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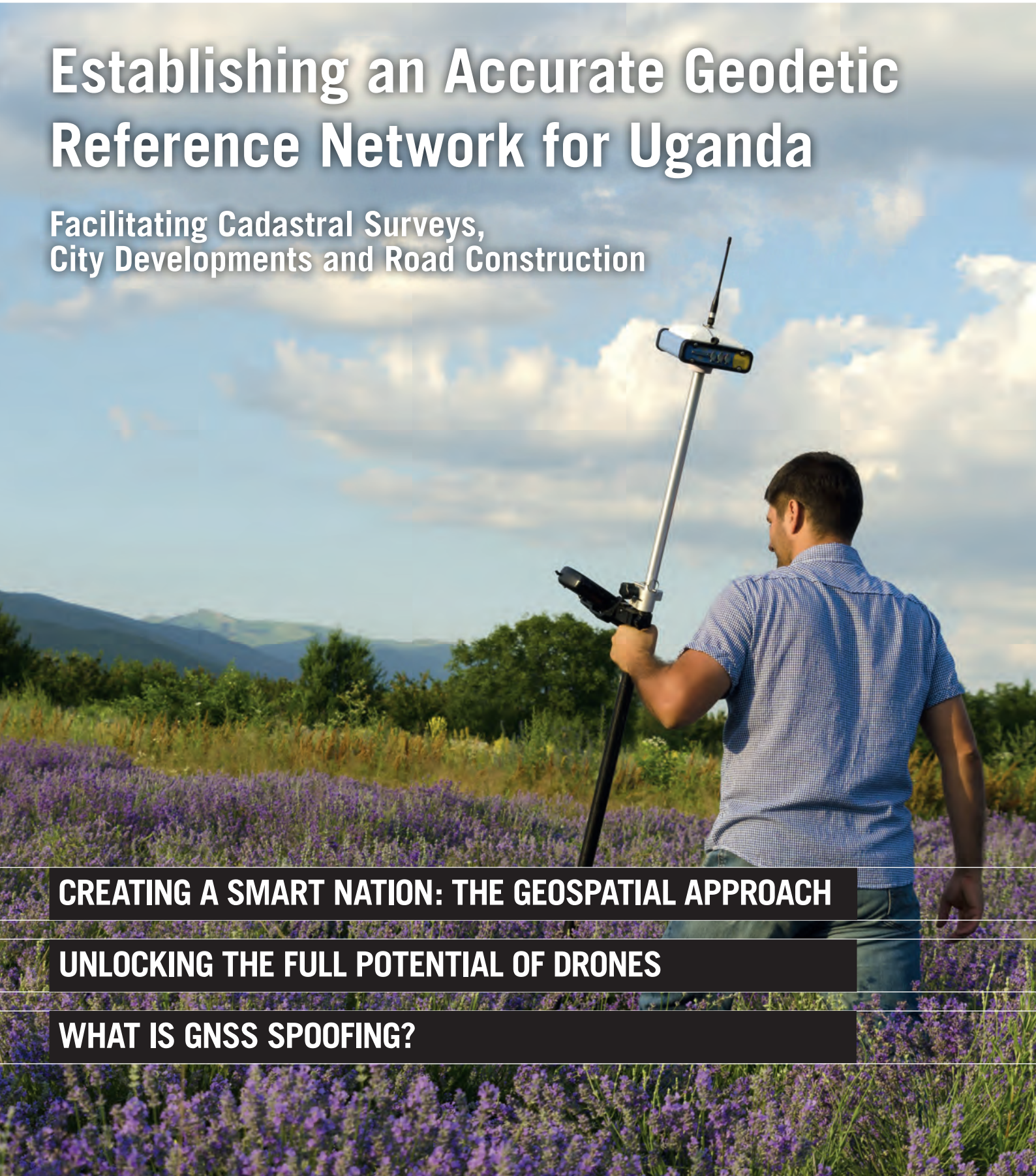
Establishing an Accurate Geodetic Reference Network for Uganda

Facilitating Cadastral Surveys, City Developments and Road Construction



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WHAT IS GNSS SPOOFING?

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COVER STORY

The front cover of this issue of *GIM International* shows a familiar scene: a land surveyor using a GNSS receiver. The user group of GNSS systems and data is growing larger by the day. Several articles in this edition are aimed at supporting a better understanding and more effective operation of satellite navigation equipment. (Image courtesy: Shutterstock)

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Signal disruptions

GNSS… it's almost impossible to run a modern geo-related business without it. Whether in navigation, surveying or even agriculture, countless activities almost entirely depend on GNSS. But what if a problem should occur? As long ago as 2001, the US Volpe report warned users about the potential impact of GNSS issues.

For many years, the eLoran system – the updated version of Loran-C – was suggested as the best alternative to GNSS. And maybe it is… or rather was, since governments around the world have increasingly lost faith in it since Barack Obama declared Loran obsolete for the USA in 2009. European governments stopped providing funding and retired their eLoran programmes around 2016. As a result, GNSS is now Europe's only navigation system – if you accept that four strictly separate systems utilizing the same technology and frequency bands can be considered a single system, that is.

So what is all the fuss about? Well, ever since the start of GPS, the system has been easy to disrupt. One type of disruption are the outages experienced due to the increase in magnetic activity during a solar storm, causing GNSS signals to become unstable or lost. However, most disruptions are man-made. It all started with the Americans themselves who decided to degrade the signals using selective availability (SA). In 2000, when Bill Clinton discontinued SA and promised never to turn it back on, selective deniability was stressed as a potential option to deny GPS signals over a certain area – so in effect a 'controlled' disruption.

But governments are not the only ones who can disrupt GNSS services. Every 'hacker' has a number of options within easy reach. The simplest form, jamming, locally blocks out all signals for specific frequencies, and even a very small transmitter can be enough to deny GNSS access over a substantial area. This is possible because satellite signals are weaker than not only other signals in general but also than the background 'noise'. On the bright side, because jamming means that everything suddenly stops working, at least it's immediately obvious that there's an issue.

Spoofing is a much more sophisticated form of disruption involving the transmission of false ('spoofed') signals that appear to be genuine ones. Since the spoofed signals are stronger, they 'overrule' the original satellite signal. Receivers locking on to these signals can be fooled into thinking they are elsewhere. This technique is relatively easy to implement yet much harder to detect. And as you can read elsewhere in this edition, even some gamers have started using this technology so that they can stay in the comfort of their own homes rather than having to go outside.

Over the years, both jamming and spoofing have become ever-more serious problems for serious applications. Most gamers probably aren't even aware of the fact that their spoofing activities could disrupt satellite navigation systems in cars, for instance. Attentive drivers are likely to notice such a problem immediately, but what are the implications for autonomous driving? Do we have backup systems in place or is GNSS our sole means of positioning?

The good news is that the designers of GNSS and also the receiver manufacturers are aware of these issues. Solutions are being implemented in receivers themselves to enable them to discriminate between genuine and false signals. More importantly, new signal-related developments will allow receivers to authenticate that a signal is actually coming from a satellite rather than a hacker on the ground. This will help to prevent spoofing – at least until hackers find a new way of disrupting GNSS services…

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Fugro to Provide First Topographic Lidar Base Map for Island Nation of Palau

▲ *Fugro is providing new countrywide topographic mapping data for Palau, an island nation vulnerable to climate change.*

Fugro has been awarded a contract by the United Nations Development Programme (UNDP) to perform high-resolution topographic Lidar base mapping for the Republic of Palau. The new countrywide topography will establish an accurate baseline for climate resilience assessments, allowing Palau to create adaptation strategies that support economic and environmental sustainability. Located in the western Pacific Ocean and comprising 340 islands, Palau is recognized by the UN as a small developing island state (SIDS) whose remote location, low-lying landmasses and heavily populated coastlines make it especially vulnerable to the impacts of climate change. Fugro will acquire geodata for the project early this year using concurrent airborne topographic and bathymetric Lidar systems. This 'topobathy' approach will ensure accurate and seamless data collection over the entire 415km^2 project area, including nearshore and coastal areas.

▸ **https://bit.ly/2YYEwsj**

Creating 5,000 Digital Twin Apartments with UAV-captured Imagery

▲ *The imagery contains hundreds of thousands of high-resolution images that have been automatically processed into photorealistic and intelligent 3D models.*

In a Swedish project with Spotscale, photo-realistic and intelligent 3D models of over 5,000 apartments based on high-resolution drone imagery will enable Riksbyggen to inspect, measure and analyse the buildings more efficiently. The project spans over 50 different housing areas of varying sizes, totalling more than 600 buildings and amounting to over 5,000 apartments all over Sweden. The underlying imagery, captured by drones, contains hundreds of thousands of high-resolution images that have been automatically processed into photorealistic and intelligent 3D models. Through a cloud-based solution, Riksbyggen can inspect, measure and analyse the buildings in a completely new way, thanks to advanced machine learning and computer vision technology.

▸ **https://bit.ly/3rBQnZu**

HERE Unveils 3D City Models for Industries to Build Reality-based Applications

▲ *HERE Premier 3D Cities contains rich data layers and attributes that are aligned with physical geometry and terrain.*

HERE Technologies, a leading location data and technology platform, has released high-fidelity, 3D models of 75 city centres around the world to give software developers the geospatial data needed to build real-world visualizations of cities. HERE Premier 3D Cities enables last-mile delivery drivers to navigate dense cities with maps that highlight precise building dimensions and entry points along their delivery routes. For the entertainment industry, the 3D models provide the building blocks for virtual site visits and seamless computer-generated imagery integration. Meanwhile, telecommunications companies can optimize their buildouts of 5G networks in 3D, and urban planners and emergency responders can build digital twins for better land-use analysis and disaster-readiness simulations. HERE Premier 3D Cities contains rich data layers and attributes that are aligned with physical geometry and terrain. Each structure is indexed, addressable and accurate in terms of physical location, volume size, elevation and façade colour.

▸ **https://bit.ly/20nh6L9**

Bhupinder Singh Joins Magnasoft's Board of Directors

▲ *Bhupinder Singh.*

Magnasoft has strengthened its leadership team with a newly formed board of directors and welcomes Bhupinder Singh, former chief product officer at Bentley Systems, as its latest addition. Magnasoft is a leader in the realm of digital geospatial information and services with a presence across India, the UK and the USA. With his over 34 years of experience in the software product industry, Bhupinder Singh needs no introduction. His 26-year tenure at Bentley Systems has enabled the company to establish itself as a leading infrastructure engineering solutions provider at global level. Bentley Systems had a successful IPO in September 2020. Phaneesh Murthy, chairman & non-executive director at Magnasoft, commented: "I have known Bhupinder for a long time and it has been an absolute pleasure. He is a great friend! His addition to Magnasoft's board is an exciting step towards the journey of growth that we are envisioning. I am confident that his expertise will allow us to scale new heights and achieve exemplary outcomes."

▸ **https://bit.ly/3aMvwMq**

How to Scan Multiple Sites in a Single Day

Crew-B – a trio of young entrepreneurs – recently discovered the best tool to scan multiple sites in a single day. Their client, a European leader in the fitness market, is currently engaged in converting its gyms to 24-hour operation and required Crew-B to provide building information modelling (BIM) models that would support data administration and the rollout of multiple upgrades. Crew-B found that NavVis VLX – a new, wearable mapping device – provided the right balance between accuracy, speed and scale. The challenge in mapping an indoor space like a fitness gym, however, is that it is a GNSS-denied environment. Concrete, pipes and wiring can weaken or create obstructions for satellite signals for positioning, and without an absolute reference surveyors need another means of creating very reliable or accurate reference points indoors. Laser scanning devices can bridge this gap. When researching the market, the team were able to choose between devices capable of tying into measurement points projected into the GNSS-denied area, or a device featuring SLAM technologies. Either way, it becomes possible to create BIM models using high-quality data from point clouds generated with a laser scanning device – a process otherwise known as 'Scan to BIM'.

https://bit.ly/3rCOYnu

NavVis VLX has SLAM capabilities and can also tie into measurement points in GNSS-denied environments.

Lidar Point Clouds to Monitor Amsterdam's Bridges and Quay Walls

Fugro has begun a trial phase of its TotaLite and mobile laser scanning technology for the large-scale monitoring of bridges and quay walls in Amsterdam, the Netherlands. This forms part of the company's framework contract with the City of Amsterdam. Fugro began testing and validating its technology in Amsterdam in mid-December. Positive findings could result in more objects being monitored in a much shorter time compared to conventional survey methods. Hundreds of bridges and kilometres of quay walls in Amsterdam have reached the end of their structural lifespan and are often in a poor state of repair. The City of Amsterdam launched the 'Bridges and Quay Walls' programme in 2019 to investigate, monitor and repair 829 bridges and 205km of quay walls. Fugro has been involved from the outset, providing accurate and objective information using traditional survey measurement techniques based on tachymetry and levelling. Using these established methods, Fugro and two other service providers are currently measuring an average of 80 objects per month.

https://bit.ly/3rFqdoX

Fugro is monitoring hundreds of bridges and kilometres of quay walls in Amsterdam, some of which have reached the end of their structural lifespan.

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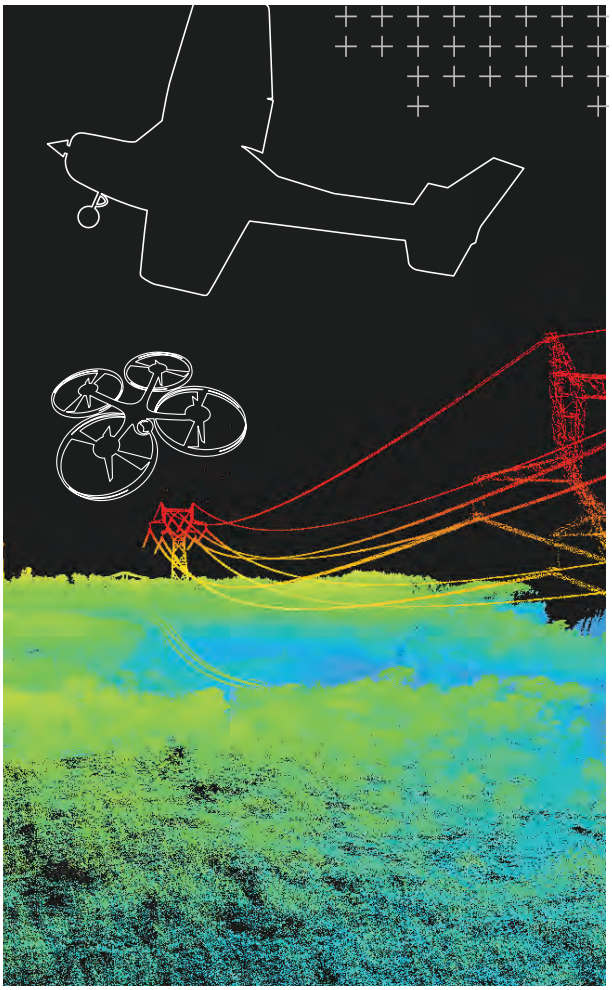

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senseFly Launches UAV for Surveyors and GIS Professionals

▲ *The eBee Geo UAV.*

senseFly has expanded its flagship eBee X UAV solution with the launch of eBee Geo, the first in a new series of fixed-wing mapping drones. eBee Geo is a cost-effective option for surveyors and GIS professionals who may be unfamiliar with fixed-wing drone mapping and data collection. With a maximum 45-minute flight time, the eBee Geo can achieve single-flight coverage of 160ha at 122m (395 acres at 400ft). This offers an ideal solution for smaller surveying firms and project-based drone service providers who are looking to upgrade their mapping capabilities while also meeting budget expectations. Operators across a range of verticals including construction, urban planning and land management can also benefit from the RGB imaging capabilities of the supplied senseFly SODA camera fixed payload, while achieving greater efficiency and absolute accuracy down to 2.5cm thanks to the eBee Geo's available real-time kinematic (RTK) function.

https://bit.ly/3jxaIBS

New Satnav Antenna Built for Ends of the Earth

A new ESA-supported wide-bandwidth satnav antenna has been designed to receive both satellite and augmentation signals from anywhere in the sky, even down to just a couple of degrees above the horizon. With a growing number of satnav constellations in operation, Canada-based Tallysman Wireless's new VeroStar antenna aims to pick up all available signals, as well as support the availability of L-band correction service signals. Its development was supported through ESA's Navigation Innovation and Support Program (NAVISP) programme. The precision of GNSS fixes is routinely sharpened with correction signals from augmentation systems, such as Europe's EGNOS and the US WAAS, which also provide ongoing integrity (or reliability) information for high-accuracy and safety-of-life uses, such as aircraft descents. However, these augmentation signals are transmitted by geostationary satellites, hanging at fixed points above the equator, meaning that they become less visible for receivers in the far north or south.

https://bit.ly/3tIZWYr

▲ *Outside testing of a pole-mounted VeroStar.*

Harxon Launches Smart Antennas Family

▲ *Harxon's senior product manager at the 'virtual' launch.*

Harxon has just launched its TS112 family of smart antennas, designed for demanding applications such as autosteering systems for agricultural machinery that require high positioning-accuracy solutions. The newly released TS112 family features Harxon's latest GNSS positioning technology and offers scalable positioning solutions with increased GNSS availability, reliability and accuracy. The TS112 family comprises three models, namely TS112 PRO, TS112, and TS112 SE. A Harxon X-Survey technology 4-in-1 multi-functional GNSS antenna is embedded in each family model which integrates 4G, Bluetooth and Wi-Fi in one compact unit. This high-gain and wide-beamwidth multi-constellation GNSS antenna features multi-point feeding technology, ensuring high phase centre stability and ultimate RTK centimetre-level positioning accuracy.

https://bit.ly/3cVHki8

Phase One Unveils Nadir and Oblique Aerial Camera System

▲ *Phase One PAS 880 nadir and oblique camera system.*

Phase One has unveiled the PAS 880, a fully integrated large-format nadir and oblique camera system for aerial mapping. The PAS 880 integrates a 280MP nadir camera with four oblique 150MP cameras into a single pod to simultaneously capture photogrammetric 2D and 3D digital imagery. "The outstanding image quality and accuracy combined with unsurpassed data collection rate make the PAS 880 the most productive large-format aerial mapping solution on the market today, based on established Phase One technology," said Dov Kalinski, vice president of geospatial business at Phase One. Operating at a capture rate of two frames per second, the PAS 880 covers extremely wide flight lines with 20,000 pixels across in nadir and 14,000 pixels in each of the oblique angles. The system can be operated at a variety of airspeeds, altitudes and lighting conditions for cost-effective blur-free image collection, with a maximum spatial resolution of 2.5 centimetres at 600 metres altitude. The combination of 90mm nadir and 150mm oblique camera lenses ensures balanced ground resolution.

https://bit.ly/3alyCRw

FACILITATING CADASTRAL SURVEYS, CITY DEVELOPMENTS AND ROAD CONSTRUCTION

Establishing an Accurate Geodetic Reference Network for Uganda

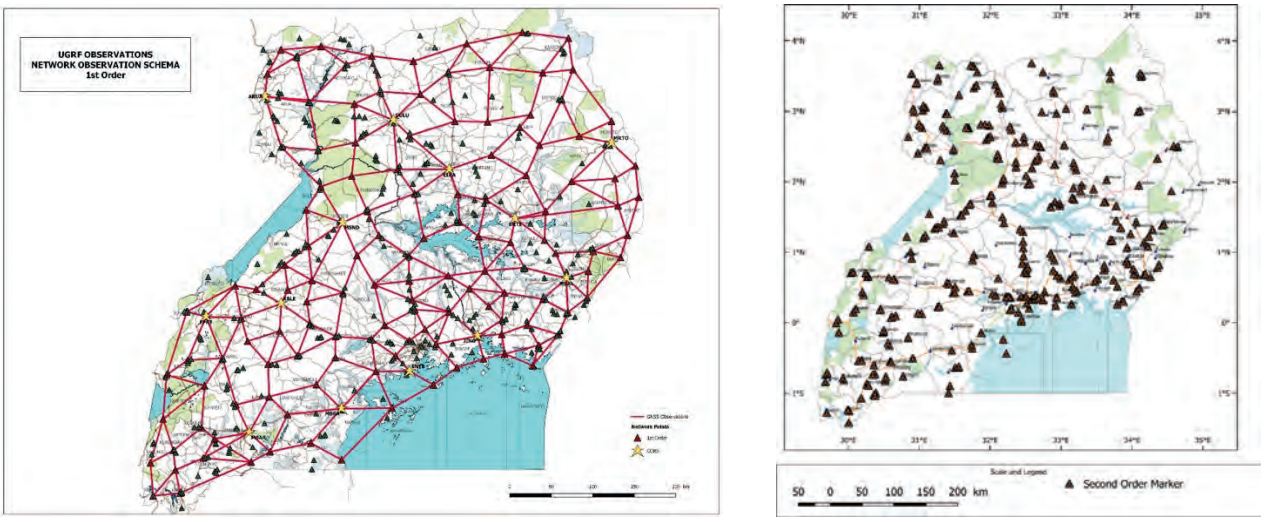
In line with the United Nations resolution to adopt a global geodetic reference network, the Government of Uganda received financing from the World Bank towards the cost of a competitiveness and enterprise development project. As part of this, Fugro was commissioned to design and implement a modern, reliable and accurate national geodetic reference network for the whole country, in addition to the deployment of a national CORS network.

Effective management of land resources is of vital importance to the Government of Uganda in order to support the country's development and reduce poverty. The improvement of the land administration system, directly linked to developing the agriculture, mining and construction sectors in Uganda, is one of the country's priorities. However, like many African countries, Uganda faces challenges in establishing the institutional and legal framework necessary for 'good land administration' and, consequently, lacks accurate and reliable land information, including up-to-date cadastral and topographic maps and orthorectified imagery.

TRANSFORMATION

The transformation of the land sector and the development of the Land Information System demonstrated a critical need for a modern geodetic network for improved reliability and accuracy of land registration information and services. Back in the 1960s, a horizontal geodetic control network was completed in Uganda using the triangulation method. It was referenced to the 1960 Arc datum and the Clarke 1880 ellipsoid, and comprised 1,730 geodetic control points and a levelling network consisting of 3,033 benchmarks (1972), all referenced to the New Khartoum vertical datum.

Over the following decades, most of the trigonometry points and levelling benchmarks were destroyed. Several independent updating campaigns created a complex database expressed in different datums and different epochs, resulting in a land administration system that was highly inaccurate and in desperate need of updating. A new system and network called the Uganda Geodetic



▲ *Figure 1: First and second orders of the new UGRF network.*

▲ *Figure 2: Reconnaissance teams travelled throughout Uganda.*

▲ *Figure 3: Construction teams set up geodetic monuments in accordance with HSSE best practices.*

Reference Network (UGRN), commissioned by the Government of Uganda, promised to be a game-changer for land surveyors from Uganda's public and private sectors because it would provide a rich new seam of reliable, accurate and easily accessible data to inform their land administration and land use planning work. The data would also be used for spatial data activities in construction and other economic sectors and for environmental protection work.

PHASE 1: NETWORK DESIGN AND RECONNAISSANCE

Fugro's 18-month project to update and implement the UGRN began in June 2017 with three months of fieldwork. During this initial phase, conditions were often challenging, typified by badly maintained roads, difficult terrain and poor access to remote areas and islands. The work involved reconnaissance fieldwork inspecting the existing trigonometry points and levelling benchmarks, plus a countrywide search for suitable sites for the new geodetic points. Of the 426 new and 106 existing network sites, only 50% were considered usable for datum transformation parameters computation.

To obtain community buy-in, control costs and ensure the longevity of the new system and network, the fieldwork was carried out by three Ugandan teams who were recruited, trained and supervised by an on-site Fugro expert. Occasionally, the team encountered resistance among local community members who could not see the long-term national economic benefits of the proposed work. To address this, Fugro employed four highly competent Ugandan sociologists who understood the social context and were on hand to intervene whenever required during the first three phases of the project.

For the field operations, Fugro developed a dedicated smartphone application to monitor the teams' progression. This application – optimized to cope with the challenging environment and poor communications network – supported health and safety and facilitated near real-time quality assurance and control. It proved more efficient, cost-effective and consistent than traditional paper-based methods and the local technicians became enthusiastic adopters of the new technology.

PHASE 2: MONUMENTATION OF GEODETIC BENCHMARKS

Phase 2 is typically underestimated when establishing geodetic networks, but it is generally the riskiest – not only for financial reasons due to the workforce and logistics involved, but also in terms of guaranteeing the quality and sustainability of the network. To reduce operational risk, Fugro selected several local organizations to carry out the monumentation of 426 geodetic markers during a six-month period. The work involved 45 people who, before starting monumentation, were provided with a detailed scope of work, methodology and rigorous training by an on-site Fugro expert. After a few weeks, the monumentation teams were managed remotely by the Fugro project team, based in France, using the online smartphone application.

PHASE 3: GNSS OBSERVATIONS

The GNSS observations took 50 field days and involved up to 42 workers with 426 new points (129 first-order markers and 297 second-order markers), 60 existing points and 993 baselines. Thanks to efficient preparation, real-time QA/QC and the dedication of all team members, resurveying took only two days, equivalent to just 4% of the total observation time. This result is particularly impressive given that there were 13 teams working in different locations throughout Uganda, and the observation constraint for all GNSS receivers to record data simultaneously.

A key part of this success was the selection and training of the Ugandan staff. The surveyors received two days of intensive training, which included health, safety, security & environment (HSSE) instructions, observation strategies, GNSS equipment methodology and the use of Fugro's smartphone application to communicate, navigate and complete the field numerical observation form. The field teams involved surveyors from the National Survey Department and three private land survey companies. This allowed knowledge sharing between Fugro and Ugandan surveyors' communities throughout the project.

PHASE 4: COMPUTATION AND ADJUSTMENT

For the final phase of the project, which took three months to complete, Fugro integrated additional GNSS observations from the newly built network of 12 continuously operating reference stations (CORS) using a dual-processing strategy; for the CORS network, calculations were performed in parallel with

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▲ *Figure 4: Training of field teams and GNSS observation of the network.*

Bernese and Gamit-Globk software and demonstrated a high level of consistency. The first-order and second-order networks were mainly computed using 'imbricated orders' methods, where each higher-order network is computed using the least square adjustments constrained to its lower-order network. This is controlled and validated by a 'full Bernese' approach involving the simultaneous processing and adjustment of all observations from zero to second order and constraining the global result to CORS network coordinates. The accuracy at 95% level of confidence is estimated at 1cm in horizontal and 2cm in vertical for the first order and 1cm in horizontal and 3cm in vertical for the second order.

The scope of work involved computing the transformation parameters between the UGRN and the historical triangulation network. To achieve this, Fugro used trigonometry points that were recovered and observed during the project to derive all possible types of geodetic transformations between reference and historical geodetic datums.

To make best use of the GNSS CORS network for non-cadastral applications, such as development of the country's civil engineering infrastructure, it was necessary to define an interim geoid model consistent with the vertical datums currently in use in Uganda. Contrary to the traditional approach, which consists of simply adjusting existing levelling benchmarks to EGM08 (the widely used global geoid model), Fugro used and slightly improved (using the residual Terrain Model) the EIGEN-6C4 global gravity model, best-fitted to levelling benchmarks that were recovered and observed during the project.

As well as the standard longitude and latitude information, Fugro's interim geoid model provides reliable height information from anywhere in Uganda. It is faster, cheaper and more accurate than traditional methods. However, the lack of gravity data across the country and existing levelling benchmarks mean that further field campaigns are necessary if Uganda is to have a state-of-the-art geoid model in the future.

TRADITIONAL GEODESY AND A NEW WAY OF WORKING

Establishing the UGRN was a huge and complicated undertaking that spanned the length and breadth of Uganda. Fugro delivered training at different stages of the project to help local technicians and surveyors derive maximum benefit from their involvement and increase their knowledge about the different products. This project was a perfect blend of traditional geodesy in challenging remote places and a new way of working. Advanced technologies for were used for field operations (smartphone application and direct payment of local surveyors) and processing (scientific software and cloud-based communication and computing) combined with stringent HSSE procedures to prevent any incidents.

The UGRN is a long-term, homogeneous, accurate and easy-to-use solution accessed via a dedicated website that allows local survey practitioners to perform complementary surveying work without the need for local adjustments. This approach is designed to maintain a high level of consistency in planimetry and height for Ugandan projects going forward, such as cadastral surveys, city developments and road construction. ◀

▲ *Figure 5: Description sheet of geodetic points.*

ABOUT THE AUTHORS

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HOW SPOOFING AFFECTS SURVEY AND MAPPING

What is GNSS Spoofing?

With spoofing attacks on the rise, survey-grade GNSS receivers need to be protected by interference mitigation technology utilizing the latest security techniques to ensure reliable positioning.

The survey and mapping industry has been benefiting for years from GPS/GNSS precise positioning technology. While GNSS spoofing is recognized as a real threat for unmanned aerial vehicles (UAVs or 'drones'), its influence on survey and mapping equipment is still underestimated. Reliable data capture is important across various mapping use cases, from man-based surveying and mobile mapping all the way to UAV photogrammetry. Ensuring dependable positioning requires the use of robust equipment, designed in such a way that alleviates all possible vulnerabilities. The use of GNSS receivers which are robust against jamming and spoofing is key to trustworthy data capture anytime, anywhere.

GPS/GNSS SPOOFING VS JAMMING

Both jamming and spoofing are a type of GNSS radio interference that happens when weak GNSS signals are overpowered by stronger radio signals on the same frequency. Jamming is a kind of 'white noise' interference, causing loss of accuracy and potentially loss of positioning. This type of interference can come from adjacent electronic devices or external sources such as radio amateurs in the area. Spoofing is an intelligent form of interference which fools the user into thinking that he/she is in a false location. During a spoofing attack, a radio transmitter located nearby sends fake GPS signals into the target receiver. For example, even a cheap software-defined radio (SDR) can make a smartphone believe it's on Mount Everest (see Figure 1)!

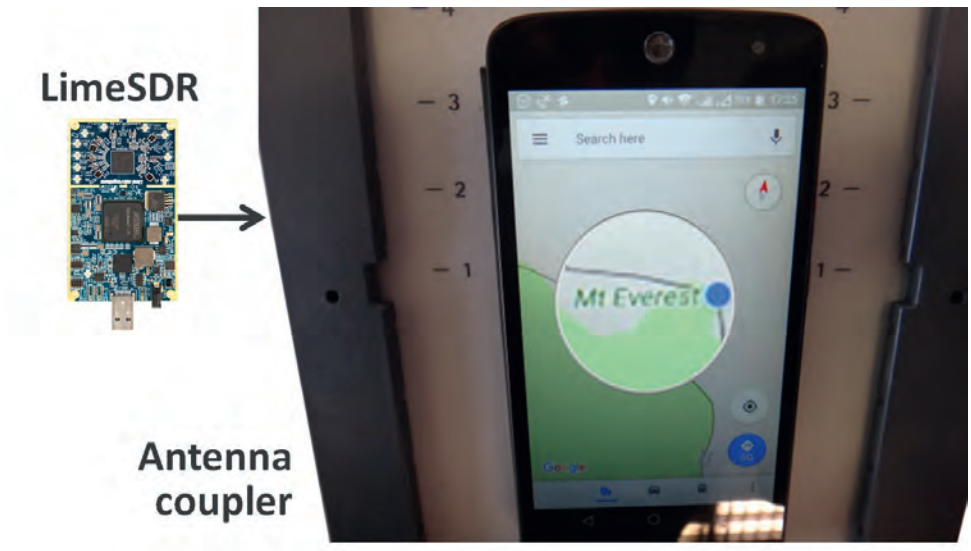
JAMMING AND SPOOFING PROTECTION IS NO LONGER A 'NICE TO HAVE' FEATURE BUT A CRITICAL COMPONENT OF A GNSS RECEIVER

GNSS users are experiencing ever-more cases of jamming, and spoofing events are on the rise too – especially in recent years since it has become easier and more affordable to create malicious spoofing systems. There are plenty of examples, from Finland – which experienced a week-long spoofing attack in 2019 – to China where multiple vessels have been the target of a spoofing attack. Hence, jamming and spoofing protection is no longer a 'nice to have' feature but a critical component of a GNSS receiver.

SPOOFING INCIDENTS ARE ON THE RISE

C4ADS, an NGO conducting data-driven analysis of conflict and security matters, concluded that Russia has been extensively using spoofing to divert aerial drones from entering airspace in the vicinity of governmental figures, airports and ports. And some of the most enthusiastic spoofers are fans of the augmented reality mobile game 'Pokémon Go', who use SDRs to spoof their GPS position and catch elusive Pokémon without having to leave their rooms.

Such attacks usually target a specific receiver. However, the spoofing transmission will



▲ *Figure 1: Even a cheap SDR can overpower GNSS signals and spoof a single-frequency smartphone GPS into believing it is on Mount Everest.*

▲ *Figure 2: GNSS spoofing could be used to manipulate movement of aerial drones.*

actually affect all GPS receivers in the vicinity. For example, an SDR can affect all GPS receivers within a 1km radius of the spoofing source, and the signal can be amplified for further propagation. This means that survey or mapping jobs in densely populated areas are at a higher risk of such 'indirect' spoofing attacks.

HOW TO SPOOF-PROOF A RECEIVER

A spoofer can either rebroadcast GNSS signals recorded at another place and time, or generate and transmit modified satellite signals. Therefore, to combat spoofing, GNSS receivers need to be able to distinguish spoofed signals from authentic signals. Once a satellite signal is flagged as spoofed, it can be excluded from positioning calculations.

▲ *Figure 3: European Galileo satellites provide an open authentication service on the E1 signal and a commercial authentication service on the E6 signal. (Image courtesy: the European Space Agency)*

There are various levels of spoofing protection that a receiver can offer. Using the analogy of a home intrusion detection system, it can be based on a simple entry alarm system or a more complex movement detection system. For added security, the home owner could decide to install video image recognition, breaking-glass sound detection or a combination of the above. An unprotected GNSS receiver is like a house with an unlocked door; it is vulnerable to even the simplest forms of spoofing. Secured receivers, on the other hand, can detect spoofing by looking for signal anomalies or by using signals designed to prevent spoofing, such as Galileo OSNMA and E6 or the GPS military code.

Advanced interference mitigation technologies, such as the Septentrio AIM+, use sophisticated signal-processing algorithms to mitigate jamming and flag spoofing. For spoofing detection, AIM+ checks for various anomalies in the GNSS signal, such as unusually high signal power. It also works together with RAIM+ integrity algorithms to ensure range (distance to satellite) validity by comparing range information from various satellites. AIM+ won't even be fooled by an advanced GNSS signal generator, Spirent GSS9000. Even with realistic power levels and actual navigation data within the signal, it can still identify it as a 'non-authentic' signal. Other advanced anti-spoofing techniques such as using a dual-polarized antenna are currently being researched.

UTILIZING FUTURE-PROOF GNSS RECEIVERS IN SURVEY, MAPPING AND UAV EQUIPMENT ENABLES INTEGRATORS TO REDUCE THEIR TIME TO MARKET WITH RESILIENT PRODUCTS

SATELLITE NAVIGATION DATA AUTHENTICATION

Various countries are investing in spoofing resilience by building security directly into their GNSS satellites. With Open Service Navigation Message Authentication (OSNMA), the European Galileo is the first satellite system to introduce an anti-spoofing service directly on a civil GNSS signal.

OSNMA is a free service on the Galileo E1 frequency that enables authentication of the navigation data on Galileo. Such navigation data carries information about satellite location and, if altered, will result in wrong receiver positioning computation. As a close partner of ESA, the European

GNSS manufacturer Septentrio has been contributing to the design and testing of the Galileo system since its inception. Today, as the OSNMA system is entering its testing phase, Septentrio receivers have successfully authenticated the first live OSNMA test signals. The US GPS system is also experimenting with satellite based anti-spoofing for civil users with its recent authentication system called Chimera.

ADVANCED INTERFERENCE MITIGATION TECHNOLOGY

OSNMA is a part of the puzzle comprising the AIM+ interference defence system. The anti-jamming component suppresses the widest variety of interferers, from simple, continuous narrow-band signals to the most complex, wideband and pulsed transmissions. The anti-spoofing component consists of signal anomaly detection, OSNMA, RAIM+ as well as other algorithms.

FUTURE-PROOF GNSS RECEIVERS

Interference mitigation technology such as AIM+ protects accurate positioning today. To ensure the best protection for tomorrow too, GNSS manufacturers are offering future-proof technology which allows users to take advantage of new GNSS security services like ONSMA and Chimera as soon as they become available. Utilizing future-proof GNSS receivers in survey, mapping and UAV equipment enables integrators to reduce their time to market with resilient products. Secured GNSS means trustworthy precise positioning and peace of mind for everyone who relies on this technology. ◂

FURTHER READING

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https://septentrio-my.sharepoint.com/:b:/p/marketing/EU99N82bWyZPsvd4Dp9g5IwBEwqQLgeT8i7wtW64TEk-tw?e=S0fGFD
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Maria Simsky is a technical writer in marketing and communication at Septentrio. She has an engineering background with in-depth experience of GNSS technologies and software. She is inspired by cutting-edge technology that helps to make the world a better place.
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WATER SUPPLY AND SEWERAGE NETWORK MANAGEMENT

How Real-time Monitoring Reduces Water Losses

At 6 bar pressure, a pipe with a 6mm hole will leak 1.8 cubic metres per hour, which equates to 1,300 cubic metres per month – and this is enough to fill an Olympic-size pool after less than two months. There could be numerous small, barely visible and hence difficult-to-detect holes across a network, resulting in substantial long-term water losses. This article explains how real-time monitoring can reduce those losses.

Non-revenue water (NRW) is a key factor in the effectiveness of water supply and sewerage (WSS) companies all over the world. The World Bank estimates the annual volume of NRW in developing countries at 26.7 billion cubic metres and losses of US$5.9 billion for the WSS companies.

BULGARIAN WSS COMPANY

The WSS company of the town of Targovishte in Bulgaria is aiming to minimize water losses and improve the network management. The first water capture for Targovishte dates back to 1898, and its water network was established in 1905. Today, the company provides services for about 111,000 consumers across 182 settlements in the Targovishte province. It employs 312 people, making it a mid-size WSS company in Bulgaria. Each year, about 13 million cubic metres of water are transported along its 2,000km network, including about 7 million cubic metres of NRW.

The specific WSS management challenges in Bulgaria are related to factors including the outdated infrastructure, lack of investment and changes in water consumption. Support teams are mostly engaged with repairs on existing – and usually visible – cracks, and activities are rarely subject to any more comprehensive planning. Registers are often stored only as Excel files and there is not usually a system for complete data management. Instead, information is stored randomly in different administrative units without procedures for exchange and quality control.

The lack of continuous logging devices is a nationwide problem. System input volumes (SIVs) of water are usually measured in-situ. The calculated water balances are based on unreliable and inaccurate data, and this makes network assessment and decision-making complex. Network mechanisms are also manually controlled, leading to additional damages.

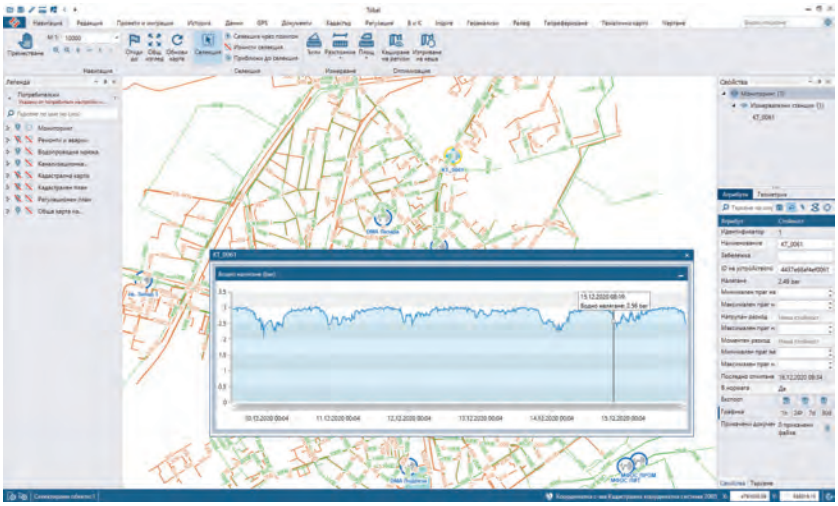
ELEMENTS OF SUSTAINABLE MANAGEMENT

Searching for, detecting and repairing leakages requires not only proper equipment for the field teams, but also accurate information. Such information is gained from data stored, processed and analysed in information systems. While some departments use specific tools and information systems like network registers, incident databases, customer information systems, etc., others compile annual water balance sheets or collect information on planned repairs. All of this information needs to be shared for a targeted use. It is however essential not only to use the data for the specific task, but also to keep it synchronized in order to keep maintain strong alignment between the different departments in a company. Such an approach supports early detection of leakages and optimal decision-making to deal with them. Therefore, the various information systems should not only to work together but also be integrated in a comprehensive GIS system.

TOBEL GIS SOLUTION

Targovishte is now working with a solution based on the Tobel GIS software from the Bulgarian company Mapex. The software uses a client-server architecture and is specifically developed for Bulgaria. It is available as a desktop, mobile and web application. As an initial step for the GIS integration in the workflow of the Targovishte WSS company, only the desktop application

▲ *Plan of the WSS network of the town of Targovishte on 12 July 1904.*



▲ *Water pressure in a station for the past week.*

– which works with a centralized database for information storage – has been used. It works with a centralized database for information storage.

The WSS database in Tobel is divided into three main categories: water supply network, sewerage network, and damages and repairs. The first two represent the variety of network assets (pipelines, pump stations, pressure controls, hydrants, etc.). For each of them, a relevant set of attributes is available consisting of common parameters such as year of construction and condition. Most attributes are asset-specific. For example, the attribute table for pipes also consists of inventory number, type, location, type of water, material, diameter, pressure, flow, depth, inspections, length, start and end points, and attached files.

An asset register is essential for a WSS in order to monitor its complex network. The best way to maintain an asset register for a water network is in a GIS environment where the network can be represented in a realistic spatial manner. The data from the asset register can be used to analyse the nightly water flow, calculate the water balance, perform hydraulic modelling, register damages in a database, register District Metered Areas (DMA) water consumption, and design the DMA and Pressure Management Areas (PMA) zones.

▲ *A DMA zone coloured blue indicates that the collected data is within the pre-defined norms.*

Although monitoring stations are an integral part of the WSS network, they are separated in an additional dataset in order to facilitate the integration of the variety of available sensors in general. This is appropriate as measurement stations differ from the regular asset information and have specific attributes. Their relation to the WSS network is set without changing the attributes of other features. As an example, a DMA zone turns to red if a value from a sensor within it passes any of the user-defined thresholds, and remains blue if it is within the norm.

REAL-TIME MONITORING AND REDUCTION OF WATER LOSSES

The availability of suitable, accurate and reliable metering devices in-situ is crucial for finding leakages and reducing water losses. There are three main methods for early warnings about new leakages and hence for effectively reducing the water losses. One method is based on continuous water flow monitoring in an open network or DMA zone, in which case increased levels of water flow indicate a possible leakage. Another method is pressure monitoring. High levels of water leakage increase the water flow and decrease the pressure. While small leakages do not have a significant impact, large ones can be detected in this way. Therefore, pressure data is used to prioritize detection activities; further analysis should start in zones with the lowest pressure levels.

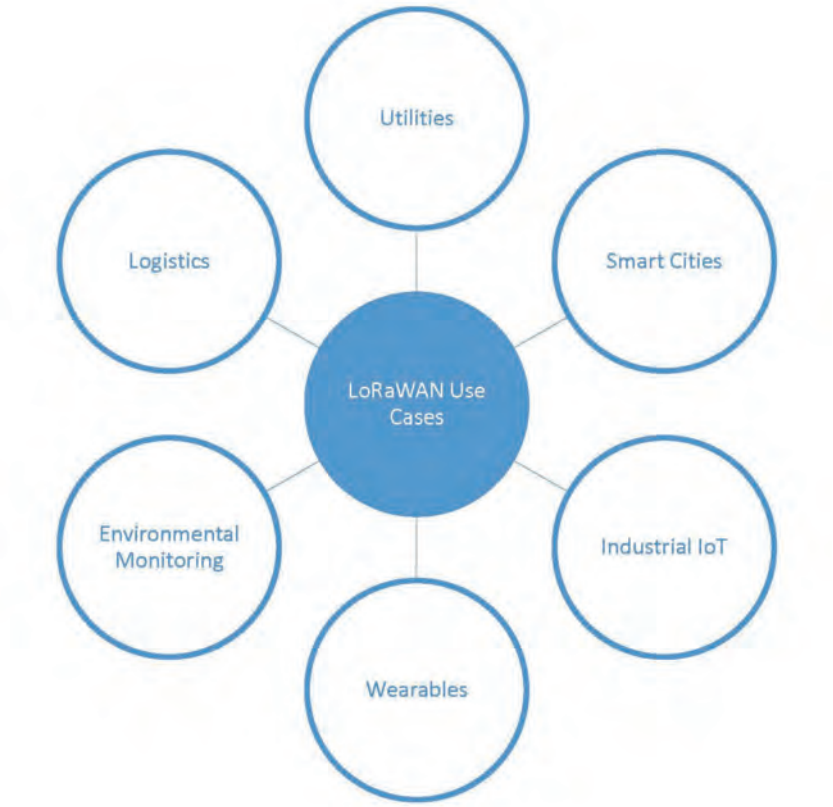
LORAWAN TECHNOLOGY IN METERING DEVICES

LoRaWAN is an open radio frequency protocol that allows devices to connect to the internet over a long range with low power consumption. With a long battery life of up to five years combined with reduced maintenance cost of the sensor network, LoRaWAN is an ideal technique for connecting metering devices to the internet. While power and internet connectivity are not usually an issue in big cities in Bulgaria, they can present a problem in smaller settlements and

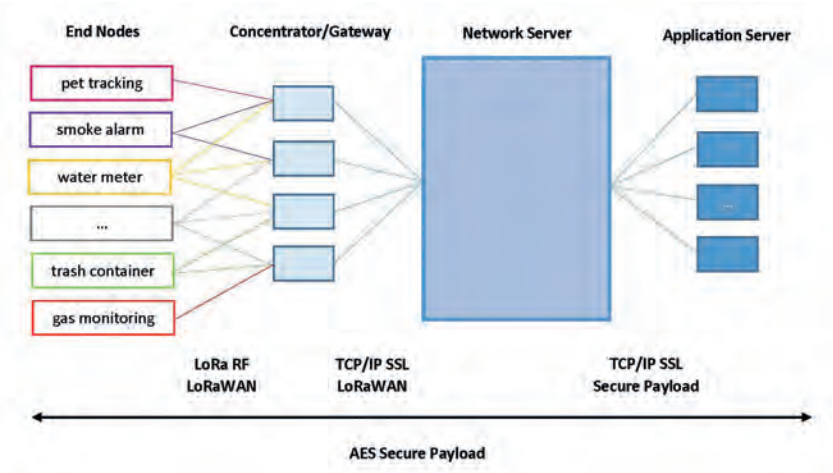
remote places where a WSS network is active. Currently there are seven LoRaWAN devices in use, all located in the town of Tragovishte. The devices have one or two analogue and one or two pulse inputs to collect resource consumption or event information from various types of analogue sensors and metering equipment. The sensors can record water pressure, water flow and water consumption and are currently set to record data every couple of minutes. This ensures continuous operation for approximately five years.

Each sensor is registered in Tobel with its location, sensor type, device type, ID and input, and coefficients. The collected raw data is stored and accessed via Tobel, using each sensor's ID to read its particular values and when those values were acquired (time and date). Depending on the sensor type, there can be some additional calculations. For example, the water flow can be calculated as a function of water consumption over a period of time.

The future plans for monitoring the WSS network, which includes five municipalities, would take full advantage of the LoRaWAN features and would eventually enable the network to be monitored with a minimum of technical support over time.



▲ *LoRaWAN use cases.*



▲ *The four main components of LoRaWAN architecture.*

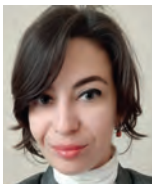
CONCLUDING REMARKS

The client-server geospatial solution presented here is a key instrument for keeping a comprehensive, accurate and up-to-date register, analysing past activities and planning for the future. But introducing the real-time monitoring takes WSS management to a whole new level. Having desktop access to current field data is crucial for timely response to leakages, and the visualization of indicators on a map will improve the search for and detection of leakages.

ACKNOWLEDGMENTS

The authors express their gratitude to the whole team that worked on developing this solution. ◀

ABOUT THE AUTHORS



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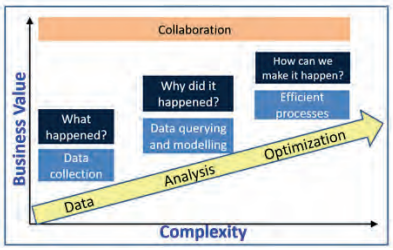
Creating a Smart Nation: The Geospatial Approach

The Fourth Industrial Revolution brings about new advancements and abilities in geospatial technologies. This article focuses on the use of these new technologies to support the creation of a smart nation in Israel. Specifically, the article is based around three questions: What is a smart nation? Why should governments get involved and invest in developing a smart environment for a smart nation? And what is the role of spatial data and technologies in a smart nation? These questions are answered and explained using five practical examples, including a recent one on minimizing the spread of COVID-19 using geospatial technologies.

Over the last century, the Third and Fourth Industrial Revolutions have transformed society into a knowledge-based society. Today, people and organizations are connected and surrounded by sensors and technologies that make daily operations more efficient and convenient (i.e. smarter). Driven by their citizens' needs, governments all over the globe are seeking to make their nations smarter.

It is often suggested that a smart nation functions according to the following formula: **collaboration + data + analysis = performance**.



▲ *Figure 1: The value of information technology increases as a function of the complexity and the extensiveness of data use (adapted from Gartner's analytics maturity model, 2016).*

Collaboration is the exchange of know-how, data and services which is happening between and across governmental entities, with local authorities, with businesses, with citizens and even with connected sensors (i.e. Internet of Things).

Data is collected using various methodologies (field surveys, remote sensing, data harvesting from operational systems, crowdsourcing, etc.) and in various formats (raster, vector, three-dimensional, unstructured text…). It should be readily accessible available for all interested parties.

Analysis transforms data into intelligence, providing tools for identifying uneven resource allocation, delivering an efficient operational plan, suggesting remedies for different problems, and predicting outcomes based on the given information. And **performance** improvement is the ultimate goal. Processes are becoming more efficient thanks to better coordination and better decision-making. This saves scarce resources and upgrades the standard of service to citizens.

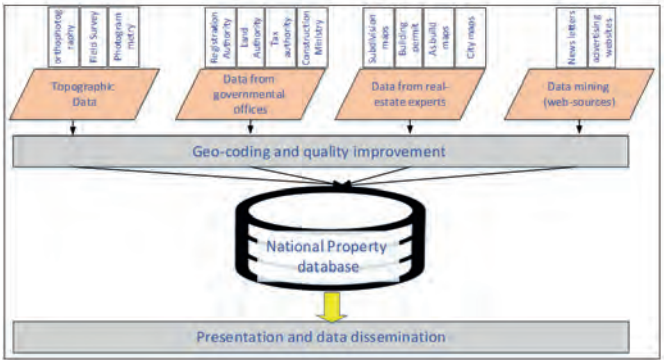
This formula corresponds to the graph in Figure 1 which shows that the best value from using information technologies is gained by optimizing processes and workflows using data analysis.

REAL ESTATE DATABASE CREATION

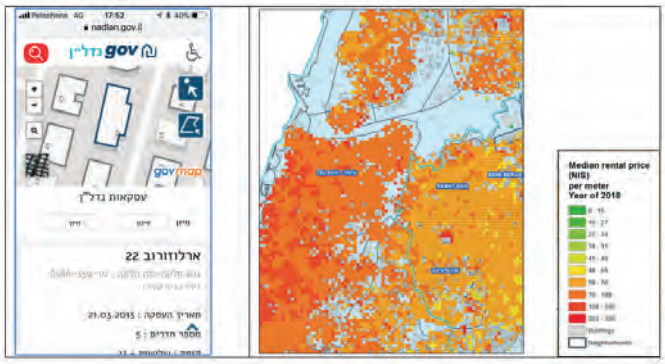
This principle is demonstrated by the example of the 'Real Estate Database Creation Project', which was initiated by the Israeli Government's Decision 374 in June 2013. It evolved from a massive public protest on the shortage of houses in Israel and the high rent prices. The project goals were twofold: 1) To reduce uncertainty in the housing market by publishing reliable and comprehensive information about properties and their prices in order to decrease speculation and burst the economic bubble, and 2) To improve collaboration among governmental agencies and expedite operations aimed at the creation of more housing units (thus increasing supply) by using geospatial technologies

The project has successfully accomplished its goals over the last six years. Firstly, a national real-estate database has been created. This database was integrated from four key resources (Figure 2):

1. Topographic data from the Survey of Israel's national spatial database, collected automatically as described in Keinan et al 2016.



▲ *Figure 2: The accumulation of data in the creation of the national property database.*



▲ *Figure 3: Real-estate data querying on a mobile device (left), and a heat map presenting rent prices in Tel-Aviv (right).*

2. Alpha-numeric governmental data collected from operational systems.
3. Expert sourcing data collected from maps produced as part of the construction process as described in Bekker and Felus 2019.
4. Web data that was harvested from internet resources such as online real-estate marketing agencies, advertisements, websites, newsletters, etc.

These data sources were integrated into a national real-estate database using the different location attributes (address, address synonyms, parcel numbers, place names, coordinates, etc.). Secondly, a geospatial portal was developed to present the data analysis in a user friendly interface through mobile and desktop devices (see Figure 3).

The 'Real Estate Database Creation Project' achieved its goal of providing data analysis for citizens, businesses and public entities so that they can make smarter decisions.

WHY GOVERNMENTS SHOULD LEAD SMART TECHNOLOGY EFFORTS

A smart nation is composed out of smart cities and smart rural areas. However, small towns and villages frequently lack the necessary knowledge and manpower to adopt advanced technologies and manage their area smartly. A situation in which small towns lag behind and provide poor services is unacceptable for a modern nation.

NATIONAL INFRASTRUCTURE INFORMATION HUB

To solve this problem in Israel, the Survey of Israel developed a basic set of IT components which will serve small towns and villages. This infrastructure should be modular enough so it can scale up with additional resources to fit large cities. The 'National Infrastructure Information Hub' project was initiated by the Israeli Government's Decision 1074 in January 2016. The project is aimed at using smart technologies in infrastructure development activities. It works on a national level as well as on a local level (i.e. in small towns and villages) and it includes all types of infrastructure: electrical power, water, drainage, sewerage, oil, fuel and gas, communication and transportation. The project was very successful and achieved the following milestones:

1. A strategy was developed by a national forum of infrastructure entities (governmental agencies, public organizations and private companies).
2. A national standard for infrastructure data exchange was approved. The standard includes all types of maps (planning, building permits, as-built…).
3. Data was acquired from all the infrastructure entities in Israel (government, public and private) – more than 80 organizations. This data has been improved and integrated into a unified national database.
4. The integrated database is now being disseminated to the infrastructure forum in a secure manner and according to the specific needs (area and layers).
5. A coordination system is being developed for the infrastructure activities which will include four steps as presented in Figure 4.

The success of the 'National Infrastructure Information Hub' project has encouraged the government to invest more resources into this effort and continue the development of smart spatial tools for infrastructure management.

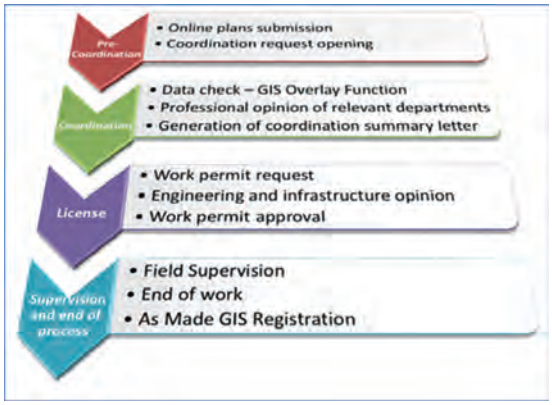
WHY A GIS PLAYS A CRITICAL ROLE IN SMART NATION ACTIVITIES

Location information is a key attribute that can link datasets from many governmental entities and of many fields of activities. The following examples demonstrate these geographic information system (GIS) functionalities as they are used to make governmental processes more efficient and smart. These examples were developed by the Survey of Israel in collaboration with the Israeli Inter-Ministerial Committee for GIS as modules in the Israeli geospatial portal (developed using ESRI software).

HOW TO PROMOTE SPORT AND A HEALTHY LIFESTYLE

A collaboration between the Ministry of Culture and Sport and the Survey of Israel has created a methodology for efficient management of the construction of 2,000 new sport facilities, thus promoting sport and a healthy lifestyle in Israel. The sports facilities have been built by local authorities with the financial support and approval of the Ministry of Culture and Sport.

A system was designed using the national geospatial portal with a spatial database that contains all the information about each sport facility (location, purpose of the facility, capacity in each activity, parking spaces, contact person, and even schedule of sport classes. The system is an efficient tool for sharing information about each sport facility and activity among government entities,



▲ *Figure 4: The flow of infrastructure coordination activities.*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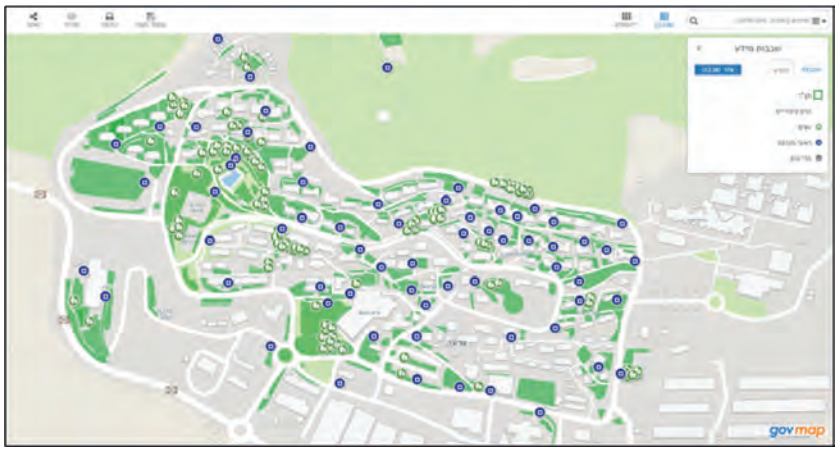


▲ *Figure 5: A map of green spaces in Tzora settlement, Israel.*

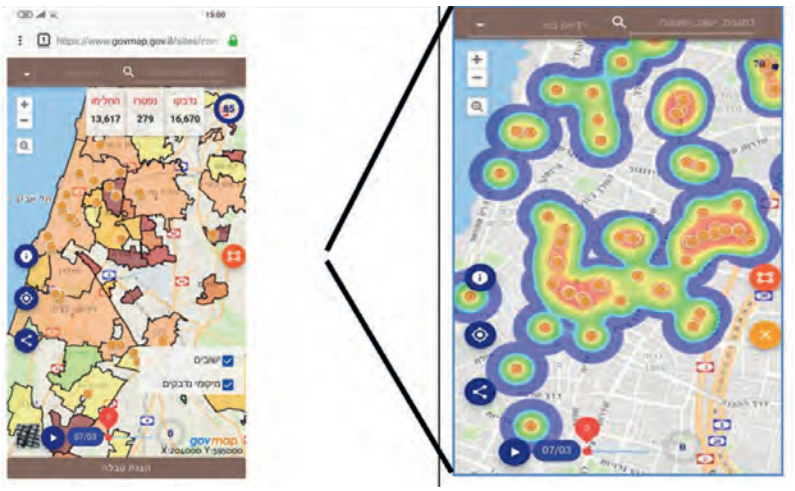
local authorities and citizens. Moreover, the system has smart tools to analyse the need for sport facilities according to demographic information. This analysis makes it easy to identify gaps (areas with a shortage of sport facilities based on the local population) or duplications and unneeded facilities.

HOW TO SUPPORT WATER CONSERVATION

In collaboration with the Water Authority, a new GIS module was developed to analyse water needs for green-space maintenance purposes. Each city and local authority use the module to map green spaces and their attributes (grass, flowers, trees) as shown in Figure 5. Based on the map, the estimated water consumption needs are calculated and approved. This allows each city and local authority to evaluate if water is utilized smartly and analyse whether there are any problems with the water network (pipeline leakage), whether there is a need to re-evaluate the maintenance plan, etc.

HOW TO MINIMIZE THE SPREAD OF CORONAVIRUS

Strong collaboration between the Ministry of Health, local authorities, police and the Survey of Israel has led to a number of smart spatial tools to assist in minimizing the spread of COVID-19. First is an online map of COVID-19 exposure locations (i.e. sites visited by infected people). This map was used by local authorities to disinfect the exposed areas and analyse the spread over time (see Figure 6). Second is an online choropleth map which show areas with a high concentration of people infected with COVID-19. In these areas, the police closely monitored places where people could gather (synagogues, churches, parks, sports facilities and so on) or even enforced a complete lockdown. Maps with all the information are being used by the police to manage the operation and set up road blocks. These tools were used successfully in the first wave of the COVID-19 outbreak and they are currently in daily use in the struggle to reduce the spread of the virus.



▲ *Figure 6: Online tools designed to assist in minimizing the spread of COVID-19. These show exposure locations with heat maps and areas with a high concentration of infected people overlaid on a city map.*

CONCLUSION

The ability to share knowledge, technology and data across all governmental organizations is critical to a smart nation. Geographic information systems provide the ideal platform to facilitate these collaborative activities. The examples above show the huge benefits when public bodies collaborate using GIS and spatial data. A smart nation needs smart tools to analyse the data streaming from multiple resources. This article has presented tools for data integration, for analytical calculations and for providing organizations with business intelligence. Lastly, the ultimate goal is to improve performance and make governmental processes more efficient and cost effective. The examples above show how geospatial technologies can enhance governmental operations, thus making a nation smart. ◀

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WHERE THE LADM AND LANDINFRA STANDARDS MEET

Interoperability Requires Sustainable Choices

The Land Administration Domain Model (LADM) is a conceptual standard developed by ISO. LandInfra is a conceptional standard with an encoding in GML (InfraGML) developed by the Open Geospatial Consortium (OGC). The two standards have partly complementary but also partly overlapping functionalities. Apart from InfraGML, there are several other implementation standards. This article is an attempt to re-open the debate on the development of standardization with future-proof choices in the domains of land surveying, land administration and infrastructure.

Land administration is by its very definition distributed among a host of different units. Efficient administration calls for the interoperability of information exchange, e.g. to implement the once-only principle of public information sharing. Usable standards reduce data exchange costs.

DISTRIBUTED RESPONSIBILITIES

Main land administration units include land registries and cadastres – linked to conveyors and surveyors, respectively. Improvement efforts may, roughly speaking, take two directions. The first is cooperation between institutions to achieve better services without changing the mandates, and the second is the merging of institutions – maybe with different professionals – under one umbrella. The latter has been known, but is often hampered by conflicting interests and traditions. The first direction is very feasible and has already been implemented in several countries under local standards. It allows a model for reaching out to other units of land administration – local government, environmental, infrastructure, spatial planning and taxation agencies – and utilities, as well as to the construction sector and the actors of the real estate market.

LADM OPERATIONALIZATION

The first edition of the LADM was published in 2012. Country profiles have been developed and are now being implemented in many countries, such as Colombia, Indonesia, Malaysia, Uganda and Scotland. LADM has been used quite widely and there are now about 30 countries known to be implementing or exploring the implementation of its parts (prototypes, etc.). However, LADM is just a generic conceptual model. Faster implementation also requires a methodology to develop country profiles and technical models (and the various implementations will continue to be quite diverse).The LADM has the functionality to distinguish the different institutions' tasks and mandates and to align them with each other, all on a conceptual level. The second multipart edition of LADM is presently being developed and the draft consists of the following: 1) fundamentals, 2) land registration, 3) marine space, 4) land valuation, and 5) spatial planning. This will likely be supplemented with 6) implementation, as the intention is that LADM Edition II will also include the encodings and technical models towards LADM implementation and operationalization (e.g. a further integration with BIM/IFC, Land XML, CityGML, LandInfra, IndoorGML, RDF/linked data or GeoJSON). This is quite a serious effort. But is all this really necessary? This is being discussed in joint meetings of the OGC Domain Working Groups on Land Administration and on Land and Infrastructure. Effectiveness and efficiency of land administration systems can be improved by optimizing the use of the open standards from ISO (LADM) and the OGC (LandInfra).

▲ *Figure 1: LandInfra is a connecting bridge between IFC and CityGML, but is conceptually, semantically and geometrically closer to CityGML. (Image courtesy: Kavisha Kumar, Anna Labetski, Ken Arroyo Ohori, Hugo Ledoux and Jantien Stoter).*

LANDXML

Throughout the entire life cycle of built assets, open standards are needed for civil engineering (e.g. road and rail), surveying of infrastructure and property boundaries, and facility and asset management. In the early 2000s, volunteer organizations and individuals contributed to the development of LandXML, an XML-based, open data model

Figure 2: LandInfra, CityGML and IFC differ but overlap in their thematic coverage. As an example, the concept of a building is common to all three. IFC is always subset into Model View Definitions (MVDs) for implementation, whereas the GML-based standards of CityGML and (the InfraGML implementation of) LandInfra can be subset optionally into profiles; for all three, the core of the schema must be implemented. Application Domain Extensions (ADEs) enable anyone to extend the CityGML standard to accommodate more specialist themes; such extensibility is also possible for the InfraGML implementation of LandInfra. The IFC extensions for domains are part of the buildingSMART governance process and therefore published as formal MVDs. (Image courtesy: OGC and buildingSMART International)

for representing civil engineering and survey measurement data via LandXML.org. As of 2009, over 70 registered software products supported LandXML. LandInfra has a rich and comprehensive functionality in support of land surveying, and its land administration functionality relates to parcels, buildings and condominiums.

LANDINFRA/INFRAGML

In the period from 2009-2013, no development of LandXML was observed. Moreover, the fact that it was not recognized as an official standard by any standards organizations such as OGC, Building Smart International (bSI) or ISO created confusion in the marketplace concerning the standard's future. Therefore, a fresh OGC standard was developed (LandInfra) based on a subset of LandXML functionality. It was supported by a UML conceptual model, and was released in 2016. The encoding of LandInfra (InfraGML) was released in 2017. Like LADM, InfraGML is published in parts: 0) LandInfra Core; 1) LandInfra LandFeatures; 2) LandInfra Facilities and Projects; 3) LandInfra Alignments; 4) LandInfra Roads; 5) LandInfra Railways; 6) LandInfra Survey; and 7) LandInfra LandDivision. LandInfra is new and not yet widely used. However, investigations explored whether LandInfra could act as a link between building information modelling (BIM) and GIS, informed by use cases on 3D cadastres, subsurface geological modelling, and surveying (see Figure 1). LandInfra/InfraGML is a suitable implementation model for LADM.

DEBATE

LandXML is in widespread use by a large user community. The bSI and OGC recently formed a joint working group for the Integrated Digital Built Environment (IDBE) to achieve better software interoperability and data integration in the geospatial and built-environment domains. By coordinating activities, they aim to stimulate the use of the new, international standards such as LandInfra to replace the existing ones such as LandXML. That working group recently released a discussion paper which stated, among other things, the need for a publicly available and shared vocabulary of terms used in the standards. For the domain of land administration, such a tool is available in the shape of the Cadastre and Land Administration Thesaurus (CaLAThe), the fourth version of which is hosted at the OGC Definitions Service. IFC and CityGML are also relevant from the LADM perspective, especially in the context of 3D cadastres (see Figure 2).

CONCLUDING REMARKS

The LandInfra/LADM alignment needs to be on the agendas of ISO/TC 211, where the second edition of LADM is being developed, and of the joint meetings of OGC's Domain Working Groups on Land Administration and on Land and Infrastructure. Part 6 of the second edition of LADM should include LandInfra/InfraGML (and maybe others) as an implementation standard. Land registry recording of condominiums is being used as proof of concept. Then the world will finally be able to benefit from this joint effort, after many years of indecision about the right way forward.

FURTHER READING

- ISO 19152:2012(en) Geographic Information — Land Administration Domain Model (LADM) https://www.iso.org/obp/ui/#iso:std:iso:19152:ed-1:v1:en
- Kavisha Kumar, Anna Labetski, Ken Arroyo Ohori, Hugo Ledoux & Jantien Stoter (2019) The LandInfra standard and its role in solving the BIM-GIS quagmire. Open Geospatial Data, Software and Standards https://doi.org/10.1186/s40965-019-0065-z
- OGC LandInfra/InfraGML https://www.ogc.org/standards/infragml
- OGC & buildingSMART International (2020) Built environment data standards and their integration: an analysis of IFC, CityGML and LandInfra https://portal.ogc.org/files/?artifact_id=92634
- Cadastre and Land Administration Thesaurus (CaLAThe) http://www.cadastralvocabulary.org/

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GINTEC
p9
Rugged Construction Field Controller
9.0
Running Faster
Point Survey
Detail Survey
CAD
Point Stakeout
Line Stakeout
GIS data collection
Stake road
Stake road by point
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How Can We Unlock the Full Potential of Drones for Advanced Mapping Operations?

For our 'Ask the Specialist' features, we invite readers to send us their burning questions about geospatial surveying. We pass the questions on to relevant industry experts who provide comprehensive and detailed answers to point geospatial professionals in the right direction.

It is no secret that, today, unmanned aerial vehicles (UAVs or 'drones') are a viable and mainstream commercial mapping tool that provide a robust return on investment. But technology does not stand still, and the result is the progress of more advanced drone operations which can help to improve safety for people both in the air and on the ground, while also saving long-term costs and increasing data collection efficiencies. From beyond visual line of sight (BVLOS) and operations over people (OOP) to flying at night or in fleets, it is clear that advanced operations present vast opportunities. So the question is: why are they not being utilized by drone operators the world over?

NAVIGATING TODAY'S LANDSCAPE

These operations are, in name and nature, more advanced than their traditional counterparts – but the answer to this question does not solely lie in the complexity of the operations themselves. Rather, it is the lengthy planning and approval process typically involved in obtaining permissions for advanced flights – combined with the lack of harmonization of drone regulations across the globe – that can elevate the barriers to entry. In 2018, thousands of companies applied to the US Federal Aviation Authority (FAA) for a Part 107 Waiver – an official document that approves certain aircraft operations outside the limitations of regulation – to be allowed to fly BVLOS but, according to AUVSI figures, only 23 were approved. So, what can be done to break down these barriers once and for all?

TESTING, TESTING AND MORE TESTING

Demonstrating that drones are capable of meeting the safety, regulatory and logistical needs of advanced drone operations is key to unlocking their potential in this space. Safety testing is paramount to achieving this, because testing and regulations are almost inextricably linked. The more data that is available supporting a drone's durability and reliability, the more evidence there will be that the technology is safe and fit for purpose; fixed-wing drones are backed by thousands of hours of safety testing, which has proven vital in helping to streamline and accelerate the approval of waiver requests and flight permissions. Sufficient safety testing data can also ensure that the operation scope is not restricted, for instance by being limited to flying in remote areas only. Indeed, it is clear that the role that testing can play in both ensuring regulatory compliance and expanding mapping opportunities should not be underestimated.

ONWARDS AND UPWARDS

Proving that a drone is capable of safely carrying out advanced flights is clearly essential to gaining approval. But how do operators know exactly what is required of them, when the rules they must follow vary depending on where in the world they are? The positive news is that important steps have been taken to address this. The FAA and Swiss Federal Office of Civil Aviation (FOCA) recently signed a declaration of intent to strengthen collaboration in the unmanned aircraft systems (UAS) space and cooperate to advance the harmonization of domestic and international UAS safety standards. And the new European rules that came into force in January 2021 are an exciting, welcome step forward in the industry's efforts to synchronize legislation in countries across the continent.

These new European regulations will also facilitate progress in streamlining approvals for advanced drone flights like BVLOS, by offering a clear and defined written process for operators. Streamlining measures are being implemented across the pond, too; the FAA recently launched its new BEYOND programme, which will support efforts to move towards BVLOS operations being carried out under established rules, rather than waivers. Type certification is also becoming increasingly important in the USA, which may further signal a potential move away from waivers in the future.

▲ *With access to more data and increasingly accommodating regulations, advanced drone operations will become more and more accessible for the modern drone operator.*

REAPING THE REWARDS

In time, the potential benefits for advanced drone operations in commercial settings are significant. Partnering with authorizing bodies or institutions, and maintaining communication throughout approvals, will be integral to enabling operators to collect more data and build on the regulations already in place. With the right connections, advanced operations can be carried out easily and efficiently, and I'm confident that commercial companies can reap the rewards. With access to more data and increasingly accommodating regulations, I look forward to advanced drone operations becoming more and more accessible for the modern drone operator. It's closer than we think. ◀

ABOUT THE AUTHOR

Pierre-Alain Marchand is R&D regulatory compliance manager at senseFly. The Switzerland-based company was founded in 2009 and quickly became a leader in mapping UAVs. senseFly is the commercial drone subsidiary of Parrot Group.

FIG in Coronavirus Mode

Like most others, FIG is affected by the current global pandemic and its consequences, both personally and economically. For example, it is not possible to travel, which is otherwise a frequent activity within FIG, especially for the FIG Council to visit regional members, surveyors and other related professions and to attend meetings in order to promote the work of the surveying and geospatial profession. Besides this, it was not possible to hold a face-to-face Working Week in 2020, which is normally the key opportunity for many FIG-related professionals to meet, discuss, network and make new contacts.

Luckily, we live in a time where online presence is possible, and many activities have been moved to online meetings. In a previous issue of *GIM International*, we introduced our e-Working Week 2021 for which a technical programme, made relevant for an online audience, is being developed as well as networking activities. We provide regular updates on the progress on our website.

20% REDUCTION ON MEMBERSHIP FEES FOR 2021

On 13 January, the FIG Council had its first council meeting in 2021. On the agenda were the finances, and especially the financial situation around the world due to the COVID-19 pandemic. The FIG Council is aware that, just like FIG itself, our members have difficulties to create income through activities like national events and seminars. As a response to this extraordinary situation, the FIG Council has decided unanimously to offer all Member Associations, Corporate and Affiliate Members a one-time 20% reduction in their membership fees in 2021. The FIG Council hopes that this offer will help to ease our members' financial situation.

NEW PUBLICATION: 'INTERNATIONAL BOUNDARIES ON UNSTABLE GROUND'

FIG Commission, Network and Task Force activities have continued during this past year, albeit in online versions. One result is the latest FIG Publication – No. 76 in the series. 'International Boundaries on Unstable Ground' is a supplement and extension to FIG Publication 59 on 'International Boundary Making'. Whereas Publication 59 mainly elaborated on the process of international boundary making with the specified and important goal to achieve a long-lasting and stable agreed boundary line, this new publication is a valuable supplement to promote just, peaceful and inclusive societies throughout the world in line with the United Nations Sustainable Development Goal 16: Peace, Justice and Strong Institutions. It is intended to promote the sharing of methodological knowledge and experience regarding delimitation of international boundaries and to promote peace throughout the world.

The publication is edited by Dr Haim Srebro and includes topics such as river boundaries, boundaries in lakes, boundaries on melting glaciers and the 'moving border' approach, and issues of instability of boundaries due to tectonic plate movement, including issues of geodetic reference systems for boundary documentation.

More information
www.fig.net
www.fig.net/fig2021

Volcano Geodesy

IAG Commission 3, Sub-Commission 3.2, joint with International Association of Volcanology and Chemistry of the Earth's Interior

Geodesy is an important tool for exploring the geometry and temporal evolution of magma plumbing systems, as well as for monitoring and hazard assessment during volcanic unrest and eruption. Geodetic techniques include measurements of both deformation (to determine the magnitude, location and geometry of subsurface sources of pressure change) and gravity (to assess subsurface mass variations). Recent decades have seen an explosion in the quality and quantity of volcano geodetic data, which has created a need for new approaches to data analysis, interpretation and modelling. In addition, geodetic data can have different temporal and spatial resolutions, as well as different origins (ground, air and space-based), and it is best utilized in conjunction with other non-geodetic datasets like seismicity and gas emissions. New tools are therefore needed for data fusion and joint interpretation, both between geodetic datasets and with other types of volcano monitoring results. This is especially relevant now given the expansion in GEO's Geohazard Supersites and Natural Laboratories initiative to volcanic sites around the globe. We feel that an International Association on Volcanology and Chemistry of the Earth's Interior (IAVCEI) Commission on Volcano Geodesy is needed to organize the diverse community and promote a better understanding of magmatic processes through geodesy.

NEW REFERENCE PUBLICATION OF INTEREST TO VOLCANO GEODESY

'Monitoring Volcanic Deformation', an introduction to several monitoring techniques used in volcano geodesy, was published by authors from multiple worldwide volcano observatories who are actively involved in monitoring volcanic unrest. The described methods include EDM, tilt, GPS, InSAR, microgravity and mathematical modelling, and the publication is intended as a reference.

RESPONDING TO VOLCANO CRISES DURING THE PANDEMIC

In March 2020, the outbreak of COVID-19 was declared a pandemic by the World Health

Organization and became a global health crisis. Authorities worldwide implemented lockdowns to restrict travel and social exchanges in a global effort to counter the pandemic. In France, and in French overseas departments, the lockdown was effective from 17 March to 11 May 2020. During this time, the 2-6 April 2020 eruption of Piton de la Fournaise (La Réunion Island, Indian Ocean) took place. The density and reliability of the OVPF networks, combined with satellite observations, allowed for trustworthy instrument-based monitoring of the eruption and continuity of the OVPF duties in issuing regular updates of volcanic activity in the context of a double crisis: volcanic and health.

DYNAMICS OF DEFORMATION AND SATELLITE THERMAL INFRARED AT DOMUYO VOLCANO, ARGENTINA

A decade-plus of analysis has been done that integrates, for the first time, InSAR surface deformation time series and satellite thermal infrared edifice-scale surface warming at a large silicic system: Domuyo volcano, in Argentina. It is found that deformation and warming are highly correlated, and depending on the sign and lag between the time series, either shallow sealing or magma influx could drive Domuyo's ongoing inflation (~0.15m/year; from an InSAR-derived tabular source, ~11×8×1km; ~6.5km depth; ~0.037km^3/year volume change rate) and warming (0.3-0.4°C/year). This study shows the potential that combined satellite surface deformation and edifice-scale surface warming time series have on assessing the physical mechanisms of silicic volcanic systems and for constraining deterministic models.

UNSUPERVISED MODELLING OF VOLCANO PLUMBING WITH GNSS

A fully unsupervised Bayesian inversion method is proposed that uses the point compound dislocation model as a complex source of deformation, to dynamically identify the substructures activated during magma migration. This method was applied at Piton de la Fournaise, using GNSS data preceding the June 2014 eruption. Obtained source shapes (dikes, prolate ellipsoids or pipes) show magma migration from 7-8km depth to the surface, drawing a mechanical 'tomography' of the magma pathway. This method was implemented operationally as an extension of the GNSS module in the WebObs system, an integrated web-based system for data monitoring and network management implemented in 15 observatories worldwide. This has been especially useful during the last eruption at Piton de la Fournaise (Peltier et al., 2020).

DEFORMATION AT SABANCAYA VOLCANO

Sabancaya is the most active volcano of the Ampato-Sabancaya Volcanic Complex (ASVC) in southern Peru and has been erupting since 2016. The analysis of ascending and descending Sentinel-1 orbits (DInSAR) and GNSS datasets from 2014 to 2019 imaged a radially symmetric inflating area, uplifting at a rate of 35-50mm/year and centred 5km north of Sabancaya.

By Emily Montgomery-Brown, chair of Sub-commission 3.2

More information

On IAG Commission 3 activities: https://com3.iag-aig.org
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Today's Cartography

The 30th International Cartographic Conference (Florence, 14-18 December 2021)

The art of making (and using) maps has already proven to be a several millennia-old human activity. Although maps (and their mapmakers) have been well established for such a long time, cartography has only been an independent discipline with the denomination 'cartography' for the past couple of centuries. Before that period, mapmakers were generally identified as cosmographers and (later) geographers. Cartography, 200 years ago, was still considered an integral part of geography (except for the projection and geodetic aspects considered as mathematic issues). Despite all this, cartography remained essentially limited to topographical cartography on the one hand during the 19th century and thematic cartography on the other (which is still situated within the geographical field); it was also an important inventory tool in the context of industrialization. It was only in the 20th century that cartography further acquired its 'autonomy' as a full discipline, technically on the one hand by new technologies entering into force (e.g. consider the use of photogrammetry after WWII), and on the other from the 1950s onwards with theoretical studies on visualization and perception (such as Bertin's Sémiologie graphique in 1967). During that period, the cartographic community also saw the need to establish a worldwide body for their interests: the International Cartographic Association (founded 1959 in Bern, Switzerland).

Over the last 20 years, cartography has evolved very quickly. In one sense, it lost a substantial part of its original purpose, specifically the inventory function, usually on geological, pedological and other such maps. But apart from that, a new form of cartography arose: screen cartography in its numerous digital applications, from routing to all kinds of GIS applications. Of course, this evolution seems positive but nevertheless some risks are involved since not every engineer or scientist disposes of the necessary cartographical literacy.

that this might not harm the scientific accuracy. A cartographical presentation should 'look good' – perhaps even be beautiful – but at the same time also requires a scientific justification. That is the reason why cartographers attach great importance to perception and respecting semiological rules. They also do not fear evaluating their own products by means of critical studies.

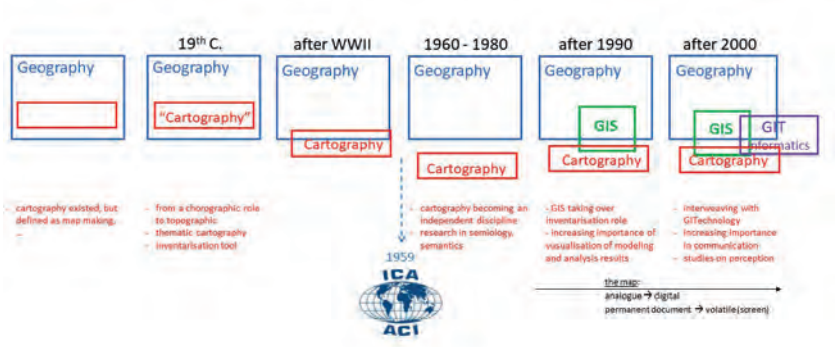
In contrast to many other scientific fields, in which computer technology is often being used as a tool to perform analysis and

IN CONTRAST TO MANY OTHER SCIENTIFIC FIELDS, IN CARTOGRAPHY THE DIGITAL WORLD IS MORE THAN JUST A TOOL – NOWADAYS, IT HAS BECOME AN INTEGRAL PART OF CARTOGRAPHIC IDENTITY...

In an earlier definition (1973), the discipline of cartography was defined by the ICA as "the art, science and technology of making maps, together with their study as scientific documents and works of art". This combination of science and technique on the one hand and art on the other makes cartography rather exceptional. Several sciences utilize techniques in order to observe, to manage data, to execute analysis and to visualize their outcomes. Naturally, this is the case for physics, chemistry, biology, etc. But cartography also aims to strive for beauty in the spatial representation of reality or the analysis and results of it, taking care of the fact

manage and visualize data, in cartography the digital world is more than just a tool. Nowadays, it has become an integral part of cartographic identity…

In its contribution to the September/October 2020 issue of *GIM International*, ICA drew the attention to the fact that many 'coronavirus maps' published since the start of the COVID-19 era had been manufactured by producers lacking basic cartographical knowledge and that – apart from fundamental, unscientific presentation choices – they often did not excel in beauty either. However, much to our satisfaction, we have noticed considerable improvements in the quality of the presentation over the past one-year period.



Cartography is one of the few disciplines in which one not only calls on scientific knowledge and technology while shaping the final product but in which its outcome also turns out to be a study subject in itself. Maps are naturally the subject of perception studies and historic cartographical studies. The latter also appear to be indispensable information sources for geographers, historians and in landscape studies – indispensable in order to understand the past and the present.

Thus, cartography covers a very broad field of aspects – and this wide range of aspects in which professional cartographers and all other map enthusiasts take an interest will be properly addressed during cartographic conferences, such as at the end of 2021 during the next International Cartographic Conference (ICC)! ICA is proud to officially announce this conference in which maps in all their facets, varying from thematic aspects (marine cartography, planetary cartography, mountain cartography, etc.), scientific (projections, toponymy, etc.), technical (standards, web cartography, map production, LBS, etc.) aspects to the history of cartography, art and cartography, map design, cognitive issues and more, will all be considered. So we welcome you all to attend the 30th ICC, which will be held in Florence (Italy), from 14-18 December 2021, as a hybrid event.

Deadline for full paper submissions:
19 March 2021
Deadline for abstract submissions:
28 May 2021

By Philippe De Maeyer
Senior full professor Cartography and GIS
Vice-President of ICA

More information
https://www.icc2021.net

ISPRS Launches New Open-access Journal

The ISPRS Council is pleased to announce the introduction of its new Golden Open Access journal, the *ISPRS Open Journal of Photogrammetry and Remote Sensing* (IOJPRS), published by Elsevier as of 1 January 2021. As an independent third journal of ISPRS, IOJPRS will offer additional possibilities for authors to publish their latest results in a high-quality peer-reviewed scientific outlet under the ISPRS umbrella.

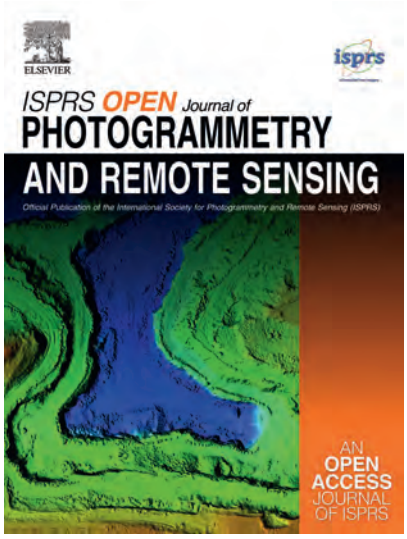
The decision to start this new journal followed a careful assessment of its pros and cons over the past 18 months. The most important point was the global development in the direction of open science in general and open access

in particular, reflected for instance in new regulations and initiatives within the European Union such as the so-called 'Plan S'. Equally importantly, the two existing ISPRS journals have been experiencing a rapid increase in the number of submissions and published papers, demonstrating the growth of our field; the two editors-in-chief of the highly ranked *ISPRS Journal of Photogrammetry and Remote Sensing* (IJPRS) currently work with 19 associate editors to handle 1,500-plus submissions a year, while the open-access *ISPRS International Journal of Geo-Information* (IJ-GI) has been publishing up to 100 articles per month as it approaches its tenth year of existence. The ISPRS Council, in cooperation with all journal editors-in-chief and Elsevier, conducted a survey to seek the opinion of the community at large and analysed the findings before reaching the conclusion that the benefits of adding a new Golden Open Access journal would be significant.

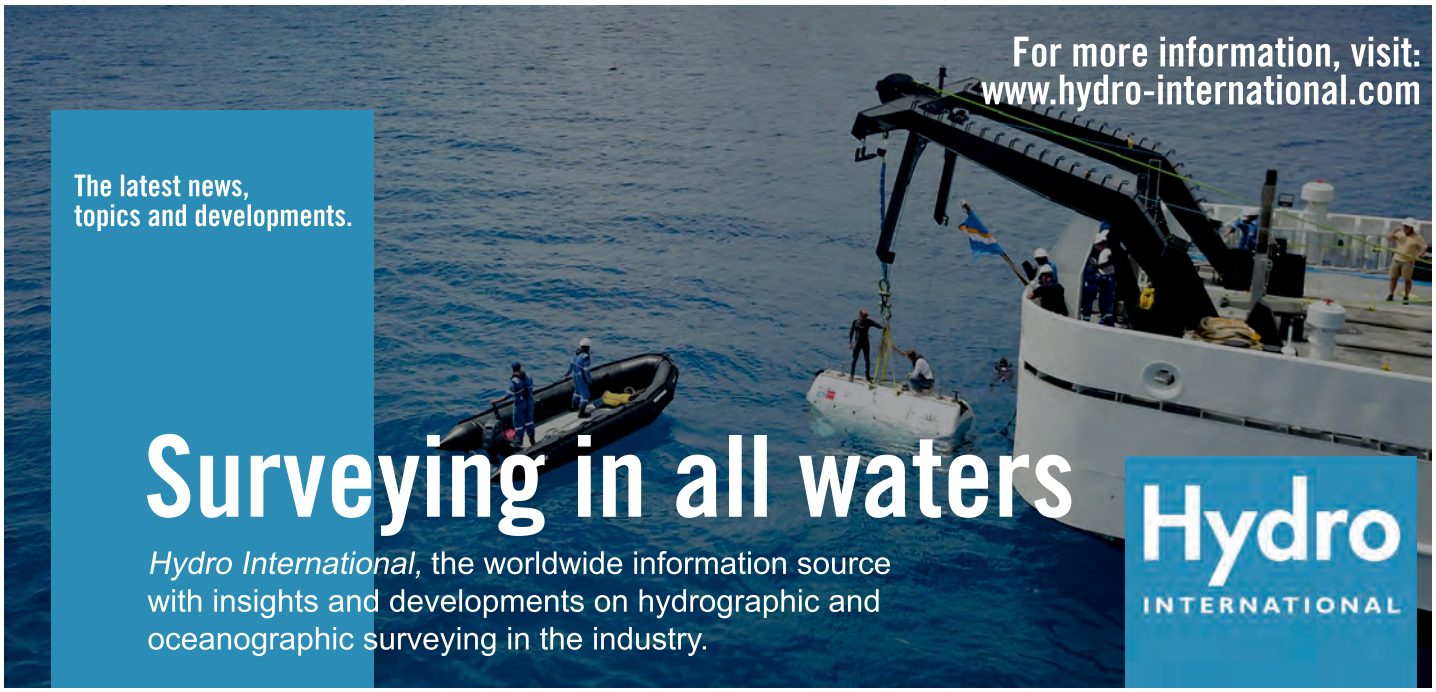
The ISPRS Council is delighted to share the news that George Vosselman, PhD, former editor-in-chief of IJPRS, has agreed to serve as the first editor-in-chief of the new *ISPRS Open Journal of Photogrammetry and Remote Sensing*. George Vosselman is a professor of geoinformation extraction with sensor systems at the University of Twente, the Netherlands.

After graduating in geodetic engineering from the Delft University of Technology in 1986, he worked at the University of Stuttgart, Germany, until 1992. In 1991, he obtained his PhD degree with honours from the University of Bonn, Germany. He was appointed a professor of photogrammetry and remote sensing at the Delft University of Technology in 1993. In 2004 he joined ITC, now a faculty of the University of Twente.

George has been instrumental in adapting ISPRS to the rise of laser scanning, including roles as WG chair (2000-2004) on reconstruction from airborne Lidar and InSAR, WG co-chair (2008-2012) on point processing, and editor of a well-known standard book (with Hans-Gerd Maas). Moreover, he has made a massive contribution to scientific standards, quality control and reviewing: he was editor-in-chief of the *ISPRS Journal of Photogrammetry and Remote Sensing* (2004-2012), a member of the International Science Advisory Committee (ISAC) and chair of the International Program Committee for the ISPRS Congress 2016. He has over 250 publications to his name, many of which have been cited numerous times. He was also the director of the very successful ISPRS Geospatial Week, organized in Enschede in 2019.



More information
www.gsw2019.org
www.isprs-ann-photogramm-remote-sens-spatial-inf-sci.net/IV-5/53/2018/
https://bit.ly/2SQ4ARy



Why Geospatial Will Always Be a People-centric Profession

I was intrigued to read recently about another step forward in the accelerating integration of different geospatial technologies. In this case, the seamless integration of North Sea oil/gas-rig data captured using unmanned aerial vehicle (UAV or 'drone') platforms, Lidar sensors and mobile/static digital photogrammetry is allowing the creation of a highly accurate geospatial model of an extremely complex structure in a very hostile natural environment. This 3D model will enable specialist engineers and other professionals to access this enormous and expensive structure 'virtually' for condition reporting and decommissioning from their land-based offices. In the UK, we tend to think of land-based and offshore/hydrographic geospatial survey as two sides of the same coin. In fact, our academic education combines both sectors. The combination of bathymetry with land-based data capture is evolving rapidly, so applying the technique in a deep-water offshore environment – as Texo DSI is doing – is a logical step forward.

The increasingly 'remote' and 'hands-off' nature of much of what we do within geospatial can cause particular issues, especially during the current COVID-19 pandemic. We are at our core a public-facing profession, dealing with people, clients and other professionals on a very regular basis. New geospatial technology will change some aspects of these relationships and we do have an important task to increase our professional understanding of how ethics and ethical data use will impact on the services that we provide. More of these issues are worthy of future discussion, but for now I'd like to consider the ethical impact of 'unconscious bias' in geospatial information and its use. Unconscious bias is unintended and subtle; it is based on unconscious thought and can lead to all kinds of unintended consequences including misuse of information, discrimination, unsupported judgments and prejudice. Algorithms drive artificial intelligence and machine learning, but the 'unconscious bias' of the code programmers and developers can seep into the system (witness the unease over the use of face recognition software in many Western capitals, or educational algorithms used to award exam grades to students during the pandemic). This bias has caused alarm within governments and even led to an independent report in the UK called 'Review into bias in algorithmic decision-making'.

In the arena of geospatial data, we pride ourselves on being objective and data-led, on being critical about data and on relying on 'control/ground truthing/markers' that we can verify and trust. But we, like all humans, are not immune. Confirmation and selection bias (forcing data to fit your own predetermined opinion) can be evident in GIS data modelling. Personal data can add potential for stigma and discrimination resulting from being associated with particular locations (this can affect everything from employment prospects to credit ratings to healthcare access) and tenant data can allow unconscious bias to inform investment, lease and rental-related decisions. Major firms are now offering unconscious bias training, and perhaps the first step in dealing with it is recognizing that it exists in the first place. The Benchmark Initiative is a good place to start for any further reading on this important subject.

When looking after the public, clients and other professionals, we can often forget to pay sufficient attention to ourselves and those that work in or are studying towards a geospatial career. Mental health issues have never been more evident than in the past year – when COVID-19 lockdowns have blurred the boundaries of work, family and home life – and the alarm bells are ringing. Recent surveys show that construction workers are three times more likely to take their own lives than the rest of the population – and that's compared with a general population where one person in six feels under intense stress. Tragically, several RICS surveyors have taken their own lives over the years and the RICS charity Lionheart has launched a campaign on this issue.

When we look to the future, geospatial students are undergoing a torrid time at present with nearly three quarters (73%) of students saying that their mental health had declined during the lockdown. Mental health still has a significant social stigma attached but it is critical for the future of the geospatial profession that we openly discuss and debate these issues. Yes, we love the technology… but let's also love and look after ourselves just a little bit more. ◂

▲ *James Kavanagh.*

FURTHER READING

https://benchmarkinitiative.com/
https://www.lionheart.org.uk/mh

ABOUT THE AUTHOR

James Kavanagh MRICS C.Geog MCInstCES is head of Land & Resources at RICS. The sixth edition of the RICS guidance note (GN) publication on imagery is expected to be launched in summer 2021 and will include coverage of UAV imagery and sensors, 'traditional' aerial imagery best practices and information on the use of Earth observation (EO) imagery and data.
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