of the UN sustainability development goals.

The commentary on IMY from the editor of ICA News sums up the event: " … One cannot help but be astonished by the incredible ingenuity of national IMY coordinators and committees in promoting the message of IMY. From national days and workshops to postal stamps and map stands, from exhibitions and posters to wine and chocolates, from fun-filled challenges for children to official events involving government ministers – you name it, it's there! The colour and energy of these celebrations was simply contagious and left us all with unforgettable memories. I think IMY achieved something truly special – it strengthened and invigorated various cartographic communities and sparked unprecedented interest of the public in maps and mapping!"

WE MAPS
INTERNATIONAL MAP YEAR 2015–2016

More information
www.icaci.org
www.un.org/sustainabledevelopment/sustainable-development-goals/

ISPRS TC III Symposium on Developments, Technologies and Applications in Remote Sensing in Beijing

ISPRS Technical Commission III on Remote Sensing will hold its mid-term symposium from 7-10 May 2018 in Beijing, China. The themes of the symposium will cover the topics of 16 TC III working groups and inter-commission working groups, including (1) Thematic Information Extraction; (2) Radar Remote Sensing for a Changing World; (3) SAR-based Surface Generation and Deformation Monitoring; (4) New Trends in Hyperspectral Image Processing; (5) Information Extraction from Lidar Intensity Data; (6) Remote Sensing Data Fusion; (7) Change Detection of Land Use & Land Cover for Updating Spatial Databases; (8) Remote Sensing and Synergic Analysis on Atmospheric Environment; (9) Challenges and Solutions in Changing Cryosphere and Hydrosphere for Sustainable Developments; (10) Climate Change and its Impact on Agriculture and Natural Ecosystems; (11) Planetary Remote Sensing, Planetary Photogrammetry and Robotic Vision, Planetary Cartography and GIS; (12) Disaster Assessment, Monitoring and Management; (13) Quality Issues in Remote Sensing in the Big Data Era; (14) Environment and Health; (15) Pattern Analysis in Remote Sensing; and (16) Global Mapping: Updating, Verification and Interoperability. Pre-symposium workshops and seminars will be arranged. Joint sessions with other international organisations will also be held.

Accepted papers will be published in the International Annals (by double-blind full paper review, indexed by CPCI, SCOPUS, DOAJ) or the International Archives (by abstract review, indexed by EI, CPCI, SCOPUS, DOAJ) of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Special issues of the *ISPRS Journal of Photogrammetry and Remote Sensing* will be organised based on best papers from the Annals and Archives. The Young Author Award and Student Best Poster Award including a bonus will be issued to young authors.

Beijing is the capital city and the political, cultural, scientific and educational heart of China with more than 3,000 years of history. Having hosted the 2008 Summer Olympics, Beijing has also been chosen to host the 2022 Winter Olympics, which will make it the first-ever city to host both events.

For more information, please see: www.isprs-tc3.tianditu.com/

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

The Great Wall near Beijing.

2018

JANUARY

14TH INTERNATIONAL CONFERENCE ON LOCATION BASED SERVICES
Zurich, Switzerland
from 15-17 January
For more information:
http://lbs18.ethz.ch

17TH OLDENBURGER 3D-TAGE
Oldenburg, Germany
from 31 January-1 February
For more information:
http://bit.ly/2AusP21

FEBRUARY

GEODESY, MINE SURVEY AND AERIAL TOPOGRAPHY CONFERENCE
Moscow, Russia
from 15-16 February
For more information:
www.con-fig.com

MARCH

GISTAM 2018
Madeira, Portugal
from 17-19 March
For more information:
www.gistam.org

GI4DM 2018 - GEOINFORMATION FOR DISASTER MANAGEMENT
Istanbul, Turkey
from 18-21 March
For more information:
www.gi4dm2018.org

MAY

26TH FIG CONGRESS
Istanbul, Turkey
from 6-11 May
For more information:
www.fig.net/fig2018

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

JULY

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

OCTOBER

INTERGEO 2018
Frankfurt, Germany
from 16-18 October
For more information:
www.intergeo.de

CALENDAR NOTICES

Please send notices at least 3 months before the event date to: Myrthe van der Schuit, account manager, email: myrthe.van.der.schuit@geomares.nl

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