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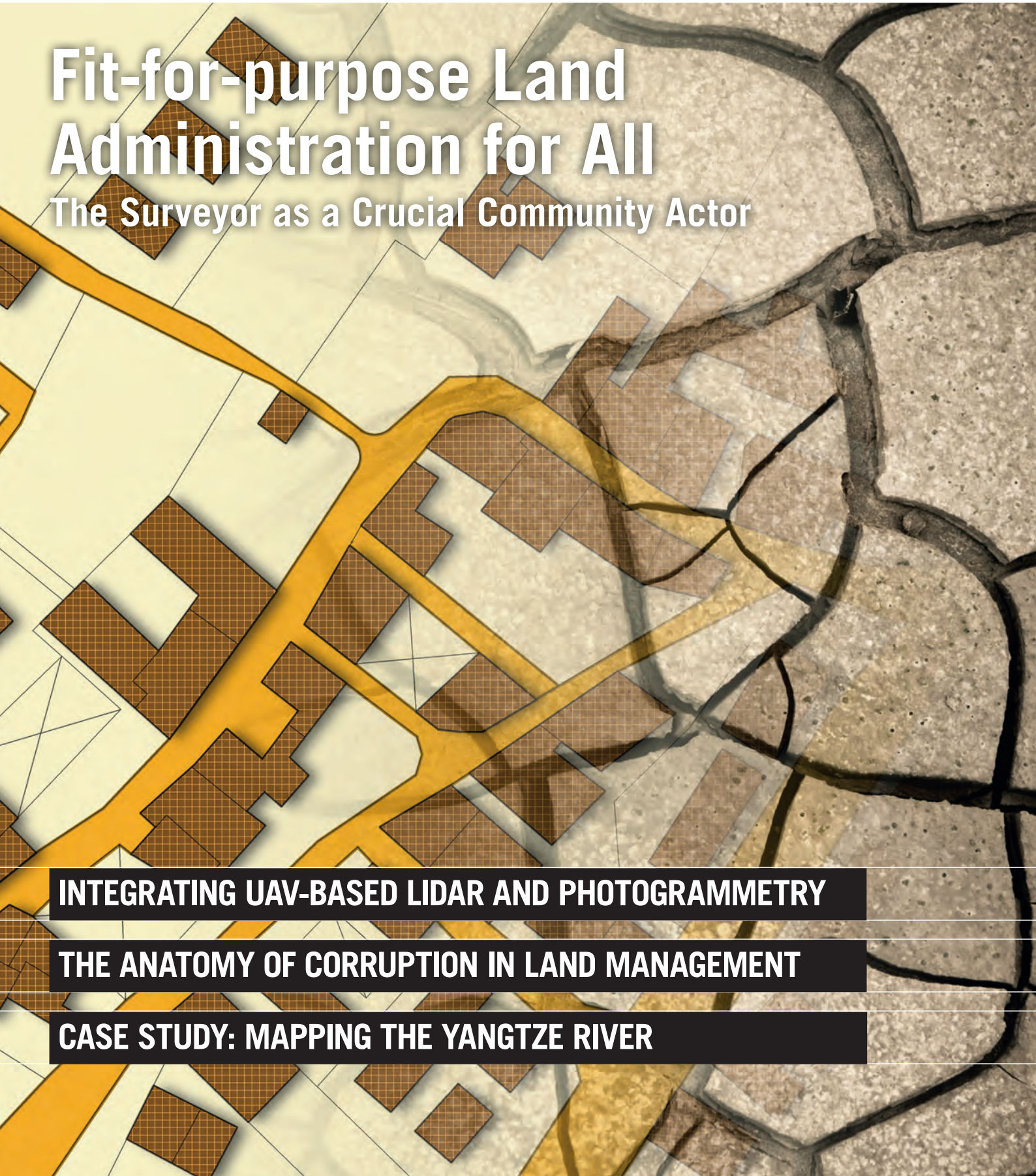
Fit-for-purpose Land Administration for All

The Surveyor as a Crucial Community Actor



INTEGRATING UAV-BASED LIDAR AND PHOTOGRAMMETRY

THE ANATOMY OF CORRUPTION IN LAND MANAGEMENT

CASE STUDY: MAPPING THE YANGTZE RIVER

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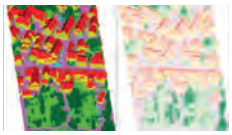

COVER STORY

Today's geospatial technology means that land administration systems can increasingly be implemented for the benefit of all. This issue of GIM International has a special focus on land management and the role of the mapping and surveying profession in this field.

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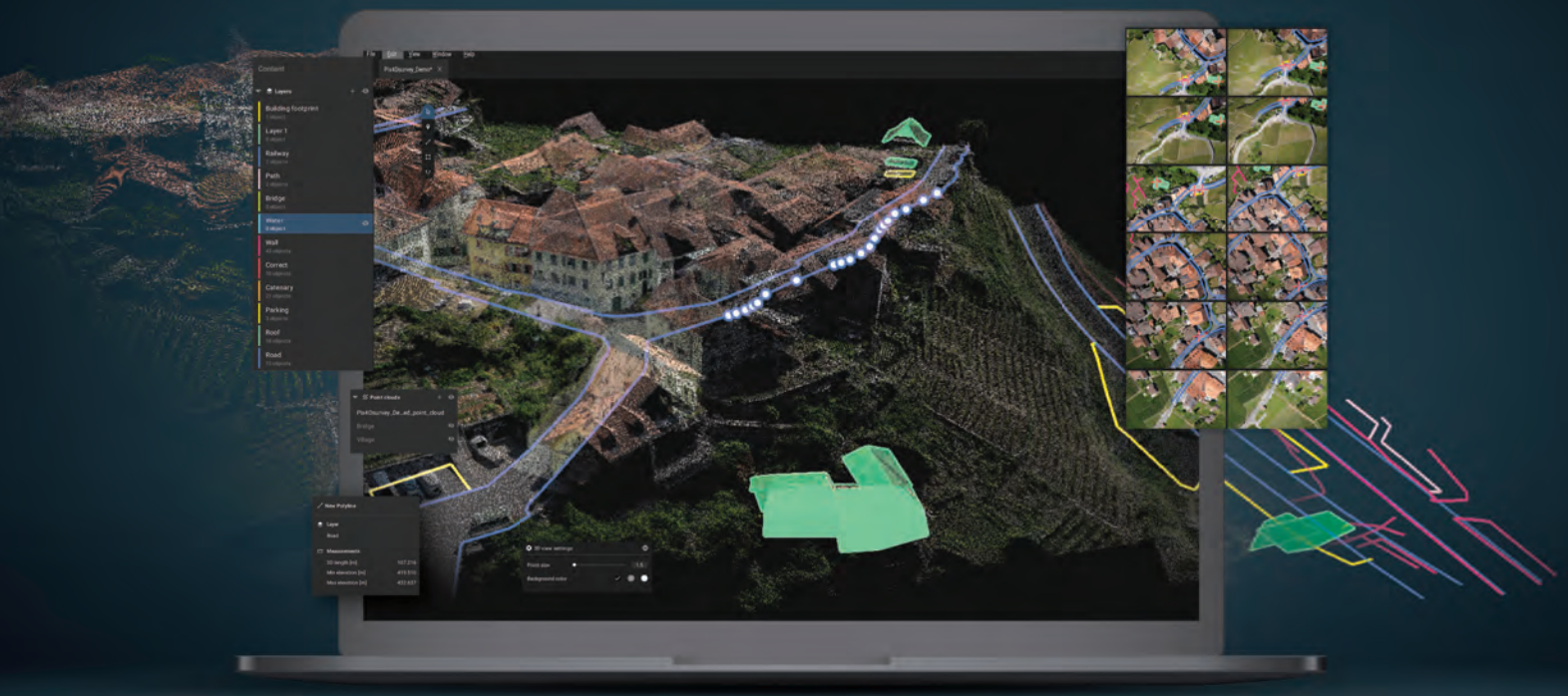

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Cloudy crystal ball

How will the geospatial community look after the coronavirus pandemic has subsided? How will industry professionals maintain their business networks and how will events be held? Will we be able to return to the way things were, or will we have to get used to a 'new normal'? Will companies have to look for other ways of announcing their innovative new solutions, putting their products in the spotlight and informing and educating customers? These and other questions are puzzling the minds of many industry professionals. At *GIM International*, we believe we are strongly positioned to support companies that are looking to attract the attention of a highly relevant target group. Our community needs to stay informed about all the impressive progress that is being made throughout the year – all the insightful studies that are conducted, all the new technology that enables geospatial surveyors to further upscale their skills, and so on – thanks to our well-established and stable platform which reaches the right people. Although my crystal ball to predict the short-term future of our sector is a little foggy right now, it's fairly safe to say that things will eventually stabilize and, who knows, perhaps the economic impact of the coronavirus crisis won't be as devastating as some foresee. Let's hope the clouds in my crystal ball will soon part to reveal some glints of optimism!

Wim van Wegen,
Content manager

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Sharing Your Experiences with Our Global Mapping and Surveying Audience

As a geospatial surveying professional, you have no doubt worked on projects or case studies based on innovative geospatial methods or technologies. In the context of knowledge exchange, why not share details with *GIM International*'s worldwide audience of fellow mapping and surveying specialists?

Despite the first-rate efforts of *GIM International's* capable and experienced global team of contributing editors at the epicentre of the geomatics world, we know that within our dynamic industry there are many more inspiring feature ideas that are worth sharing with our readers. So why not contribute an article yourself? Perhaps you are working on relevant topics such as photogrammetry, remote sensing, Lidar, GIS, BIM, satellite imagery, Earth observation, UAV mapping and suchlike. Or do you use geomatics in your day-to-day work in a sector such as precision agriculture, mining, transport & infrastructure, construction, urban planning or land administration? If so, we encourage you to contact us with your ideas!

Please contact Wim van Wegen (wim.van.wegen@geomares.nl) to learn more!

Comforting

This issue of *GIM International* is largely a 'home-made' edition. Much of the planning, writing, editing, design and coordination to put together the final layout and get the file ready for the printers has been done by the editorial team working from various living rooms, kitchens, studies and maybe even attics. Obviously, this is all due to the coronavirus pandemic that is now heavily impacting on life in Europe and North America, just as it has already in China and elsewhere around the world. These are strange times in which conducting business via video call has become the new normal, often with multiple people at once – and for many while also keeping an eye on the children because the schools are closed.

Hopefully, a lot of the restrictions will have been lifted by the time this issue reaches you and the virus outbreak will have passed its peak. Here in Europe, several countries are opening up again and gradually getting back to work, so perhaps the economic damage will not be as severe as the International Monetary Fund recently warned. But only time will tell, because this is the first time in recent history that complete economies have been brought to a standstill so quickly and also the first time in a century that we have had to face a virus like COVID-19.

In this issue of *GIM International*, our contributing editor Rohan Bennett has worked together with co-author Eva-Maria Unger on an article titled 'Fit-for-Purpose Land Administration for All' (see page 22). Fit-for-purpose land administration offers a range of advantages, including for professionals: more work and income, a wider professional horizon with the adoption of new technologies, and the opportunity to bring high-level technical leadership while at the same time increasing tenure security for many in a fast and efficient way. This is always an interesting topic, but it's more relevant than ever during the current pandemic. Taking things a step further, Rohan Bennett and Eva Maria Unger have teamed up with Christiaan Lemmen and Kees de Zeeuw to explore the role of land administration in the coronavirus crisis in a very interesting article titled 'COVID-19, the Land Administration Sector and Spatial Information' which is published on www.gim-international.com. It is still early days, of course, and historical relevance only becomes apparent after the passage of time, but there appears to be a major – and often not acknowledged – role for land administration. There are numerous good examples of how accurate and up-to-date land administration can be helpful, including in measures to track the outbreak, enforcing quarantines and shutdowns, and subsequently combating tenure insecurity when people are left jobless due to the crisis. Amidst all the doom and gloom around at the moment, it is quite comforting to read about the many unexpected consequences that are highlighting not only the core purpose of land surveyors and other geoprofessionals, but also the many positive side effects of their roles.

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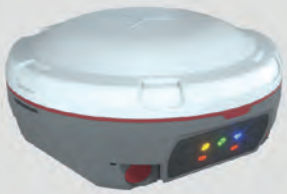
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Digital Terrain Model of the Netherlands' Busiest Bridge

The Van Brienenoordbrug bridge – a large twin tied-arch bridge on the eastern side of Rotterdam – is the busiest in the whole of the Netherlands, with an average of 235,000 vehicles driving over it every day. Approximately 150,000 ships and boats pass under it annually, and it is raised around 150 times a year to allow them through. To keep this bridge safe – now and in the future – it was necessary to gain a complete picture of its current state of repair, so Geomaat designed a digital terrain model (DTM).

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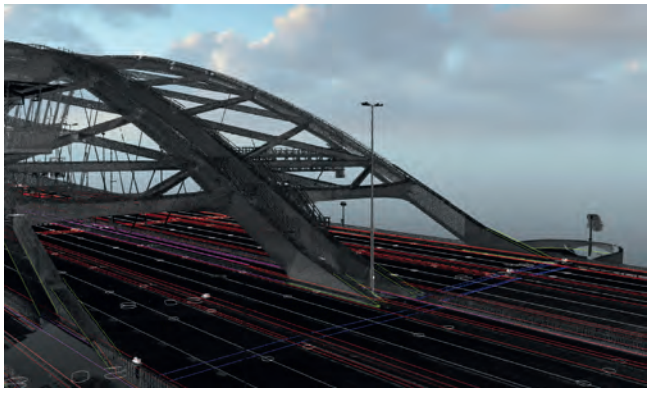

All the data was converted into a 3D point cloud, which was subsequently used to design a complete DTM of the bridge from above.

Trimble Dimensions Cancelled; Esri User Conference Goes Virtual

Trimble has announced the cancellation of the 2020 edition of its annual Trimble Dimensions event. Due to the uncertainty regarding the coronavirus, the geospatial powerhouse has made the decision not to hold the event this year. Meanwhile, Esri has announced that its Annual User Conference, normally held in San Diego, California, will switch to a completely virtual format this year. The three-day event will take place online from 13-15 July 2020.

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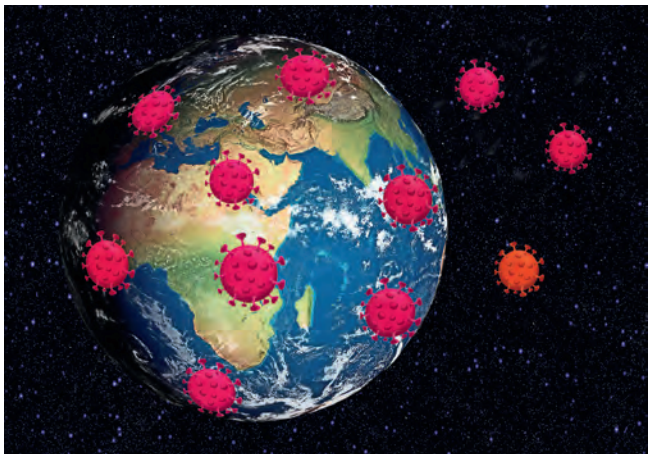

The coronavirus outbreak has led to challenging times for event organizers.

How to Speed up Stockpile Measurement with Drones

Unmanned aerial vehicles (UAVs or 'drones') are a powerful tool for stockpile measurement in industries such as mining, forestry and construction. They allow the same region to be flown regularly and progression of the work to be monitored over time. Imagery is collected over the region of interest at high resolution, often at the sub-centimetre level. Workflow advancements are now speeding up this process. SimActive has recently released an enhanced workflow in its Correlator3D to accelerate stockpile measurement. The overlapping images are processed by the software to create a digital surface model (DSM), which accurately describes the topology of the terrain. Then, regions of interest can be created (or imported). Finally, automatic volume calculation is performed and outputted in comprehensive reports.

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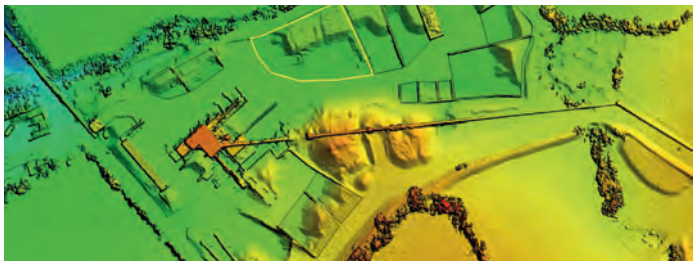


DSM used for volume calculation, created with SimActive Correlator 3D.

Colombian Mayors Learn about Fit-for-purpose Land Administration

▲ *During the first three months of their term, the Colombian mayors and governors are requested to submit a municipal development plan that also includes cadastral policy.*

At a meeting for new mayors and governors in Colombia, the Kadaster International team presented the Land in Peace project and introduced the fit-for-purpose approach. Up to 60% of the rural population in Colombia does not have legal proof of ownership over their land. At the current pace, it will take centuries to realize tender security for all. The Land in Peace project is aimed at speeding up the process by applying the fit-for-purpose method: the farmers themselves walk along the borders of their land with a GPS to demarcate their plot.

▸ **https://bit.ly/2VB76zc**

ISPRS Congress Postponed until 2021

ISPRS has announced that, due to the coronavirus crisis, the XXIV ISPRS Congress to be held in Nice, France, has been postponed until 2021. In a statement, the association commented: "The Council is aware that this decision has many consequences, but the very real health risks and the capacity to travel for the Congress participants did not leave us with any other alternative." As the reviewing process of scientific submissions is nearly completed, the preparation of the ISPRS Archives and Annals scheduled for this summer is on track, and the proceedings will be published as planned. All registrations for this year's congress will be carried forward to next year. This means that anybody who has registered and paid the registration fee until 4 May 2020 can use that fee to participate in the Congress in July 2021 and, if desired, submit a new paper for it.

▸ **https://bit.ly/2S4e1yz**

Apple Unveils New iPad Pro with Lidar Scanner

Apple has announced its most advanced iPad Pro ever, which even includes a Lidar scanner. Equipped with the A12Z Bionic chip, the new iPad Pro is faster and more powerful than many PC laptops. The break-through Lidar scanner delivers depth-sensing capabilities, opening up more specialized workflows and supporting professional photo and video apps in combination with the ultrawide camera and studio-quality microphones. The Lidar scanner – along with pro cameras, motion sensors, pro performance, pro audio, a Liquid Retina display and powerful apps – lends weight to Apple's ambition to offer the world's best device for augmented reality (AR). The California-based high-tech giant has been working on bringing Lidar technology to the consumer market for years.

▸ **https://bit.ly/2yH8tmE**

▲ ***The iPad Pro is the company's first device to be equipped with a Lidar scanner – but is there more to come from Apple?***

DENSE 3D POINT CLOUD GENERATION WITH ULTRA-HIGH PRECISION

Integrating UAV-based Lidar and Photogrammetry

Recent unmanned aerial vehicle (UAV or 'drone') platforms jointly collect imagery and Lidar data. Their combined evaluation potentially generates 3D point clouds at accuracies and resolutions of some millimetres, so far limited to terrestrial data capture. This article outlines a project that integrates photogrammetric bundle block adjustment with direct georeferencing of Lidar point clouds to improve the respective accuracy by an order of magnitude. Further benefits of combined processing result from adding Lidar range measurement to multi-view-stereo (MVS) image matching during the generation of high-precision dense 3D point clouds.

The project was aimed at the area-covering monitoring of potential subsidence of about 10 mm/year by a repeated collection of very accurate and dense 3D point clouds. The considerable size of the test site in Hessigheim, Germany, prevents terrestrial data capture. As visible in Figure 1, the site consists of built-up areas, regions of agricultural use and a ship lock as the structure of special interest.

For traditional monitoring, a network of several pillars was established in the vicinity of the lock. As depicted in Figure 2, photogrammetric targets signalized the pillars to make them available as check and control points for georeferencing. For UAV data collection, a RIEGL RiCopter octocopter was used equipped with a RIEGL VUX-1LR Lidar sensor and two Sony Alpha 6000 oblique cameras. With a nominal flying altitude of 50m above ground level, a strip distance of 35m and a scanner field of view (FoV) of 70°, the system captured 300-400 points/m² per strip and 800 points/m² for the entire flight block due to the nominal side overlap of 50%. The flight mission parameters resulted in a laser footprint diameter on the ground of less than 3cm with a point distance of 5cm. The ranging noise of the scanner is 5mm. The trajectory of the platform was measured by an APX-20 UAV GNSS/IMU system to enable direct georeferencing.
The two Sony Alpha 6000 oblique cameras mounted on the RiCopter platform have a FoV of 74° each. Mounted at a sideways-looking angle of ±35°, they captured imagery at a ground sampling distance (GSD) of 1.5-3cm with 24 megapixels each.

LIDAR STRIP ADJUSTMENT AND AUTOMATIC AERIAL TRIANGULATION

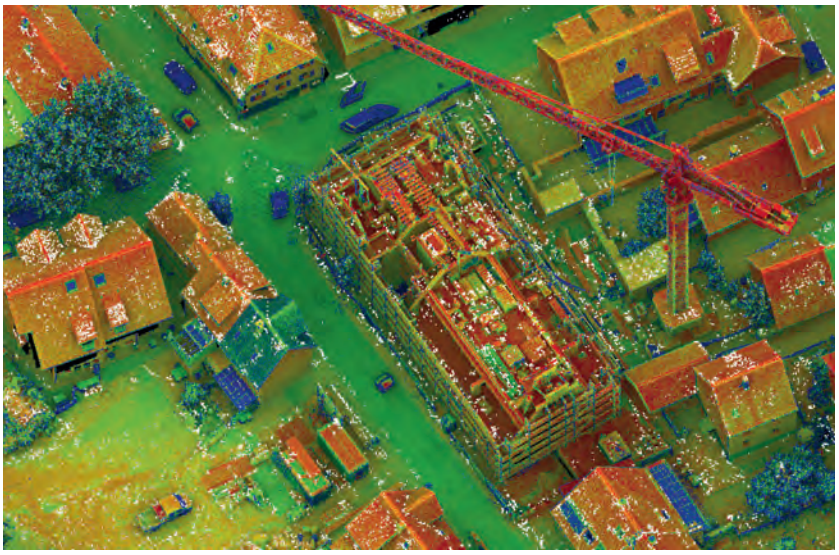
After direct georeferencing, a typical Lidar workflow includes a strip adjustment to minimize differences between overlapping strips. This step improves georeferencing by estimating the scanner's mounting calibration as well as correction parameters for the GNSS/IMU trajectory solution. Typically, a constant offset (Δx, Δy, Δz, Δroll, Δpitch, Δyaw) is estimated for each strip. Alternatively, time-dependent corrections for each of these six parameters can be modelled by splines.

Figure 3 exemplarily depicts a Lidar ground control plane used for absolute georeferencing. Each signal features two roof-like oriented planes at a size of 40cm × 80cm with known position and orientation.

▲ *Figure 1: Test area at the Neckar River in Hessigheim, Germany.*

▲ *Figure 2: Photogrammetric target on pillar.*

▲ *Figure 3: Lidar control plane.*



▲ *Figure 4: Lidar points coloured by intensity and photogrammetric tie points (white).*

The evaluation of this project's Lidar strip adjustment additionally applies the signalized pillars depicted in Figure 2. These photogrammetric targets provide elevation differences to the georeferenced point cloud at 33 targets. In the investigations, these differences resulted in an RMS accuracy of 5.2cm. To enable georeferencing of the Sony Alpha oblique image block by automatic aerial triangulation (AAT), six of the photogrammetric targets were selected as ground control points (GCPs). The remaining 27 targets provided differences at independent check points (CPs) ranging between 5.2cm (max.) and 1.2cm (min.) with an RMS of 2.5cm.

Thus, neither the Lidar strip adjustment nor bundle block adjustment yield the required 3D object point accuracy during an independent evaluation of the different sensor data. However, accuracy improves significantly if both steps are integrated by so-called hybrid georeferencing (Glira 2019).

HYBRID GEOREFERENCING OF AIRBORNE LIDAR AND IMAGERY

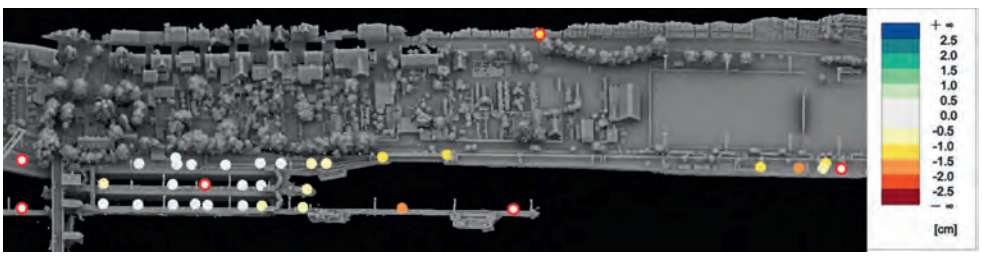
Figure 4 depicts a section of the project's Lidar points, colour-coded by the intensity value. The overlaid white points represent tie points from the bundle block adjustment of the Sony Alpha imagery. Usually, this step estimates the respective camera parameters from corresponding pixel coordinates of overlapping images. The object coordinates of these tie points are just a by-product.

In contrast, hybrid georeferencing applies these tie point coordinates to minimize their differences to the corresponding Lidar points. This process estimates time-dependent corrections of the flight trajectory similar to traditional Lidar strip adjustment. Within this step, tie point coordinates add geometric constraints from AAT. This provides considerable constraints from the image block to correct the Lidar scan geometry. This is especially helpful if both sensors are flown on the same platform and thus share the same trajectory. Hybrid georeferencing additionally opens up information on ground control points used during bundle block adjustment. Thus, georeferencing of Lidar data no longer requires dedicated Lidar control planes. Instead, all the required check point and control point information is available from the standard photogrammetric targets, which is of high practical relevance.

The authors applied a flexible spline as a powerful model for trajectory correction. This flexibility can potentially result in systematic deformations if applied during standard strip adjustment. In contrast, integrating information from stable 2D image frames as oriented during bundle block adjustment reliably avoids such negative effects. Figure 5 depicts the result of the hybrid approach from the OPALS software used. The six GCPs marked by the red circles and the remaining 27 targets used as CPs coincide with the AAT already discussed. For hybrid georeferencing, the elevation differences are -1.5cm minimum, 0.7cm maximum and -0.4cm mean. The corresponding standard deviation of 0.6cm clearly indicates that sub-centimetre accuracy is now feasible.

COMBINED POINT CLOUDS FROM LIDAR AND MULTI-VIEW STEREO

Photogrammetric tie points as depicted in Figure 4 are just a by-product of bundle block adjustment, since dense 3D point clouds are provided by MVS in the subsequent step. In principle, the geometric accuracy of MVS point clouds directly corresponds to the GSD and thus the scale of the respective imagery. This allows 3D data capture even in the sub-centimetre range for suitable image resolutions. However, stereo image matching presumes the visibility of object points in at least two images. This can be an issue for very complex 3D structures. In contrast, the polar measurement principle of Lidar sensors is advantageous whenever the object



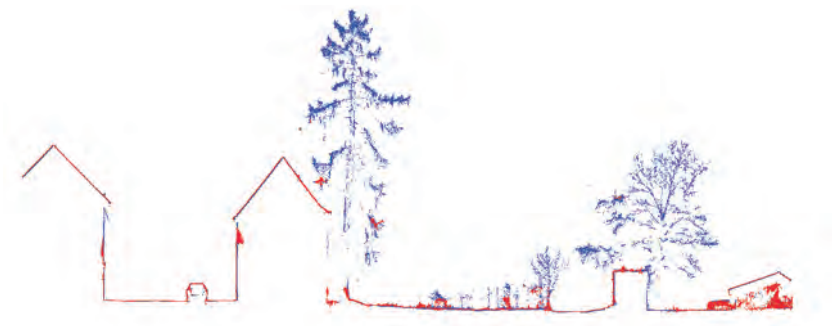
▲ *Figure 5: Elevation differences of Lidar point cloud to signalized targets. GCPs are marked as red circles.*

▲ *Figure 6: Textured 3D mesh from MVS.*

▲ *Figure 7: Textured 3D mesh from Lidar and MVS.*

appearance changes rapidly when seen from different positions. This holds true for semi-transparent objects like vegetation or crane bars (see Figure 4), for objects in motion like vehicles and pedestrians, or in very narrow urban canyons as well as on construction sites. Another advantage of Lidar is the potential to measure multiple responses of the reflected signals, which enables vegetation penetration. On the other hand, adding image texture to Lidar point clouds is advantageous for both visualization and interpretation. In combination with the high-resolution capability of MVS, this supports the argument to properly integrate Lidar and MVS during 3D point cloud generation.

▲ *Figure 8: Comparison of 3D points from MVS (RGB) and Lidar measurement (height coded). Yellow line defines profile depicted in Figure 9.*



▲ *Figure 9. Extracted profile with 3D points from Lidar (blue) and MVS (red).*

Figure 6 shows a 3D textured mesh generated from the Sony Alpha images by the MVS pipeline realized in the SURE software from nFrames. As can be seen in Figure 7, much more geometric detail is available, e.g. on the top of the church and in vegetation, after Lidar data is integrated. Face count typically adapts to the geometric complexity, which is also visible for the small section of the church tower. As an example, Figure 6 consists of approximately 325,000 faces, while Figure 7 features 372,000 triangles.

Figures 8 and 9 demonstrate the complementary characteristics of Lidar and MVS for 3D points at another part of the test site. Figure 8 depicts the RGB-coloured points generated by MVS; the overlaid Lidar data is colour-coded according to the respective elevation. Lastly, the yellow line represents the profile used to extract the points depicted in Figure 9. The discrepancies between the point clouds from MVS (red) and Lidar (blue) are especially evident at trees, where Lidar allows the detection of multiple returns along a single laser ray path.

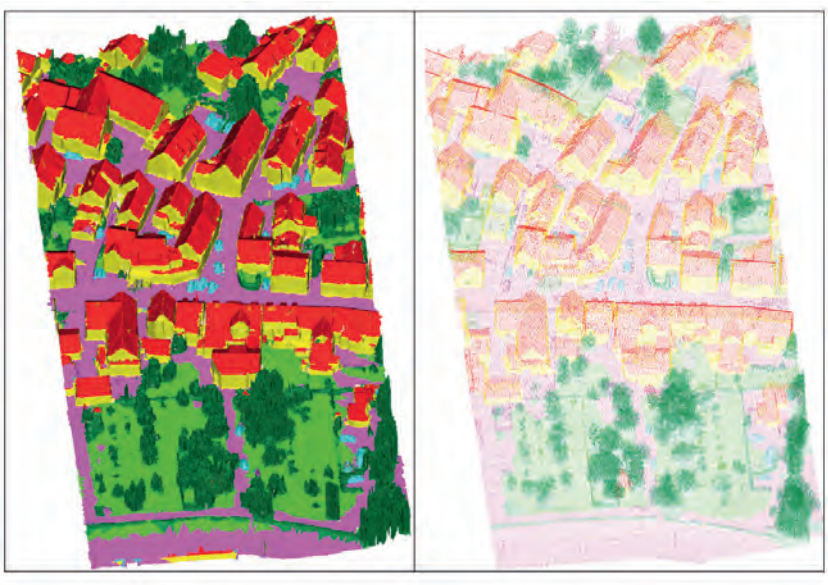
Whereas point clouds as shown in Figures 8 and 9 are an unordered set of points, meshes as depicted in Figures 6 and 7 are graphs consisting of vertices, edges and faces that

provide explicit adjacency information. The main differences between meshes and point clouds are the availability of high-resolution texture and the reduced number of entities. This is especially useful for subsequent automatic interpretation. Generally, many (Lidar) points can be associated with a face. The authors utilized this many-to-one relationship to enhance faces with median Lidar features derived from the respective associated points. This enabled them to integrate inherent information from both sensors in the mesh representation in order to achieve the best possible semantic segmentation. Figure 10 shows the labelled mesh as predicted by a PointNet++ classifier (left) and the labels transferred to the dense Lidar point cloud (right), subsampled by factor 20 for visualization. The following class colour code is used: facade (yellow), roof (red), impervious surface (magenta), green space (light green), mid and high vegetation (dark green), vehicle (cyan), chimney/antenna (orange) and clutter (gray).

The label forwarding was accomplished easily by re-using the many-to-one relationship between Lidar points and faces. Thereby, the semantic segmentation of the Lidar point cloud uses features that have originally only been available for the mesh, e.g. texture. Hence, the semantic mesh segmentation uses inherent features from both representations, which is another benefit of joint image and Lidar processing.

CONCLUSION

This article presents a workflow for hybrid georeferencing, enhancement and classification of ultra-high-resolution UAV Lidar and image point clouds. Compared to a separate evaluation, the hybrid orientation improves accuracies from 5cm to less than 1cm. Furthermore, Lidar control planes become obsolete, thus considerably reducing the effort for providing control information on the ground. The authors expect a further improvement by replacing the current cameras mounted on the RIEGL RiCopter with a high-quality Phase One iXM system to acquire imagery of better radiometry at higher resolution. This will further support the generation and analysis of high-quality point clouds and thus enable UAV-based data capture for very challenging applications. ◀



▲ *Figure 10: Labelled mesh (left) and the labels transferred to the dense Lidar point cloud (right).*

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FURTHER READING

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Dominik Laupheimer holds an MSc in Geodesy and Geoinformatics from the University of Stuttgart. Currently, he is a PhD candidate at the university's Institute for Photogrammetry. His main research interest is the semantic interpretation of 3D urban scenes as acquired by photogrammetric and Lidar sensors. His work is focused on the semantic segmentation of meshes leveraging machine learning techniques.

HOW 3D SCANNING REBUILDS CRIME SCENES FOR COURTROOMS

Capturing Crucial Evidence to Aid Justice

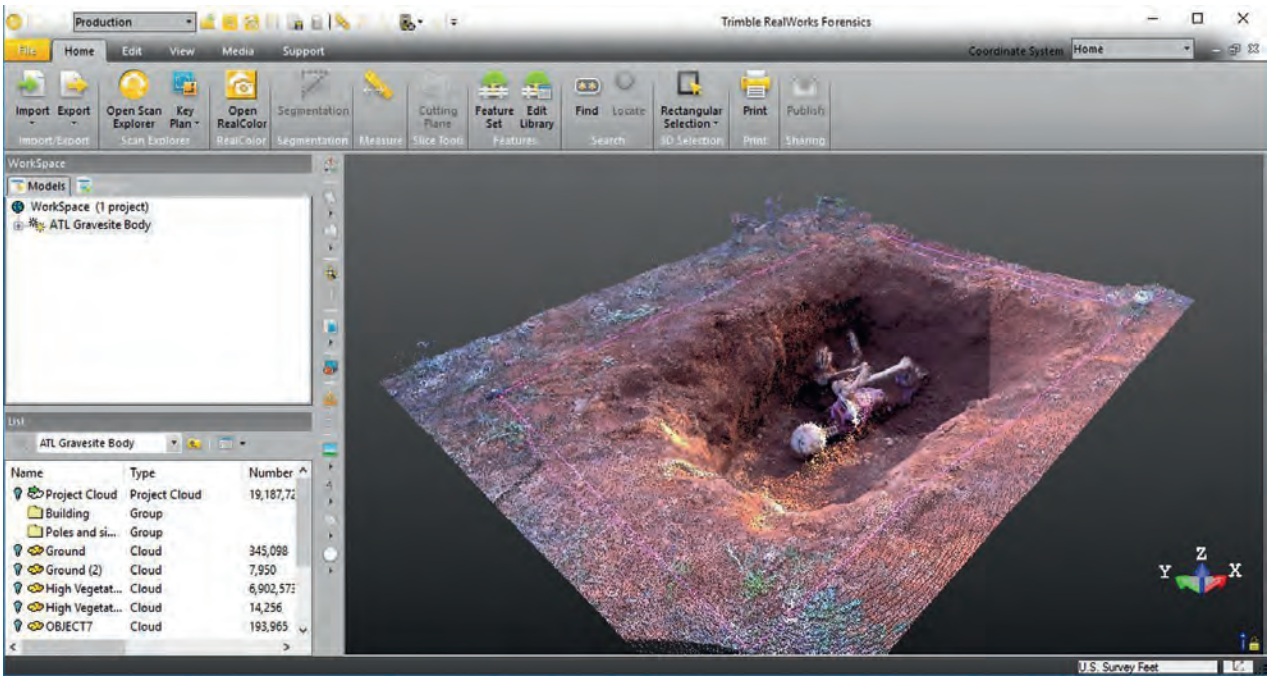
Crime scene investigators with larger US metropolitan police departments and state patrols are increasingly deploying 3D laser scanners to tell detailed, data-based stories that will withstand public and legal scrutiny while bringing justice to victims. 3D laser scanning technology is being used to accurately depict the relational aspect of each piece of evidence so investigators can rebuild and reconstruct crime scenes. This is a powerful investigation tool, especially as legal systems grow more comfortable with high-tech evidence in courtrooms.

In this digital age, the use of 3D laser scanners is expanding the role of geospatial technology in crime scene investigations. As a result, rather than having to rely on photographic imagery alone, judges and juries are able to see accurate, feature-rich visualizations that recreate the scene of the crime and put complex evidence into context.

This relational aspect is important to investigators because they can capture accurate locations of evidence, reconstruct the scene in its end state and rebuild the circumstances that led to that end. The result is a more comprehensive investigation that goes beyond the capabilities of the traditional forensic tools or the talents of the humans hired to record a scene. As acceptance grows for high-tech tools in the courtroom, 3D scanning is likely to become a standard forensic practice.

FORENSICS TOOLS

The documentation of crime scenes is a painstaking process complicated by a short time to collect evidence, logistical challenges of many people working at the scene, and the need to quickly determine what might be relevant in a trial that will not take place until months, or possibly years, later. Traditional forensic tools include cameras (stills and video images), tape measures and measuring wheels. As geospatial technology has advanced into other industries, it has also entered the forensics investigator's toolbox, which has grown to include unmanned aerial vehicles (UAVs or 'drones'), photogrammetric



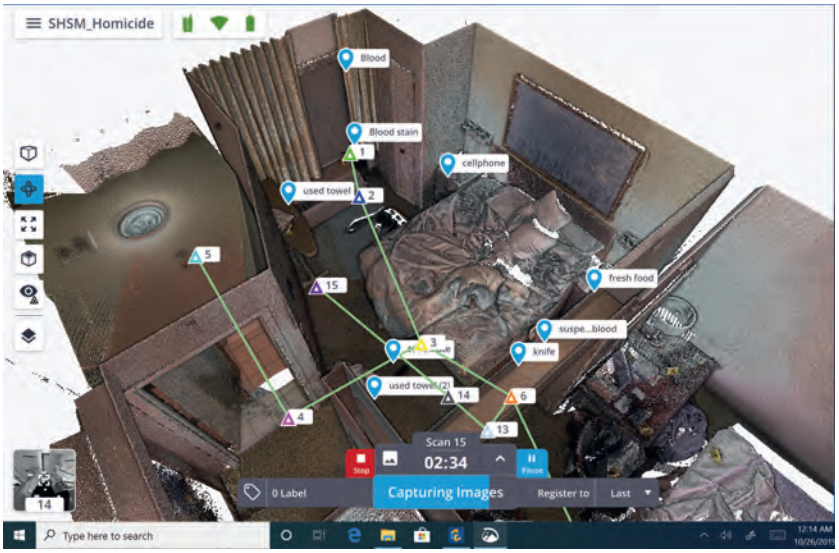
▲ *In this mock-up, a point cloud of a clandestine grave site was created using a Trimble Forensics SX10 solution and is displayed in Trimble RealWorks.*

analysis, total stations, GNSS systems and, more recently, 3D laser scanners.

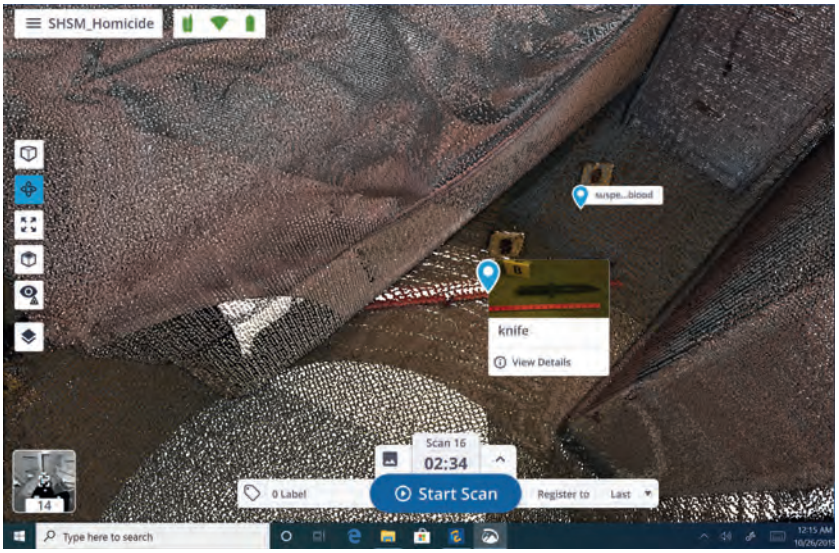
3D SCANNING

3D scanning systems in particular have the power to bring a crime scene into the courtroom through photorealistic 3D models using methodical, scientific approaches. They allow analysts to collect precise dimensions, evidence and features to be recorded for later analysis. By capturing large amounts of data quickly, 3D scanners enable investigators to create a complete 360-degree image of a scene in a matter of minutes.

There are two main technologies used within 3D laser scanners to accurately determine the location of an object with respect to the scanner position: time of flight or phase shift-based technology. In the past, there was a distinct difference between systems using the different methods. Time of flight scanners were slow (a 360° scan could take more than 30 minutes) and offered lower resolution (point density) but had a great distance range (100-1,000 metres) to obtain a return from an object. Phase shift-based systems were fast (a 360° scan would take approximately five minutes) with high density but had limited range (>80 metres) and did not perform well in full sunlight. However, with today's advances in technology, this difference between methods is not as pronounced; time of flight systems are now collecting data as fast and as densely as phase shift-based systems, which in turn now have increased range. For example, 3D point accuracy can be in the order of six millimetres at 40 metres on a scan that takes under three minutes to complete (including image capture) and collects approximately 12 million points. Today, some 3D laser scanning systems include automatic levelling and automatic calibration features.



▲ *In this mock-up of a crime scene in a hotel room, a variety of objects of evidence are identified in the point cloud relative to each other and the entire room in 3D. It was created using a Trimble X7 3D laser scanning system combined with Trimble Perspective field software.*



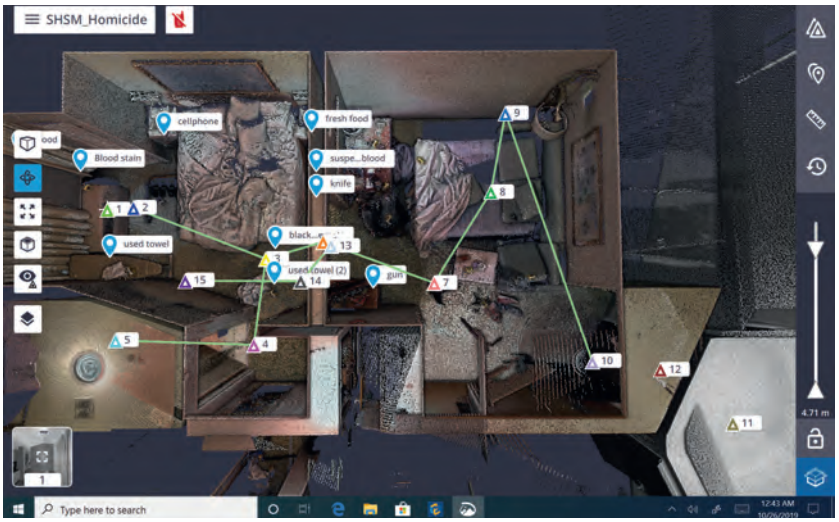
▲ *A knife is revealed as important potential evidence in this mock-up of a crime scene. Images can be attached directly to the point cloud.*

GATHERING EVIDENCE

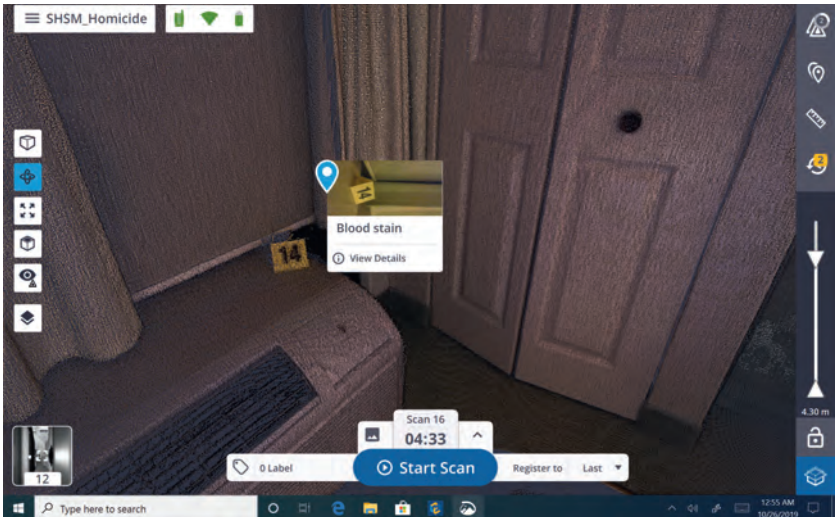
Until recently, 3D scanners were slower to be adopted by forensics teams, mostly because resources are tight for law enforcement agencies. While violent, heinous crimes are a smaller portion of incidents investigated by law enforcement agencies, crime scene units sometimes have more access to newer technologies due to the seriousness of the offences. By delivering accuracy and precision quickly, scanning solutions help investigators reconstruct crime scenes methodically and build stronger cases. Part of the value of using 3D scanners to investigate crimes is that evidence can be documented, analysed and processed later, as needed. Besides enabling investigators to clear a scene more quickly, this is also useful if new evidence surfaces or if suspects change their stories.

3D scanning allocates a coordinate to almost any object the laser hits – from bodies to blood splatter to bullet holes. In addition, point cloud data can reveal missed evidence or enable collected evidence to be considered in new ways. By changing the intensity values in a point cloud, objects with different reflectivity are revealed, such as footprints in a grassy area that might otherwise go unnoticed in standard black and white imagery. The higher the density settings and the closer to the item, the closer together the points on an object will be. Conversely, objects farther away from the scanner will have lower density settings and some space between points.

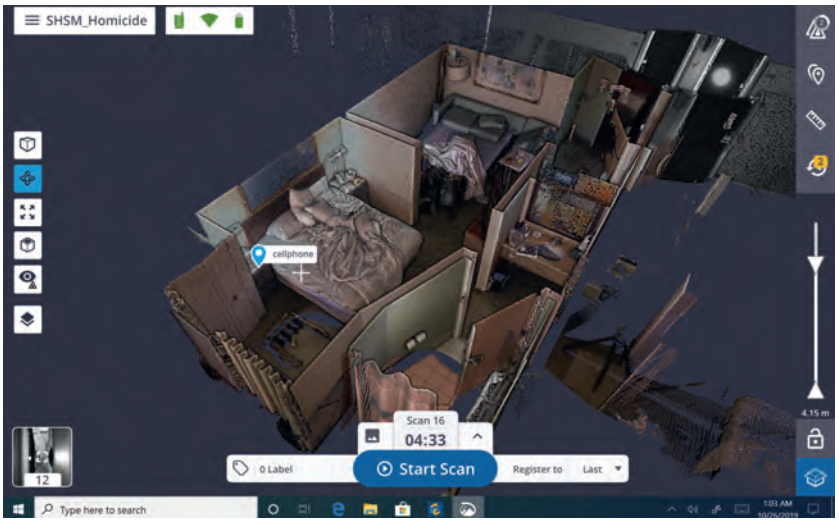
Since a 3D scanner can only collect data it receives from a return signal, for a complete 3D representation more than one scanner set-up location is needed to collect the reverse side of objects or other hidden items. With multiple scan positions around an object



▲ *From this angle, the point cloud reveals the larger apartment space, helping to establish the proximity of evidence and activity. A point cloud can be used for a complete perspective of a crime scene from different viewpoints.*



▲ *A blood stain is revealed in this scan both by point cloud and the attached image.*



▲ *Viewing the point cloud from this angle clarifies the relative positioning of the evidence to the room entrance.*

or scene, the density of the scan will increase, filling in gaps in the point cloud. Previously, users had to stitch together multiple scans from various set-up locations, utilizing specific office software and powerful computers. Today this 'stitching' of the data can be performed at the scene on a tablet as the scans are being taken. The investigator can then review the 3D data as collected prior to leaving the scene.

To truly explore the value of 3D scanning at crime scenes it is necessary to discuss some of the more sensitive areas of evidence: bodies, blood and bullets.

BODIES

In the case of violent crimes, the bodies of perpetrators, victims and witnesses – whether alive, injured or dead – are key evidence. A focus in any violent crime investigation is determining where an individual was located, as well as the points of view of all involved. The point clouds generated by 3D laser scans can serve as walk-through visualizations of a scene, giving jurors various points of view in the crime scene. Because the data collected by 3D scanners generates a very dense collection of points that have a location in space, very accurate measurements can be obtained. Point clouds are often colourized by the images that are taken by the 3D scanner at the time of data collection. This colourization enhances the visualization and can give jurors the sense that they are at the scene with spatial and visual reference.

BLOOD

There is a science around blood splatter that analyses the direction and shape of how the blood has landed on walls, floors or other surfaces. Are the drops big or small? Do they form a spray pattern? Questions like this, explained through the 3D reconstruction, reveal the possibilities of what occurred. If blood drops are small, a technician would want to use a high-density setting and scan the area from different positions. Larger pools of blood as well as blood smears from a crawling victim or footprints from a perpetrator can all be captured with a 3D scanning solution. Moreover, light is not required to scan a scene. A grayscale value can be assigned to certain points based on the intensity of the signal received by the instrument, revealing differences between

the blood on the floor and the floor itself. This means it is possible to scan a dark scene, view the point clouds and analyse the different intensities to produce a photorealistic model from a completely dark setting.

BULLETS

3D laser scanning technology also provides advantages in investigating shootings. Assessing a scene where a gun was fired requires analysis of all aspects including the location of the gun and where the shooter was positioned, as well as the resulting bullet holes ('wall defects'). If the bullet hole is prevalent enough, specially trained investigators will use a trajectory rod to indicate from which direction the bullet entered the wall and where the shooter was standing. By putting a rod into the hole and scanning it, investigators can get an accurate representation of the path taken by the bullet and, likely, a location for the shooter. If there are multiple bullet holes, the intersection of the possible directions will give an investigator a likely position and height of the weapon when fired.

TECHNOLOGICAL ADVANCES

Data visualization is a major component of modern forensics work, and 3D laser scanning technologies with better workflows are making it easier and faster to achieve storytelling that holds up in court. Faced with challenging environments, law enforcement agencies need scanning solutions that are fast, easy to operate and complete in their data. Barriers to acquiring the 3D scanning solutions are increasingly coming down, with recent advances decreasing the cost of ownership while also providing new features, such as automatic infield registration, elimination of the need for annual calibration, longer warranties, and data capture capabilities from highly reflective and dark surfaces. Thanks to built-in integrations, varying geospatial forensics technologies can work together, enabling investigators to collect evidence and create diagrams, animations and fly-through models that tell an accurate story of the events. The models bring clarity and build understanding of complex testimonies and exhibits, delivering immense value to the criminal justice system. ◂

ABOUT THE AUTHOR

Devin Kowbuz is portfolio manager for the Trimble Forensics business area within Trimble Geospatial. He is responsible for the current portfolio of solutions and the forward-looking development of the market. He holds a degree in geomatics engineering from the University of Calgary, Canada, and is a licensed professional land surveyor in Colorado and Ohio, USA.

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RECOMMENDATIONS FOR MITIGATION

The Anatomy of Corruption in Land Management

"Have you ever heard of the International Association of Land Grabbers? To my knowledge, no such association exists," writes Jack McKenna in this article. If such an association were to exist, there would be no shortage of qualified members. There are hundreds, if not thousands, of land grabbers throughout the developing world. Among their ranks are drug cartels, judges, lawyers, notaries, surveyors, the societal elite and politicians. How can a national cadastre help to mitigate corruption in land management?

Populations are expanding. Available land is shrinking and you have probably noticed that they're not making any more land (except perhaps in the Maldives). No one is more aware of this than politicians. Unfortunately, after being elected to office, too many of them find – to their unbridled joy – there is still some land that is up for grabs… and they grab it for themselves, their families and for sale to unscrupulous land developers. Mostly their target is government-owned land, but they also go after privately owned land.

GOVERNMENT-OWNED LAND

The reason they go after government land is simple: it is the lowest-hanging fruit in the land grabbing game. Many governments of developing countries have no idea how much government-owned land there actually is, because they have never created an inventory of it – despite land being their most valuable asset. Actually, it is not their land; it is the people's land. But when an inventory of land does not exist, it cannot be measured. If it cannot be measured, it cannot be managed. Simply put, it is up for grabs by the many unscrupulous means at the grabbers' disposal. And a sad reality regarding government land in some smaller countries is that there is none left. It has been grabbed to the point of extinction.

▲ *Cadastral boundaries digitally drawn by local people in Kenya, using handheld GPS devices.*

PRIVATE LAND

Government-owned land is not the only target of the land grabbers. Many legitimate landowners become the victims of judges, lawyers, notaries, surveyors, the societal elite and politicians who decide that, for whatever nefarious reason, they want a particular piece of land. Those citizens who do not possess the financial means to resist a land grab from a corrupt party often give up their property without a fight. They – and the laws that are supposed to protect them, their rights and the security of their land tenure – are legally and financially bludgeoned into submission.

Adam Smith, author of *The Wealth of Nations*, wrote in 1776 that "It is only under the shelter of the civil magistrate that the owner of that

valuable property, which is acquired by the labour of many years, or perhaps of many successive generations, can sleep a single night in security". Millions of citizens in developing countries do not have the remotest chance of being "under the shelter of the civil magistrate". How shocked Smith would be today to discover that, all too often, the role of the civil magistrate is to aid and abet the grabbing of land by so many in too many parts of the developing world.

Problems with Third World governance, including corruption, are often caused by a lack of financial resources, inefficient economic development and the scurrilous use of aid. One way or another, the root causes of corruption can be traced back to the insidious practice of patronage whereby unscrupulous rulers provide land, money, jobs and political favours in return for support. Patronage is perhaps the biggest reason why there is a strong correlation between a country's high corruption rating and the amount of foreign aid it receives and abuses. (Mark Moya, 2015)

IDEOLOGY

Most non-government organizations (NGOs) and donor agencies operate at the fringes of the developed world. Their operating environment is not at all like Western Europe or the USA where ethical rules are in play, and they operate with impunity where the US Foreign Corrupt Practices Act (FCPA) has no say. Government-appointed judges in developing countries too often allow their ideological and political views to guide their legal opinions. Their ability to exercise professional judgment is either impaired or entirely absent. When they are criminally ideological, they become the most potent weapon at the beck and call of despotic heads of government as they practise their black art of corruption, often in the form of massive land grabs at the expense of the hapless citizens they are meant to serve.

Government workers in Third World countries often live below the poverty line themselves, which provides the incentive for them to seek ways to profit from their government-provided jobs. For this reason, every government-related transaction undertaken by the citizens in many countries is an opportunity for them to be corruptly taken advantage of. The magnitude of the corruption increases exponentially when the government transactions involve the highest level of government 'servants'.

EXAMPLES OF CORRUPTION IN LAND ADMINISTRATION

In 1957, Ayn Rand, the author of *Atlas Shrugged*, wrote the following: "When you see that in order to produce, you need to obtain permission from men who produce nothing – when you see that money is flowing to those who deal, not in goods, but in favours – when you see that men get richer by graft and by pull than by work, and your laws don't protect you against them, but protect them against you – when you see corruption being rewarded and honesty becoming a self-sacrifice – you may know that your society is doomed." A recent example of corruption was reported in a Devex article (Lisa Cornish, 2020). World Vision Australia is facing a major blow to its reputation, with allegations of nepotism and corruption within its ranks that led to ongoing kickbacks as part of a AUD2.5 million (US$1.6 million) printing and marketing contract. One example of corruption that I observed first-hand involves an older guy who was tasked with retrieving land records documents for paralegals who came to the land registry office looking for copies of deeds and titles. He would collect fees, rarely more than 50 cents per paralegal, perhaps three or four of them a day. He had a little den set up amongst the archive records that was invisible to a casual passer-by. It was also a little drinking den and he drank rum during most of his 'working' day. The meagre amount he collected from stealing the copying fees was more than enough to support his drinking habit. He was a member of a government employee union and there was no chance of him ever having his employment terminated. He is probably still 'working' in the registry office. The archive guy was probably the lowest on the totem pole of the ministry that employed him. However, the head of that ministry had much bigger fish to fry. While in office, he repeatedly sold land illegally to his family members for literally pennies on the dollar. When finally caught after several years of grabbing his country's land, he was interviewed on television. He calmly explained that his family deserved being given access to land in this manner as they "were not like ordinary citizens". It took another two years to oust him from office and court cases are ongoing in an attempt to get the land back in the hands of the citizens. Come to think of it, that particular minister would be an excellent president of The International Association of Land Grabbers.

10 RECOMMENDATIONS FOR NATIONAL CADASTRES

So how could corruption in land administration be mitigated by a national cadastre? Such a national cadastre would have a minimum set of attributes, and the development and integration of the national dataset would be overseen by a national cadastre coordinator, working with private and public-sector stakeholders. The national coordinator could play the role of ombudsman/woman in investigation of reported cadastre (and registry) workflow irregularities. This approach could be based around the following ten recommendations:

1. Identify and root out the drug cartels, judges, lawyers, notaries, surveyors, the societal elite and, most significantly, politicians and other government 'servants' who aid and abet land grabbing from the citizens. Perhaps surprisingly, most of their unscrupulous behavior is known by most of the citizens.

2. In order to achieve nationally integrated land parcel data, there should be a national cadastre coordinator. A panel should be established to determine which stakeholder has the authority and capacity to serve as the coordinator.

3. As part of the Geospatial Line of Business process, the coordinator should identify the role of parcel data in the collection and maintenance of identified data themes.

4. The coordinator should coordinate the development and maintenance of a single, comprehensive and authoritative geographically referenced database for land parcels managed by the government, including public lands, and should include leasing of all government-managed lands.

5. The coordinator should develop and oversee a land parcel data business plan. This plan should serve as the basis for evaluation of the programme and as a model for all stakeholders.

6. An office of special trustee for traditional lands would manage a programme to coordinate

▲ *Working Registry Office in Nigeria, also known as 'Land grabbers' Parcel Buffet'.*

and fund the development and maintenance of a geographically referenced database for traditional trust parcels. The data should then be made available to the coordinator and integrated with national land parcel data.

7. The government should explore potential policy options that would allow its digital data on building addresses and their geographical coordinates to be placed in the public domain while maintaining privacy protections.

8. The coordinator should develop a national spatial data infrastructure (NSDI)-compliant parcel data business plan and manage the relationships among all levels of government agencies involved in parcel production. The plan and programme should achieve comprehensive border-to-border parcel coverage for all public and privately owned property within the country.

9. The coordinator should develop a plan for a sustainable and equitable inter-agency funding programme for the development and maintenance of parcel data. The funds for this programme should come from existing national programmes that require parcel data; however, new funding will be required to establish an initial baseline, integrate the data and make it available through a web interface for revenue generation.

10. To participate in national geospatial programmes such as government collection and dissemination of ortho imagery, public and private-sector stakeholders should be required to make their NSDI-compliant parcel geometry and attributes needed for the national cadastre available in the public domain. (FGDC, 2020 and Jack McKenna, 2020)

CONCLUSION

It is a truism that the ruling classes of the poorest of countries do not go hungry. They focus on their own self-interests; the public good be damned. It is no coincidence that those countries that perform justly and morally towards their citizens enjoy increased economic benefits. Rather than enabling only their friends and families to prosper, when fair and decent government rulers encourage their citizens to be entrepreneurs, invest in land and share in the wealth, economies improve and outside investment is easier to attract (Mark Moya, 2015). Like the common cold, there is likely no cure for corruption. Human nature being what it is, there are individuals who will try to find a way to work any system, no matter how secure or well intentioned, to their financial advantage. But, also like the common cold, there are ways to bring about relief – such as by implementing the recommendations above. ◀

THE MAGNITUDE OF THE CORRUPTION INCREASES EXPONENTIALLY WHEN THE GOVERNMENT TRANSACTIONS INVOLVE THE HIGHEST LEVEL OF GOVERNMENT 'SERVANTS'

FURTHER READING

Atlas Shrugged, Ayn Rand, 10 October 1957
Article on Devex.com, World Vision Australia corruption allegations: What's happening and lessons for NGOs, Lisa Cornish, 16 March 2020
Federal Geographic Data Committee, National Spatial Data Infrastructure Strategic Framework (2020)
Wall Street Journal article, 'The Virtues of Corruption', Mark Moya, 1 June 2015

ABOUT THE AUTHOR

Jack McKenna is a technical project manager and has worked on various recent cadastral mapping projects, including Anguilla, Antigua and Barbuda, St. Kitts and Nevis, Bermuda, Belize, Benin and US local government agencies. He is responsible for the formulation of the methodology developed for the successful completion of ownership mapping projects. He has over 40 years of experience in the field of land administration in 53 countries in Europe, Asia, Africa, Latin America and the Caribbean.
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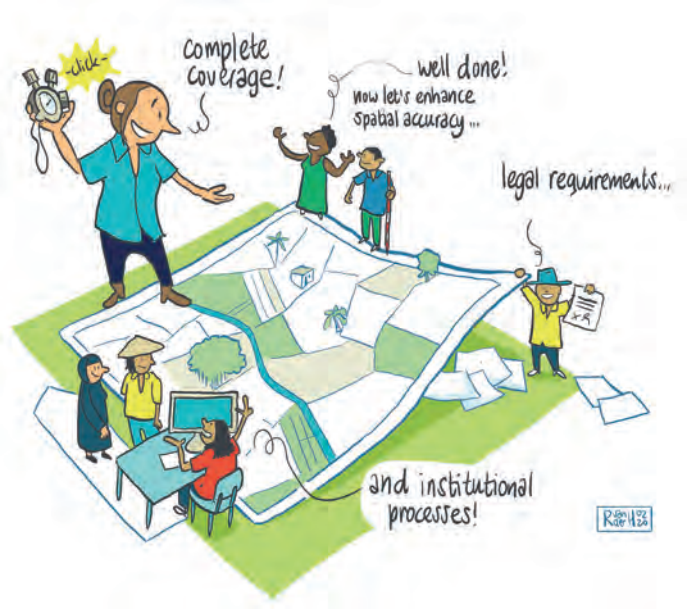
Fit-for-purpose Land Administration for All

Over the last decade, fit-for-purpose land administration (FFPLA) has developed into a viable philosophy with accompanying methodologies and tools for delivering land tenure security on a large scale. A new publication called *Fit for Purpose Land Administration for All*, which is backed by Kadaster International, suggests that FFPLA should be recognized as a once-in-a-generation opportunity for all stakeholders, and specifically for private surveyors.

The methodologies and tools of FFPLA contribute to large-scale land tenure in several ways: by encouraging participatory approaches, simplifying legal procedures, streamlining institutional processes and making use of innovative frontrunners and leading-edge technologies. The benefits of the approach have been proven in many country contexts and FFPLA has been backed by the World Bank, International Federation of Surveyors (FIG) and UN-Habitat, amongst other leading agencies. The FFPLA methodology emerged due to the problems with existing land administration approaches. Cadastral mapping and land registration activities are often slow, expensive and reliant on a few skilled professionals. In many countries, this has resulted in just a very small percentage of land rights being formally recorded. This increases land disputes and uncontrolled development, decreases land productivity and may mean little or no government investment into land and infrastructure.

Whilst the benefits of FFPLA are now clear, it has still not yet become mainstream in many of the countries that need it most. FFPLA requires a whole-of-sector approach. In many countries, it is the role of the private sector to complete cadastral work. Although the need for FFPLA is often appreciated, private surveyors, lawyers, notaries, conveyancers and other land administration professionals rightly ask questions about its impact on job security and survey quality. Private surveyors were not involved in some FFPLA applications, and this highlighted the issue of stakeholder acceptance. For FFPLA to work in these countries, private surveyors also need to be on board. They must play a significant role in awareness raising, adoption, implementation and maintenance of FFPLA. The private sector is seen as essential for any level of scaled land administration in the developing world. Governments often lack the resources and technical capacity to sustain the land administration effort alone. The work behind the new publication *Fit for Purpose Land Administration for All*, backed by Kadaster International, suggests FFPLA should be recognized as a once-in-a-generation opportunity for all stakeholders, and specifically for private surveyors. It maintains that, for those in the profession, FFPLA:

- Can mean more work and income, not less
- Will offer the opportunity to broaden professional horizons with the adoption of new technologies
- Presents opportunities for both undertaking and delivering new training



- Offers the opportunity to bring high-level technical leadership.

Moreover, the publication also busts a few myths, including by revealing that:

- Concerns over FFPLA accuracy and quality are hyped and misplaced
- Citizen confidence does not drop with the use of FFPLA
- Widespread FFPLA adoption can increase surveyor status and recognition
- Surveyors can play a role in raising awareness and helping to overcome legal and organizational blockers.

In many countries, many of the ingredients needed to make FFPLA a success are already in place. A willing, supportive and frontrunning surveying profession is essential. The new report also shows how, through the adoption of FFPLA, surveying professionals will be playing a direct and meaningful role in responding to major societal concerns. This includes direct support to climate change response, disaster risk management, women's access to land, mass urban migration, overcoming conflicts and disputes, and the overall achievement of the 2030 Agenda and the Sustainable Development Goals (SDGs). In each case, the surveyor is a crucial community actor, delivering benefits to their community and raising the esteem of the profession… and all whilst doing business. The publication provides guidance on pathways forward and support mechanisms for land sector professionals, including exposure to the global scene, key policies, agencies, resources and materials. A simple self-assessment for countries helps to show land administration professionals and related associations where their country stands in terms of FFPLA uptake, and what actions are needed. Initial actions range from self-education and awareness-raising to instigating pilots and financing. Further actions can include undertaking FFPLA work in the field, educating the next generation of surveyors and taking up the role of FFPLA champion to advocate it across regional and global domains. ◀

WHAT IS FIT-FOR-PURPOSE LAND ADMINISTRATION?

Fit-for-purpose land administration (FFPLA) means that land administration systems should be designed to meet the need of tenure security for all in a relatively short time and at a relatively low cost, adapting relevant legal, spatial and institutional frameworks accordingly. The aim is to achieve complete coverage and a complete overview first, and then improve incrementally over time, by enhancing spatial accuracy, legal requirements and institutional processes.

FURTHER READING

https://www.kadaster.com/-/new-publication-fit-for-purpose-land-administration-for-all

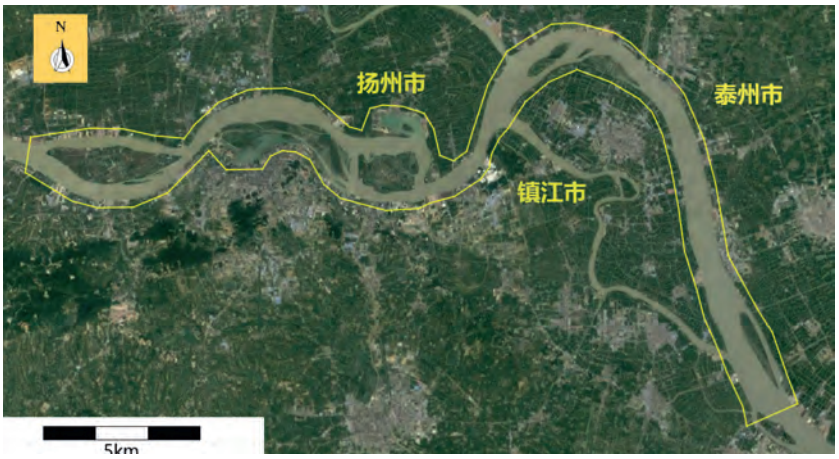
ONE LOCAL AUTHORITY, 400KM², 21,000 IMAGES AND ONE MAP

Mapping the Yangtze River

The Zhenjiang Municipal Flood Control Bureau is a short walk from the Yangtze River: staff can clearly see the river from the office. In July 2019, a massive orthophoto was created from 21,000 images, representing 400 square kilometres. Before this, the region's flood planning maps, water conservation data and related information were stored as separate, discrete files. For such a big project, the team needed to bring all these together with a custom base map.

Zhenjiang is a transport hub lying on the southern bank of the Yangtze River near the Grand Canal, and at constant risk of floods. The People's Municipal Government of Zhenjiang commissioned a high-resolution (8cm) orthophoto of 100km of the Yangtze River, an on average 2km-wide river with 500m of coastline on either side, representing a total of 400 km². The project area stretched from the Dadao River in Jurong City in the west to Xilaiqiao Town in Yangzhong City, including a few islands in the river. The purpose of the orthophoto was to better understand the risks of flooding and to gain a complete overview of how the riverbank is being developed and used. The maps will also strengthen and maintain the river's ecology.

▲ *Creating ground control points with drone mapping.*



▲ *Mapping the Yangtze River.*

DRONE SURVEY

While large-scale drone mapping has been achieved before, it's a big challenge for any team. For this project, the MMC UAV Griflion M8 vertical takeoff and landing (VTOL) fixed wing drone was selected, equipped with a high-resolution 42 megapixel ortho camera and an RTK/PPK system. VTOL drones combine the advantages of fixed wing and multirotor drones. Like multirotor drones, VTOL drones can take off and land just about anywhere, but have the faster flight speed and longer battery life associated with fixed wing drones.

Real-time kinematic (RTK) GNSS positioning is remarkably accurate but, for such a large and important project, the team wanted to confirm the accuracy of their results. Two days before flying began, the project team marked control points throughout the survey area. Following best practices for a corridor mapping project, the ground control points were placed in an offset or 'zigzag' pattern. All 160 ground control points were surveyed with a GNSS receiver to an accuracy of 2cm horizontal and 4cm vertical.

▲ *Preparing for a drone flight.*

▲ *Reconstructing water as an orthomosaic.*

A total of 41 flights of about one hour were required for the full survey, each from its own launch point and spread over 15 days. Upon arrival, the drone was assembled. A route was then planned in the drone to ensure usable photographs. To ensure an accurate reconstruction and to achieve the required 8cm ground sampling distance (GSD), the team set a 75% frontal and 70% side overlap for the photographs. The drone was constantly tracked during the flight using a ground control station from the MMC UAV. Take-off and landing was fully automatic using the RTK positioning.

DATA PROCESSING

Each day, the collected data was processed using Pix4Dmapper. This allowed the team to find potential issues such as missing images early on, saving a lot of time. Image overlap was also checked during processing. Pix4Dmapper's fast processing option allowed the team to review large datasets quickly and the automatically generated quality report confirmed that the results were reliable in terms of, among other things, number of usable images and points extracted and matched.

Once the team had checked the fast-processed data, it was reprocessed with Pix4Dmapper at a higher resolution. Images were stitched into a continuous, undistorted and measurable orthophoto using the RTK data and ground control points. While this took time, it was largely an unsupervised process requiring only minimal human intervention. RayCloud was used to mark ground control points using machine learning. After manually marking a couple of tie points, the software took over and automatically marked the rest of the tie points. While a little manual fine-tuning was needed, the team reported the feature as "very convenient and practical!" The results were checked once more in the quality report to ensure that they were mapped to the project requirements, with resulting accuracies horizontally of 10–20cm and vertically 20–30cm. The final result was delivered just one month after the first drone flight.

With a large-scale, longer-term project, weather is something of an issue as the light changes from one day to the next, creating banding across the merged outputs. To achieve natural-looking colours throughout the project, some areas were recaptured. In other cases, blending and balancing the colours was all that was needed. The resulting orthophotos had natural-looking colours, while the good overlap meant there were very few gaps. A few 'cracks' appeared in the river as water is very difficult to reconstruct, but the team was able to plug the holes with the surface tool in the rayCloud, greatly improving the appearance of the finished model.

CONCLUSION

Drones may seem an unusual choice for a project of this size, but light aircraft are prohibitively expensive to fly and logistically difficult, while satellite imagery doesn't have the resolution needed. Also, the available satellite images are not always up to date. One clear example is a basketball court, which was not completed when the satellite images were captured but is easy to spot in the orthophoto.

Orthophotos have a major advantage over stitched satellite images: their accuracy. Except in the rare areas where the terrain is perfectly flat, stitching images introduces artifacts where photos are potentially misaligned. Rectified orthophotos take the height of the terrain into account through the DSM (digital surface model). Orthophotos produced with drone imagery are more accurate than satellite images – and more practical than capturing images from manned aircraft.

The Zhenjiang City Municipal Flood Control Bureau usually uses small drones to make high-precision orthophotographs of individual small rivers and lakes. This project with hundreds of square kilometres of data has been successful and adds to the organization's confidence in the processing capacity of large areas. The Zhenjiang City Municipal Flood Control Bureau plans to regularly update the Yangtze River orthophoto and to extend the technology to more rivers and lakes in Zhenjiang. With this project as an example, the team hopes that more cities will begin similar drone programmes. As well as contributing to improving the area's resilience to floods, it may mean that, eventually, all 6,300 kilometres of the Yangtze River can be mapped. ◀

ABOUT THE AUTHOR

Minyi Pan works as a data engineer at Pix4D – a Switzerland-based leading developer of software solutions to convert photogrammetry imagery data into high-end geospatial solutions. She received an MSc in Geomatics from Lund University, Sweden.

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COMBINING TECHNICAL AND CULTURAL CHANGE INITIATIVES

Modernization of Suriname's Public Domain Cadastre

In 2017, Suriname's Ministry of Land Management decided to digitize and automate the process of citizen requests for land and the management of land, which had mainly been paper-based for the past decades. This article outlines how the approach of consciously addressing technical and cultural aspects in combination with modernizing the public-domain land administration in Suriname has enabled significant results within a time span of two years.

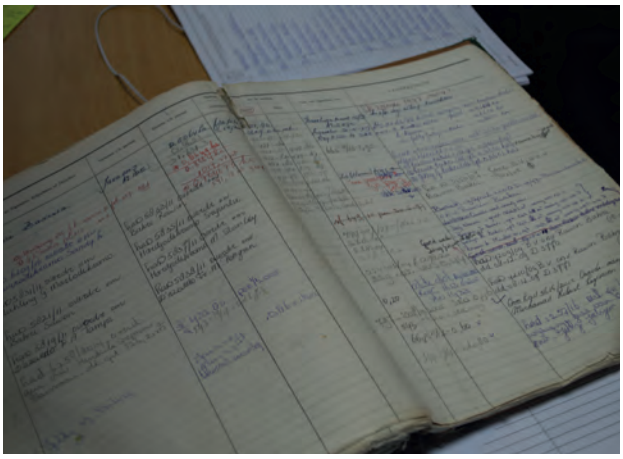
Suriname is a former Dutch colony that became independent in 1975. The country has a population of approximately 540,000 and comprises an area of just under 164,000 square kilometres. More than half of the population live in the coastal area and the rest in the interiors, with very often no claim nor title on the lands they live on. In Suriname, citizens are entitled to receive land on lease from the government for farming, agriculture or habitation. The process of requesting land has been paper-based for the past decades. The process of managing public and leased domain land in Suriname has also mainly been paper-based. Part of the process chain has been digitized and was brought separately into an institute in 2008.

CADASTRE MODERNIZATION

In 2017 the country's Ministry of Land Management decided to digitize and automate the process of citizens request for land and the management of domain land. The ministry received technical support from the e-Government unit to optimize the process and develop tools. The tools, systems and optimized process are well accepted and widely used. The open-source solutions built now enable digital storage of citizens' requests for land, and faster and more transparent enquiries into the status of a request. This development also contributes to the Sustainable Development Goals (SDGs) related to land, specifically SDG 1 'No poverty' and SDG 2 'Zero hunger'. Thanks to the digitization and automation of the process, all men and women in Suriname now have equal rights to land with legally recognized documentation.

TECHNICAL IMPROVEMENT INITIATIVES

Like many other countries around the world, Suriname needs a well-functioning land administration system, or cadastre, for national stability and social welfare. Without



▲ *Figure 1: Paper-based record keeping.*

▲ *Figure 2: Feedback was collected as the tool was being built.*

an efficient and effective cadastral system, the authorities will not be able to ensure property rights and land-based economic development.

The Domain Office within the Ministry of Land Management has kept paper-based records for the past 45 years. In 2017, it committed to an integral approach to digitize and automate its processes. The geographically spread public offices were first connected via IT networks. The existing process was mainly text-based, outdated and interpreted differently by different process actors. Overall, the solution demanded software, hardware and network infrastructure guaranteeing real-time access, high performance and scalability.

To reduce costs and ensure fast and lasting results, the agile methodology was used to understand the process and then build the application. This method resulted in a fit-for-purpose system in which the accuracy of information grew with each iteration.

PROCESS FIRST, THEN TOOLING

Thanks to the process being modelled in Business Process Model and Notation (BPMN) and published via a web-based process portal, all stakeholders had a uniform understanding of the process and were more effectively and comprehensively collaborating towards improving and implementing the optimized process.

An open-source code generator was used to build the application and immediately show the results, receive feedback from the process actors and refine the application. The generated code cut down development time by more than 60%. The most significant benefit of working with a code generator was that it immediately showed the process actors how they would work in the new situation. Simply discussing how things could be creates a risk of misinterpretation and misperception, whereas immediately showing the actual results ensures clarity from the beginning.

CULTURAL IMPROVEMENT INITIATIVES

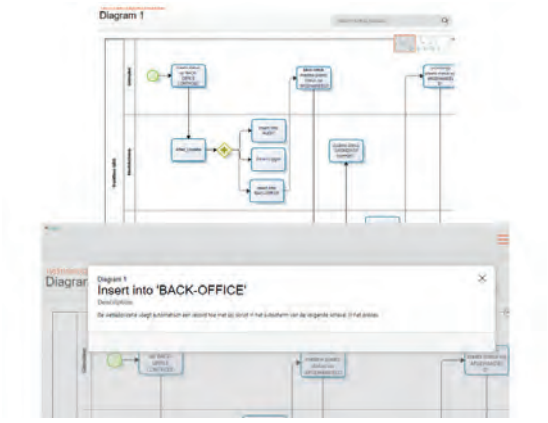
In the end, the optimization of the process and the development of the application took relatively less time than the time needed to transition the people from a paper-based working culture towards a digital workflow. The following areas needed thorough attention to successfully transform the culture from paper to digital:

- Connecting with all stakeholders
- Defining new roles with the process actors
- Continuous leadership involvement.

CONNECTING WITH ALL STAKEHOLDERS

In the communication with stakeholders, it is important to make an extra effort to first make a connection with all relevant stakeholders at an early stage, even the ones that are indirectly involved. They should also be kept regularly informed about the initiatives, independent of the size of the organization. Keep in mind that people have different communication styles. A very simple and effective tool for understanding the information processing, thinking and decision-making styles of different personalities is the Myers-Briggs Type Indicator (MBTI). By identifying and using these insights in communication, it is possible to more effectively:

- elicit requirements
- deal with resistance to change
- share information
- stimulate teambuilding.



▲ *Figure 3: The web-based process portal was easily accessible to all relevant stakeholders.*

DEFINING NEW ROLES

As the process changes, some activities may become redundant and others will be done within the tool instead of on paper. Instead of making it an HRM exercise, sit with the relevant people to define new roles, such as coordinators within units or departments throughout the process. One important role that will be needed is that of 'champions'. The champions will be the individuals who promote the tool, encouraging other process actors to use it and gathering feedback for further improvement. The champions participate in regular sessions with all the other champions to share findings, with the focus on handovers between the process chain. By better understanding what other

▲ *Figure 4: Built applications that can be used immediately.*

▲ *Figure 5: Regular update meetings were held with the whole team, including directors.*

▲ *Figure 6: Collecting feedback from process actors.*

units or departments within the process do, more quality of output can be achieved.

CONTINUOUS LEADERSHIP INVOLVEMENT

It is possible that leaders may consider it unnecessary to be involved throughout the transformation, but this is actually one of the key success factors. Having leadership involved in the process improvement workshops and the tool development sessions, and also using the application, sends a strong message to the process actors about the importance of the transformation.

CONCLUDING REMARKS

The approach of consciously addressing technical and cultural aspects in combination with modernizing the public-domain land administration in Suriname has enabled significant results within a time span of two years. The cultural initiatives ranged from role definition sessions to teambuilding and leadership involvement. The technical initiatives ranged from process improvement workshops and tool development sessions to infrastructure improvement initiatives. By actively and consciously looking at cultural and technical aspects, the reciprocal insights made it possible to significantly and rapidly address challenges.

Good land governance facilitates economic development and offers a means of escape from poverty (SDG 1: No Poverty). Every country has its own unique technical structures and culture. Taking into account challenges in both areas better equips reformers with tools and solutions to successfully modernize the country's land administration. ◀

ABOUT BUSINESS PROCESS MODEL AND NOTATION

Business Process Model and Notation (BPMN) is a graphical representation of specifying business processes in a business process model. It is maintained by the Object Management Group (OMG). BPMN is also ratified as ISO 19510. The objective of BPMN is to support business process management for both technical and business users. The notation is intuitive to business users and enables representation of complex process semantics.

ABOUT THE AUTHOR

Krieshen Ramkhelawan works as an advisor to the board of MI-GLIS, the cadastre in Suriname. He has been working in the field of land administration for the past ten years, leading different e-government projects for the Ministry of Spatial Planning, Land and Forest Management. He has also worked closely with specialists from Dutch Kadaster International on projects in Suriname and Aruba, including to design processes and solutions for efficient drone image capturing and public inspection of cadastre information. Together with Christiaan Lemmen, chair of a FIG working group, Ramkhelawan has implemented a fit-for-purpose approach for the cadastre in Suriname.

NEXT-GENERATION REAL-TIME NETWORK FOR FLANDERS

The Evolution of FLEPOS 3.0

A continuously operating reference station (CORS) provides GNSS data to support very accurate 3D positioning and additional geophysical applications. Flemish Positioning Services (FLEPOS) is the real-time global navigation satellite system (GNSS) CORS network for the Flanders region in northern Belgium. This article outlines the evolution of the next generation of the real-time network, FLEPOS 3.0.

FLEPOS is part of Informatie Vlaanderen, a Flanders public administration organization. The first version of FLEPOS was established in 2002. Between 2002 and 2018, FLEPOS evolved through version 2.0 into the current FLEPOS 3.0 RTK real-time network (RTN) thanks to support from the Trimble Network Operations team.

FLEPOS 1.0 AND 2.0

From the initial FLEPOS 1.0 system in 2002 to the end of FLEPOS 2.0 in 2018, there was a large increase in users and their demand for high-quality data. There were also extensive technology improvements. FLEPOS 1.0, operational in 2002, was equipped with dial-up access and designed for 50-500 users. User support was available from 9 a.m. to 5 p.m. The hardware was multi-party manufactured.

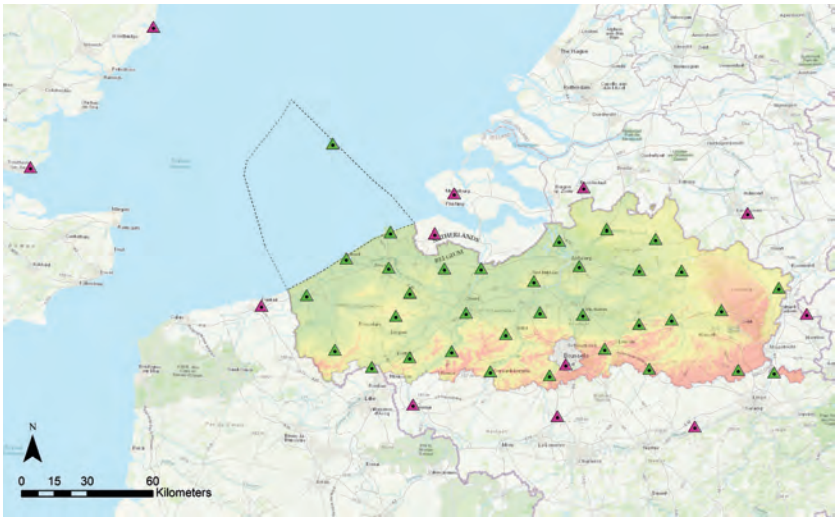
The next generation, FLEPOS 2.0, built on FLEPOS 1.0 and was operational from 2010 to 2017. It was designed for 500-3,500 users and, while still using dial-up access, it supported GLONASS using multi-party receivers. From a maintenance perspective, it was designed to minimize on-site interventions and was equipped with seven servers, a web interface and a remote power switch. User support was still only available from 9 a.m. to 5 p.m., even though customers were increasingly active outside of those 'office hours'.

FLEPOS 3.0 SERVICES

FLEPOS 3.0 was required to provide 100% coverage of Flanders, which included two user zones (land and water). Reliable, uninterrupted coverage is paramount for key industries in Flanders, which include survey, agriculture and construction on land, as well as hydrographic survey, river pilotages, dredging and offshore windfarm users in water. FLEPOS 3.0 also had to be capable of supporting 3,500 registered users, including peaks of more than 800 users simultaneously. Additionally, FLEPOS needed a dependable and consistent service for the outsourcing of information technology operations tasks. This led to a shift to Trimble cloud-based services. The shift to superior cloud-based services was a priority for FLEPOS to avoid a repeat of past service disruption issues that resulted in forced shutdowns of all servers, several days of non-service and a multitude of employee overtime hours.

Not only are there more users nowadays (including a more than 5,000% increase in

▲ *CORS installation in Ruiselede, Belgium.*



▲ *Map of the FLEPOS CORS network for the Flanders region in northern Belgium.*

simultaneous users over the past ten years), but those users are also more diverse and applying data in innovative ways. As the scale of the data's impact has broadened, the user tolerance for outages has drastically decreased because data use affects public safety more than ever before. For example, Flanders' river pilots use RTK for guiding massive container ships into the Port of Antwerp's locks.

FLEPOS 3.0 TECHNOLOGY

The current version, FLEPOS 3.0, was made available in 2018 after a 15-month design and build process by the project partners: FLEPOS, Trimble and local Trimble dealer AllTerra BeLux. Stakeholders were involved during the design process, which required strategic planning, in-depth research, experience-based recommendations and strong collaboration between all project partners. The project team took local geography, land ownership, climate, data communications and power supply resources into consideration. The system is streamlined with six servers, including two RTN servers, two Networked Transport of RTCM via Internet Protocol (NTRIP) servers, one SQL server and one test server. The network has the capability to permanently archive data collected by the receivers.

The size of the network was increased due to the need to support Galileo and BeiDou satellite systems, as well as to accommodate the increase in users and data applications. The network now has a total of 45 CORS consisting of 33 FLEPOS-installed GNSS reference receivers and 12 receivers from surrounding networks. Because of the Sparse GNSS app in the Trimble Pivot Platform, only a subset of the reference stations need to be equipped with Galileo and BeiDou for FLEPOS customers to obtain corrections that include all the constellations. This made it possible to reduce the amount of new hardware without compromising on data quality and allowed customers to upgrade their rovers over time. Approximately 50% of the CORS are now equipped with GPS/GLONASS receivers and 50% are GPS/GLONASS/Galileo/BeiDou receivers.

STANDARDIZATION

In FLEPOS 1.0 and 2.0, the network was a combination of different hardware and software brands, and this worked fine early on, before user demands and system complexities increased. However, as more GNSS constellations and signals were added, it became apparent that some features of hardware and software products only worked in a single-manufacturer product environment, meaning they could no longer be used by FLEPOS.

Furthermore, by the time FLEPOS 3.0 was designed, the existing GNSS hardware was eight years old, which for GNSS receivers can be considered outdated. FLEPOS therefore faced a very real risk of hardware failure, which meant decreased user productivity, an unhappy customer base and increased operational costs. As a result, in FLEPOS 3.0 all system software and nearly all hardware is now standardized using Trimble RTN solutions with Ethernet ports and a web interface. This standardization has helped to ensure high compatibility, enabling easy integration between the field and office for operator control of the network.

FLEPOS 3.0 OPERATIONAL CHANGES

Due to higher usage activity outside of office hours (9 a.m. to 5 p.m.), FLEPOS engaged a 24/7 Trimble Network Management support team to keep a constant eye on the performance of the FLEPOS service. That team provided expertise and support ranging from early planning and consultation to complete operational and maintenance responsibility for FLEPOS 3.0. In instances of service interruption, Trimble and AllTerra BeLux respond on behalf of FLEPOS to provide reliable and trusted support to users. Thanks to the backup support of Trimble Network Management, FLEPOS network operations staff can take time off without needing to be on call. The team members now work far fewer overtime hours and FLEPOS has improved its culture and its employees' health by allowing them to achieve a better work/life balance.

In FLEPOS 3.0, downtime has been eliminated thanks to full migration to the cloud and the addition of backup servers. The risk of failure has been reduced by performing network configuration tests on a dedicated server and correcting issues before bringing changes into production, leading to higher overall service satisfaction. FLEPOS has also achieved maintenance update operational efficiencies, since these updates can be completed during standard business hours versus after-hours (i.e. overtime hours) once field users have left for the day. Overall, operating efficiencies have increased, operating costs have decreased, employees and customers are happier and FLEPOS is enjoying a steady return on investment.

▲ *The evolution of the FLEPOS network.*

CONCLUSION

The region-wide FLEPOS network is the result of careful planning, team collaboration, cultivating strong business relationships and simply knowing what was necessary to keep customers working well into the future. The network meets current and future needs for the organization and its users, yields a satisfied customer base and offers a better work/life balance for employees. FLEPOS 3.0 provides 100% coverage of Flanders 24/7 and all year round, while outsourcing the service to Trimble Network Operations and operational support to AllTerra BeLux. The system also eliminates the risk of downtime by providing dedicated servers for testing and system upgrades. Now, after a year of FLEPOS 3.0 operations, the team can reflect upon several advantages to the system upgrade, including increased operating efficiencies and decreased operating costs. The Trimble Network Management team and local dealer provide extremely valuable support in terms of their knowledge and expertise. ◀

FURTHER READING

- Trimble real-time networks: https://www.trimble.com/Real-Time-Networks/Index.aspx
- FLEPOS's region-wide network system: https://overheid.vlaanderen.be/informatie-vlaanderen/producten-diensten/centimeternauwkeurige-positiebepaling-flepos

ABOUT THE AUTHOR

Bart Dierickx has been the network operator of the FLEPOS service since 2005. Prior to this role, he was active as a surveyor in the dredging world and for the public administration of Flanders, Belgium. He recently led efforts to evolve the FLEPOS regional real-time network (RTN), with support from a Trimble Network Operations team, to accommodate additional users, decrease operating costs and increase return on investment.

FIG Working Week 2020+1

FIG Working Week 2020 in the Netherlands will be moved to 2021

On 25 March, with heavy hearts, FIG and the local organizers from the Netherlands were forced to cancel FIG Working Week 2020, which should have taken place from 10-14 May 2020 in Amsterdam, the Netherlands. The decision was made due to the COVID-19 situation.

Once it was clear that FIG Working Week 2020 would have to be cancelled, intense activity took place to find a solution that would be the best for all participants, sponsors and exhibitors. It became clear that postponing the Working Week to later in 2020 would present a risk, as it seems as though the COVID-19 situation will affect meetings and travel for some time to come.

GENEROUS OFFER FROM GHANA

The local organizers for Working Week 2021 in Ghana have very generously offered for the FIG Working Week that should have taken place in the Netherlands in 2020 to now be held in the Netherlands in 2021 instead of Ghana. This is a very generous offer from the Ghanaian Local Organizing Committee, for which both the FIG Council and the Dutch local organizers are very grateful. It shows true FIG spirit to come up with such an offer!

The FIG Council has therefore made the following decisions:

- FIG Working Week 2021 will be held in the Netherlands instead of Ghana, and the Dutch local organizers have accepted this generous offer so that their preparations have not been in vain.
- Due to this very special offer, FIG Working Week 2024 will be given to Ghana without competition. It will be a pleasure to welcome you all to Ghana in 2024, and we hope that you will support FIG Working Week 2024.
- The two bids that have been received for FIG Working Week 2024 will be moved to 2025. The bidding for 2025, which will take place next year in the Netherlands, will not be re-opened to other bidders.

We are very happy with this solution, and we are grateful to the Ghanaian Local Organizing Committee for making this option possible.

It is with pleasure that we can therefore invite to you FIG Working Week 2021 (...or 2020+1) in the Netherlands.

FIG and the Dutch Local Organizing Committee are looking forward to working on the details of preparations for Working Week 2021, and we will get back with more information as soon as possible.

The proceedings and technical programme of the original FIG Working Week 2020 have been published online. The content will be highlighted in the GIM newsletters.

www.fig.net/fig2020
Paula Dijkstra and Louise Friis-Hansen

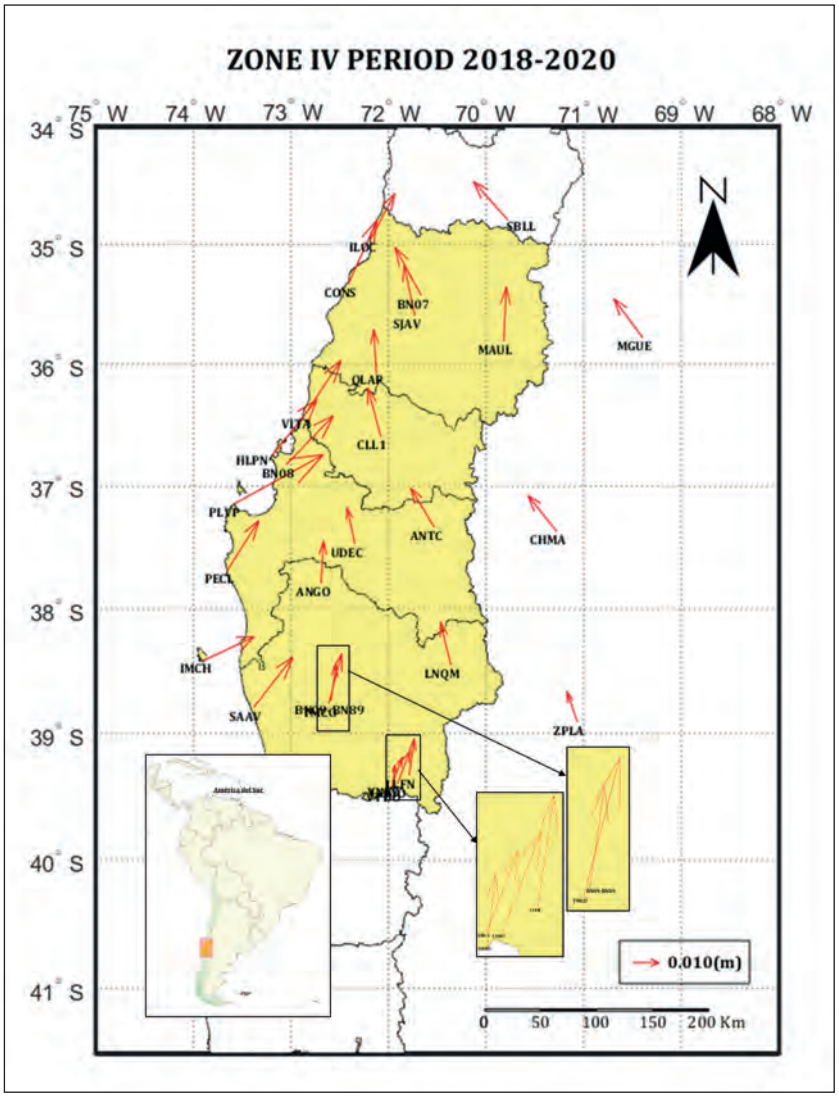
More information
www.fig.net/fig2019

Geodesy in Chile (SIRGAS USC CENTER): a Place Where the 4D Component Presents its Maximum Expression

At the SIRGAS symposium held in Rio de Janeiro in 2019, Working Group I officially approved the inclusion in SIRGAS (Geocentric Reference System for the Americas) of a new official processing centre after one year as an experimental centre. The new centre is located at the University of Santiago de Chile (USC), where they also have a GPS station (USCL) included in the SIRGAS-CON network. Currently, in addition to the weekly processing of 96 stations throughout South America, which is carried out for SIRGAS in the form of a semi-equilibrium solution, more than 220 stations are used to analyse behaviours of the Earth's crust throughout Chile, where very heterogeneous displacements are observed in the magnitude of 4cm over 20km.

The processed data stems from mainly seismological and cartographic organizations, and is freely available. Based on the above, the projects that are currently being carried out are:

- Model the displacement and velocity of the Earth's crust in the convergence zone between the Nazca and South American plates.
- Volcanic monitoring of volcanoes in the convergence zone between the Nazca, South American and Antarctic plates.
- Evaluation of the height of the sea level and its impact on the coastal mapping of Chile along its 4,000km long coastline.
- Generation of two hybrid geoid models in northern and central Chile, and another in Spain from EUREF data.
- Development of distortion models to implement the transition from classical data, such as PSAD56, to modern ones such as SIRGAS.



We can say that the last project is the sum of all the previous ones, because they had to correct the PSAD56 heights with our models of physical geodesy, as well as update passive data of the SIRGAS coordinates using our modelling in the trajectories of the cortex. This is due to the high temporal variability, as from one year to the next the coordinate can vary by 2cm to 4cm in an inter-seismic period.

The support of SIRGAS, starting with the installation of the USCL GPS station in 2017 up to the recent realization of the USC processing centre in 2019, has been essential to obtain optimal results in an incredibly variable environment for carrying out geodetic projects, without which surveying works using drones, 3D scanners and mobile mapping systems could not be performed.

More information
https://sites.google.com/uniroma1.it/hotinemarussi2018

Results of 2019 ISPRS Scientific Initiatives Projects

ISPRS funds projects under the Scientific Initiatives (SI) to enhance its international status in the field of photogrammetry, remote sensing and spatial information sciences, and to benefit its members and communities at large. These projects involve developing datasets and tools for benchmarking, open data, software and standards, and online resources for supporting scientific research. The level of funding is limited to CHF10,000 per project and may be extended to one more year. In 2019, six projects were funded.

FUNDED PROJECTS

Title	PIs
ISPRS benchmark on multi-sensorial indoor mapping and positioning	Cheng Wang
Development of an open source multi-view and multimodal feature matching tool for photogrammetric applications	Diego González-Aguilera
International Benchmarking of terrestrial Image-based Point Clouds for Forestry	Markus Hollaus, Martin Mokroš, Yunsheng Wang
GeoBIM benchmark: reference study on software support for open standards of city and building models	Francesca Noardo
The ISPRS Benchmark Test on Indoor Modelling	Kourosh Khoshelham
Capacity-building for object detection and tracking in UAV videos using deep learning	K. Vani

PROJECT RESULTS

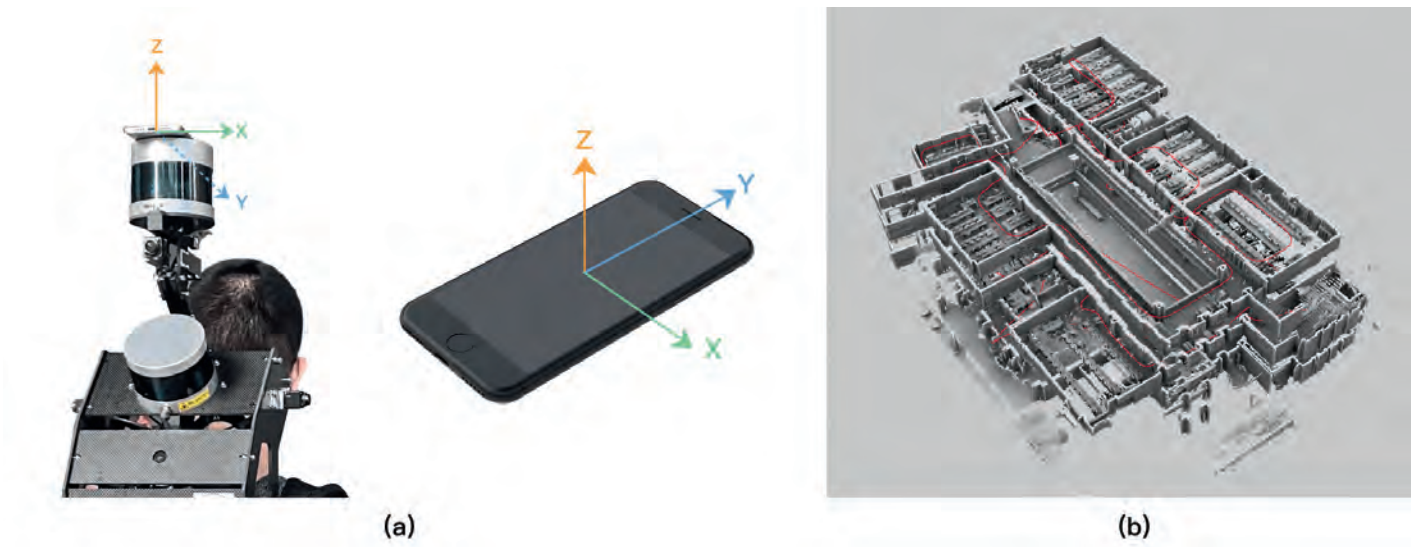
The GeoBIM Benchmark project involved performing benchmarking tests on a number of identified software tools that are needed to better support the integration of 3D City Models (from GIS) and Building Information Models (BIM) towards GeoBIM. A reference framework was also developed for researchers and practitioners working on geo-BIM integration. Three projects focused on 1) evaluating Lidar-based SLAM, BIM feature extraction, and smartphone-based indoor positioning methods, 2) indoor modelling methods in terms of level of automation, computational complexity and the quality of the generated model, and 3) terrestrial image-based point clouds in a plot-level forest inventory. These studies developed either benchmark test datasets or evaluation frameworks, which can be used by others.

Another project developed an open source feature extraction and matching platform (called PhotoMatch), which guarantees the best combination of the detector/descriptor/matcher triplet. The last project developed learning materials and tools for object detection and tracking in UAV videos using deep learning with the aid of open source software.

Further information about the funded projects and project reports are available on the ISPRS website: https://www.isprs.org/society/si/default.aspx.

This is the fourth round of ISPRS SI projects, in addition to many projects funded in 2014, 2015 and 2017. The outcomes of all the funded projects indicate that the initiatives programme is well positioned to support smaller projects, which may have the potential to expand, as well as benefitting working groups and other ISPRS activities. The next call for SI projects will be announced in June 2020.

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



▲ *The smartphone-based indoor positioning benchmark.*
(a) Setup of the attached smartphone, (b) SLAM platform trajectory as synchronize reference.
(source: http://www2.isprs.org/commissions/comm1/wg6/isprs-benchmark-on-multisensory-indoor-mapping-and-positioning.html)

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