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Enhancing reality mapping with different perspectives

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Comparing vertical and oblique aerial images

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Is it possible to create a cadastral map of Europe?
Reflecting the importance of cadastral data for land management and spatial development, various initiatives have been launched over the past 20 years. But how have these initiatives enhanced the possibility to build a cadastral map of Europe in terms of promoting the harmonization, integration and interoperability of spatial data across Member States?

Today's GIS technology puts multipurpose cadastre within reach
Decades of global vision and progress toward a map-centric land rights system align with today's technology, paving the way for a fully operational multipurpose cadastre. This momentum is fueled by concerns for disaster and climate mitigation, and the imperative for seamless agency integration and collaboration.

Transforming cadastral surveying for Ghana's future
Smart methodologies in cadastral surveying are enhancing Ghana's land acquisition system, reducing time and costs significantly. A recent project saw a cadastral map created in just 20% of the proposed duration, thanks to the use of mobile applications by local communities in the surveying process.

Enhancing reality mapping with different perspectives
Both vertical and oblique aerial images have their own advantages, making them valuable in different reality mapping applications. So how can you choose between the two? This comparison will help you to assess their benefits from the perspective of the specific requirements and objectives of the project or analysis at hand.

Unveiling the PLACE initiative
The non-profit tech organization PLACE is built on the belief that location data is crucial for addressing global challenges like climate change, population growth, urban expansion, and resource scarcity. How does PLACE assist, and how can organizations participate?

Quebec gears up for climate impacts with Topobathymetric Lidar
The Quebec Metropolitan Community (CMQ) identified the necessity for precise watercourse surveys to enhance flood preparedness. This article delves into the topobathymetric Lidar survey conducted by NV5 Geospatial, discussing the techniques for exceptional precision and the logistical challenges that can affect similar projects.

The invigorating geospatial vibes in Vegas
In the rapidly evolving landscape of geospatial technology, the annual Trimble Dimensions gathering is a dependable beacon for the surveying and mapping fields, providing a panoramic view of the current state and future trajectory of the sector. This year's knowledge update took place in Las Vegas from 6-8 November.

Pioneering precision in Swedish skyscrapers
Sweden's tallest skyscraper is reshaping Gothenburg's skyline. Overcoming stability and precision challenges in its construction, the innovative core wall control survey method, featuring an advanced receiver and active GNSS control points, establishes impressive accuracy in the vertical alignment of high-rise buildings.

Cover story
Founded in 1832 on the orders of Napoleon, the Land Registry in the Netherlands (which is now an independent administrative body known as Kadaster) has been in existence for almost two centuries. Much has changed in that time, and the country has even created a completely new province on land 'conquered' from the sea: Flevoland. The stunning satellite photo on the cover of this edition gives a good impression of the spatial planning in the Netherlands' youngest province. (Copernicus Sentinel-2, ESA)

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Shaping the future of cadastres

With its pivotal role in land management and development, cadastral data has become indispensable across areas ranging from spatial planning and land tenure security to agriculture, forestry and the environment. Finally, following decades of incremental strides towards the establishment of a comprehensive map-centric land rights system, the current wave of technological advancements seems to be propelling us ever closer to a fully operational multipurpose cadastre. This momentum is bolstered by a heightened focus on addressing numerous urgent global challenges encapsulated in the Sustainable Development Goals (SDGs), such as equality and societal well-being, disaster mitigation and climate resilience, and the growing need for seamless integration, information sharing and collaboration between diverse agencies. For example, noteworthy milestones have been achieved in the USA, including successful statewide parcel aggregation projects and the recent enactment of the FLAIR Act mandating the creation of an up-to-date federal land inventory. These underscore the commitment to larger-scale land administration initiatives integral to the eventual realization of a multipurpose cadastre. Guided by frameworks such as the Land Administration Domain Model (LADM) and Open Geospatial Consortium (OGC) standards, we can unleash the power of modern GIS technology on the available global base maps, imagery and data to turn the vision of a multipurpose cadastre into a tangible reality. For in-depth exploration of this transformative intersection of GIS technology and land administration, I encourage you to delve into the insightful contribution by Esri's Linda Foster in the article titled 'Today's GIS technology puts multipurpose cadastre within reach' on page 19 of this edition. Another very informative article on the complexities of land administration in this issue of *GIM International* is by Vlado Cetl et al, who offer a compelling insight into how various initiatives are contributing to the harmonization, integration and interoperability of spatial data as the foundation for building a comprehensive digital cadastral map of Europe. In this context, the INSPIRE Geoportal has contributed to significant progress in the sharing of spatial data, although an assessment of the availability and accessibility of cadastral data in the EU and EFTA countries reveals that some challenges persist. Nevertheless, the fact that cadastral data has been acknowledged as a core dataset by UN-GGIM: Europe and recognized as a high-value dataset in recent European policies offers hope that cadastral data will be increasingly open and accessible in the years to come. For more details about the evolving cadastral landscape on the European continent, I strongly recommend reading the feature starting on page 12. As you can see, numerous articles in this issue prompt reflection on the vital role geospatial information plays in shaping innovative modern cadastres. If you find yourself inspired by these ideas and feel the urge to contribute to the discourse, we welcome you to reach out to share your suggestions so that together we can sustain the dialogue that is essential to the future of society and the world. ■

Wim van Wegen, head of content

Prague: a fitting setting for a mobile mapping innovation

Prague recently served as the testing ground for the integration of Mosaic's 360-degree camera system with SmartDelta's mobile mapping software. Known for its rich history and stunning architecture, the city was the ideal location to showcase the fusion of these geospatial technologies. According to Mosaic and SmartDelta, the results demonstrate that this solution has the potential to be a game-changer in a wide range of mobile mapping applications. The Czech capital boasts a rich history of trailblazing surveyors and astronomers, including renowned figures like Tycho Brahe and Johannes Kepler. Notably, the oldest known maps of the Czech Lands date back to 1518 (map of Bohemia), 1561 (map of Silesia) and 1569 (map of Moravia). Additionally, Prague can claim the honour of publishing the first textbook for surveyors, back in 1617. Its characteristic buildings, picturesque streets and enchanting beauty add an extra dimension to any mapping project, and the collaboration between Mosaic and SmartDelta was no exception. Mosaic's 360-degree camera systems, including the Mosaic 51 and Mosaic X models, were designed to be standalone units, with internal GPS, built-in GPU and CPU for onboard storage. As an extra bonus, however, these dual-purpose cameras come with an AUX port, allowing them to be integrated with additional sensors or used in tandem with other devices.

▲ *Mobile mapping vehicle and surveying crew beneath the Jirásek Bridge, which spans the majestic Vltava River in Prague. (Image courtesy: Mosaic)*

Mapping altitudes in the Alpine region

Gravitational acceleration measurements were conducted in the Allgäu region of southern Germany by the Federal Agency for Cartography and Geodesy (BKG) in September this year. In high-altitude locations, helicopters were utilized to access the measurement points. These measurements play a crucial role in enhancing altitude determination through satellite-based methods such as GNSS. The elevations derived from satellite navigation systems such as GPS and Galileo cannot be directly applied to many practical scenarios, as they pertain to a geometrically defined reference surface. In contrast, everyday elevation references are based on a zero-level surface known as the mean sea level geoid, which has an irregular shape influenced by the Earth's gravity field. To make use of GNSS measurements, a transformation model – known as a geoid model – is necessary (e.g. for the satellite positioning service SAPOS) to determine accurate altitudes. With the continuous technological advancements in satellite methods and their expanding applications, such as in construction and avalanche protection, the demands for geoid model accuracy and reliability have heightened. In the Alps, the target accuracy of one centimetre has not been consistently attained across all areas. Achieving a precise geoid model necessitates various factors, including extensive measurements of gravitational acceleration to within a few kilometres. Notably, data gaps still persist, especially along the German-Austrian border.

▲ *In September 2023, the Federal Agency for Cartography and Geodesy (BKG) conducted gravitational acceleration measurements in the Allgäu region of southern Germany. Helicopters were deployed in high-altitude locations to access the measurement points. (Image courtesy: BKG)*

DJI Zenmuse L2 unveiled at Intergeo

DJI, a global leader in civilian uncrewed aerial vehicles (UAVs or 'drones') and cutting-edge camera technology, selected Intergeo in Berlin as the stage for unveiling the DJI Zenmuse L2. This highly integrated Lidar system builds on the success of DJI's Zenmuse L1 to bring new benefits to the geospatial community. Thanks to the enhanced RGB camera, upgraded Lidar module and improved precision, professionals utilizing the DJI Matrice 300 RTK or DJI Matrice 350 RTK platform can now achieve heightened accuracy, efficiency and reliability in 3D data acquisition. Furthermore, when combined with DJI Terra, the DJI Zenmuse L2 delivers a comprehensive solution for 3D data collection and high-accuracy post-processing. This product launch marks a significant leap forward for DJI in the geospatial UAV-Lidar market. "The DJI Zenmuse L2 marks a new era of 3D data acquisition," said Christina Zhang, senior director of corporate strategy at DJI. "Three years ago, we were excited to introduce our reliable and cost-effective Lidar system for aerial platforms used by land surveyors, powerline inspectors, forestry professionals and more. This solution is paramount in providing real-time 3D data, efficiently capturing the details of complex structures and delivering highly accurate reconstructed models. In line with our aim of promoting industry development in all enterprise verticals, we are continuing to tackle user pain points through technical innovation and reshaping industry productivity."

▲ *The DJI Zenmuse L2 is considered a groundbreaking leap in 3D data acquisition. (Image courtesy: DJI)*

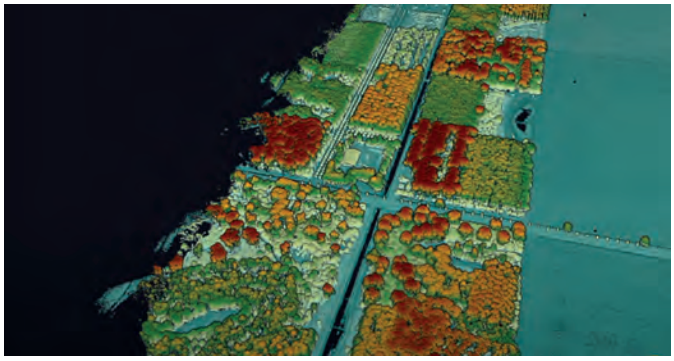
Geospatial pioneer celebrates anniversary with mobile mapping solution launch

Celebrating four decades as a pioneering force in the UK and Ireland's geospatial industry, Murphy Geospatial has unveiled its innovative mobile-mapping solution called GeoDrive. This groundbreaking technology enables the collection of up to 100km of geospatial survey data daily, empowering clients with insights for data-driven decision-making in their projects. In a world where sustainability and infrastructure maintenance are paramount, Murphy Geospatial provides unparalleled accuracy, equipping asset owners with the knowledge they need for informed decisions, safeguarding long-term resilience and efficacy. The company has introduced its proprietary mobile-mapping technology to address the growing demand for swift and precise geospatial data within the built environment. Tailored for large-scale endeavours in construction, infrastructure, energy and utilities, this service excels in efficiently collecting substantial data across expansive geographic regions, offering cost-effective advantages over traditional data collection methods. The GeoDrive mapping solution uses high-precision scanners and a multi-camera system to collect sub-centimetre accuracy information and is mounted on top of an eye-catching, uniquely branded vehicle. Alternatively, it can be fixed to trains or other moving vehicles. The extremely precise data captured by this new service is also thanks to Murphy Geospatial's emphasis on quality control of workflows, managed by well-trained staff with their own expertise in geomatics, allowing them to focus on even the most trivial details of a project.

▲ *GeoDrive, a specialized mobile-mapping technology, is engineered to optimize the efficiency and accuracy of geospatial data collection in the construction environment. (Image courtesy: Murphy Geospatial)*

DeltaQuad and YellowScan team up for Lidar-powered 3D mapping

Lidar developer and manufacturer YellowScan and drone manufacturer DeltaQuad have announced a renewed partnership aimed at delivering high-quality 3D mapping data to professionals worldwide. The collaboration involves the integration of the YellowScan Surveyor Ultra Lidar system, which features an embedded camera, into the DeltaQuad Evo drone, offering dense point cloud data covering up to 1,200 hectares. The YellowScan Surveyor Ultra is a lightweight 360° Lidar system with a 120° field of view, optimized for top-notch mapping and surveying. Distinguished by its high point density and lightweight design, it can now be fully utilized with the DeltaQuad Evo uncrewed aerial vehicle (UAV or 'drone'). The Evo is a modern fixed-wing vertical take-off and landing (VTOL) UAV designed for versatile long-range missions. Thanks to its modularity, the Evo can simultaneously carry multiple payloads, including the latest YellowScan Surveyor Ultra with an auxiliary battery, allowing the Evo to achieve flight times of up to 225 minutes and capture up to 100 data points per square metre. This data can be rapidly and efficiently processed using the YellowScan CloudStation software, making the integration ideal for large-scale surveying projects.



▲ *Lidar imagery resulting from a Surveyor Ultra aerial mapping campaign.*

3D Target still contributing to pioneering UAV-Lidar evolution

3D Target has continued to make significant advancements since launching its inaugural Scanfly model at Intergeo in 2016, at a time when Lidar technology in the UAV industry was still in its infancy.

▲ *The Scanfly v3 features a versatile, multi-platform design, tailored to accommodate a unified workflow across UAVs, land vehicles and even when worn as a backpack. (Image courtesy: 3D Target)*

3D Target's versatile device was designed for use in a variety of vehicles, prioritizing a user-friendly experience while delivering uncompromising performance. Fast-forward seven years, and 3D Target unveiled the third generation of Scanfly, known as Scanfly v3, at this year's Intergeo exhibition held in Berlin. Scanfly v3 continues its multi-platform design, offering a seamless workflow across UAVs, land vehicles and even as a portable backpack solution. It takes the user-friendly approach to new heights with its innovative tool-less and cable-less design. The multi-pin interface allows easy integration with dedicated mounting accessories and a selection of high-resolution cameras. Scanfly v3 is available in two distinct configurations. The Scanfly EVO represents the natural evolution of the previous Scanfly series, maintaining a compact form factor. Equipped with the Applanix APX-15L INS and the Hesai PandarXT-32 Lidar head, the Scanfly EVO stands as a dependable workhorse, serving as a versatile mobile mapping solution.

Geo Week announces sneak peek at 2024 keynote lineup

The organizers of Geo Week have released a preview of two keynote sessions for 2024 – 'The Bright Future Ahead: Navigating AEC, 3D, and Geospatial Innovation and Change', and 'Geospatial for Good: How is Geospatial Technology Changing the World?'. The 2024 edition of Geo Week, one of the premier events that champions the coming together of geospatial technologies and the built world, will take place from 11-13 February in Denver, USA. "Keynotes set the tone for an entire event, and this year's topics and speakers are doing so in ways that will resonate across the geospatial and built world industries," said Lee Corkhill, event director at Diversified Communications. "Sunday's keynote is all about looking towards the future, emerging technologies and workforce development, while Monday's keynote is focused on how geospatial technology is currently addressing critical problems in climate change, sustainability issues, disaster response, public health and social justice. This combination will help attendees understand how to take the next step to use geospatial technology to better our world."

▲ *The skyline of the city of Denver by night.*

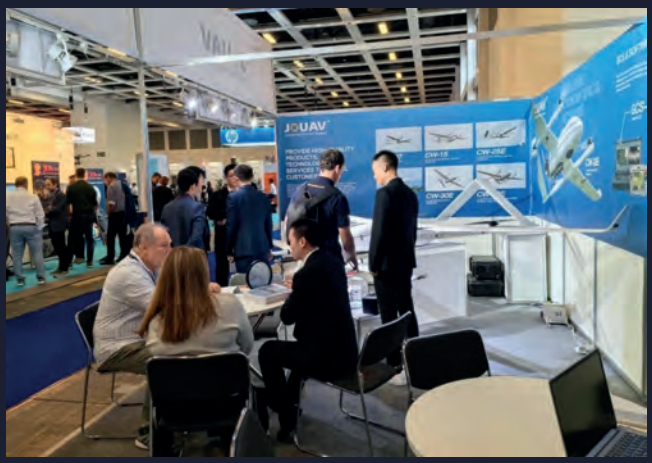
EUSI integrates Pixxel's hyperspectral data for enhanced imaging

European Space Imaging (EUSI), a leading provider of very-high-resolution (VHR) satellite imagery, has recently announced a strategic partnership giving users direct access to the world's most detailed hyperspectral imagery from Pixxel, a leader in pioneering hyperspectral earth-imaging technology. Combined with EUSI's capability to build insights and products, the partnership is poised to set a new benchmark in remote sensing applications in the region. The ever-expanding offering from EUSI solidifies its position as a hub for Earth observation (EO) data in the region. With this collaboration, customers can now acquire Pixxel's hyperspectral dataset in addition to world-leading optical and SAR imagery, all from one single source. "High-quality hyperspectral imagery has been an elusive dataset within the Earth observation community, and therefore the opportunities to drastically impact industries across the globe are yet to be realized," said Adrian Zevenbergen, CEO of European Space Imaging. "Pixxel's innovative technology is filling this gap and EUSI is proud to partner with them to help bring the benefits of hyperspectral data to the market and demonstrate our commitment to Europe's agriculture and energy production goals through the use of remote sensing."

◀ *The partnership gives EUSI users direct access to the world's most detailed hyperspectral imagery from Pixxel.*

JOUAV presents VTOL Hangar to geospatial experts at Intergeo

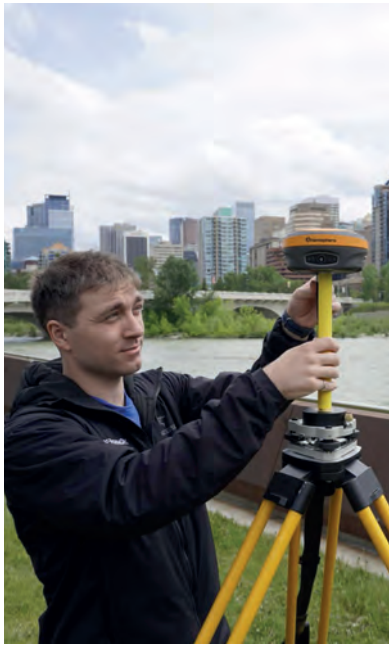
A global audience of geospatial professionals witnessed the presentation of the JOUAV VTOL Hangar, a groundbreaking development in the field of vertical take-off and landing (VTOL) drones, at Intergeo 2023. This innovative technology contributes to advancing uncrewed aerial vehicle (UAV or 'drone') automation, heralding a new era of precision and efficiency. The JOUAV VTOL Hangar is an innovative system designed to deliver intelligent, efficient, stable and reliable drone operations across diverse sectors, including powerline inspection, aerial mapping, highway monitoring, smart cities and open-pit mining. This comprehensive system comprises the JOS-C2000 hangar, the CW-15X VTOL UAV and the Jocloud cloud management platform. Together, they offer exceptional performance and a wide array of functional features. This innovative technology stands as a testament to JOUAV's commitment to pushing technological boundaries. The comprehensive system encompasses a range of features designed to elevate drone operations to new heights. It offers advanced endurance, with the CW-15X VTOL drone equipped with state-of-the-art battery technology, ensuring operational longevity with flight times extending beyond 100 minutes. This extended endurance translates to more efficient and productive missions. Additionally, the system boasts remote communication mastery, with a communication radius stretching up to 30km, supporting seamless remote operation and data transmission.



▲ *The VTOL Hangar featured at JOUAV's Intergeo booth piqued considerable interest. (Image courtesy: JOUAV)*

CNH strengthens tech expertise with Hemisphere GNSS acquisition

CNH Industrial has successfully concluded its acquisition of Hemisphere GNSS, a globally recognized leader in satellite navigation technology. This strategic purchase, valued at US$175 million and initially disclosed on 30 March 2023, underscores CNH's commitment to enhancing its technological presence in the agriculture and construction sectors. The acquisition solidifies CNH's in-house capabilities in precision, automation and autonomy technology, further cementing its position as a prominent technology provider in the agriculture and construction industries. This move underscores CNH's dedication to delivering advanced core technologies to its clients' fleets, ensuring optimal performance and a seamless user experience. Leveraging Hemisphere's significant expertise and extensive network, CNH is expediting its strategic goals to achieve a leadership role in automation technology. This endeavour is designed to hasten the realization of a fully autonomous farming cycle and expand automation and autonomy across various applications within agriculture and construction.



▲ *CNH Industrial has successfully concluded its acquisition of Hemisphere GNSS. (Image courtesy: Bench Mark)*

Trimble's GNSS technology to aid landmine identification and clearance in Ukraine

Trimble has announced a partnership with the HALO Trust, the world's largest landmine-clearing non-profit organization, to help expand its demining operations across Ukraine. The grant from the Trimble Foundation Fund will focus on strengthening the HALO Trust's capacity to locate and remove landmines, unexploded ordnance and other explosive hazards from civilian areas to create safer communities. In addition, it will enable HALO to support the Ukrainian national authorities in planning and coordinating landmine clearance activities by streamlining the mapping and data flow from the operational teams in the field to the national database. The Russian invasion of Ukraine has resulted in the contamination of massive swaths of the country with landmines, unexploded ordnance and improvised explosive devices. These explosive hazards block access to farmland, impede reconstruction efforts, prevent displaced persons from returning to their homes and continue to hinder the safety of Ukrainian civilians. The Ukrainian government estimates that 174,000km^2 of the country's land may be contaminated. HALO has been on the ground in Ukraine since 2016. More than a thousand members of staff are active daily, both to clear explosives in critical priority areas and to recruit and train hundreds of new staff members to help keep communities safe from dangerous weapons left behind. Global navigation satellite system (GNSS) technology for surveying and mapping has played a significant role in the success of HALO's operations around the world, including in Ukraine. Over the last six years, Trimble R1 and Trimble R2 GNSS receivers have been used by HALO in conjunction with Esri ArcGIS Survey123 software for the identification and clearance of landmines.

▲ *A mine clearance team in Ukraine setting up a Trimble R2 GNSS receiver that is used to support landmine identification and clearance by mapping land at 2cm spatial accuracy.*

Hope and optimism for openness and availability

Is it possible to create a cadastral map of Europe?

By Vlado Cetl, Sanja Šamanović, Olga Bjelotomić Oršulić and Anka Lisec

Reflecting the importance of cadastral data for land management and spatial development, various initiatives have been launched over the past 20 years. But how have these initiatives enhanced the possibility to build a cadastral map of Europe in terms of promoting the harmonization, integration and interoperability of spatial data across Member States?

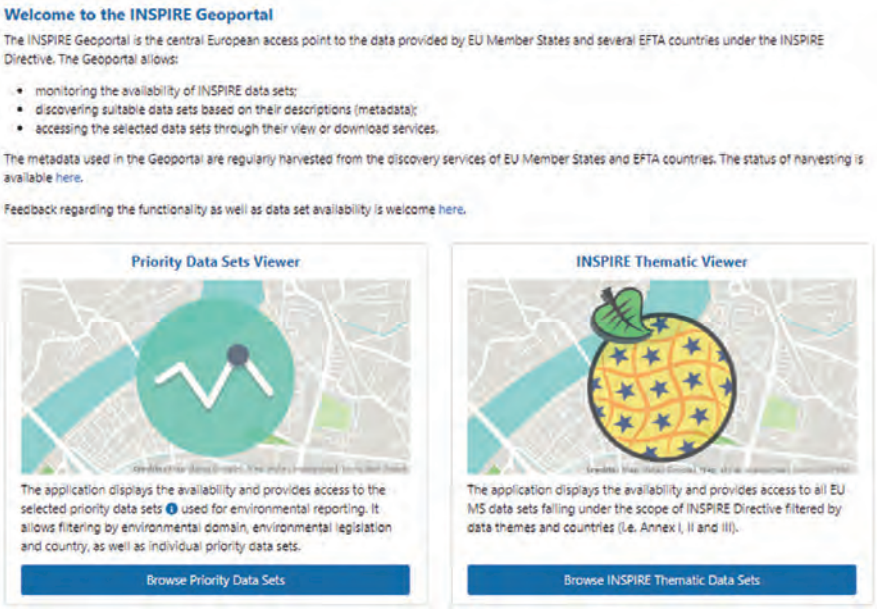
Cadastral data is one of various geospatial datasets of key importance for land management and spatial development. Cadastral maps with accompanying land-related attributes have become fundamental for many application fields, such as spatial planning and development, protecting state lands, securing of land tenure, real estate market analysis, facilitating land reforms, land consolidation, administering agricultural subsidies through the Land Parcel Identification System (LPIS), forestry, soil protection and environmental measures. They underpin land governance, property rights, economic activities, infrastructure development and sustainable resource management, contributing to social stability, economic prosperity and environmental sustainability.

So is it possible to create a digital cadastral map of Europe to trigger long-term socio-economic benefits by facilitating data integration, exchange and analysis across borders? Ideally, the map should be simple to use desktop GIS or online GIS software to find, access, download and combine data about Europe's cadastral parcels. But this would require common standards and formats to achieve interoperability between the various national data sources. In this context, several initiatives regarding cadastral and other geospatial data have been launched in the last 20 years. At the European level, it started with the Permanent Committee on Cadastre in the European Union, the European Land Information Service (ELIS), INSPIRE, UN-GGIM Europe with the FELA and recent European policies on open data and high-value datasets.

In order to serve its purpose and assure transparency in land administration systems (LAS), cadastral data – including cadastral maps – should be open and publicly available to all. In many jurisdictions, the land cadastre has remained the key LAS component, with georeferenced cadastral maps and land-related attributes organized within land information systems (LIS) becoming an integral part of national spatial data infrastructures (NSDIs).

Strong demand for a European cadastral map

The data related to the cadastral parcels can be widely used in various phases of policymaking. By enabling the link with the parcel owner, it is possible to know if the land is public or private; this is key information for decision-makers who may take different means of action according to the land ownership status. It also makes it enables governments to manage their public land (e.g. by acquiring new parcels for a project), to

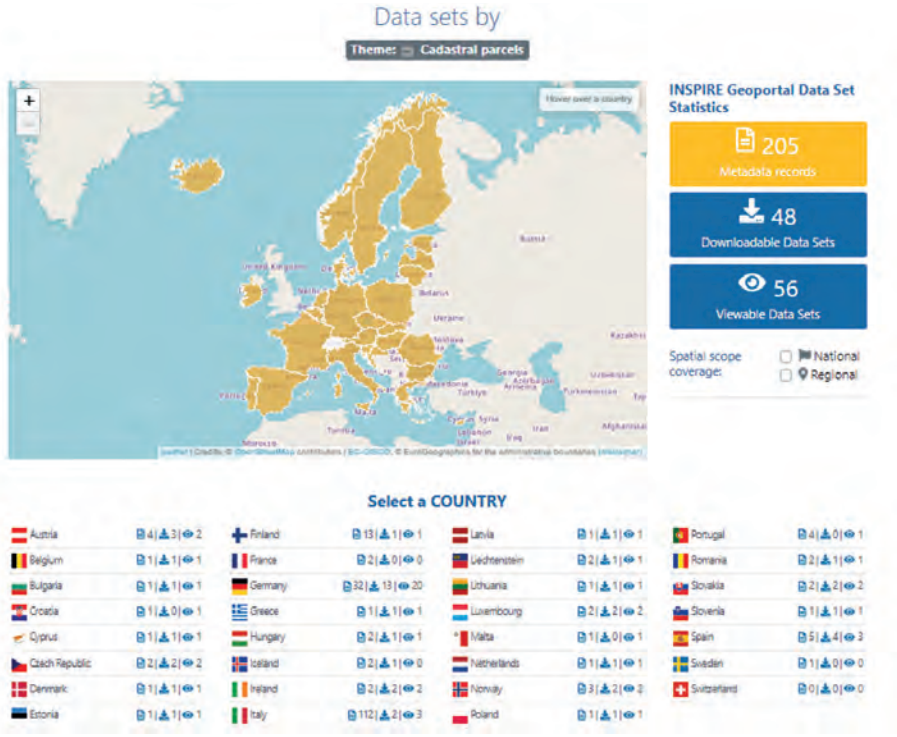


▲ *Figure 1: The INSPIRE Geoportal.*

organize land consolidation, to improve conditions for agriculture, to target owners with specific communication (e.g. to encourage them to better isolate their buildings in order to save energy or to reduce vulnerability to risks), to check if a permit claimant is the parcel owner, or to find the owner of a polluting parcel.

There is a clear, strong demand for the creation of pan-European datasets including a European cadastral map. The main user here is the European Commission (EC) itself, especially DG JUST, DG AGRI and DG ESTAT regarding the cadastral data. Until a few years ago, the requirements of the EC and EU agencies for geospatial information were limited in terms of scope and scale. In most cases, they were met by the products delivered by EuroGeographics. However, in recent years, use cases and consequently demand have evolved. This requires integrating and processing different types of geospatial data with a wider scope, higher spatial quality and better spatiotemporal resolution. The number of spatial analyses has increased and spatial analytics is now common practice in many services of the EC. Spatial information derived from spatial data supports policymaking in various application domains such as environment, statistics, agriculture, transport and energy, or other EU community data programmes such as Copernicus.

The cadastral parcel data also helps in understanding the spatial development patterns and land use characteristics. In the EC Common Agriculture Policy (CAP) context, it is quite common for cadastral data to be used to define the eligible area for subsidies. Furthermore, a background cadastral map is necessary for land use planning and land management measures, where rights, restrictions and responsibilities can be displayed on maps, thus making everyone aware of the restrictions and responsibilities that apply on a property. In addition, the adoption of the UN 2030 Agenda for Sustainable Development and of the related indicator framework for monitoring the realization of the Sustainable Development Goals (SDGs) requires various types of data, including geospatial and land-related data. There are, of course, many other users of cadastral data.



▲ *Figure 2: The availability of the cadastral data in the EU as of 2 November 2023.*

The role of INSPIRE

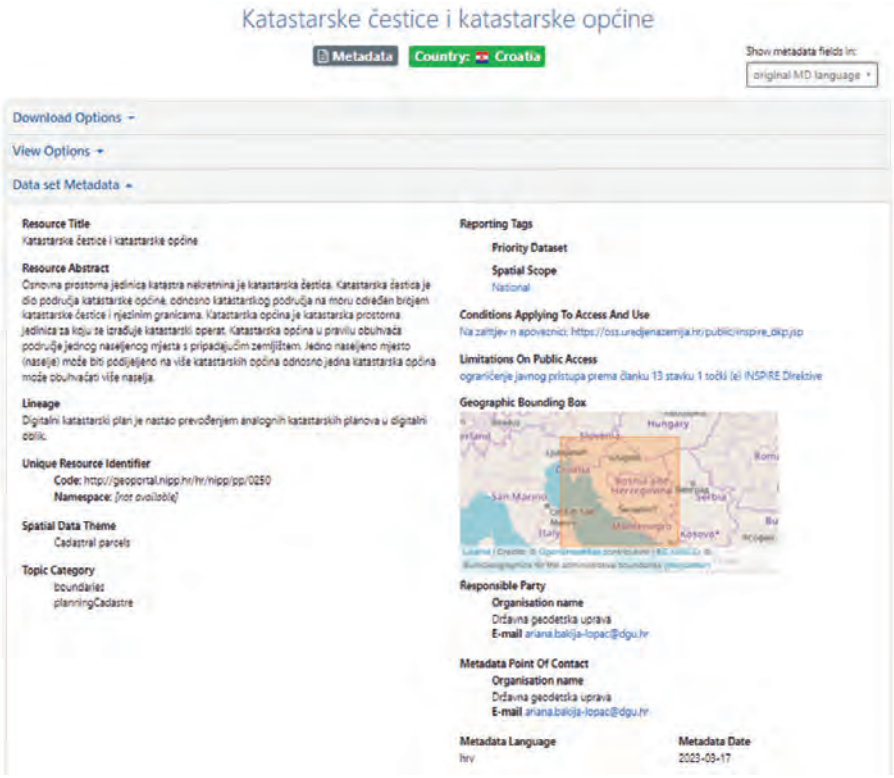
Looking at the current EU cadastral data landscape, there are many initiatives aiming to provide open cadastral data in Europe and the possibility to share and use them in an interoperable way: PCC, EULIS, INSPIRE, EuroGeographics Open Cadastral Map, and UN-GGIM: Europe. INSPIRE is regarded as the most reliable source of information since it is a legally driven initiative and as such obligatory in the EU Member States.

The legal framework of INSPIRE has been set by the Directive (2007/2/EC) and interdependent legal acts, which are called 'implementing rules', in the form of Commission regulations and decisions. The cadastral parcels data theme is included in

The number of spatial analyses has increased and spatial analytics is now common practice in many services of the EC

Annex I of the INSPIRE Directive, which means that it is considered as reference data, i.e. data that constitutes the spatial frame for linking and/or pointing at other information belonging to a specific thematic field such as environment, soil, land use and many others. As much as possible, in the INSPIRE context, cadastral parcels should be forming a partition of national territory. A cadastral parcel should be considered as a single area of the Earth's surface (land and/or water), under homogeneous property rights and unique ownership, property rights and ownership being defined by national law (adapted from UN ECE 2004 and WG-CPI, 2006).

The entry point to the INSPIRE infrastructure is the INSPIRE Geoportal (Figure 1). It serves as a central access point to the data and services from public organizations in the EU Member



▲ *Figure 3: Metadata for the cadastral data in Croatia.*

States and EFTA countries which fall under the scope of INSPIRE. Geoportal offers a range of data formats and may include INSPIRE-conformant and non-conformant datasets. It is possible to search cadastral parcel data based on country, theme or other criteria, and access relevant metadata and download links. The INSPIRE Geoportal enables cross-border data discovery, access, visualization and download.

To assess the availability (aimed at the existence of metadata describing spatial data) and accessibility (aimed at the existence of related services for spatial data viewing and downloading) of cadastral data, the authors followed the quantitative indicators used in INSPIRE monitoring and reporting. These values refer to the ability to find (metadata), access, view and/or download data directly from the INSPIRE Geoportal.

Figure 2 shows the total number of metadata records (205), downloadable datasets (48) and viewable datasets (56) found for the

▲ *There is a pressing demand for a digital cadastral map in Europe. INSPIRE has played a pivotal role in fostering the harmonization and sharing of spatial data, encompassing crucial cadastral information.*

Further reading

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Minghini, M., Cetl, V., Ziemba, L.W., Tomas, R., Francioli, D., Artasensi, D., Epure, E. and Vinci, F., Establishing a New Baseline for Monitoring the Status of EU Spatial Data Infrastructure, EUR 30513 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-27384-4, https://doi:10.2760/296219, JRC122351.

cadastral data theme on 2 November 2023. An overview for each Member State and EFTA country is provided at the bottom. Clicking on a particular country provided a more detailed overview for that specific country (see Figure 3 for metadata for the cadastral data in Croatia).

Supporting cadastral unification

It is clear that the situation still differs from country to country. The INSPIRE initiative has played a significant role in supporting the cadastral unification at the European level by promoting the harmonization, integration and interoperability of spatial data across Member States. While INSPIRE does not specifically focus on cadastral data, its principles and framework have facilitated the exchange and sharing of cadastral information among European countries taking their first steps toward today's efficient provision of high-value datasets.

But while INSPIRE provides a framework for harmonizing and sharing spatial data, including cadastral data, the cadastral unification at the European level also relies on the willingness and efforts of individual countries to align their cadastral systems, policies, and practices. National cadastral agencies and governments play a crucial role in implementing the necessary reforms and initiatives to support the unification process.

Conclusion

There are many initiatives that aim to provide easy and simple access to cadastral data, because cadastral data is necessary – and often irreplaceable – in so many use cases. The importance of a cadastre lies in its ability to provide accurate, up-to-date and accessible information about land parcels, property boundaries, land ownership and related attributes. They underpin land governance, property rights, economic activities, infrastructure development, and sustainable resource management, contributing to social stability, economic prosperity, and environmental sustainability. Therefore, there is a strong need for a digital European cadastral map. INSPIRE has made significant contributions to the harmonization and sharing of spatial data, including cadastral information. The authors have assessed the availability and accessibility of cadastral data in the EU and EFTA countries using the INSPIRE Geoportal. The results of their analysis show that there is still work to be done. Despite INSPIRE and other initiatives, it seems that it is not yet currently possible to quickly and simply create a cadastral map of Europe.

However, recognition of cadastral data as a core dataset by UN-GGIM: Europe and as a high-value dataset in recent European policies awakens hope and optimism that the cadastral data will become open and available in years to come. If all countries implement INSPIRE according to its requirements together with the guiding principles of findability, accessibility, interoperability and reusability (FAIR), it would be fairly straightforward to produce the necessary Europe-wide geospatial datasets including cadastral ones. This would ultimately enable the possibility to build a cadastral map of Europe.

Acknowledgments

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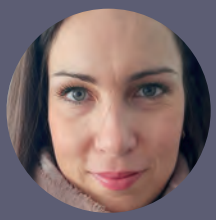
About the authors

Vlado Cetl has been a full professor in the Department of Geodesy and Geomatics at the University North in Varaždin, Croatia, since 2021. Before joining the University North, he worked for the European Commission at the Joint Research Centre in Ispra, Italy, and as an associate professor in the Faculty of Geodesy at the University of Zagreb, Croatia. His main professional interests are spatial information management, spatial data infrastructures, cadastre, land management, geoinformatics, GIS and risk management.

Sanja Šamanović is an assistant professor in the Department of Geodesy and Geomatics at the University North in Varaždin. She previously worked in the Faculty of Geodesy at the University of Zagreb. Throughout her career, at the teaching, scientific and professional levels, her areas of interest have included GIS, remote sensing and photogrammetry. She continuously researches new scientific advancements, keeping pace with their development and application in science, industry and everyday life.



Olga Bjelotomić Oršulić is an assistant professor in the Department for Geodesy and Geomatics at the University North, Croatia. Her interests include physical geodesy, geoid determination, remote sensing, tectonic movement and landslides, and risk management. Prior to joining the University North, she worked in the IT and GIS industries, leading and managing projects. She holds a PhD in Technical Sciences and Geodesy from the University of Zagreb.

Anka Lisec is a professor in the Faculty of Civil and Geodetic Engineering at the University of Ljubljana (UL FGG), Slovenia. Since 2021, she has been chair of the EuroSDR Commission 5 (Knowledge Transfer). Besides her research work within national and international projects in the fields of land administration and geoinformatics, she is currently actively engaged in developing strategic guidelines for the national geospatial information infrastructure. At the international level, she is involved in many initiatives and organizations, including in the international initiative for effective land administration (FELA).

What's new in Global Mapper Pro v25?

All-in-one GIS package includes new tools for analysis, positioning and custom classification training

Blue Marble Geographic's flagship software, Global Mapper Pro, is an all-in-one GIS package for analysing and processing vector, terrain, image and point cloud data. Compatible with over 380 different file formats, Global Mapper can be seamlessly brought into existing workflows. In version 25, new updates to the software include a new automatic point cloud analysis tool, the ability to position an optimal flattened site plan, plot the least cost path across a landscape, image painting, use vector features in watershed analysis, and significant improvements to the processing speed in pixels to points.

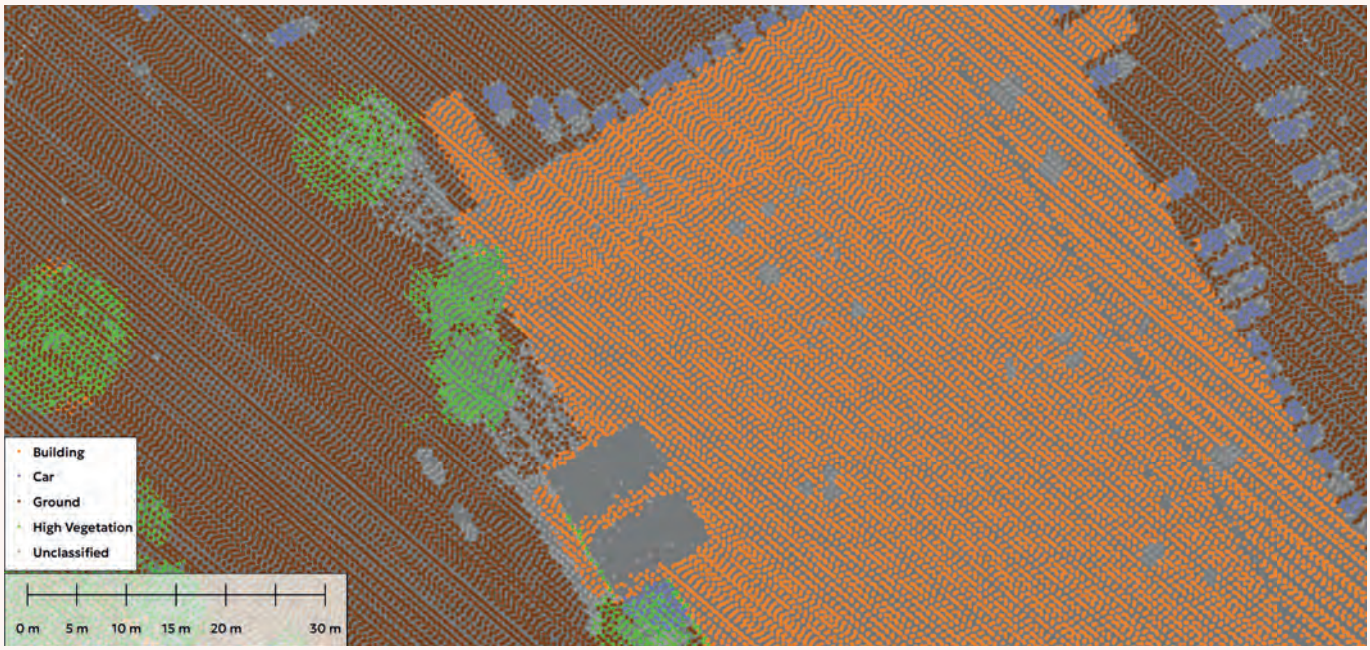
The segmentation tool in Global Mapper's Point Cloud Analysis system is extremely useful for dynamically classifying points based on existing attributes. Imagine being able to train Global Mapper to look for similar features in other point clouds. Global Mapper's existing automatic classification tools cover the most commonly classified point structures, such as ground, buildings, poles and more. The new Custom Feature Classification tool lets users define custom classifications based on user-created training samples. They can now create their own automatic point cloud classifications to find unique objects in their point clouds.

Training a custom point cloud classification tool

Segmentation finds objects in a point cloud by looking at the attributes and structure of the points. For example, to segment paint stripes on the road, users would look for points that make up a flat surface, have the same colour, etc. This method operates on the assumption that each 'object' in the point cloud, each cluster of points, has a signature made up of attributes and/or structures that separate it from its neighbours. The new Custom Feature Template tool takes advantage of these signatures so that a custom classification tool can be trained to look for a specific signature in the point cloud.

Conducting least-cost path analysis

Forging a new path across terrain often requires navigation around existing structures and difficult areas. New in Global Mapper version 25, the Least Cost Path tool provides a terrain analysis method for finding the shortest and most efficient path between locations. By iterating through all possible options, it identifies the best route between specified point features across a terrain layer based on minimized terrain slope angle and avoiding unwanted areas. This simple tool



▲ *This point cloud was segmented to separate individual cars from the surrounding points. These car points were then used to train an automatic car-classification tool.*

can connect multiple locations into a single path, avoid existing structures or discover the most accessible location. This tool is a quick and easy way to avoid the pitfalls of poor road planning, such as when planning roads through a construction site.

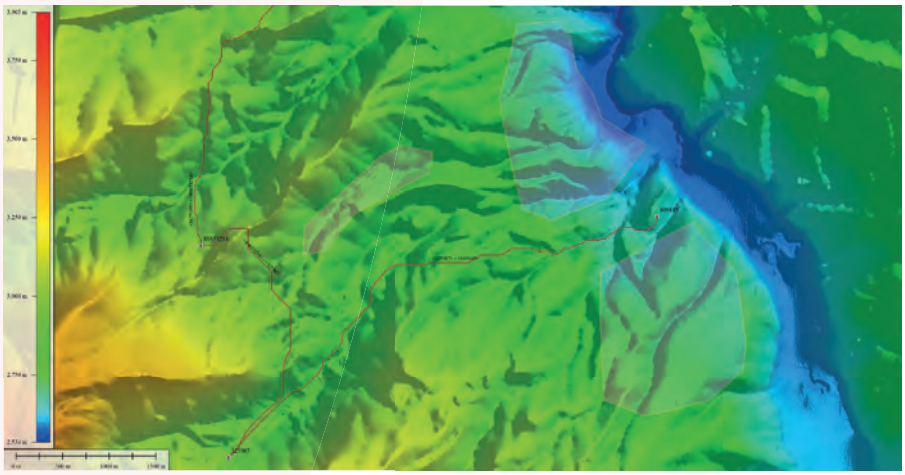
Generating a photogrammetric point cloud

Pixels to Points is a photogrammetric processing tool within Global Mapper Pro that creates photo-textured 3D models, orthoimages and high-resolution point clouds via Structure from Motion (SfM) and multi-view stereovision. Using overlapping images collected using an uncrewed aerial vehicle (UAV or 'drone'), these generated data models can be used in Global Mapper to measure terrain volume, asses structures, create detailed base maps and more. The new version 25 release improves the Pixels to Points tool, including significant speed advancements to decrease the processing time and revisions to the Input Wizard to further streamline workflows.

The Pixels to Points Input Wizard is designed to increase ease of use for existing users and to make photogrammetric processing more approachable for new users by streamlining settings choices. Users can simply import their images and choose their most important output, including the option to run a quick output for quality assessment. Global Mapper adjusts the Pixel to Points settings to match the input, providing an optional follow-up option to tweak the settings if desired. They can also use the primary dialogue to add control points and assess more advanced settings such as masking and colour harmonization. With Global Mapper Pro's powerful point cloud processing tools, Pixels to Points provides a powerful and streamlined option for creating and editing spatial data.

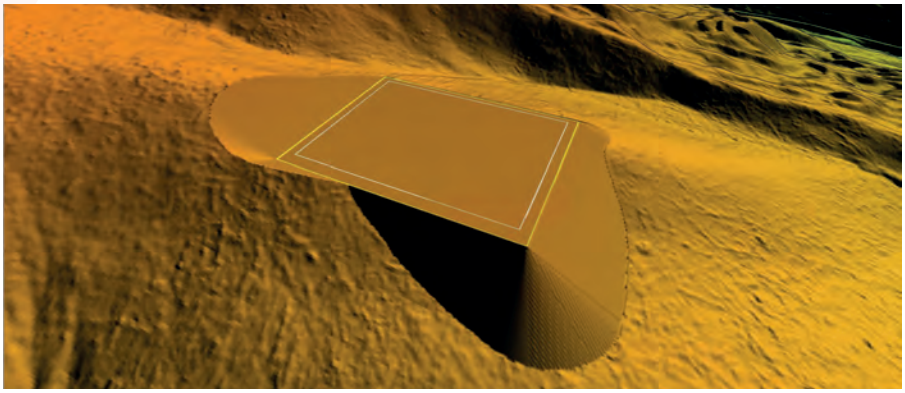
Automatic search for the optimal location for the Flattened Site Plan

Create a Flattened Site Plan is a popular tool for preplanning the best location, elevation and required earthworks for the creation of a flat surface in a terrain layer. As a new option in the tool, Create an Optimal Flattened Site Plan can take advantage of any flexibility in the exact placement and orientation of the flattened site. Global Mapper assesses the terrain in a specified location to find the optimal placement and orientation for the site that requires the least amount of earthworks.



▲ *The new Least-Cost Path Analysis tool determines the best path across a terrain surface based on desired parameters and conditions.*

▲ *Point clouds of all types, from Lidar to photogrammetric, can be processed in Global Mapper Pro.*



▲ *Modelling the position of a flattened site can provide the opportunity to optimize the use of existing soil, creating a site that doesn't require additional fill or removal.*

Once the optimal site has been calculated, the tool will provide measurements of the soil volume to be added or removed to create a level surface and a break-even elevation. The flattened site plan and other volume tools optimize the cut-and-fill values and even out the landscape into a flat surface using only the soil on site, thus minimizing soil or fill transportation costs.

Explore the features in a free trial

Whether users are working with Lidar data, complex terrain surfaces, vector features or looking to streamline workflows with Python, Global Mapper Pro can significantly improve their workflow. To explore all the features available in Global Mapper Pro 25, download a free trial today at bluemarblegeo.com. ■

Bridging the gap between vision and reality

Today's GIS technology puts multipurpose cadastre within reach

By Linda Foster, Esri

Following decades of a global vision and small-scale progress towards a comprehensive map-centric land rights system, there are indications that today's technological advances are putting a fully operational multipurpose cadastre within reach. This is being accelerated by the increased concern for disaster mitigation, climate mitigation and sustainable development, and the need for integration, sharing and collaboration between agencies.

Ever since the US National Research Council (NRC) published the groundbreaking 'Need for a Multipurpose Cadastre' report in 1980, there has been a global vision for implementing a system that represents all land rights, restrictions and responsibilities in a geographic context or map-centric system. Since then, much work has been done in the direction of multipurpose cadastre (MPC), mostly on a small, localized scale. Modernization, digitalization and automation have occurred in many government agencies with land information systems – registry, valuation, planning, natural resources, administrative records and others – but a fully operational MPC has yet to be realized.

While the content of land records has long been considered a function of local government (NRC, 1980), users now require precise spatial information in real time for the ability to develop and implement cross-jurisdictional and inter-agency solutions that are designed to meet priorities such as disaster response, climate mitigation and sustainable development goals (Williamson, 2008). In turn, these solutions are prompting greater consideration of how to integrate, share and collaborate with other agencies that are also managing land for a single, comprehensive view of authoritative land information. This pattern proliferates globally.

Many computerized systems are proprietary or have limited interoperability with others due to a reliance on closed standards

Vision versus reality

While the vision of an MPC is relatively straightforward in concept, the time that has elapsed since the 1980 report highlights some very real challenges in making that concept a reality (Figure 1). This lack of operational realization is due to a number of factors. In many countries, including the USA, land information is stored and maintained at local and state/provincial jurisdictions. Adding further complexity are the land information silos that exist in these jurisdictions. For instance, information necessary for valuation and taxation purposes is often compiled and maintained by valuation officials. Data involving real property transactions might be maintained and managed by a different group, often in a registry or recording office. If a mapping component exists, it may be with one group or the other but not necessarily linked together and, in some instances, mapping is maintained by an entirely different department.

▲ *Figure 1: Challenges in land administration (GKI, 2022) contributing to slow realization of an MPC.*

Records have also traditionally been stored in a wide array of systems: some paper-based and others computerized. Many of the computerized systems are proprietary in nature or are limited in their ability

to be interoperable with other systems due to inherence to open standards. The government tendency is for slow adoption of technology and for abrupt change in general because land administration systems underpin the economy of nations (GKI, 2022). The result is siloed data and static or transactional data sharing between all organizations, both private and public, with a vested interest in land information.

The 1980 US National Research Council report cited capacity as a concern for the viability of developing an MPC. That issue persists today and, along with little to no resource commitment at the federal level, it has contributed to slow progress towards an MPC.

Advancements in GIS technology

Modern geographic information systems (GIS) technology has evolved and is now capable of sharing and aggregating land information from disparate government departments to deliver single, authoritative access to the nature and extent of property rights, restrictions and responsibilities. This ability to share and aggregate data more readily provides a solution that helps address some of the challenges in land administration (Figure 1) which continue to hold back progress towards an MPC. Efficiency and accuracy are gained by limiting manual transmission of data, duplication of effort and using current data straight from the source. These advantages cannot be understated in a world fraught with accelerating challenges and the need for new discoveries.

▲ *Figure 2: The five key characteristics of modern GIS promoting sharing and aggregation of data.*

Substantial advances in recent years mean that artificial intelligence (AI) is continuing to mature and grow in sophistication. With the ability to match, or in some cases even surpass, human accuracy at tasks such as image recognition, reading comprehension and translating text (Land, 2022), the capacity challenge in realizing an MPC may soon find some relief.

5 characteristics of GIS

The following five key characteristics of modern GIS technology promote sharing and aggregating of land information (Figure 2):

1) Scalability: The scalability of modern GIS provides the opportunity for organizations of any size, and at any stage in their land administration odyssey, to fully realize the benefits of modern GIS. Whether working at an individual project level or as a multi-faceted organization comprised of many teams, there is a suitable configuration (Figure 3).

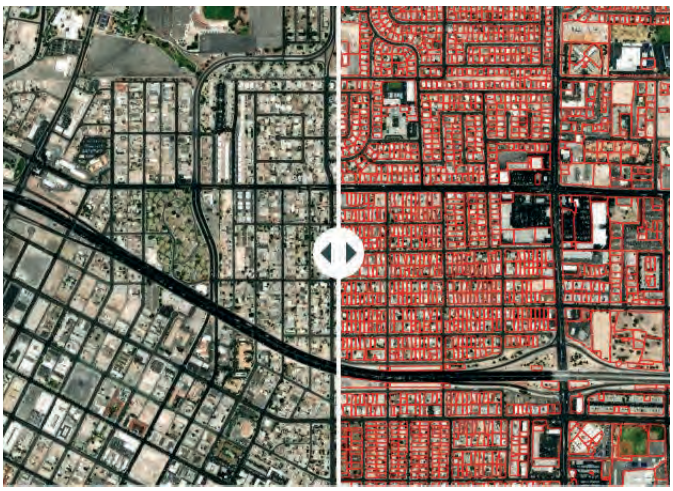
2) Security: Modern GIS technology, and specifically commercial, off-the-shelf software (COTS), is designed and managed in alignment with regulations, standards and best practices. Comprehensive security is provided throughout the ecosystem including products and services, solutions, cloud infrastructure, and specific privacy and security initiatives (e.g. GDPR and FedRAMP).

3) Standards and interoperability: With a decades-long commitment to open standards and interoperability, modern GIS technology continues to contribute to and support international standards development, and has a history of open-sourcing its format specifications. With support for reading and writing standard and common data file types using industry and international standard data formats, and via the web through Open Geospatial Consortium (OGC) services, GIS technology provides the interoperability needed to meet the evolving needs of the land administration community.

The intersection of AI and GIS, referred to as geoAI, is creating enormous opportunities in the land administration space

4) Services through the web: Utilizing web services allows all government agencies to remain focused on their areas of responsibility while sharing up-to-date, authoritative data to a single point of access for use by agencies and others with overlapping interests. Efficiency and accuracy are gained by limiting manual transmission of data and duplication of effort, and by using current data straight from the source. These are advantages that cannot be understated in a world fraught with accelerating challenges and the need for new discoveries.

▲ *Figure 3: Modern GIS technology is scalable to meet organizational needs.*



▲ *Figure 4: Parcel extraction using a pre-trained model in GIS.*

About the author

Linda Foster oversees Esri's worldwide strategic vision for land administration and surveying. With 20 years of experience working in the land and resource industry, she is a registered professional land surveyor and certified GIS professional. She also holds a BSc in Geological Engineering, and a master's degree in GIS from Penn State University. Linda is currently the vice president of the National Society of Professional Surveyors (USA).

5) Sustainability: Long-term sustainability is the sum of the preceding four characteristics of a modern GIS. System sustainability is critical in the pursuit to achieve an MPC. As noted previously, one of the challenges in realizing an MPC is the custom-built nature of legacy land administration systems. Custom-built systems are often vulnerable to security threats, require a high-level of specialized maintenance, and are susceptible to high levels of technical debt.

Artificial intelligence

Generally speaking, AI is the ability of computers to perform tasks that typically require some level of human intelligence (Land, 2022). The intersection of AI and GIS, referred to as geoAI, is creating enormous opportunities in the land administration space. Two areas showing promise are the detection of cadastral boundaries from remotely sensed imagery (Figure 4) and the mapping of boundary descriptions from scanned documents using techniques like natural language processing (NLP) and machine learning (ML).

Each approach applies to different stages of land administration maturity. Boundary detection from imagery is being explored as an alternative to 'boots on the ground' surveying to expedite the first registration of land, thus securing property rights and mobilizing land capital. Mapping of boundaries from existing documentation is intended to propel those organizations that have land registered in paper form, but not accessible in a mapped, digital format. First registration mapping or converting paper records into a digital format is the first step in the process towards realizing an MPC.

Conclusion

Although a widespread operationalized MPC has yet to be realized, all indications are that technological advances and increased concern for disaster mitigation, climate mitigation and sustainable development are accelerating the process. In the USA, for example, a number of statewide parcel aggregation projects have been successfully completed, and the federal government recently passed the FLAIR Act which calls for the creation of a current, accurate inventory (cadastre) of federal land. Both signify a commitment to larger land administration projects needed to eventually achieve an MPC.

By leveraging today's GIS technology and standards such as the Land Administration Domain Model (LADM), OGC standards and globally available base maps, imagery and data, achieving a multipurpose cadastre can be a reality. ■

Further reading

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Innovative methodologies and mobile technology integration

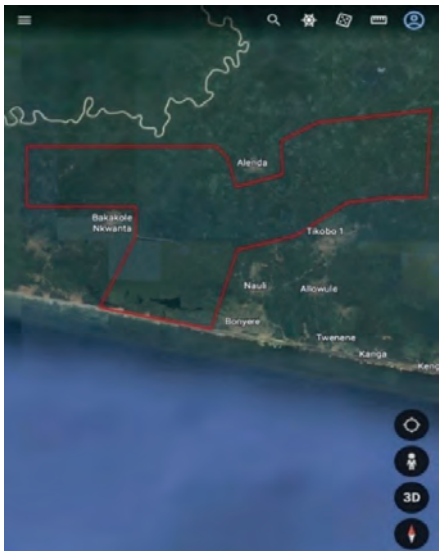
Transforming cadastral surveying for Ghana's future

By Naa Lamkai Quaye-Ballard, Daniel Asenso-Gyambibi and Jonathan Arthur Quaye-Ballard, Ghana

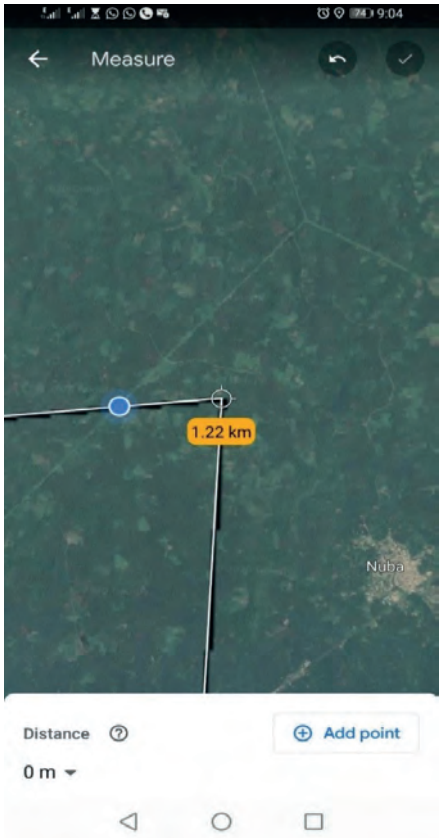
Incorporating smart methodologies in cadastral surveying is improving the land acquisition system in Ghana. Traditional cadastral surveying is time-consuming and, if not planned out well, could cost a fortune to survey larger land areas. In a recent project, a cadastral map was produced for a large area in just 20% of the proposed duration thanks to the use of mobile applications by local townsfolk in the cadastral surveying process.

The aim was to prepare a cadastral plan for 21,000 acres (approx. 8,500 hectares) of land situated at Jomoro in the Western Region of Ghana. The land to be surveyed is generally mountainous with lush green vegetation, farms, towns, villages and roads, and is bounded on the south by the Atlantic Ocean. The main occupations of inhabitants are coconut farming and fishing.

The traditional way of preparing a cadastral plan would have involved sending a survey party ahead of the actual survey to locate and clear the entire boundary in order to mount pillars. This would have been an arduous task, possibly involving the use of handheld GPS to locate the boundary points and the deployment of labourers to clear the line of sight where necessary. In an area with dense vegetation, it could take a whole day or more to survey 1km of boundary. The survey party would be made up of surveyors, local guides and labourers only; any other accompanying persons would be of little to no help in locating boundary pillars. The other time-consuming challenge would have been to identify the best and fastest accessible route to arrive at a boundary point. When it comes to routing, even experienced local guides are no match for today's tools such as Google Earth.



▲ *Figure 1: Google Earth mobile app showing study area.*



▲ *Figure 2: Navigation using the Google Earth app.*

Data collection methodologies would usually involve creating an on-site office with computers to capture all the attribute data in a database, scanners to scan paper documents, cameras and cameramen to take photographs of farm owners, printers and verification machines. For 21,000 acres of land, a minimum of 20 workers – including data collectors with expert knowledge in computing, especially Microsoft Office – would need to be employed for at least ten months to collect and process all the data. A separate survey team would have to be employed, equipped with handheld GPS, to accompany farm owners to all the boundaries to measure, process, plot and reconcile with the attribute data collected. With this running concurrently with the main boundary survey, data processing, plotting and approval, the estimated duration of such a project could be a minimum of 20 months.

The need for faster ways of surveying

To support policy decisions, however, there was an urgent need to complete this entire project within four months, so faster ways of surveying were required. Mobile technology,

GIS and the use of uncrewed aerial vehicle (UAV or 'drone') technologies had already been successfully implemented on other projects with outstanding results and were therefore considered for use in this project.

In terms of the reconnaissance survey and preparation for data collection, the only available data was a paper map indicating the proposed boundary of the land. The position of the boundary on the ground was unknown. However, the towns where the proposed boundary was passing through were located, visited and informed ahead of the survey. The paper map of the area to be surveyed with coordinates in the Ghana National Grid coordinate system was scanned into QGIS, georeferenced and the boundary digitized. A total of 26 pillar points and 100 auxiliary points were picked along the boundary to be set out on the ground. The boundary shapefile was then converted to a Keyhole Mark-up Language (KML) file in the WGS84 system and imported into the Google Earth mobile application.

The only available data was a paper map indicating the proposed boundary of the land

More than half of the population of Ghanaians own smartphones with good network coverage. To enable the use of smart technology as a tool in promoting sustainable development, local townsfolks with Android smartphones were selected and trained in Google Earth, Mobile Topographer and Open Data Kit (ODK). The selected data collectors were chosen based on their efficient data collection and interpretation skills after two days of training and assessment. Free mobile applications of Google Earth, Google Maps, Mobile Topographer and ODK were downloaded and installed on the data collectors' smartphones.

Navigation and boundary location using Google Earth

A typical day's work included planning the points to be established by each survey party, driving on motorable roads in a pickup truck to get as close as possible to those points, then changing to either a three-wheeler or motorcycle to use paths, trails or farm routes to get even closer to the boundary point.

With GPS-supported smartphones which had the Google Earth mobile application installed on them, survey parties navigated to the boundary points (Figure 1). The location tracker of the smartphone was enabled in order to know the surveyor's position at any point in time. Google Earth and the loaded KML file were opened. As the surveyors moved towards a boundary point, they could determine the shortest distance and the fastest way (Figure 2). The 'Measure' tool in Google Earth was used to measure the remaining distance between the surveyor and the location of the boundary point. This informed the surveyor of the remaining distance, best route and also the direction to the boundary point of interest. Prior to entering areas with poor mobile network connectivity, the surveyors loaded and start navigation on Google Earth in order to be able to locate boundary points offline.

▲ *Figure 3: Working with trained local residents reduced labour and accommodation costs and also addressed language barriers.*

▲ *Figure 4: On the way to gather geospatial data.*

Once at the boundary point, the surveyor placed a temporary pole on stable ground. This was subsequently used by the pillaring team to establish concrete pillars. If the boundary point was located at a farm, the owner was contacted before concrete pillars were mounted. In the case of a few areas with dense vegetation, labourers were hired in the local town to clear it and provide easy access.

About the authors

Naa Lamkai Quaye-Ballard has worked as a consulting geodetic engineer in Ghana for over 15 years. She is currently a researcher with the Council for Scientific and Industrial Research (CSIR) – Building and Road Research Institute (BRRI), Ghana, with an interest in geospatial technologies and sustainable public transportation, and is pursuing her doctorate degree at the Kwame Nkrumah University of Science and Technology (KNUST). She is a council member of the Ghana Institution of Engineering (GhIE), chair of the Welfare Committee of GhIE, a council member of Women in Engineering Ghana (WinE), a committee member of Women in Engineering of the Federation of African Engineers (FAEO) and a professional member of the Ghana Institution of Surveyors (GhIS).

Daniel Asenso-Gyambibi is the director of the CSIR-BRRI, Ghana. His research areas are land administration, GIS and mapping. In his 23 years of professional experience, he has been involved in numerous projects related to the built environment, including the Ghana Land Administration Project (LAP). He holds a doctorate, an MPhil and BSc in Geomatic Engineering from KNUST. He is a member of Ghana Institution of Surveyors and Ghana Institution of Engineering.

Jonathan Arthur Quaye-Ballard is a professor and head of the Department of Geomatic Engineering at KNUST, where he has worked for the past 20 years. He also holds a BSc in Geodetic Engineering from KNUST, an MSc in Geo-Information Science and Earth Observation from ITC, Enschede, the Netherlands, and a PhD in Geodesy and Survey Engineering from Hohai University, Nanjing, China. He is a licensed surveyor and member of the Ghana Institution of Surveyors (GhIS) and the Ghana Institution of Engineering (GhIE).

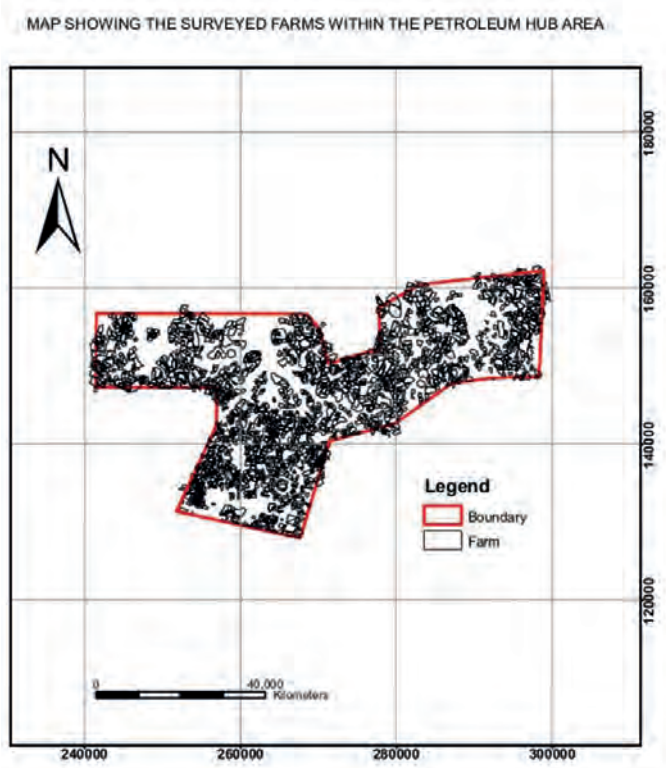
A static GPS survey was conducted to survey all the concrete pillars, commencing from a national benchmark base with known national coordinates. On average, the accuracy of the located points was below 5m. This was largely due to the small-scale nature of the paper map, map generalization and digitization.

Most farm owners were delighted to finally know the actual size of their lands at no cost to themselves

Auxiliary data collection using Mobile Topographer and ODK

To create a land information system (LIS) to aid valuation for compensation in the land acquisition process, it was necessary to identify ownership of farmlands. Most farm owners had documents dating back hundreds of years with landmarks as boundary identification, and many farm owners used the traditional way of land measurement by employing the 10m stick method. Despite these challenges, every farm owner was able to show their boundaries with other farms without misunderstandings. However, for the purposes of the cadastral map, it was decided to use technology to confirm and digitize these boundaries.

Mobile Topographer application uses the GPS functionality in a smartphone to obtain geographical coordinates. This application



▲ *Figure 5: Map showing boundary and auxiliary data (parcels of farmland).*

turns the smartphone into a handheld GPS device that can be used for measurements with an accuracy of less than 1m. After receiving training in the use of Mobile Topographer and ODK, data collectors were put in groups with opinion leaders in each town to facilitate the coordination between the surveyor and the farm owners.

On a typical working day, an early-morning announcement in the town confirmed the location where the survey party would be working and reminded people about which types of documents to take along to the farms for the data collection exercise. Prior to the survey, farmers were advised to clear their boundaries for easy access. The survey party proceeded to the first farm and the farm owner – together with opinion leaders and the owners of neighbouring farms – walked along their boundaries. The data collector followed, picking eastings and northings at a minimum interval of 20m. The data collectors stored the data of each boundary separately with a unique parcel identity number, exported it in Excel CSV format and then sent it to the surveyor for data processing at the end of the day.

The ODK application is a simple tool for data collection. A questionnaire was developed to collect relevant information – in addition to the farm size – from farm owners to aid valuation and compensation. The proof of identity and other documents were captured using smartphone cameras and uploaded into ODK. Other details such as name, age, contact details and so on were also requested and recorded. At the close of the day, the collected data was uploaded onto a server which surveyors could access using a link. The final output was a cadastral map and digital map (Figure 5) showing attribute data of farmland parcels in a GIS environment.

Conclusion

Working with trained townsfolk reduced the labour and accommodation costs as well as bridging the language barrier. The project also supported technology transfer and created employment for the townsfolk, which improved their standard of living. Google Earth made it easier to find the shortest accessible routes to establish boundary points, with minimal clearing of farmland and vegetation. Since their own people were part of the measurement and survey process, townsfolk were cooperative and there were no disputes. The use of Mobile Topographer helped more farmers to engage with the trained data collectors privately, and most farm owners were delighted to finally know the actual size of their lands at no cost to themselves. The data collected with ODK created a comprehensive database which improved the valuation and compensation process. The project took a total of four months, rather than 20 months if the traditional method had been employed. It can be concluded that incorporating smart technologies makes surveying easier, faster and more cost effective. ■

Further reading
Quaye-Ballard N. L., Asenso-Gyambibi D., Quaye-Ballard J. A., Yeboah E. and Asamoah A. Application of Smart Technologies in Cadastral Surveying of Large Areas in Ghana, FIG Congress 2022 'Volunteering for the future – Geospatial excellence for a better living', Warsaw, Poland, 11-15 September 2022

To govern or not to govern? Territory is the question!

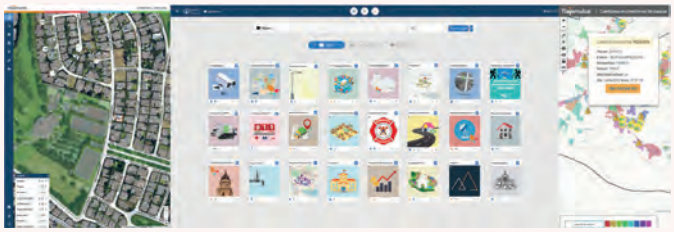
Cartomorphosis: an evolution that starts with cadastre

Over the past 15 years, geospatial information has enabled the transformation of towns, cities and a whole state in Mexico. The customer and data provider teamed up to create up-to-date datasets to enable municipalities to enhance their finances through assertive land-management public policies. For this Mexican region, modernizing cadastres has been the first step towards achieving public financial freedom and empowering multidisciplinary decisions through maps.

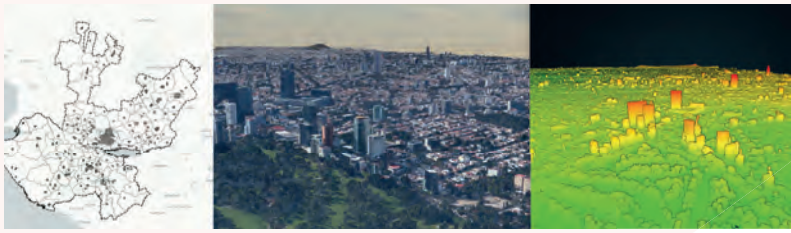
In 2010, Juan Partida was appointed CFO as part of the new government of Tlajomulco. This 716km^2 municipality is part of Jalisco, Mexico's third-largest state (by GDP) comprising 80,000km^2 and 125 municipalities in total. The government officials received a mapless cadastre of alphanumerical registries, ten-year-old aerial photographs and some paper-based property outlines. The municipality was in dire need of fresh resources to fund the modernization of its administrative capabilities to keep up with the fast-paced land development in its territory. It used federal programmes to finance a geospatial dataset, software and restructured processes. The dataset, the first of its kind in Mexico, included aerial vertical and oblique imagery at 10cm ground sample distance (GSD), mobile mapping and was one of the first to use uncrewed aerial vehicles (UAVs or 'drones') for micro-coverage updates.

The entire dataset was made available to the cadastral office and the rest of the municipal areas through eCarto, CartoData's web mapping platform. Each municipal area had its own eCartoApp, allowing the property ID to be the primary key to every municipal transaction based on cross-checking with other areas for its validity and eligibility. To date, 183 apps and maps provide a governing framework enabling team collaboration through a common shared context: the territory. Apps range from cadastral and general land management all the way to security dispatch, garbage collection, weather monitoring, disaster management and restoration of public space.

Interdisciplinary workflows were also put in place. Every time the dataset gets updated, scripted routines now validate the amount of built square metres in a property versus the ones in the registry. In the case of a mismatch, the system cascades to building permit verification, updates the cadastral registry and triggers an inspection while disabling any additional commercial or construction permits. Intertwining data, software and processes into a coordinated effort held the key to making this happen. This resulted in a four-fold increase in revenue linked to land registry over a five-year period, improved financial health, stronger credit ratings (S&P and Fitch) and numerous awards such as the Geospatial Latin American Award



▲ *Figure 1: Tlajomulco's eCarto has over 183 map apps ranging from cadastre to garbage collection.*



▲ *Figure 2: 221 towns in Jalisco now have access to land management tools, Lidar and digital twins.*

for best cadastral system and the most innovative organization in the public sector in 2018.

Replicating and scaling up

The state of Jalisco, within which Tlajomulco is located, had historically acquired aerial photographs of the state's most relevant towns roughly every ten years. These remained in the archives and rarely made it beyond the desks of specific cadastral experts. When Partida changed offices, he became aware of the situation. The team decided to replicate Tlajomulco's platform by treating each municipality as an independent entity with access to all of its historical data, all the way back to 1967. The archives were digitized and made available along with an updated dataset acquired in 2020. The new dataset included 10cm GSD imagery, oblique images and Lidar data. The state bore the costs of acquiring and processing the new dataset, providing municipalities with the rare opportunity to capitalize on fresh geospatial information at minimal cost.

Grasping the low-hanging fruit in Tequila

Tequila, home to the eponymous spirit, was one of the municipalities that exploited Jalisco's data, Tlajomulco's experience and CartoData's manpower. In a record six weeks, it implemented the cadastral system on eCarto and increased net tax revenue by an impressive 232% in just two years. This was partly due to the fact that many tequila-manufacturing facilities had been registered as sheds or plantations, resulting in missed tax collections spanning several decades. The added revenue helped break a long-standing vicious circle of poor public services due to weak municipal finances.

A self-financed first step towards a smart city

Latin American urban planning is quite different from American or European models; it is more chaotic and has an abundance of informal settlements, making cadastral tasks challenging in nature. Thanks to the cumulative experiences gathered over the last 15 years of continuously assisting governments in Mexico navigate the ins and outs of cadastral dataset modernization and design, it has been possible to continuously tailor and streamline the Cartomorphosis framework. So far, CartoData has implemented it at different levels in over 63 municipalities and two countries, including El Salvador. If the aim is to design a smart city, the first building block is to have a cadastral dataset that approximates reality as closely as possible and is constantly updated by daily transactions. While dataset modernization can sometimes require sizable investments of time and money, these investments quickly pay for themselves several times over, whether in terms of higher tax revenues, better control of land resources, or because they generate useful data to bolster various other public services. ■

About the authors

Juan Partida is CFO of the government of Jalisco, having been a civil servant for the last 15 years. From the outset, his involvements have included modernizing and designing cadastral datasets at the municipal and state levels, primarily for the purpose of improving tax collection and generating tools to oversee land development. As a finance professional, CFA charter holder and certified accountant, he has a proven ability to successfully lead and manage financial teams under challenging conditions. Besides demonstrating excellent communication, relationship-building and team-building skills, he is a solid analyst of administrative systems with a focus on continuous improvement in process efficiency.

Felix Audirac is CEO of CartoData, the mapping company implementing the Cartomorphosis cadastral mapping framework and the 'El Salvador Maps' project. With a Master of Business Entrepreneurship & Technology and a bachelor's in Computer System Engineering, he is a geospatial information technology evangelist with 20-plus years of experience. His efforts are focused on democratizing the geospatial information generated by CartoData through exponential technologies such as cloud computing, mobile devices, drones, blockchain and artificial intelligence.

▲ *Figure 3: The municipality of Tequila made immediate use of the geospatial dataset provided by the state and increased its net tax revenue by 232% over two years.*

Further reading

'How El Salvador empowered growth and efficiency through mapping', *GIM International* 6, 2023
www.gim-international.com/content/article/how-el-salvador-is-empowering-growth-and-efficiency-through-mapping

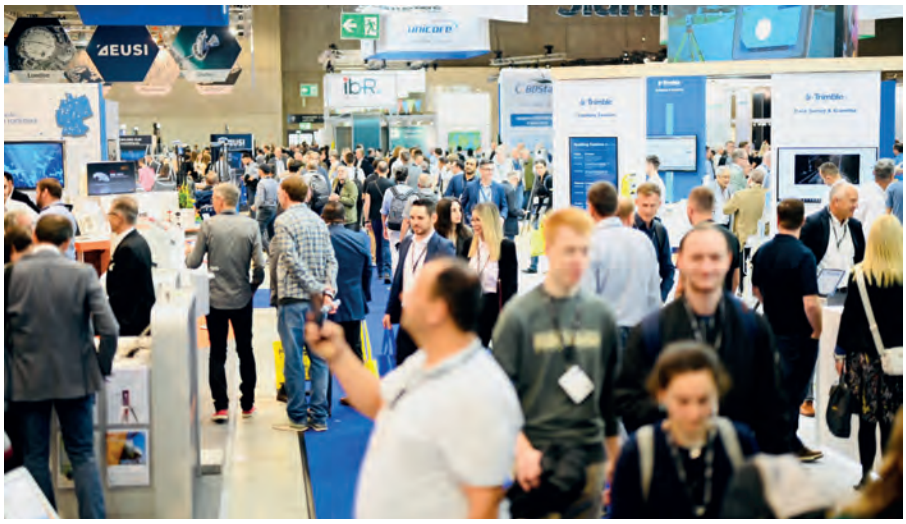
Intergeo 2023 unleashed geospatial innovation and connectivity in Berlin

By Wim van Wegen, GIM International

Intergeo 2023 was an electrifying three-day event in Berlin, transforming the city into the global geospatial capital. From 10-12 October, professionals from across the globe convened for the world's premier international trade fair dedicated to geodesy, geoinformation and land management. This edition exuded a sense of pre-COVID enthusiasm, characterized not only by the substantial turnout of visitors but also by the palpable excitement generated through numerous product launches and updates that showcased significant technical advancements in the field.

Intergeo, as the industry's leading event, serves as the hub that unites the geospatial community, forging connections between professionals across various sectors. This year's Intergeo achieved a staggering attendance of nearly 17,000 trade visitors from 112 different nations, who descended on Berlin to explore the offerings from 571 exhibitors representing over 40 countries. Additionally, the conference hosted over 300 speakers and 841 attendees from 42 nations, reaffirming Intergeo's stature as the preeminent trade fair and international congress platform for all facets of geodesy, geoinformation and land management.

Prof Dr Rudolf Staiger, president of the German Association for Geodesy, Geoinformation and Land Management (DVW), expressed satisfaction with the event's resonance, stating: "The response of the exhibiting companies and the visitors at the exhibition, and the feedback from the conference participants, confirm our concept. We have positioned strong themes such as Earth observation and environmental monitoring, smart city, building information modelling (BIM) for infrastructure, digital twins, maritime solutions, 4D geodata and 3D cadastre. These are all elements of geospatial data-driven solutions for sustainable development. With this focus, we have struck a nerve."



▲ *With its bustling exhibition floor, Intergeo 2023 reaffirmed its position as the primary marketplace and pivotal meeting point for the geospatial community.*

Earth observation and GIS

It was undeniably clear at Intergeo 2023 that global Earth observation technologies, including Copernicus and Galileo, play a vital role in informing localized decision-making on issues such as climate change, poverty alleviation, clean energy and sustainable urban development. The event underscored the significance of global monitoring and Earth observation in providing foundational insights necessary for understanding complex interconnections in a world facing the urgency of climate change and other crises. Precise spatial information is indispensable for individuals making crucial local decisions, and geospatial industry practitioners stand ready to provide this critical data. Jack Dangermond, founder and CEO of GIS software group Esri, highlighted the importance of GIS in charting a sustainable future. He emphasized the role of shared geographic knowledge in addressing contemporary challenges, saying: "Sustainability begins with geography because it provides a deep understanding of holistic events. GIS as the foundation for digital twins enables us to understand impacts, model scenarios and derive necessary decisions. We must act because we are living beyond our means. Geospatial data is the foundation for generations to come."

Industry's toolkit

Moreover, Intergeo 2023 firmly established itself as the primary marketplace and pivotal meeting place for the geospatial community. The event showcased the industry's toolkit of innovations – including cloud technologies, artificial intelligence, digital twins, BIM, uncrewed aerial vehicles (UAVs or 'drones'), GIS, big data and more – that offers remarkable possibilities to be extended to users in diverse sectors. In terms of innovative product launches, DJI unveiled the Zenmuse L2, a high-precision aerial Lidar system with a 4/3 CMOS RGB camera enhancing data collection accuracy for drones. IGI introduced the EcoMapper, a five-band aerial camera system with thermal imaging capabilities, and Vexcel showcased the UltraCam Dragon 4.1 hybrid oblique imaging aerial mapping system known for its precise elevation data and high-accuracy imaging. RIEGL presented a range of products, including the VQX-2 helicopter pod and the VUX-180-24, ideal for high-speed surveying missions.

Hexagon/Leica introduced the groundbreaking BLK2GO PULSE, a first-person laser scanner reshaping reality capture, and JOUAV presented the VTOL Hangar, promising precision and efficiency across various industries. Exail showcased the Atlans 3, a cost-effective inertial navigation system (INS) dedicated to land and air mobile mapping applications. New aerial mapping solutions, such as the Ecomapper from IGI and Sony's integration of the new a6100 Oblique camera into its flagship surveying drone, garnered attention. Several new applications attracted interest for use in transport and industrial applications, including Prevu3D for creating digital twins and positioning solutions that go broader than surveying. Needless to say, this is just a small selection of the many impressive innovations to be discovered at this edition of Intergeo.

Sustainability through geodata

During the traditional annual press conference at lunchtime on the Wednesday of the event, there was a notable focus on sustainability through geospatial data. The fact that many construction companies are now adopting autonomous solutions, for instance, suggests a move towards more sustainable practices. However, there was some debate about whether enough attention is being paid to ways in which the geospatial sector can further improve its contribution to sustainability. Boris Skopjlak of Trimble argued that, given the abundance of environmentally friendly tech solutions, our industry should facilitate broader access for scientists, archaeologists, ecologists and others to harness our data. The key message to the business community was clear: let's prioritize education and commitment!

Next-generation surveyors

The integrated side event called BIM-Days Germany highlighted the growing synergy between the geospatial industry and the digital construction industry. The 71st German Cartography Congress (DKK) was seamlessly integrated into Intergeo 2023, exploring topics such as generalization with machine learning and artificial intelligence, maps tailored for mobile use, and hazard mapping. Rooted in engineering sciences, the fields of geodesy, geoinformation and land management are committed to nurturing young talent and specialists. DVW eV launched the Arbeitsplatz Erde platform to connect aspiring youngsters with the geospatial industry, supporting this with intensive promotional activities during the Intergeo Expo and Conference to inspire the next generation. The Geodesy Prize and Promotion Prize recognized outstanding final theses by students in the domains of geodesy, geoinformation and land management. Strikingly – and encouragingly – there seemed to be a large number of young visitors in attendance at this year's event.

International growth

The event's international growth was underlined by the heightened presence of international exhibitors and trade visitors, as well as the participation of the World Geospatial Council (WGIC), confirming the expanding international market presence. DVW President Staiger remarked on the significant increase in international participation at both the expo and the conference, highlighting the overwhelming response from exhibitors, visitors and conference attendees. Looking to the future, many exhibitors have already secured their participation in the next edition of Intergeo, scheduled for 24-26 September 2024 in Stuttgart. The city's reputation as a vibrant hub for international corporations and cutting-edge technology makes it an ideal host for the leading gathering of the worldwide geospatial community, shaping the future based on geoinformation-driven innovation in administration, business and science. And hopefully, besides from an international audience, next year's event will also attract as much – and perhaps even more – attention from a young audience, as this would be very good news for the geospatial sector! ■

▲ *At the annual press conference on Wednesday, there was a strong emphasis on sustainability through geospatial data.*

▲ *Many companies have already secured their booth for Intergeo 2024.*

Comparing vertical and oblique aerial images

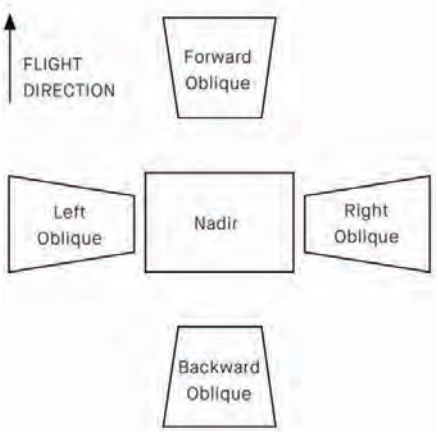
Enhancing reality mapping with different perspectives

By Arkadiusz Szadkowski and Kristen Maglia, Esri

Both vertical and oblique aerial images have their own advantages, making them valuable in different reality mapping applications. So how can you choose between the two? This comparison will help you to assess their benefits from the perspective of the specific requirements and objectives of the project or analysis at hand.

The value of aerial photography was recognized almost immediately after the invention of photography itself. Since then, aerial photography techniques have undergone remarkable advancements. While balloons, kites and even pigeons were initially used, today we have sophisticated tools such as uncrewed aerial vehicles (UAVs or 'drones'), crewed aircraft and satellites that can capture images of virtually any location on Earth, offering endless possibilities in mapping, problem solving and observation.

To understand the value of aerial photography, it is important to differentiate between the two primary types of images. Both vertical and oblique images have their own advantages and are valuable in different applications. The choice between the two depends on the specific requirements and objectives of the project or analysis at hand.



▲ *Figure 1: Sketch of aerial image footprints for a typical multi-head camera system.*

Vertical vs oblique imagery

Vertical photographs, often referred to as nadir images, are captured directly downward from the camera to the ground, aligning with a nearly 90º angle. The primary characteristic of these images is the absence of noticeable sides of objects. This ensures a consistent scale, minimizes distortion and offers accurate measurements and precise representation of features on the ground, making vertical imagery ideal for mapping, surveying and cartography applications.

In contrast to vertical imagery, oblique imagery offers a more angled perspective. It is captured at an angle typically greater than 30º from the vertical line. This technique provides a 'sideways' view, revealing the sides of structures and other features, lending a more three-dimensional feel to the images. Modern oblique cameras are designed innovatively; they feature one nadir-viewing camera paired with four cameras tilted between 30° and 50°. These angled cameras offer forward, backward, left and right viewing directions, making the imagery extremely versatile. Given its unique perspective, oblique photography adds value in visual inspections, urban planning, real estate marketing and anywhere a more comprehensive spatial context is paramount.

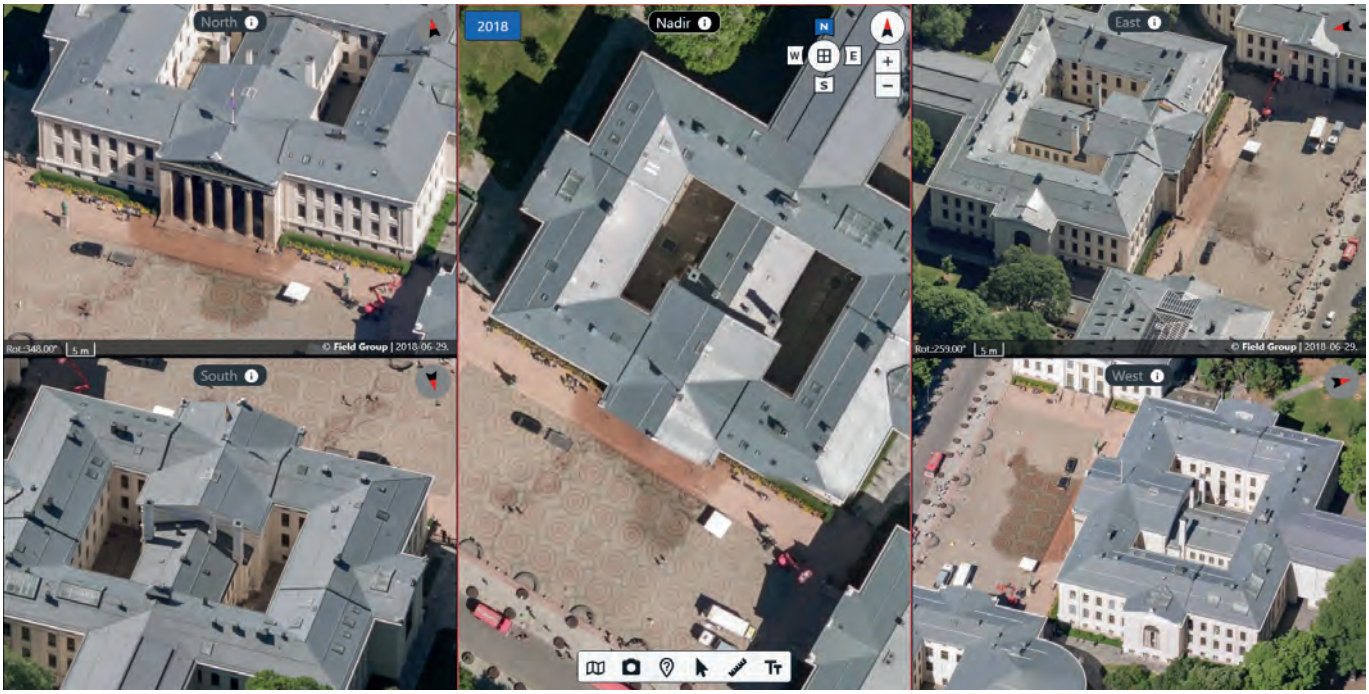
3D reality mapping

3D reality mapping is the process of capturing and recreating the real-world environment in a three-dimensional digital model. This realistic representation allows users to explore, interact with and analyse the environment in various ways that would be virtually impossible in traditional two-dimensional maps. The process has practical applications across diverse industries, from urban planning and entertainment to defence and architecture, engineering and construction (AEC).

Now that the rapid evolution of sensor technology is making data capture more efficient and available for any project, capturing multiple views simultaneously – including nadir and oblique perspectives with matching resolutions – has become a reality and a standard today. As a result, both types of datasets are commonly used for 3D reality mapping production.

Harnessing the power of oblique imagery in 3D models

While it is possible to create 3D models with nadir imagery only, the addition of oblique images significantly enhances 3D reality mapping and the accurate creation of mesh models. Firstly, the blend offers a richer perspective thanks to the multiple angled views of structures and terrains provided by the oblique imagery in combination with the top-down view from vertical or nadir imagery. This makes the 3D mesh models more detailed and comprehensive. Additionally, the angled nature of oblique images adds a natural sense of depth to resulting 3D model, providing a more realistic representation and a clearer context. Moreover, the geometric shape is not enough to create realism in a 3D mesh model; the surface



▲ *Figure 2: Penta view (the same object presented from five perspectives): nadir, and east, west, north and south oblique view. (Image courtesy: Field Group)*

7 steps in the aerial reality mapping process

Step 1: Capture
Images of a specific site, object or area of interest are collected using aerial photography techniques such as using drones, crewed aircraft or satellites. Factors like budget, time constraints, area size and government regulations influence the choice of capture method. For instance, drones or aeroplanes may require government approval, while satellite images can be used in situations without such requirements. With high-resolution cameras on the various platforms, images are captured from different angles and perspectives, serving as visual input for creating a digital representation of the real world. The collected images can be nadir, oblique or a combination of the two.

Step 2: Import into software and detect features
The data is important into reality mapping software for detection of unique features or key points within each image. These are specific points or patterns that stand out and can be reliably identified across multiple images, such as the corner of a building or a distinct landmark. The software then compares features between multiple images to find matches. When the same feature is identified in multiple images, it provides a reference point that algorithms can use to understand the spatial relationship between those images.

Steps 3 & 4: Orient and align the images
Based on the matched features, the relative orientation (position and angle) of each image to its neighbours is determined. Triangulation is then used to estimate the 3D coordinates of the matched features. By knowing the position and angle of each camera (from the orientation step) and the position of a feature in each image, the 3D position of that feature in the real world can be deduced.

Step 5: Process data to create geospatial products
Dense reconstruction algorithms go a step further than specific matched features to estimate the 3D position of many more points. This fills in the gaps and creates a dense cloud of points that represents the shape of the scene. Purpose-built algorithms then create a mesh (a collection of interconnected triangles that form a cohesive surface) which serves as the foundational 3D structure of the scene. To make it look realistic, textures are added by 'draping' the original images over the mesh (i.e. a portion of one or more source images is projected onto each triangle in the mesh). In areas where multiple images overlap on the mesh, blending algorithms are used to smoothly transition between them, ensuring there are no abrupt colour changes or visible seams.

Step 6: Refine
Post-processing steps to optimize the texture may involve adjusting brightness and contrast, or removing artifacts to ensure the final 3D model is as realistic as possible.

Step 7: Share
The resulting geospatial products can be shared to geographic information systems (GIS) so they are ready for further analysis, such as GeoAI, and they can be easily visualized by stakeholders.

▲ *Figure 3: Comparison of 3D model reconstruction and texturing using nadir only vs nadir and oblique imagery. (Image courtesy: City of Stuttgart)*

texture is equally vital. Oblique images provide high-resolution details of building facades, which can be used to texture the sides of 3D models, making them more lifelike.

Since oblique imaging captures shadows differently than vertical imaging, the images can be used to enhance the realism of 3D models. Moreover, understanding the play of light and shadow in urban environments can be crucial in specific applications like urban planning. Similarly, oblique imagery provides the required perspective to accurately reconstruct spaces in 3D in urban modelling to understand the space between buildings, ensuring alleys, overpasses and building setbacks are correctly represented. And while buildings are a significant part of 3D urban meshes, the natural environment plays a vital role too. Oblique images help in capturing the side view and therefore accurately representing vegetation and topography such as trees, cliffs and other natural features. In the final stages of aerial reality mapping, oblique images – with their multiple perspectives – allow for enhanced ground truthing, i.e. a more thorough verification process to ensure that the created 3D mesh is accurate when compared to the real world. Last but not least, oblique imagery offers today's modern 3D reconstruction algorithms a wealth of data to work with, leading to more accurate and high-fidelity models.

▲ *Figure 4: Example of a reality mapping 3D model for the city of Utrecht, as the foundation for digital twins of cities. (Image courtesy: Kavel 10 and Esri)*

Oblique imagery: advantages and challenges

Oblique imagery, with its unique vantage points and perspectives, has found its way into a variety of industries, offering a multitude of advantages. Local governments utilize this technology for tasks ranging from public safety initiatives to urban planning, where it provides urban designers with a holistic view of cityscapes and enables them to make well-informed decisions. The field of property and casualty insurance benefits from oblique imagery's precision, allowing for accurate property measurements essential for underwriting and claims adjustments. In the realm of roofing, oblique imagery delivers accurate measurements and 3D models, streamlining estimation processes. Real estate marketing is also taking advantage, as potential buyers can gain a comprehensive view of properties, elevating the effectiveness of sales pitches. Furthermore, in the aftermath of disasters, oblique images provide an invaluable perspective on damage to the sides of structures, which might otherwise remain hidden in traditional vertical shots. Despite its numerous applications,

▲ *Figure 5: Example of a reality mapping 3D model for the city of Boston, as the foundation for digital twins of cities. (Image courtesy: Bluesky and Esri)*

integrating oblique imagery into reality mapping comes with its own set of challenges. One of the foremost hurdles is the sheer volume of data generated by oblique photography, which can strain storage and processing resources. Privacy concerns are another aspect to consider, as the unique angles employed have the potential to inadvertently capture private spaces. Moreover, interpreting oblique images may prove more complex than traditional vertical shots, necessitating the development and utilization of specialized tools and expertise for effective analysis. Addressing these challenges will be key to fully harnessing its benefits across various sectors.

A foundation for observing the world

Advancements in photogrammetry, computer vision and the field of geometry processing now empower the creation of meshes that serve as comprehensive 3D representations, replacing multiple layers of vector and raster data. This optimization saves each element and texture just once, while implementing intelligent level-of-detail management and advanced compression techniques. This not only streamlines data transfer but also enables the seamless delivery of real-world environments to clients via the web.

While both vertical and oblique aerial photography have their distinct merits, their combined use promises a comprehensive, detailed and enriched view of the world. As technology advances, the potential applications and advantages of these methods will continue to grow. Reality mapping is a foundation for many future and existing digital twins, improving the ability to observe the world thanks to rich insights and reducing the risk of making wrong decisions. ■

About the authors

Arkadiusz Szadkowski is senior business development manager of reality mapping, imagery & remote sensing at Esri. He is passionate about leading the change towards 3D GIS and bridging the gap between complex geospatial data, customer needs and business opportunities. After graduating from Warsaw and Vienna University of Technology in Photogrammetry and Remote Sensing, he worked at Field Group (formerly Terratec) on imagery, Lidar, MMS and 3D modelling for almost 13 years before joining Esri.

Kristen Maglia is senior product marketing manager at Esri. She started her marketing career in imagery analysis software immediately after graduating from Colorado State University, and has had the unique opportunity to grow with the remote sensing industry. Now supporting reality mapping products at Esri, she enjoys writing about how technology solves real-world problems.

From data trust to global solutions

Unveiling the PLACE initiative

By Denise McKenzie and Frank Pichel, PLACE

The new global not-for-profit technology organization PLACE is founded on the belief that location (i.e. 'place') data and information is critical for understanding, responding to and solving the greatest challenges our planet currently faces: climate change, population growth, urban expansion and resource scarcity. So how does PLACE help, and how can organizations get involved?

PLACE is a global not-for-profit technology organization that is passionate about partnering with governments to ensure national sovereignty over geospatial data. Its mission is to make very high-resolution, precisely positioned aerial and street imagery more open, reliable and accessible. This will help governments improve the lives of their citizens, create economic opportunity, strengthen public services and better care for the environment. Through the development of a unique model in which spatial data is treated as a type of digital public infrastructure, PLACE has a vision "to be the most compelling data trust of mapping data for the benefit of people, community and planet". Once mapping data has been collected by PLACE and its local partners, it is owned by the local government. A copy is stored in the PLACE Trust in perpetuity for use by the members of the PLACE Community. These trusted members use the data to better understand global challenges and build critical solutions for responding to climate change, economic development, urban planning and disaster resilience. Further applications and innovations will continually increase as the membership base grows.

Disparity in geospatial infrastructures

Recent decades have seen massive innovations in the geospatial industry, and while tools like GNSS and readily available aerial imagery are now ubiquitous, geospatial data is far from equally available and accessible around the world. Power imbalances, lack of skill and capacity, varying paces of innovation, funding issues and the industry's own quirky geospatial lingo have all contributed to a disparity between those that can maintain and leverage a geospatial infrastructure, and those that cannot.

▲ *Figure 1: Aerial imagery of Anguilla, captured in 2023.*

Ever-increasing numbers of satellites provide ever-increasing volumes of mapping data, but the data can be expensive, difficult to use and have restrictive licensing terms, making it hard for governments in emerging economies to access and own the data. Companies like Snap, Google, Bing, Meta and Niantic Labs are now the largest global mapping entities on the planet, but their maps are used for commercial purposes and are not generally available to governments. Data is captured by such international actors without ever being passed to governments and the citizens from whom the data has been collected. However, even these global platforms find it difficult to maintain detailed and up-to-date mapping data for many parts of the world – particularly in the rapidly growing urban centres of the Global South.

The need for data in a changing world

Over the next 30 years, 2.5 billion people and up to a billion more vehicles will be added to urban centres. Three-quarters of the infrastructure that will exist in cities by 2050 has yet to be built. 80% of global GDP is produced in cities, 75% of energy-related emissions come from cities, and 70% of city-dwellers lack reliable access to at least one core service such as housing, water or electricity.

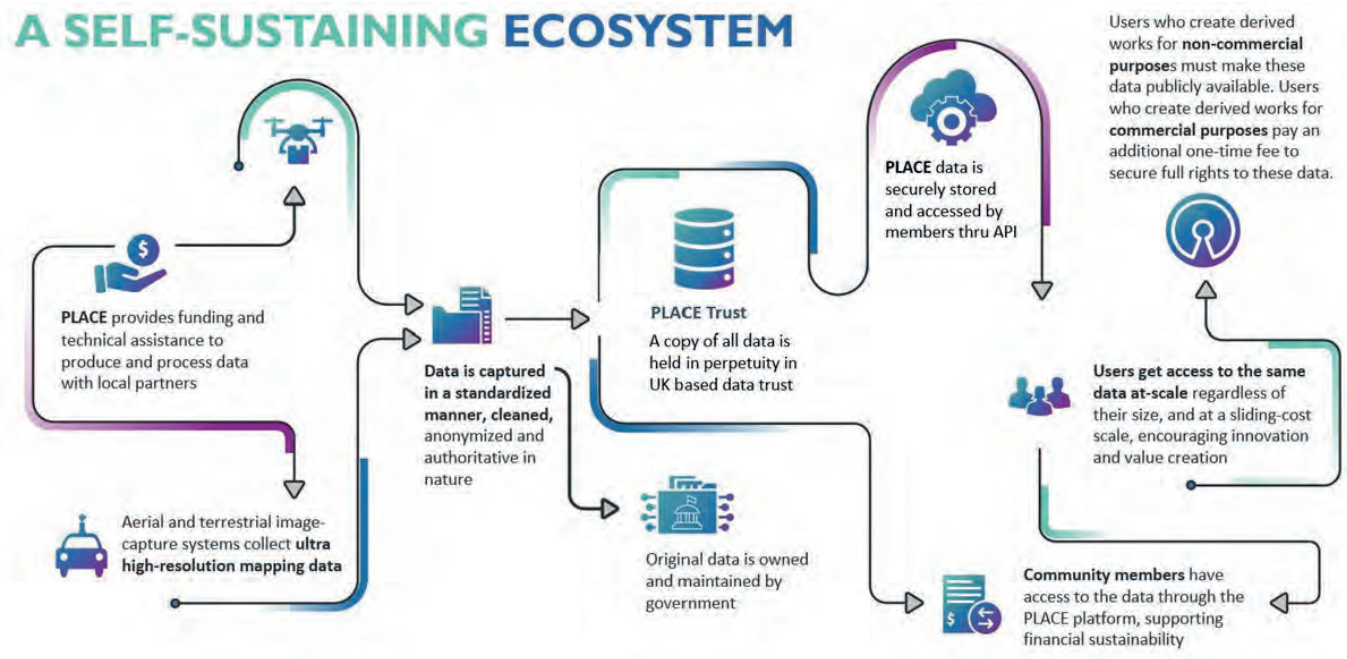
The reality is that the system is broken. As many places on our planet face the most significant challenges the human race has ever seen – climate change, population growth, urban expansion and resource scarcity – we still lack the necessary data and insights to make evidence-based decisions and understand the consequences of our actions. Many emerging economies – which already unfairly endure the majority of the climate change impact and possess the fastest growing urban population centres – are unable to access and utilize the very spatial data that is most critical for monitoring and responding to these changes. PLACE offers a unique model for governments to own the regularly updated, ultra-high-resolution geospatial data needed to adapt to the changing world.

▲ *Figure 2: Formal and informal housing in the Caribbean, PLACE 2023.*

What is PLACE and how does it help?

PLACE was formed from the Property Rights initiative at Omidyar Network (ON) in 2020, in part to address a common challenge across the portfolio of ON grantees and investees: the lack of authoritative and up-to-date spatial information available to partner governments. Led by a team of specialists with a solid background in the land information, development, data standards and geospatial sector, PLACE is working to solve the inefficiencies of modern-day mapping by creating a trusted intermediary between the public and private sectors. This creates a self-sustaining ecosystem for the delivery of hyperlocal, accurate and detailed optical imagery of the Earth's surface. Everyone needs such imagery, but it is difficult to produce and to maintain alone.

PLACE partners with the government agencies authorized and responsible for mapping urban and peri-urban areas in their country, and provides funding and training for mapping and processing of data. All data produced in partnership with PLACE belongs to the government. In return, PLACE receives from each government an irrevocable, perpetual, royalty-free licence to a copy of the data for its use by PLACE Community members through the PLACE Trust.
The PLACE Trust is a permanent legal data trust based in the UK. Just as trusts have been used to look after and make decisions about other types of assets in the past, such as land trusts that steward land on behalf of local communities, a data trust provides independent, fiduciary stewardship of data.



▲ *Figure 3: PLACE creates a self-sustaining ecosystem for the provision of regularly updated, ultra-high-resolution geospatial data.*

▲ *Figure 4: Processing tools allow government partners to put data to use immediately; in this case a 3D model of the Central Business District in Anguilla was created in the week of data capture.*

What can the data do?

The data from the PLACE Trust is already creating positive impact in a number of parts of the world. As an example, in early 2023 the PLACE team travelled to the Turks and Caicos Islands. Working closely with Wayneworth G. Hamilton, director of surveys and mapping there, PLACE collected high-resolution aerial photography of the primary islands for the first time in more than a decade. The data was put to use the very day after it was delivered, and the government is now using it to assist with property inspections, assessments and improved Crown Land management. Hamilton is excited about the myriad uses of the data going forward, and describes it as the most impactful resource the government now has at its disposal. "Delivering and engendering geospatial success through a collaborative approach, the Turks and Caicos Islands government and PLACE have crafted a strategic partnership to deliver accurate aerial imagery, street views and the transfer of expertise and technical resources to continue our geospatial development. We are elated to benefit from our status as a PLACE Community Member," he states.

According to Hamilton and other government officials, they now see the following key application areas for the data:

- To make informed decisions across the built and natural environments
- To address climate change impacts such as risk management, risk transfer, gentrification, coastal protection and coastal monitoring
- To identify and address informal settlements and urban sprawl
- To develop models for hazard mitigation and disaster management
- To provide a framework for modernizing the census and the new identification cards programme
- To analyse zoning and land use regulations and requirements
- To serve as the base for the new design of a multipurpose cadastre.

Key to the success of PLACE is the ability to collect data once, but enable its reuse many times

Enabling data reuse

Key to the success of PLACE is the ability to collect data once, but enable its reuse many times. In early 2023, to expand the number of organizations able to apply and access the data, membership of the PLACE Community was opened to any organization in good standing. The growing PLACE Community is diverse and international, spanning across Africa, Europe, Asia-Pacific, the Caribbean and North America, and with organizations ranging from small to large commercial operations, research institutions and academia as well as NGOs. Early members have included ESRI, Radiant Earth and Global Land Alliance.

Members can use PLACE data under either a commercial or non-commercial licence, with any derived or value-added work remaining the property of the member. In the case of commercial

▲ *Figure 5: Data capture in the Turks and Caicos Islands included PLACE Aerial (5cm aerial) and PLACE Ground (360-degree street view), engineering-grade data that can be used for measurements, coordinate identification, etc.*

use, a licence fee will be applied. Within the PLACE model, this is key to the organization's long-term financial sustainability. Members also participate in working groups that help to shape pricing and licensing, technology development and governance within the organization. Importantly, all PLACE members must agree to use the data in an ethical and responsible manner. An independent ombudsman role is in place to oversee any investigations.

PLACE is a founding signatory of the Locus Charter (10 principles for the ethical and responsible use of location data), and so ethical behaviour, trust and the responsible use of location data are at the core of everything at PLACE. These principles are critical to building and maintaining trust between governments and members alike. As well as the charter, PLACE's own 9 core principles guide the purpose, platform and function that enables trust to be built and maintained in an ever-changing and developing technology world.

Expanding membership

With over half a dozen national partners, and further active discussions with more than 40 countries underway across the regions of Africa, the Caribbean and Pacific, PLACE is continuing to expand in terms of both partnerships and data collection. With a number of countries already creating positive impact with the data, the next chapter of the PLACE journey will be to see how the new PLACE Community members start to build and innovate with new services and solutions. This is an exciting time to become part of this new data trust organization and to help shape and build a global knowledge sharing community around high-quality and high-resolution geospatial data. PLACE is keen to build and expand the membership. Organizations that are intrigued by this new model should get in touch to learn more. ■

PLACE datasets

PLACE collects two primary datasets:
1) PLACE Aerial: 10-20cm aerial resolution images, positionally accurate to within 15-30cm.
2) PLACE Ground: Positionally accurate 360-degree images captured every 10-15m and de-identified to remove faces and number plates.

Further reading

PLACE: https://thisisplace.org
Locus Charter: https://ethicalgeo.org/locus-charter/

About the authors

Denise McKenzie is managing partner for PLACE Trust. She has previously held a variety of roles across government and non-profits that have enabled her to build broad expertise spanning numerous domains, including environment, insurance, defence, health and indigenous land issues. In addition, she is a co-author of the Locus Charter: 10 principles for the ethical and responsible use of location data, the former chair of the Association for Geographic Information (AGI), and supporter of the Women+ In Geospatial Network and multiple award-winning public-private partnership technology projects over the past 25 years. She holds a BA in Public Policy and a Master's in Sustainability.

Frank Pichel is a land information specialist with experience in designing, managing and implementing technology-based solutions for improved land management around the globe. At PLACE, he works to drive data-collection partnerships and relationships with partnering governments, ensuring data is no longer a barrier to effective land governance.

Survey supports hydraulic modelling and flood planning

Topobathymetric Lidar helps Quebec prepare for climate-change impacts

By Sven Cowan, NV5 Geospatial, Canada

As a result of major recent flooding events in Canada, the Communauté Métropolitaine de Québec (Quebec Metropolitan Community/CMQuébec) recognized the need for highly accurate surveys of its watercourses to inform flood preparedness and civil security. This article explores the techniques used to achieve an exceptional degree of precision in the topobathymetric Lidar survey conducted by NV5 Geospatial, as well as the logistical challenges that can impact the success of similar projects.

Over the last decade, several of Canada's provinces and major cities have experienced major flooding events, including Alberta (2013), Vancouver (2021) and Quebec (2017). These devastating weather events were global news stories, demonstrating the potential threat posed by Canada's extensive coastlines and watercourses. In Quebec, the 2017 floods caused significant damage and disruption, leading Quebec's Ministry of Public Safety to develop an action plan for civil security and flood preparedness.

While Quebec City itself was not impacted by the 2017 flooding, CMQuébec understood the need to prepare for potential flooding events in the future. Home to more than 500,000 inhabitants, Quebec City sits on the bank of the Saint Lawrence River and is dotted by a network of smaller bodies of water. Rising water levels could prove disastrous for the city, threatening both physical and economic security. CMQuébec needed highly accurate maps and models of its watercourses in order to prepare for the consequences of various flooding scenarios.

▲ *CMQuébec 2022 study areas and current regulated flood zones. (Image courtesy: Frédérick Lafrance, CMQuébec)*

The topobathymetric Lidar method

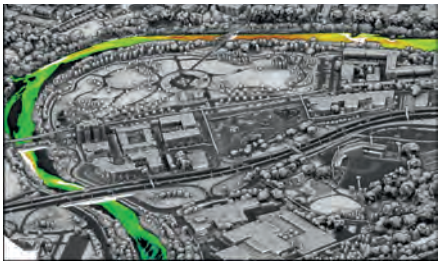
Topobathymetric Lidar was identified as the appropriate method for accurately mapping and modelling the watercourses in Quebec. This method of remote sensing simultaneously measures and records three separate surfaces: water, land and submerged land. A combination of airborne laser-based sensors are used to collect data on the disparate surfaces; a near-infrared laser maps land and the surface of the water, and a visible green laser penetrates the water to map the submerged land.

CMQuébec commissioned its first topobathymetric Lidar surveys in 2019. The results led the organization to commission a wider survey in autumn 2022. NV5 Geospatial (NV5) was contracted to collect topobathymetric Lidar data over eight additional watercourses, amounting to a total area of 7,000 acres (2,833 hectares). The largest component of the survey was the Saint-Charles River, with the survey including 2,000 acres (809 hectares) of land along the banks of the river. The city planned to use the expanded datasets to inform extensive hydraulic modelling, which would allow the local government and businesses to prepare for flooding events more effectively.

Situational challenges

Topobathymetric Lidar surveys are heavily dependent on suitable weather conditions. Not only can inclement weather impact both airborne data acquisition and ground preparations, but it can also affect tide conditions. Water surfaces must be sufficiently calm during the survey to ensure precise, usable data.

Airborne Lidar surveys can also be hampered by other factors, including airspace restrictions and private property access. A successful topobathymetric Lidar survey requires extensive preparation to work efficiently and complete the assignment within the allotted time frame. CMQuébec expected the work to be conducted during typically low-flow conditions. Any significant delays in the data acquisition process could have resulted in NV5 missing the window of opportunity before the onset of winter and increased precipitation.



▲ *Lidar-derived surface model of the Saint-Charles River, Pointe-aux-Lièvres Park, with bathymetry shaded by depth. (Image courtesy: Chris Miwa, NV5 Geospatial)*

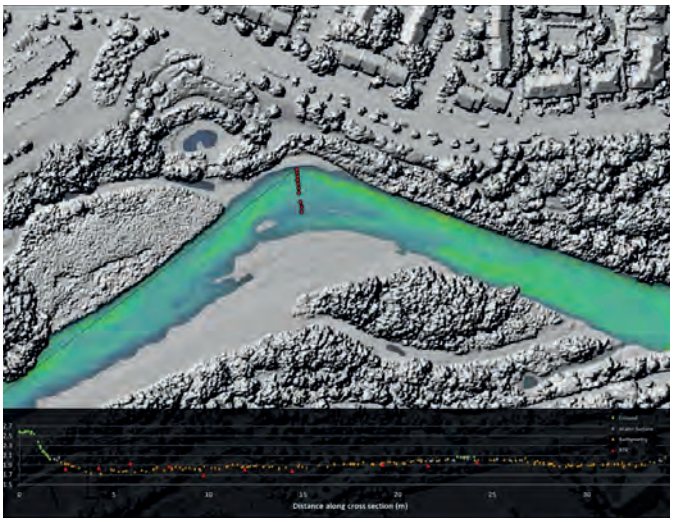
Preparation, collaboration and communication

Both CMQuébec and NV5 understood that detailed preparation and seamless communication would be necessary to achieve the desired results of the survey. Building off the previous experience with topobathymetric Lidar, CMQuébec conducted the pre-flight ground surveys and provided detailed recommendations to the NV5 survey team. The two teams also worked to identify structures which control water flow along the rivers in the survey area, coordinating with the responsible institutions to maintain still waters whenever possible.

Recognizing the need for consistent performance within a limited window of time, CMQuébec wanted to review each day's data as soon as possible following completion of the survey. NV5 delivered the collected data in near-real time using its client portal, INSITE, and the two teams worked together to determine which surveys were successful and which required additional flights. The NV5 survey team conducted all survey flights in a Piper Navajo aircraft, using a Leica Chiroptera 4X shallow-channel topobathymetric Lidar sensor and a HawkEye 4X deep-channel bathymetric Lidar sensor to collect the necessary measurements.

Novel solution to changing weather

In a typical topobathymetric Lidar survey, the team will identify which flights produced the best data for each specific area and will then conduct manual and automated processing. The process is akin to capturing several separate images, editing the images and then stitching them together for a complete image. However, the ever-changing weather of Quebec City led the NV5 team to take a novel approach to this process. Because of the unpredictable shifts in weather during each individual flight, the data processing team realized that individual flights contained both exceptional survey data and data that had been compromised by sudden rainstorms. Therefore, the NV5 team integrated the best results from each flight into a single, highly precise composite point cloud. As a result, CMQuébec could be sure that the received point cloud delivered the absolute best possible results. These efforts will pay off for years in the city's future hydraulic modelling and civic planning efforts.



▲ *Lidar-derived surface model of the Rivière du Berger, with bathymetry shaded by depth, and a cross-section of the classified Lidar point cloud. (Image courtesy: Chris Miwa, NV5 Geospatial)*

About the author

Sven Cowan is NV5 Geospatial's programme manager for Canada. He has over 20 years of experience in customer-facing positions within the geospatial information industry and has worked for multiple geospatial remote sensing organizations in various roles. His current focus includes regional strategy, business development, relationship management and brand awareness for NV5 Geospatial.

Valuable set of best practices

By combining CMQuébec's experience with NV5's expertise, the two parties achieved a groundbreaking result: the first complete bathymetric digital model in Quebec City. So which lessons can be learned from this project? Firstly, it confirmed the importance of detailed, careful planning and of taking every possible step to minimize water flow and potential weather disruptions. Moreover, the project underlined the value of committing to a longer period for data acquisition; the NV5 survey team spent nearly one month in the Quebec City area, ensuring that the acquisition process could take place without pressure or stress. Lastly, this topobathymetric Lidar project demonstrated an effective approach to post-acquisition data processing. By providing raw data in real time, NV5 allowed CMQuébec to confirm satisfaction with the acquisition process and participate in decisions on where and when to conduct additional survey flights.

The NV5 team's innovative approach to point cloud mapping also showcased the performance improvements that are possible when going beyond standard practices in order to deliver the optimal result. The planning, acquisition and processing phases of this project could serve as a valuable set of best practices for future topobathymetric Lidar surveys in North America and beyond, helping other cities with major watercourses to face the threats of climate change and rising water levels. ■

▲ *Lidar-derived surface model of the Saint-Charles River, with bathymetry shaded by depth. (Image courtesy: Chris Miwa, NV5 Geospatial)*

5 Questions to...
Jeff Turgeon, Trimble

In our Q&A section, we invite geospatial industry experts to share their insights into the current state of the sector and their expectations for the future. This time around, the honour goes to Trimble's Jeff Turgeon.

Jeff Turgeon is the technical product manager for 3D laser scanning software at Trimble, the product manager for Trimble RealWorks and Trimble Perspective, and the vertical lead for the scanning module within Trimble Business Center. He was attracted to the geospatial industry for its technological advancements, problem-solving complexity, global relevance and commitment to improving efficiency and sustainability across various sectors.

Looking at terrestrial laser scanners, what do you consider to be the biggest improvement over the last five years?
In the past five years, field software advancements, such as with Trimble Perspective, have revolutionized the laser scanning industry. Historically, laser scanning projects required employees with significant experience to understand the strategies for a successful field campaign. Today, the workflow has been simplified by enabling immediate point cloud visualization, on-the-fly targetless registration and real-time data analysis. This advancement is shifting part of the office workflow into the field, optimizing on-site productivity and providing confidence in results before leaving the jobsite.

One issue with laser scanners of any type is the massive amounts of data they collect. How do you deal with that?
There are several strategies to maintain a streamlined laser scanning workflow and avoid big data delays. With Trimble scanners, your data is collected using a .tzf file format. This compressed format has a smaller storage requirement which is faster for data transfer between devices. On the software side, you can choose to extract specific points for a given part of the workflow, filter unwanted points and decimate point clouds in overly dense areas of collection.

Laser scans require georeferencing. How do you solve this issue with the latest generation of laser scanners, especially indoors?
Georeferencing is a critical element in our laser scanning portfolio. The Trimble X-series laser scanners contain an onboard laser pointer specifically designed to observe georeferencing tie points. These observed points can be matched with survey control in Trimble Perspective, georeferencing your project in the field. Trimble RealWorks office software goes a step further, allowing you to set multiple reference frames within the same project. One reference frame might allow you to work from a global coordinate system, while another can be established locally. This is commonly used to set a local system within a building, defining the origin point to a building corner and aligning a building wall to a cartesian axis.

The laser scanning workflow is often time-intensive due to many data points but also in terms of editing and point classification. How does Trimble support this workflow?
Preparing points clouds for deliverable creation is often one of the most time-consuming steps in a laser scanning workflow. Trimble addresses this with easy-to-use processes such as automatic registration, AI-assisted segmentation, and classification trained with machine learning. Trimble Business Center recently introduced an updated Deep Learning Point Cloud Classification tool that allows users to train their own custom classes. Once a custom class is trained, it can be used to automatically classify that feature in all future projects.

Looking towards the future, which developments in laser scanning and the associated processing software can we expect from Trimble?
Future laser scanning developments will focus on building smarter, faster and better connected workflows to help our customers build efficiency in their business and develop new opportunities. The Trimble Dimensions 2023 user conference showcased several such advancements in areas of artificial intelligence (AI), cloud-based environments and inter-software connections. These areas will continue to progress, reducing the time required to complete laser scanning projects while unlocking more of the data collected. ■

More information:

A terrestrial laser scanning study in Nigeria

Investigating the slow uptake of technology in developing countries

By Ugonna Nkwunonwo, Okwuchukwu Nwaka and Elijah Ebinne, Nigeria

Instrumentation plays a critical role in both the theory and practice of land surveying. However, slow adoption of technology can pose significant challenges to professional practice. This is particularly evident in Nigeria, where the uptake of high-end surveying techniques such as terrestrial laser scanning (TLS) has been sluggish. The lack of research on the specific aspects that influence the adoption of modern TLS technology in different countries and individual cities is a significant knowledge gap that undermines efforts to improve surveying practices. To address this issue, the authors of this article have studied the factors that contribute to the slow TLS adoption in Nigeria. The insights gained from this research are applicable to other developing countries across the African continent and beyond, and can help to enhance understanding of this important issue.

Instrumentation has been a foundational element of land surveying (LS) since antiquity. Ancient populations employed multiple primitive tools to comprehend the land and its characteristics, and to illustrate them graphically for title, fiscal and legal objectives. It has been established that those primitive tools are, in fact, the predecessors of today's conventional LS tools such as tapes, theodolites and total stations, and techniques such as chaining, the ray method and photogrammetry.

Over time, these methods and the equipment used have become increasingly cumbersome and incapable of obtaining data with the precision required for definition of the organic and built world with the desired accuracy. Moreover, traditional LS approaches can require unnecessary intrusion on a site, not to mention the extensive project execution timeframe. Additionally, traditional LS is not suited for collecting the datasets demanded for the modelling operations of the intricate aspects entrenched in many of today's projects. While conventional LS procedures can only do point sampling, terrestrial laser scanning (TLS) offers a technological solution to many of these challenges, thanks to its ability to sample three-dimensionally and on the surface with high accuracy.

TLS project to model an offshore facility

Recently, an engineering survey in Nigeria examined the capacity of TSL to generate a three-dimensional model, employing a fusion of interpolations to transform data into surface models and address the shortcomings with traditional LS data acquisition methods. This process is non-intrusive and aggregates millions of data points at great speed. The project was aimed at constructing an as-built model – a three-dimensional likeness – of the offshore gas platform to aid in the planning and execution of retrofitting and refurbishment of the facility. The project used the HDS Leica ScanStation-2 TLS (see Figure 1) with the following properties:

- Position: 6mm (at 1m-50m range, 1δ)
- Distance: 4mm (at 1m-50m range, 1δ)
- Angle (horizontal/vertical): 0.003º/0.003º (60μrad/60μrad).

The main methodological aspects of the project were:

1. Choosing a suitable location for the TLS and targets
2. Authorizations from the management of the offshore facility for sampling
3. Systematic scanning of the facility to capture 3D point clouds
4. Data processing (including auto-rectification, point cloud filtering and modelling and exporting of the maps) of the point cloud using Cyclone 7.0 software.

Overcoming obstacles

The TLS fieldwork encountered some obstacles, predominantly the unfavourable conditions typically associated with marine environments, such as gusty winds and

▲ *Figure 1: HDS Leica ScanStation-2 TLS used for the 3D modelling of the offshore gas platform. (Author's own image)*

downpours. Strong winds impeded the operation of the scanner, making it move faster than normal when it was going with the breeze, and impeding its progress when the scanner was facing in the opposite direction. To overcome this obstacle, field technicians placed the scanner in positions where segments of the platform shielded it from the wind. While scanning in the rain, raindrops picked by the Leica ScanStation 2 introduced extraneous noise into the data which was interpreted as signals. In this case, the scanning operation was delayed until favourable weather conditions had returned. Despite these obstacles, the quality assurance of the finished product illustrates that the HDS Leica ScanStation-2 TSL produced a 3D as-built model of the offshore gas platform quickly and with high precision (see Figure 2).

Research into slow adoption of TLS in developing countries

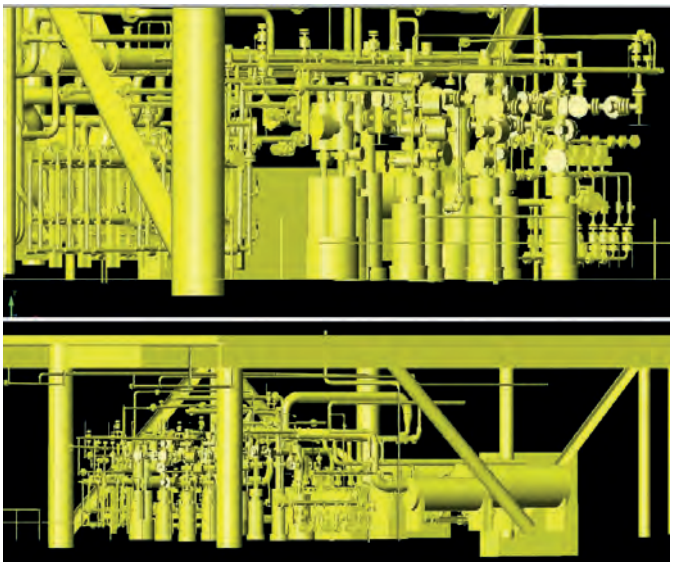
Although TLS has proven to be immensely useful in the aforementioned project, and also in the wider LS and geomatics industry, its adoption in many of the third-world countries has been sluggish. The literature does not provide a definitive reason for the slow uptake of TLS in such countries. Therefore, the authors conducted a survey among 81 practicing registered land surveyors in Enugu, Nigeria, with a variety of experience, length of practice, academic qualifications and awareness of LS instrumentation.

The survey revealed that only approximately 3.7% of the respondents have used terrestrial scanning technology. Around 38% of respondents indicated that they had heard about the technology but not seen it, while around 45.6% said they had seen it but not used it for any practical LS activity. According to the data, there is a dominance of mostly regular LS operations, including cadastral services, engineering surveying and land information management (LIM). These can often be implemented using basic indigenous logistics. The findings underscore evidence of slow adoption of TLS in the study area and suggest that the contributing factors to this situation include lack of funds, poor technical capacity and the shrinking value and scope of work exclusive to traditional land professionals.

Implications and the way forward

Despite a plethora of issues associated with existing LS instrumentation, such as breakdowns, considerable inaccuracies and a lack of personnel and technical expertise, the overall contentment with the current LS instruments and practices, as measured by the study, appears to be acceptably high. Indeed, most land surveyors in the study area think that they do not need TSL or any other high-end surveying equipment. Nevertheless, they would be open to receiving and/or providing financial, political, policy-related or scholarly support that would boost the current and future professional profile of LS theory and practice in the region.

This underlines the essential importance of technology transfer and adoption, and emphasizes the value of instrument training as a requisite for the mandatory continuing professional development (MCPD) for surveyors. Moreover, the enhancement of the status of LS professionals is contingent upon conforming to existing global professional standards. This can only happen if local surveyors are willing to embrace and use advanced technology. This will improve the currently deteriorating prospects of surveying in Enugu, which also touches on matters concerning women in surveying (WIS) and the comprehensive geoinformation system of Nigeria.



▲ *Figure 2: The 3D model of the offshore gas platform, scanned by the HDS ScanStation-2 TSL. (Author's own image)*

Conclusion

Instrumentation has been a fundamental feature of land surveying for ownership and fiscal purposes throughout history. TLS can meet today's demands for bigger and more accurate geospatial datasets, going beyond what traditional LS instruments and methods can accomplish. It provides the requisite capacity for rapid data acquisition, two- and three-dimensional modelling of intricate structures, and supports data transmission and collaboration. Results from a real-life project using the HDS Scanstaion-2 TLS to model an offshore gas platform and build an as-built map in Nigeria reveal that the scanning system is a suitable answer for new global problems in developing countries. But despite this potential, the acceptance of TLS is slow-paced in most of those countries, as evidenced by a survey among a sample of registered land surveyors in Nigeria. The momentary causes of this are the lack of funds to purchase modern equipment, lack of technical expertise and the declining status of the surveying profession in the region. However, more may be at play, and more research is required to comprehend all aspects of the TLS issue across different regions. This can them form the basis for developing initiatives and schemes aimed at enhancing the position of land professionals and the geospatial sector in developing countries. ■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A review of Trimble Dimensions 2023

The invigorating geospatial vibes in Vegas

By Wim van Wegen, GIM International

In the rapidly evolving landscape of geospatial technology, the annual Trimble Dimensions gathering is a dependable beacon for the surveying and mapping fields, providing a panoramic view of the current state and future trajectory of the sector. This year's knowledge update took place in Las Vegas from 6-8 November.

Trimble Dimensions 2023 kicked off with an electrifying opening keynote that not only showcased the industry's adaptability and precision, but also tied into the excitement surrounding the eagerly awaited Formula 1 Grand Prix event in Las Vegas. The spotlight was on reality capture as it was demonstrated how leading US survey firm SAM expertly mapped the F1 circuit using X7 and X12 laser scanners. The result was a stunning visual representation of The Strip, composed of 13.6 billion meticulously collected data points.

▲ *Trimble Dimensions 2023 was located at the Venetian Resort.*

The keynote featured Mark Gallagher, a seasoned F1 executive with over 30 years of high-performance motor racing experience who has demonstrated a passion for leveraging technology and data to enhance risk management and driver safety. In his light-hearted presentation, he shared a fascinating glimpse into the dynamic world of F1, exploring strategies for success in the business of winning. Gallagher's insights covered aspects of high-performance leadership, technology utilization and teamwork, all of which are essential for both on-track and off-track success – and equally apply in the geospatial industry.

"A lot can change in a year, and that's why we convene annually," remarked Rob Painter, Trimble's president and CEO, summing up the dynamic nature of the industry. Famous NHL hockey legend Wayne Gretzky's quote, "Skate where the puck is going," resonated throughout the keynote, symbolizing the industry's proactive stance towards embracing new technological trends and developments.

Where, what and why?

Trimble Dimensions is traditionally focused on the essence of connecting the 'where', the 'what' and the 'why'. In the 2023 edition, artificial intelligence (AI) was clearly an overarching theme. While acknowledging that AI is a transformative force, the event also emphasized that AI is only as good as the data it utilizes. The importance of high-quality data for AI emerged as a fundamental narrative.

The event's global significance was underscored by the 4,000 participants from 50 different countries. The attendees represented a broad spectrum of surveying and mapping professionals, spanning enterprise resource planning, civil design, construction, building scanning, architecture and asset management.

In their presentation, Trimble's Chris Trevillian, director product management GNSS, and Riley Smith, marketing director, monitoring and tunnelling, took the attendees on a journey through the inherent power of geospatial data. Participants engaged in discussions on prevalent trends within the survey industry, and identified data quality, reality capture, AI, automation, drone technology and recruitment as recurring themes. The presenters underlined the key role of geospatial data in catalysing transformation across diverse industries. Recognizing that geospatial data serves as the backbone for innovation and progress, they urged professionals not to stay in the background, but rather to spotlight their contributions.

The realization that approximately 56% of the Earth's surface currently remains

unmapped prompted discussions on how to encourage future professionals to join the geospatial industry. Initiatives like Trimble employees visiting schools and the 'Get Kids into Survey' programme were hailed as crucial steps in nurturing the surveyors of tomorrow.

Current state of surveying

One event highlight was the panel discussion on the current state of surveying by panellists including Farrah Etcheverry, Ronald Ssengendo, Andy Zoutewelle, Davey Edwards and Jean-Yves Pirlot. In fact, one panel member took to the stage carrying an issue of GIM International, which was a high-profile reminder of the important role of trade publications! During the discussion, the panellists stressed the need for robust dialogue between industry professionals, academia and policymakers. Jean-Yves Pirlot accentuated the responsibility of surveyors to maintain high standards, as people entrust their property based on the profession's educational level and trustworthiness. Andy Zoutewelle advocated aligning surveyors' licensing and education pathways with those of engineers and found some optimism amid concerns about a shortage of new surveying professionals. Farrah Etcheverry posed thought-provoking questions about the ongoing debate on higher education requirements and accessibility, sparking conversations about how to support young surveyors in their career pursuits.

Ronald Ssengendo shed light on the evolving role of surveyors in African countries, where technological advances are challenging traditional perceptions. He proposed a model inspired by the accountancy sector, with a focus on professional examinations and recognized qualifications. In view of the urgency created by the aging workforce, Davey Edwards, representing the National Society of Professional Surveyors (NSPS), declared a mission to attract the next generation of surveyors for 2023 and beyond.

Emerging markets and technological frontiers

The Trimble Dimensions 2023 programme included too many sessions to mention them all here, but one topic that deserves more attention among those working in the geospatial industry, according to Ronald van Coevorden (senior key account manager linear corridors/mobile mapping) is fibre broadband. Providing fibre-to-the-home (FTTH) for millions of households and businesses represents a massive amount of potential work for surveyors, not least because wireless 5G also relies on fibre. However, the developers of fibre networks are often unfamiliar with the possibilities offered by the geospatial sector. Van Coevorden stated that mobile mapping is an extremely useful tool for the FTTH challenge as it can save up to 60% of time, so it can play an essential role in fulfilling the FTTH ambitions across the globe. Moreover, Lidar-based mobile mapping of the streets can be combined with other technologies such as ground penetrating radar (GPR), and the marriage of AI with point clouds can also generate considerable benefits in the context of fibre-to-the-home mapping. The Trimble MX9 was presented as a suitable solution for FTTH: a complete field-to-finish mobile mapping solution that combines hardware, intuitive field software and integrated office software.

Diving into other technological frontiers, Trimble Dimensions 2023 highlighted the possibilities of autonomous technologies. The discussion expanded to encompass Lidar processing – including

▲ *During his keynote, Rob Painter, president and CEO of Trimble, wove in connections to the Formula 1 Grand Prix in Las Vegas.*

the rapid evolution of Lidar mapping in conjunction with uncrewed aerial vehicles (UAVs or 'drones) – as well as simultaneous localization and mapping (SLAM), automated object detection, and the fusion of AI with autonomy. However, Kevin Andrews, strategic marketing manager autonomy, emphasized that AI enhances human capabilities rather than replacing them.

Boris Skopljak, vice president of Trimble's surveying and mapping division, offered insights into the changing landscape and widening scope for geospatial professionals. For example, reality capture has become omnipresent over the past decade. Skopljak highlighted the transformative role of UAVs, stating: "What drones have done for the industry is incredible." Nevertheless, despite the influx of new technologies, the need for skilled surveyors remains paramount to ensuring the profession's continued relevance. Furthermore, Skopljak acknowledged the challenges posed by handling big data and emphasized the importance of effective data governance.

The shift from the exchange of static geospatial files to the seamless, real-time sharing of geospatial data was underscored. Trimble Connect is a solution that actively involves all project participants, allowing them to comprehend the project holistically from the broader perspective to the finest details. Thanks to ensuring the timely delivery of precisely what is needed by seamlessly uniting individuals, technology and information, it has already been embraced by over 30 million customers.

Pivotal role

Trimble Dimensions 2023 was an invigorating event offering a multifaceted view of the geospatial industry and Trimble's pivotal role within it. The versatility of the industry was apparent through the various sessions and the ensuing discussions, as well as through interactions on the exhibition floor. As technological advancements continue at a rapid pace, the annual update at Trimble Dimensions helps professionals across the geospatial spectrum to remain well-equipped to navigate the challenges and opportunities that lie ahead. Next year's edition of Trimble Dimensions will be held in Las Vegas from 11-13 November 2024. ■

Reducing risks to firefighters, settlements and infrastructure

Imaging solutions combined with AI and 5G hold promise for forest health and wildfires

The number of wildfires has increased dramatically in recent years due to diminishing forest health caused by the drastically changing climate across the world. Longer dry-weather periods and pressure from a variety of pests and diseases, such as bark beetles, are affecting the large forest areas in Northern Europe. In addition to financial losses, these impacts are resulting in lower carbon accumulation and vast ecological changes.

In 2022, a total of 2,397 wildfires were registered in Germany alone. More than 3,058 hectares of forests were destroyed, predominantly in the federal states of Brandenburg and Saxony. Monitoring forest areas with aircraft or uncrewed aerial vehicles (UAVs or 'drones') can help to detect potential issues in time. In addition, observation towers equipped with the latest camera and sensor technology – and combined with artificial intelligence (AI) to detect smoke columns as an indication of a wildfire – can be a perfect solution to assist in the fight against the widespread destruction of wildlife habitats.

Forest monitoring project

A research project – initiated by Landkreis Goerlitz in Saxony and Germany's Federal Ministry for Digital and Transport (BMDV), in cooperation with the firm Geotechnology, Geoinformatics and Services GmbH (GGS) – focused on monitoring an overall forest area of 170km^2 in the northeast of Germany. The project delivery was based on multiple approaches. Due to the large area covered, a surveying aircraft and UAVs were used for monitoring by air, while on the ground observation towers with the latest sensor technology and ground sensors were used.

Camera setup for aerial survey

The camera setup for the aerial survey was based on GGS's OIS technology with the addition of near-infrared (NIR) and thermal cameras. GGS chose a Phase One iXM-RS 150 with a 90mm lens for nadir imaging. Two additional Phase One Achromatic iXM-100 cameras with NIR filter (bands 700-850nm and 750-850nm) and two 70mm lenses were added. For generating a 3D surface model, four Phase One iXM-100 oblique cameras, each equipped with an 80mm lens, were also integrated into the camera pod. Alongside the nadir cameras, two further thermal cameras were used to capture the entire footprint at lower resolution to determine the influence of microclimate changes on forest health.

▲ *A wildfire raging through a forest.*

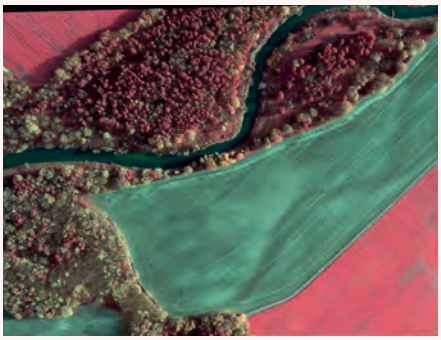
Data processing and model generation

The gathered RGB, CIR and NDVI data was first processed with Phase One's iX Capture software, before being further processed with specialized photogrammetric software to generate true orthophotos. The red edge data was generated after producing the orthophotos of both NIR bands and refined by raster conversion between the two NIR orthophotos. The RGB data of the oblique system (nadir and oblique) was processed with Skyline's software package Photomesh to generate a 3D model.

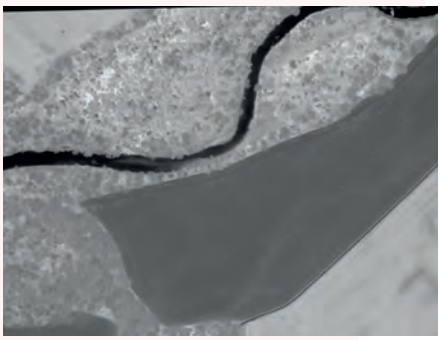
Applications in forest management

The resulting data models can be used for a variety of applications, including:

- Forest health assessment: The RGB,NIR, CIR, NDVI and red edge orthophotos can be used by forest experts to detect high-risk areas for wildfires, areas suffering from drought or pests/diseases – such as the bark beetle – or to assess soil health status. These areas are then labelled as high risk and hence have higher priority regarding fire observation. The red edge detection in the 700-750nm band allows for faster and easier detection of health problems than NIR/CIR images alone. Thus, it can be labelled as a rapid indicator of stress within trees.
- Emergency maps: The RGB orthophotos can be used as part of the emergency navigation system for firefighters in combination with other information, such as the accessibility of paths, lakes



▲ *CIR image.*



▲ *NDVI image of the same area.*

▲ *RGB/CIR/NDVI/NIR1/NIR2 images of the same area.*

for accessing water, information about critical infrastructure, and inaccessible areas. This data, e.g. a true orthophoto mosaic, is part of a cloud-based GIS application. It is frequently updated with ancillary data, e.g. UAV-gathered data about the dimensions and dynamics of wildfires as well as the associated risks for nearby settlements and infrastructure. This navigation application can also be used to coordinate and direct emergency responders.

- 3D simulation: The 3D data from the oblique cameras can be used to generate a perfect 3D model of the area being processed with Skyline's Photomesh. Using Skyline's TerraExplorer software helps to perform analytics in the surface model, e.g. visual line of sight of the observation towers and optimized UAV flights to detect seats of fires. Using different AI modules, the 3D model also allows simulation of wildfires to check whether the fires are visible from remote points like the observation towers, or from UAV flights at different heights and using different flight strategies.

Next steps

Currently, there are three observation towers available within the 170km² of forest studied in this research project. However, only one of them is equipped with a camera system, and that camera system is based on older technology. As a next step, an innovative gimbal-mounted camera array capturing RGB, NIR, AC and thermal data will be installed on two of the three towers. The gimbal will scan the area at 270 degrees, while the cameras will capture images with a 60% side overlap. The resulting data will be streamed via 5G to a central crisis management server and analysed using AI algorithms to detect wildfires. If a wildfire is detected, an alarm will be triggers and a UAV will be deployed to assess the situation. In combination with the observations from the other towers, the location of the fire can be easily calculated and verified.

Smaller areas can be monitored with UAVs equipped with RGB, NIR and red edge cameras. To enable a longer flight time, these drones only carry small-format compact cameras. After the alarm is raised, a single UAV will be deployed initially. In certain situations, a UAV swarm may be sent out to observe a larger area to check for additional fires. The data gathered – in combination with visual inspection of wind speed and direction – is crucial to determine the speed and direction of the spread of the fire. Streamed via the 5G network, the combination of all gathered data informs the strategy and deployment of the emergency services, while mitigating the risks to firefighters, settlements and infrastructure ■

For detailed insights, scan both QR codes.

▲ *3D model of the forest area during data processing using the Skyline software.*

▲ *Fire simulations to train AI modules.*

Rising tides: exploring the expanding horizons of bathymetric Lidar applications

By Anders Ekelund, vice president, Airborne Bathymetric Lidar at Hexagon Geosystems

In this article, we examine the evolving landscape of bathymetry with insights from Anders Ekelund, vice president of airborne bathymetric Lidar at Hexagon Geosystems. Beyond mapping seagrass, Ekelund unveils Lidar's pivotal role in addressing climate-driven challenges, from coastal management to flood prediction. Anticipating a shift towards full waveform data analysis, he emphasizes Hexagon's expertise in efficiently mapping shallow waters. Experience the precision of airborne Lidar, which is reshaping our comprehension of coastal and underwater environments.

How do you map a seagrass meadow?

An area the size of a football field of seagrass is estimated to disappear every half hour, with huge implications for the planet. The carbon storage potential of seagrass, which can store carbon in its roots several metres deep, is much more powerful than that of forests. Preserving this habitat is therefore essential for climate change mitigation. How do we know that a football field-sized area of seagrass is disappearing every half hour? The truth is that we don't. Mapping seagrass is complex, and to accurately assess how much of it is disappearing we must map it regularly.

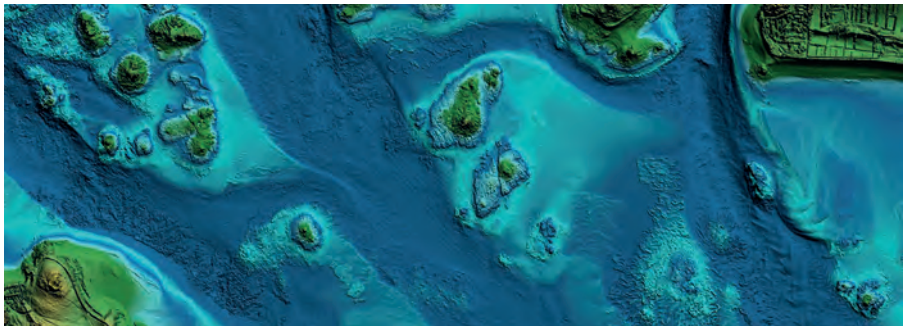
There is therefore an increased need for the systematic and accurate mapping of seagrass meadows, which will enable the development of sustainable business models, by tracking the disappearance and regrowth of vegetation that sequesters carbon into the seabed over time. Hexagon's sustainable investment subsidiary R-evolution has been working with the non-profit organization Beneath The Waves and the government of The Bahamas to create a scalable method for mapping seagrass meadows. Using Leica Geosystems' bathymetry solutions, they have produced multidimensional, intelligent maps to assess the density of the seagrass ecosystem and its carbon storage potential.

Climate change drives the need for bathymetry

Blue carbon (the carbon captured by the world's ocean and coastal ecosystems) is not the only space where bathymetry contributes to tackling urgent environmental challenges driven by climate change. Approximately 40% of the global population lives near the coast, so that coastal erosion, rising sea levels and natural disasters such as hurricanes, tsunamis and storm surges threaten many communities and populations. In fact, complete small island nations may disappear due to global sea-level rise. Bathymetric surveys are essential for optimizing urban developments, protecting new and existing infrastructure and for coastal resource utilization planning.

Inland too, bathymetric solutions are key for river mapping and flood simulations. Climate change forecasts predict a ninefold rise in the frequency and up to a 19% increase in the intensity of rainfall in Western Europe. Bathymetry data from riverbeds, combined with drainage models derived from topographic Lidar, helps develop advanced flood risk analyses and early flood warning systems from weather forecasts that will proactively safeguard communities and critical infrastructure.

Some countries are responding to the need for data-driven flood prediction and mitigation by employing bathymetry. In some regions, airborne topographic/bathymetric data solutions are integrated with boat-based multibeam solutions to form a seamless model from deep water to land. This integration facilitates advanced flood modelling solutions, and more countries are likely to adopt similar approaches in the future. ■



▲ *Airborne Lidar imagery captured with the Leica Chiroptera-5. (Image courtesy: Hexagon)*

Read the full article by scanning this QR-code.

The use of GNSS technology for heightened construction accuracy

Pioneering precision in Swedish skyscrapers

By Joël van Cranenbroeck, Belgium, and Kyla Gao, China

Towering at 246m, the Karlatornet will be Sweden's tallest skyscraper and is poised to redefine the skyline of the city of Gothenburg. Due to its impressive height, the construction work poses challenges of stability and precision. One key solution is the core wall control survey method, a pioneering technique ensuring the vertical alignment of high-rise buildings. With the revolutionary use of active GNSS control points, including the cutting-edge SinoGNSS T300 receiver, accuracy is being prioritized in this iconic structure, both during and after construction. This approach is setting new standards in the dynamic landscape of high-rise architecture.

The new 74-storey Karlatornet skyscraper holds symbolic importance in modern Swedish architecture and urban development. When completed, it will occupy an extensive footprint of 143,000m^2 and soar to an impressive height of 246m, creating a historic milestone as Gothenburg's inaugural skyscraper.

Its towering height presents construction challenges including stability, accuracy and safety. Tall buildings are susceptible to bending and swaying due to wind and loads, demanding precise alignment. Deviations from settling, shrinkage or tolerances pose structural risks. Even minor shifts can have significant consequences, underscoring the critical role of precision.

Elevating skyscrapers with the CWCS technique

The core wall control survey (CWCS) method represents an advanced technique designed to ensure the vertical alignment of high-rise buildings, particularly tailored for skyscraper construction ventures. Originally used during the construction of the Burj Khalifa in Dubai and subsequently applied in the construction of many high-rise buildings worldwide, this innovative system has now found successful application in the Karlatornet project at the request of the Swedish surveying company Teodoliten. Core walls emerge as pivotal components in the structural support of high-rise edifices and necessitate a layered construction approach, with each core wall element requiring multiple concrete pours.

▲ *Visualization of the Karlatornet skyscraper, seamlessly integrated into its surroundings.*

The mastery of CWCS lies in its ability to meticulously align the self-climbing formworks and therefore the core walls with the vertical axis of the building as they are gradually constructed. This precision is the bedrock of ensuring stability and accurate positioning. The CWCS method harmonizes a suite of sophisticated tools such as GNSS technology, total stations, inclinometers and more to deliver pinpoint precision and rigorous control during the construction of high-rise buildings. This, in turn, safeguards the structural integrity and safety of the building, particularly when addressing deformations caused by external factors such as wind loading, sunlight exposure and seismic activity.

What are active GNSS control points?

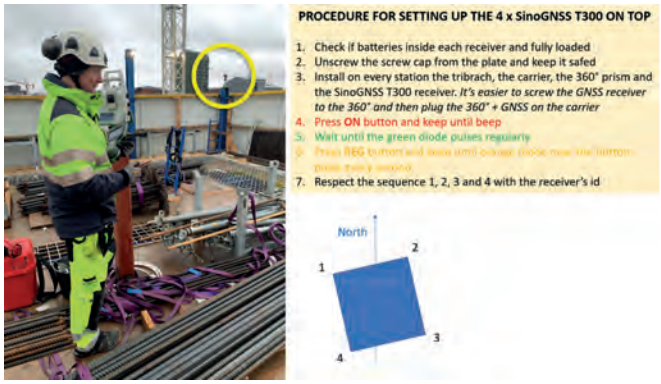
In the realm of high-rise construction, the continuous measurement of the positions of various elements at the summit of the building is a paramount requirement to

▲ *A total station operator sighting the four active GNSS control points to determine the coordinates of the instrument and the orientation of the primary axis.*

ensure rigorous vertical alignment. Active GNSS control points, an ingenious technology leveraging GNSS, actively governs the building's positioning. Conventionally, four GNSS receivers each with a 360° prism screwed at the bottom are strategically placed atop the building to supply three-dimensional coordinate data for setting up the total station.

Furthermore, a reference station is established nearby to record its observations for use in post-processing calculations, thereby guaranteeing final high-precision coordinates for the 360° prism co-located with each GNSS receiver. The total station operator can sight the four active GNSS control points and determine the coordinates of the instrument and the orientation of the primary axis.

▲ *Typical setup of an active GNSS control point using the SinoGNSS T300.*



▲ *Procedure for setting up the four active GNSS control points.*

The advantages

Throughout the construction process of the Karlatornet, four SinoGNSS T300 units serve as active GNSS control points, strategically positioned on the top platform of the building and providing comprehensive 3D coordinate data for the total station. A fifth unit is designated as the base station. Active GNSS control points boast a distinctive advantage as they offer an effective positioning method at high-rise construction sites without the necessity for an extensive array of ground control points that are often not visible from the top. This revolutionary technology empowers surveyors with amplified flexibility in their operations, all the while ensuring the vertical stability and accuracy of the building, ultimately mitigating measurement errors. Another advantage compared with the use of vertical laser plummets is that it is not necessary to have holes in the slabs and to keep those openings free from obstructions.

Furthermore, the adoption of the post-processed kinematic (PPK) mode represents a pivotal leap towards achieving unprecedented precision across various domains. PPK harnesses state-of-the-art technology and algorithms to augment positioning accuracy and refine data collection. By processing and analysing GNSS data subsequent to its acquisition, PPK mode diligently filters errors, yielding highly reliable and very accurate results. The coordinate accuracy obtained is within a few millimetres.

GNSS-RTK technology can also be harnessed for the post- construction deformation monitoring of high-rise structures

Since the platform on top of any high-rise building moves under the various loads applied on the structure, the coordinates provided by the active GNSS control points must be corrected by the deflection of the building main axis. That is the reason to use the dual-axis inclinometers that are sequentially placed along the core walls. These high-precision devices output the tilt value of any displacement in X and Y in the building reference coordinate system. By using a rigorous least squares adjustment and knowing the floor height where these devices are placed, it is possible to derive the corrections in dX and dY that must be applied to the active GNSS control points to fit with the design coordinates where the self-climbing formworks are positioned.

Post-construction deformation monitoring

GNSS-RTK technology can also be harnessed for the post-

COMPARISON OF 4 x ACTIVE GNSS CONTROL POINTS SESSIONS

POINT	DATE and TIME	X Easting	Y Northing	H	X Mean	Y Mean	H Mean	ΔX	ΔY	ΔH
GNSS_1	11/29/2019 11:04:30	146371.658	6398972.209	13.534	146371.659	6398972.208	13.535	-0.001	0.001	-0.001
GNSS_2	11/29/2019 10:55:26	146386.917	6398977.945	13.552	146386.915	6398977.941	13.552	0.003	0.003	0.000
GNSS_3	11/29/2019 10:59:06	146392.311	6398963.632	13.504	146392.310	6398963.630	13.504	0.001	0.002	0.000
GNSS_4	11/29/2019 11:02:31	146377.058	6398957.895	13.526	146377.058	6398957.893	13.527	0.000	0.000	0.000
GNSS_1	11/27/2019 10:41:12	146371.660	6398972.206	13.536				0.001	-0.003	0.001
GNSS_2	11/27/2019 10:47:12	146386.915	6398977.940	13.553				0.000	-0.001	0.001
GNSS_3	11/27/2019 10:47:27	146392.311	6398963.628	13.506				0.000	-0.002	0.003
GNSS_4	11/27/2019 10:49:12	146377.057	6398957.892	13.550				0.001	-0.003	0.004
GNSS_1	11/30/2019 12:49:52	146371.659	6398971.209	13.535				0.000	0.000	-0.002
GNSS_2	11/30/2019 12:55:28	146386.914	6398977.959	13.548				-0.001	-0.001	-0.005
GNSS_3	11/30/2019 12:58:00	146392.310	6398963.629	13.502				-0.001	-0.001	-0.002
GNSS_4	11/30/2019 12:57:44	146377.058	6398957.894	13.524				-0.002	0.001	-0.002
GNSS_1	11/30/2019 16:00:31	146371.658	6398972.209	13.537				0.000	0.001	0.001
GNSS_2	11/30/2019 16:05:48	146386.915	6398977.941	13.553				-0.002	0.000	0.001
GNSS_3	11/30/2019 16:03:42	146392.310	6398963.632	13.505				0.000	0.001	0.001
GNSS_4	11/30/2019 16:01:17	146377.056	6398957.894	13.526				-0.001	0.001	-0.001
								ΔX	ΔY	ΔH
								0.003	0.003	0.004
								-0.002	-0.003	-0.005
								0.000	0.000	0.000
								0.001	0.002	0.002

▲ *Typical results obtained by four sessions using active GNSS control points.*

▲ *Active GNSS control points with the SinoGNSS T300.*

construction deformation monitoring of high-rise structures. This crucial monitoring endeavour is designed to assess and document any potential deformations or alterations in shape that may manifest after the construction phase. Such deformations may stem from various factors, including (but not limited to) wind loading, exposure to sunlight, fluctuations in temperature, settling of the foundation and seismic activity. Monitoring these deformations stands as a linchpin for ensuring the structural integrity and safety of the building.

This assumes even greater significance in the context of high-rise structures that are inherently more susceptible to external influences. The SinoGNSS T300 receiver could play an instrumental part in deformation monitoring in the Karlatornet once construction work has been completed, thanks to its advanced RF and baseband chips, complemented by a unique Quantum-RTK algorithm. The receiver also delivers comprehensive support for multiple satellite constellation systems, effectively surmounting the constraints of traditional RTK methodologies in terms of continuity, accuracy, efficiency, availability and reliability.

The future of high-rise buildings

As the Karlatornet project hurtles towards completion, it stands as an unequivocal testament to the inherent potential of modern construction methods and technologies. This significant project underscores the groundbreaking capabilities of GNSS technology in the realm of high-rise construction. As GNSS technology continues on its evolutionary journey in tandem with innovative measurement methodologies, it paves the way for an array of forthcoming milestones and pioneering advancements in the realm of high-rise construction projects. These towering marvels will persist in shaping city skylines as evidence of the relentless progression of modern architectural and engineering technologies, in which surveyors are playing a key role. ■

▲ *Cezary Modzelewski, a surveying engineer and temporary worker of the Teodoliten team.*

About the authors

Joël van Cranenbroeck is a geodesist, founder of CGEOS Creative Geosensing SRL and scientific advisor at the University of Liège, Belgium. He has extensive experience at institutions like the National Geographical Institute and Leica Geosystems, and is former vice-chair of Commission 6 of the International Federation of Surveyors (FIG). He holds two patents, including for the CWCS technique which he invented during the construction of the Burj Khalifa in Dubai.

Kyla Gao is a key contributor in e-commerce operations at ComNav Technology, a company specialized in the development and manufacturing of GNSS OEM boards, receivers and solutions for high-precision positioning applications worldwide. Her commitment lies in elevating the company's digital footprint, ensuring optimal customer satisfaction and fostering the exceptional performance of the company in the GNSS industry.

The appointed chair of the network, Dan Roman from the USA, presented the proposal for a new regional capacity development network in the Americas region to the General Assembly in Orlando, Florida, on 1 June 2023.

FIG establishes third regional capacity development network

The FIG regional capacity development network idea stems from the FIG Africa Task Force 2009-2014 that delivered a clear direction for African member associations to actively increase their presence in FIG. This resulted in the establishment of the first Regional Network in Africa (ARN) in 2015. The current FIG president, Diane Dumashie, chaired first the Task Force and thereafter the first term as a network.

Vision of ARN

According to the current chair, Mohammed Mamman Kabir from Nigeria, ARN's vision for 2030 is for African land professionals to provide global thought leadership and promote professional leadership qualities amongst its members within their associations.

From 21-23 November 2023, the chair organized the First High-Level Forum Meeting of Presidents of Land Associations in Africa, held as a pre-event to the Fifth Conference on Land Policy in Africa (CLPA) which was organized by Africa Union. The aim was to address capacity development challenges facing African land professionals in their tasks of ensuring that land information in Africa is not only comprehensive, timely and integrated, but also demand-driven and delivered in a form and manner that it can be used in decision-making while involving minimal cost and effort at all levels of African societies. This objective is in tandem with the mission of FIG-ARN and supports the Africa Union towards attainment of Agenda 2063: The Africa We Want.

Why regional capacity development networks?

FIG's idea is to have a global network operationalized on a regional basis. The advantages of regional network platforms are:

- The concept can readily be seen as a template and adopted by groups of land professionals in other world regions
- It becomes an identifiable entity in the minds of public and civic institutions and can more clearly be engaged
- It will deliver a high-profile activity that contributes to the FIG corporate brand by maintaining meaningful links into the work activities of strategic donor partners and their associated international mandates
- It can increase the presence and involvement of young surveyors, drawing upon the Young Surveyors Network as key partners.

Asia Pacific (AP-CDN)

The Asia Pacific Regional Capacity Development Network (AP-CDN) was formed in 2016 in response to the FIG Pacific Small Island Development Symposium (SIDS) Suva Statement on spatially responsible governance, held in Fiji in September 2013. The activities of FIG AP CDN are focused on:

- Addressing the technical geodetic and geospatial challenges
- Advocating how geospatial and geodetic information can influence the socioeconomic issues being faced today.

The mission is to ensure that geospatial and geodetic professionals have the capability to modernize geospatial reference systems and to meet future challenges. The network has been chaired by Rob Sarib since its start and is currently undergoing a transition.

Americas regional network

The FIG Working Week 2023 was held in Florida, USA, engaging representatives from both North and South Africa and the Caribbean. It included a workshop and session that determined a real need and recommendation for an Americas CDN to develop capacity in the Caribbean as well as South and Central America. The organizers encouraged the FIG Council and General Assembly to establish this new Americas network. The overarching mandate of the Americas region will be "to develop workshops to build the capacity of land professionals to enable them to effectively embrace current global trends in their respective region", together with relevant partners. The Americas CDN spans all of the Americas and will need foci in subregions that conform to the broader linguistic and cultural groupings. This will facilitate interaction inside each subregion to maximum potential. However, coordination must exist between the subregions as a part of the broader regional CDN activity. Many issues in each subregion will require coordination across the boundaries. Fortunately, regional activities and meetings are already in place that facilitate communication between the subregions. ■

By Louise Friis-Hansen

More information:

https://www.fig.net/organisation/networks/capacity_development/index.asp

▲ *Screenshot of the EPOS Data Portal.*

EPOS-GNSS: data and products for the solid Earth community

The European Plate Observing System (EPOS) is an e-infrastructure that provides, through a unique portal, open access to standardized multidisciplinary data in support of solid Earth science with the goal to advance the understanding of the complex Earth's dynamic system. EPOS is organized in thematic core services (TCSs), such as the TCS Seismology, TCS Geomagnetism or the TCS GNSS Data and Products (also called EPOS-GNSS). Each TCS ensures the contribution of their specific community to EPOS.

Four community portals

EPOS-GNSS coordinates the distribution of quality-controlled GNSS data, metadata and data products to the EPOS data portal through four dedicated community portals:

1. The GNSS Data Gateway, providing access to daily RINEX data of more than 1,600 permanently tracking GNSS stations distributed throughout Europe and neighbouring regions.
2. The GNSS Products Portal, providing access to accurate station positions, position time series, velocities and strain rate fields in Europe.
3. The GNSS station metadata portal, providing access to GNSS station site logs, data access conditions and Digital Object Identifier (DOI), with the aim to evolve towards findable, accessible, interoperable and reusable (FAIR) data management.
4. The GNSS data quality monitoring portal, providing information on the availability and data quality of all GNSS data distributed through the GNSS Data Gateway.

Dedicated software package

EPOS-GNSS has developed GLASS, a dedicated software package serving as the backend for the dissemination of the GNSS data and products, supporting the workflows between the data nodes (most RINEX data is kept at local/national repositories), the dedicated analysis centres (to compute the various products) and the EPOS-GNSS portals.

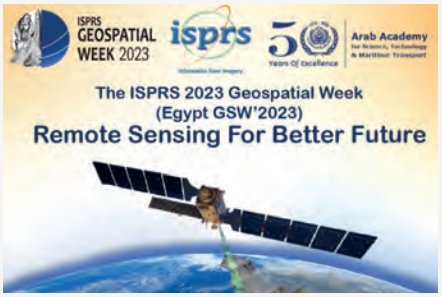
The EPOS-GNSS efforts are done in close partnership with the geodetic GNSS community represented by the IAG sub-commission for the European Reference Frame (EUREF).

The ultimate goal of the GNSS TCS is to provide access to all publicly available GNSS data at the European level (including high-rate data in the near future) and to generate accurate scientific products based on this larger number of stations to foster open science and progress in Earth science. ■

More information

EPOS: https://www.epos-eu.org
EPOS-GNSS: https://gnss-epos.eu

▲ *The ISPRS president with the students from AAST who served on the LOC.*



Looking back on the ISPRS Geospatial Week 2023

On behalf of the Arab Academy for Science, Technology and Maritime Transport (AASTMT), it was a great honour to host the International Society for Photogrammetry and Remote Sensing (ISPRS) Geospatial Week 2023 (GSW'2023) at the Semiramis Cairo Hotel, on the magnificent River Nile, with the theme of 'Remote sensing for a better future'. As the first ISPRS Geospatial Week to be held in Africa and the Middle East, the conference was chaired by Professor Naser El-Sheimy and Professor Ismail Abdelgafhar as the honorary chair and host of the conference, under the auspices of H.E. Professor Mostafa Madbouly, Prime Minister of the Arab Republic of Egypt. The event was the culmination of 18 months of hard work from many committees, including an international scientific committee of over 80 scientists from all over the world, and close to 40 local organizing committee (LOC) members from AAST, chaired by Professor Alaa Abdel Barry.

Conference highlights

The conference programme included:

- 4 tutorials (on UAVs, sensor fusion, geospatial in public health, and deep learning in remote sensing) given by the best specialists in the field. Approximately 200 attendees (plus 50 students who were offered free registration) joined these four tutorials.
- 15 exciting keynote and plenary presentations from leaders in geospatial technologies.
- 25 major industries in the fields of remote sensing, mapping, navigation, geospatial technologies and GNSS.
- 3 space agencies (from Taiwan, UAE and Egypt).
- 2 major mapping agencies (from Egypt and Saudi Arabia).
- 29 workshops divided into 100 sessions which included over 650 presentations and posters. The 29 workshops included the state-of-the-art and future trends in geospatial technologies and their applications in many industries and economic sectors.

Awards

The conference also witnessed the announcement of many awards, including the ISPRS TIF awards, best paper awards and best presentation awards. Moreover, Professor Chen Jun was presented with ISPRS Honorary Membership, Professor Kohei Cho received the ISPRS Fellowship, and the ISPRS Brock Gold Medal Award was presented to Professor Deren Li.

This rich programme enabled the participants to remain at the state-of-the-art on the current trends in geospatial science, technology and business, and also gave them the opportunity to meet and network with a very large number of experts and to cross-fertilize ideas with colleagues from neighbouring fields. Additionally, the conference provided a platform for international scholars, graduate students, future scientists and representatives from industry to learn and exchange knowledge and experience in the application of up-to-date geospatial technologies for sustainable development.

Vibrant and fascinating Egypt

The GSW'2023 Conference was not only about science, but also about Egypt – a vibrant, fascinating and welcoming country where, most probably, the first geospatial mapping systems were developed thousands of years ago! The dazzling capital Cairo is home to some of the best Pharaonic, Coptic and Islamic sights in Egypt, including the mystifying pyramids, the vast sand dunes of the deserts, the oasis and the River Nile with countless temples and tombs along its banks. Most of the attendees visited some of Cairo's architectural and cultural treasures, and the GSW'2023 organizers arranged two social events: a dinner and show in the Nile Crystal Cruising Restaurant, and a dinner and show at the Citadel of Cairo. We are happy that the attendees enjoyed the ISPRS Geospatial Week and could bask in Egypt's warmth and thousands of years of civilization. ■

By Professor Naser El-Sheimy, PEng, CRC, FCAE, FION
ISPRS GSW'2023 conference director

▲ *ISPRS President Professor Lena Halounova, GSW'2023 Director Professor Naser El-Sheimy and Chair of the LOC Professor Alaa Abdelbarry, with the recipients of the Best Paper Awards.*

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