GIM INTERNATIONAL

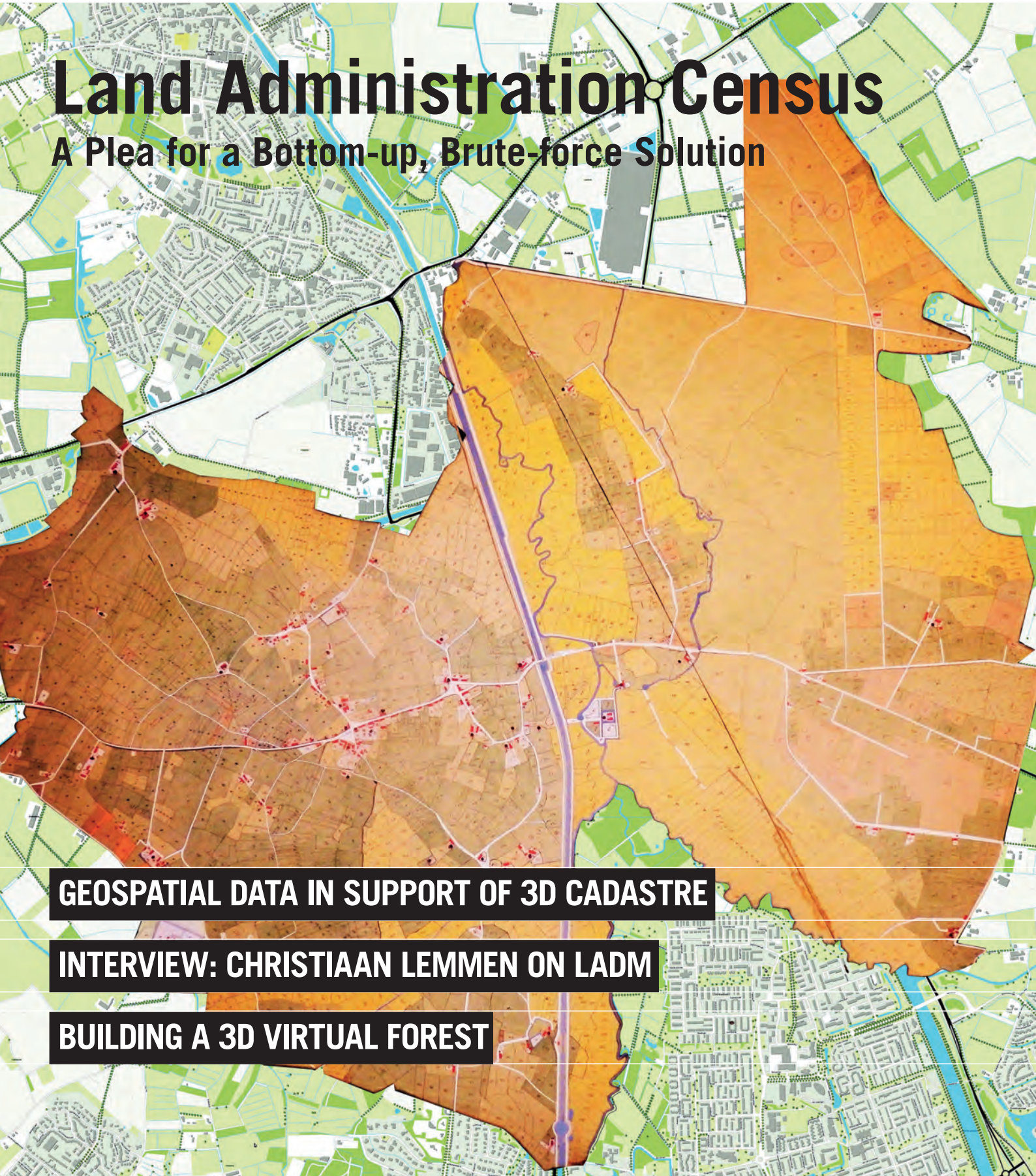
THE GLOBAL MAGAZINE FOR GEOMATICS
WWW.GIM-INTERNATIONAL.COM

geomares

ISSUE 3 • VOLUME 33 • MAY/JUNE 2019

Land Administration Census

A Plea for a Bottom-up, Brute-force Solution



GEOSPATIAL DATA IN SUPPORT OF 3D CADASTRE

INTERVIEW: CHRISTIAAN LEMMEN ON LADM

BUILDING A 3D VIRTUAL FOREST

SOUTH
Target your success

N6

World's First Total Station Without Dimmer Motor

- Faster Return Signal
- Higher process ability of CPU
- Accuracy improvement

A1

World's First Android Total Station

- Available for any 3rd party software
- Available for customized software based on your own request
- 5.0 Inch capacitive screen with multi-touch technology, quick and smooth for operations

E-mail: mail@southsurvey.com
www.southinstrument.com www.southsurvey.com

GIM INTERNATIONAL

DIRECTOR STRATEGY & BUSINESS DEVELOPMENT Durk Haarsma
FINANCIAL DIRECTOR Meine van der Bijl
SENIOR EDITOR Dr Ir. Mathias Lemmens
CONTRIBUTING EDITORS Dr Rohan Bennett, Huibert-Jan Lekkerkerk, Frédérique Coumans
CONTENT MANAGER Wim van Wegen
COPY-EDITOR Lynn Radford, Englishproof.nl
MARKETING ADVISOR Sybout Wijma
MARKETING ADVISOR Sharon Robson
PRODUCTION MANAGER Myrthe van der Schuit
CIRCULATION MANAGER Adrian Holland
DESIGN ZeeDesign, Witmarsum, www.zeedesign.nl

GIM INTERNATIONAL
GIM International, the global magazine for geomatics, is published bimonthly by Geomares. The magazine and related e-newsletter provide topical overviews and accurately presents the latest news in geomatics, all around the world. *GIM International* is orientated towards a professional and managerial readership, those leading decision making, and has a worldwide circulation.

SUBSCRIPTIONS
GIM International is available bimonthly on a subscription basis. Geospatial professionals can subscribe at any time via https://www.gim-international.com/subscribe/print. Subscriptions will be automatically renewed upon expiry, unless Geomares receives written notification of cancellation at least 60 days before expiry date.

ADVERTISEMENTS
Information about advertising and deadlines are available in the Media Planner. For more information please contact our marketing advisor: sybout.wijma@geomares.nl.

EDITORIAL CONTRIBUTIONS
All material submitted to Geomares and relating to *GIM International* will be treated as unconditionally assigned for publication under copyright subject to the editor's unrestricted right to edit and offer editorial comment. Geomares assumes no responsibility for unsolicited material or for the accuracy of information thus received. Geomares assumes, in addition, no obligation to return material if not explicitly requested. Contributions must be sent for the attention of the content manager: wim.van.wegen@geomares.nl.

COVER STORY

The illustration on the front cover of the magazine shows a cadastral map of Aarle-Rixtel, a village in the Dutch province of North Brabant. This issue of GIM International has a focus on land administration, reflected by an interview with Professor Christiaan Lemmen and an overview article on geomatics and land administration written by our senior editor, Mathias Lemmens.

To subscribe to GIM International *go to www.gim-international.com/subscribe*

geomares

Geomares
P.O. Box 112, 8530 AC Lemmer,
The Netherlands
T: +31 (0) 514-56 18 54
F: +31 (0) 514-56 38 98
gim-international@geomares.nl
www.gim-international.com

Reliable. Affordable. Sustainable.

Complete Desktop Survey CAD Solution.

We've been working hard to implement changes based on user feedback, focusing on core improvements in stability and reliability for MicroSurvey CAD 2019. You won't find flashy experimental features in 2019, only robust improvements to increase productivity and enhance your day to day use of the program!

Sustainability is important to your bottom line, and MicroSurvey offers perpetual licensing and maintenance plans at a price everyone can afford. Fully compatible with AutoCAD® 2018 and 2019 drawing files, MicroSurvey CAD ensures easy sharing of drawing information with your customers and partners. We also provide industry-leading support and learning resources so you can get the most out of your investment. Thousands of surveyors rely on our solutions, and so can you. We've got you covered.

microsurvey.com/cad

PART OF HEXAGON

MicroSurvey CAD 2019

Kind and gentle

The messenger is partly responsible for the success of any message; they have a certain tone of voice, approach or strategy to achieve the goal they envision for their message. In this issue you will find an interview with Christiaan Lemmen (or Chrit, as he is commonly known), the newly appointed professor of land administration modelling at Twente University's Faculty ITC for Geo-Information Science and Earth Observation (see page 14). Chrit was a contributing editor of *GIM International* for nearly 20 years so it seemed very fitting for him to be interviewed by our senior editor Tjeu Lemmens, who has been contributing editorially to *GIM International* for at least the same amount of time, if not a little longer.

Sadly, Chrit recently decided he could no longer combine the tasks of a contributing editor with his professorship. Chrit has always been a very busy man, and over the years he has said with increasing regularity that he "was not able to do as much for *GIM International* as he would have liked" – although such a statement was often promptly followed by the submission of a new contribution! But his new job is so time-consuming that we have to accept that, regretfully, his contributing editorship now really has come to an end. We will dearly miss his high-quality and in-depth input, which was always bang up to date with the newest developments in land administration and always took account of the citizens in need of better and more secure tenure rights.

Much of the success in disseminating the message for good, fair, timely, continuing and standardized land administration (via the Land Administration Domain Model – LADM – which is explained in more detail in the interview) can be credited to Professor Christiaan Lemmen, not only because he has been the leading designer of the system, but moreover because he is a very amiable, kind and gentle person who naturally inspires people to listen to his message and act on what they hear.

Chrit, I'd like to take this opportunity to say a big thank you for investing so much time and energy in *GIM International*! I am sure that I am conveying this message on behalf of all our readers, whom you have helped to keep up with all the developments in land administration over the years. It was an honour to work with you and I wish you all the best for the future. At *GIM International*, we will always be happy to provide you with a channel for your messages to the geomatics community!

Durk Haarsma, director strategy & business development
durk.haarsma@geomares.nl

Be a geomatics ambassador

When I first started working for *GIM International* nine years ago, I was unaware of the true extent of the role of land surveyors and GIS professionals. As an avid map lover I had some knowledge of cartography, I knew about measuring land parcels and I was of course familiar with land surveyors who are a familiar sight on construction and infrastructure project sites. Since then, it has become increasingly apparent to me that geomatics has a much bigger impact on everyday life than I ever imagined.

I have attended countless trade shows and conferences over the years, and I have coordinated the editing process of hundreds of articles submitted by renowned and highly skilled mapping and surveying experts. All this has given me lots of new insights into just how vital geomatics is for many aspects of our lives. Even so, I still find myself struggling to explain to others what our area of expertise encompasses. What exactly is geomatics? What do geospatial professionals do? And how do they contribute to society?

By covering relevant developments in the hugely diverse geospatial industry, we strive to help spread the word. But this message should reach a much wider base – not only because it deserves to, but also because geomatics holds the key to solving many of today's challenges. Climate change, migration, the food issue, the matter of rising income inequality, land disputes… in fact, I believe it is safe to say that none of the 17 Sustainable Development Goals (SDGs) can be achieved without geospatial expertise.

Considering the influence of our profession, it is time to join forces and make ourselves heard! This will have the added advantage of increasing the understanding and appreciation of geomatics among a much broader audience. And as a bonus, this will hopefully end my (and everyone else's!) continuous struggle to communicate the benefits of our work to family, friends, acquaintances and business partners from other industries. I hope you will join me in becoming a geomatics ambassador!

Wim van Wegen, content manager
wim.van.wegen@geomares.nl

Advertisers

The Incredible Potential of Land Administration

'Development aid' is an umbrella term that encompasses many types of financial support provided by governments to stimulate socioeconomic development in developing countries. Although it aims to reduce poverty in the long term by contributing to a better economic and social situation, foreign aid has always been the topic of debate and opinions are divided on its effectiveness. The political situation in the recipient country is of course an essential factor in the distribution of foreign aid. In addition, there are huge differences in the success rates of the various types of development aid – and geomatics plays a surprising role in one of them.

It is important to note that development aid is not limited to funding alone. In fact, it is fair to say that foreign aid is as much about knowledge as it is about money. This perspective reveals a more objective view of a developing country's long-term needs: the foundations for a well-functioning society, or – to be more precise – a well-governed country. The ingredients for this include a sound financial system, good access to education, well-organized infrastructure (including transport) and decent healthcare, for example. But another important pillar – and one that is often underestimated – is also required: a reliable land administration system. Just some of the benefits of good land administration include fair taxation, efficient land use, the resolution of conflicts of ownership, and the conservation of natural and cultural heritage. In other words, well-functioning land systems contribute to private wealth, stability and equal rights. To put it succinctly, since a solid cadastral system is an effective way to manage valuable land information, this approach deserves much more investment than it currently receives!

It should be the top priority of the biggest donors to put much greater emphasis on transferring their knowledge of land administration. The Netherlands serves as a good example, and the project in which the Dutch government is contributing to the implementation of the Peace Agreements in Colombia with fit-for-purpose (FFP) land administration is particularly worth mentioning. In addition to significant benefits for the recipient countries of this investment in land administration, it also opens up interesting opportunities for the geospatial industry. New techniques for surveying and mapping will be needed, as millions of land parcels will have to be surveyed in a quick and easy manner. In a nutshell, this is what makes geomatics as such an inspiring discipline. We have the necessary tools and expertise to truly make the world a better place. Stimulating socioeconomic development is not about investing in billions in aid, with the risk that much of it will not be well spent or won't lead to real improvements for the people most in need; it is about providing countries with a strong foundation, about providing them with the right means for a flourishing future.

Recognizing and acting on land administration as a fundamental public good holds the key to a better and more sustainable future for many countries on our planet. In the interest of a more stable world and in order to accomplish the mission of reducing poverty and improving global inequality, we are compelled to act. As *GIM International's* contributing editor Rohan Bennett and his fellow researchers wrote, failing to recognize land administration as critical public-good infrastructure impedes funding and maintenance regimes and puts the benefits of the systems at risk. ◀

▲ *Wim van Wegen.*

FURTHER READING

Bennett, R., Tambuwala, N., Rajabifard, A., Wallace, J., and Williamson, I., On recognizing land administration as critical, public good infrastructure, *Land Use Policy*, Vol. 30, Issue 1, 2013, pp. 84-93

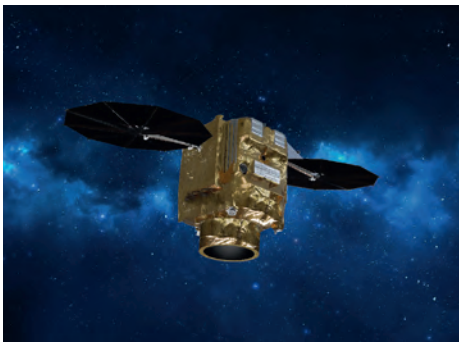
Satellite-derived Information and Airborne Lidar to Combat Cocoa-fuelled Deforestation

Fermented cocoa beans drying in the Ghanaian sunshine.

African governments and the world's cocoa companies are to be handed a crucial new tool in their battle to end deforestation caused by their supply chains. Using satellite-derived information from the UK Space Agency's Forests 2020 project led by Ecometrica, the Ghana Forestry Commission has been supported in the development of a landscape-level map that separates cocoa from forestry. This is critical to measure how the cocoa industry is driving deforestation. With over two million small-scale farmers growing cocoa in the Ivory Coast and Ghana – the world's two biggest cocoa-producing countries – it has proven difficult to track where each bean is coming from and therefore to exert pressure on suppliers to end unsustainable practices.

https://bit.ly/2G9ivOI

Airbus and SSC to Cooperate on Pléiades Neo Earth Observation Constellation



Pléiades Neo satellite. (Courtesy: Airbus Defence & Space)

Swedish Space Corporation (SSC) and Airbus Defence and Space have signed a contract for SSC ground segment support services to the new Pléiades Neo constellation of very-high-resolution Earth observation satellites. The contract marks an important step in the long-term partnership between SSC and Airbus, and extends the capabilities of both companies. The first two very-high-resolution Pléiades Neo satellites will be launched in mid-2020, followed by a second pair in 2022. The new satellites will join the existing Airbus constellation of optical and radar satellites, and will offer enhanced performance and the highest reactivity in the market.

https://bit.ly/2P1xJIv

New Japanese Partnership in Space Business

ALOS-2 satellite.

SKY Perfect JSAT has reached a business partnership agreement with PASCO. The aim of the partnership is to create high added-value services and to mutually make effective use of the technologies and resources owned by both companies in fields ranging from satellites to the geospatial data business. Additionally, the agreement also seeks increased efficiency for the low-Earth-orbit (LEO) satellite-based services currently offered by both companies and expansion of the markets for these services.

https://bit.ly/2D32o3u

Intergeo 2019: A Mind-boggling Amount of Data

It is generated in huge volumes and grows by the hour – data, data and more data. It stems from sensors, apps, IoT-linked devices, plants and satellites. According to the 'DataAge 2025' study, the data volume generated worldwide is set to rise from its current level of 33 zettabytes to around 175 zettabytes by 2025. Gathering, processing and visualizing data is particularly important in the geospatial industry. There has never been such a wide range of tools for this task as there is now. The possibilities have increased enormously, and the sky is full of point clouds. Now in its 25th year, the leading international trade fair Intergeo is focusing on the core issues this raises, asking: Who needs this mass of data? How can it be turned into information? And is it the currency of the future?

https://bit.ly/2Imj4q2

The global datasphere will grow to 175 zettabytes in 2025.

NavVis Introduces Cloud-based Platform for Immersive 3D Buildings

NavVis IndoorViewer routing.

NavVis, a German provider of indoor spatial intelligence solutions for enterprises, has announced the launch of NavVis Cloud. This new cloud-based platform gives laser scanning professionals access to NavVis IndoorViewer as a Software-as-a-Service (SaaS) solution. Fully immersive, web-based 3D buildings can now be delivered as part of every scan project using point cloud files from terrestrial laser scanners and the NavVis M6 indoor mobile mapping system (IMMS). NavVis IndoorViewer is a web-based application that transforms data captured by laser scanners into fully immersive 3D buildings. With a few clicks, scan data is automatically structured into a basic model of the building and displayed as realistic 360° walkthroughs, point clouds and customizable floorplans. Users can then move around scanned spaces as if they are on site and use the interactive functionality to add, search for and route to geotagged information, as well as take accurate measurements.

▸ **https://bit.ly/2I6OGAP**

Pix4D to Hold First User Conference in Denver

Denver, Colorado.

Pix4D will be hosting its first user conference on 2 and 3 October 2019 in Denver, Colorado, USA. Pix4D users, UAV enthusiasts and GIS experts are invited to the 'Mile High City' for two days of discussion about surveying, mapping, drones and technology which is changing the world. The lineup of user stories, which will be announced soon, will be a highlight of the Pix4D User Conference. Users are invited to share experiences about their work with drone mapping: for surveying, construction, agriculture, public safety, humanitarian purposes and more. Pix4D photogrammetry software has been used to map on every continent, including even Antarctica. In 2018 alone, Pix4D's 50,000 active users mapped more than 120 million acres.

▸ **https://bit.ly/2WVedjx**

Gexcel Launches Solution for Multi-source 3D Data Processing

Gexcel Reconstructor.

Gexcel, an Italian developer and producer of point cloud processing software, indoor mapping systems and Lidar monitoring solutions (OPMMS), has announced the new Reconstructor 4.0 release. This expands the opportunities to integrate 3D data collected with tripod, mobile, handheld scanners and UAVs, including imagery datasets. The new software version allows users to work more efficiently with multi-source and multi-scale 3D data, especially in BIM, mining and geospatial applications where 3D and 2D sensors often have to be integrated to cover large areas with different resolutions. Among several new and updated tools and using a completely new rendering engine to display 3D models, Reconstructor 4.0 users can benefit from three new key functions: automatic registration of CAD and BIM models, indoor mobile data acquisition and X-ray orthophotos.

▸ **https://bit.ly/2InN8Ig**

CHC Navigation Opens North American Headquarters in Arizona

CHC Navigation's North America headquarters.

The Shanghai-based GNSS technology and solutions company called Shanghai Huace Navigation Technology (CHC Navigation) has announced the establishment of its new North American subsidiary, CHC Navigation USA Corporation (CHC USA) and the opening of the headquarters of its North American operations in Scottsdale, Arizona. "On the heels of strong CHC Navigation growth in the US in 2018, the time was right to establish a domestic US sales and service office and warehouse with a local team of positioning industry professionals," states George Zhao, CEO of CHC Navigation. The company was established in 2003 and was ranked as one of China's top GNSS and RTK technology and solutions companies in 2017. It currently has customers in over 100 countries worldwide and has been providing GNSS and RTK products and solutions to the US marketplace since 2009. The establishment of a North American head office in Scottsdale represents CHC Navigation's ongoing commitment to expanding its products, services and customer support in the US and North American marketplaces.

▸ **https://bit.ly/2D3iPg8**

Trimble Unveils Next-generation Mixed-reality Device

Trimble XR10 with HoloLens 2.

Trimble has announced a new wearable hard hat-compatible device that enables workers in safety-controlled environments to access holographic information on the work site: the Trimble XR10 with HoloLens 2. In addition, an expanded set of Trimble software and services will be available to provide field-oriented workflows that leverage constructible 3D models and mixed reality to solve daily work tasks. The Trimble XR10 with HoloLens 2 is the first device created with the Microsoft HoloLens Customization Program and integrates the latest spatial computing technology into a certified solution for use with a hard hat for worker safety. With a wider field of view, improved usability and a flip-up viewscreen, the Trimble XR10 with HoloLens 2 combines state-of-the-art mixed reality and safe operation in restricted-access work areas.

▸ **https://bit.ly/2Uo6SMG**

New GeoSLAM Scanner Combines Detailed Data Points with High-resolution Imagery

Geospatial mapping technology specialist GeoSLAM has launched its latest product that offers property professionals the ability to capture floorplans and high-resolution photography simultaneously. The ZEB PANO, a handheld simultaneous localization and mapping (SLAM) scanner and panoramic camera, has been developed for the property sector. SLAM technology is widely known for its use in the automotive industry for self-driving cars, but the technology has applications far beyond that. Capable of capturing 43,000 data points per second and high-resolution panoramic imagery at the same time, the ZEB PANO stores the exact location of each panoramic image enabling quicker, more accurate and less intrusive property surveys. Property agents can use this information to create a floorplan and property descriptions in considerably less time. Complementing the existing ZEB range of scanners, the scanner's 'walk-and-scan' method of data collection allows users to quickly and easily survey a property, producing accurate data and high-resolution photography.

▸ **https://bit.ly/20Y21fa**

GeoSLAM ZEB PANO.

IAS Event Provides Full Overview of Latest Drone Developments

The use of unmanned aerial vehicles (UAVs or 'drones') is still only in its infancy, with a phase of rapid development just around the corner. Despite signs of professionalization, the UAV industry is still mainly dominated by startups, and this is likely to be reflected at the sixth edition of Europe's leading commercial trade show for drones. Interaerial Solutions - part of Intergeo (IAS) will take place from 17-19 September 2019 in Stuttgart, Germany. Besides the world market leader DJI and other established drone providers, the show is expected to feature a particularly high number of companies presenting new business models based on industry-specific drone applications, such as for infrastructure inspections or surveys.

▸ https://bit.ly/2GcHG3c

Emlid Launches Affordable Multi-band RTK GNSS Receiver

Emlid, the creator of Reach, a centimetre-accurate RTK GNSS receiver, recently launched its multi-band GNSS receiver, Reach RS2. The new receiver features built-in LoRa radio, 3.5G modem and a survey app for iOS and Android. The Reach RS2 gets fixed solutions in seconds and provides positional accuracy down to several millimetres. The receiver tracks GPS/QZSS (L1, L2), GLONASS (L1, L2), BeiDou (B1, B2), Galileo (E1, E5), and SBAS (L1C/A) and works reliably for distances up to 60km in RTK mode and 100km in PPK mode. A multi-feed antenna with multipath rejection offers robust performance, even in challenging conditions. RINEX raw data logs are compatible with OPUS, CSRS-PPP, AUSPOS and other PPP services so it is possible to get centimetre-precise results anywhere on Earth.

▸ https://bit.ly/2GaFI8H

Emlid Reach RS2.

Focusing on true performance!

PENTAX

D-600

Precise Aerial Imaging System

6 Rotor Multicopter with Autopilot

R-1500N & R-2800N

Reflectorless Total Stations

Total surveying solutions

W-1500N & W-2800

Windows CE Total Stations

Truly integrated systems

G6 Ti | Ni & G5

GNSS Receivers

Precision Satellite Surveying with wireless communications

S-3180V

Scanning System

3D laser measurement system

TI Asahi Co., Ltd.
International Sales Department
4-3-4 Ueno Iwatsuki-Ku, Saitama-Shi
Saitama, 339-0073 Japan

Tel.: +81-48-793-0118
Fax: +81-48-793-0128
E-mail: International@tiasahi.com

www.pentaxsurveying.com/en/

Achieving Sustainable Development with the Copernicus Programme

There is a burgeoning demand for Earth observation (EO) data in order to find innovative solutions for today's challenges such as climate change, food security or water supply. With more than 15 terabytes of free EO data generated by the Copernicus programme every day, the Copernicus services deliver near-real-time data on a global level – contributing towards the sustainable management of the environment. Simultaneously, the Earth observation industry is constantly growing. New data platforms are being developed to receive and process the huge amount of satellite data collected from the Sentinels and other contributing commissions. These data platforms are established in the cloud and work with artificial intelligence (AI) and machine learning, enabling the development of new applications in the EO sector. The Copernicus Masters 2019 – Europe's leading innovation competition for Earth observation (EO) – is searching for such outstanding applications, solutions and business concepts from future-oriented SMEs, startups, universities and individuals in the fields of business, research and higher education.

▸ https://bit.ly/2UIzhMK

Esri Acquires indoo.rs and Announces ArcGIS Indoors Release

The indoo.rs software solution has become part of Esri's ArcGIS Indoors.

Esri has recently completed the acquisition of indoo.rs GmbH, an Austrian provider of indoor positioning system (IPS) technology. The indoo.rs software will become part of Esri's ArcGIS Indoors, a mapping product that enables interactive indoor mapping of corporate facilities, retail and commercial locations, airports, hospitals, event venues, universities and more. The acquisition will additionally provide users of Esri's ArcGIS platform with imbedded IPS location services to support indoor mapping and analysis. The indoo.rs headquarters will also serve as an Esri R&D centre based in Vienna focused on cutting-edge IPS capabilities. There is rapidly growing interest in the ability to accurately map, manage, navigate and plan indoor spaces in order to decrease costs, increase safety and provide users of indoor spaces with a better experience. ArcGIS Indoors does this by providing floor-aware 3D maps and focused apps to support a variety of workplace and facility users, including owner/operators, maintenance and service personnel, security staff, employees and visitors.

▸ https://bit.ly/2XU3VI5

Maptek Sentry Now Monitors Ground Movement in Cold Climates

Maptek has released a cold climate model of its award-winning mobile Sentry system for stability monitoring. The system allows for continuous, reliable measurements of ground movement, irrespective of the environment. "Risk management remains a priority," says product manager James Howarth. "If anything, the reliable operation of technical equipment is even more critical in extreme conditions. Climate factors play an important role in the execution of any mining project. Extremely low-temperature conditions require considerable planning and logistics, especially from an operator safety perspective." Maptek Sentry is a mobile remote monitoring system that uses laser scanning to continuously measure ground movement with extremely fine spatial resolution and accuracy. Housed in a self-contained unit with autonomous power and communications capabilities, Sentry relies on sophisticated software to monitor, analyse and report in real time.

▸ https://bit.ly/2I7TbLs

Maptek Sentry in action.

GIM INTERNATIONAL INTERVIEWS CHRISTIAAN LEMMEN

Standards Are a Great Help for **Establishing Land Administration**

In 2017 Dr Christiaan Lemmen, a former contributing editor of *GIM International*, was appointed as professor of land administration modelling at Twente University's Faculty ITC for Geo-Information Science and Earth Observation. He is the leading designer of the ISO 19152 international standard for geographic information – Land Administration Domain Model (LADM), the second edition of which has been in development since 2018. In this interview, he discusses the importance of LADM standards, poverty and tenure security, and the long and winding road to put well-functioning land administration in place in developing countries.

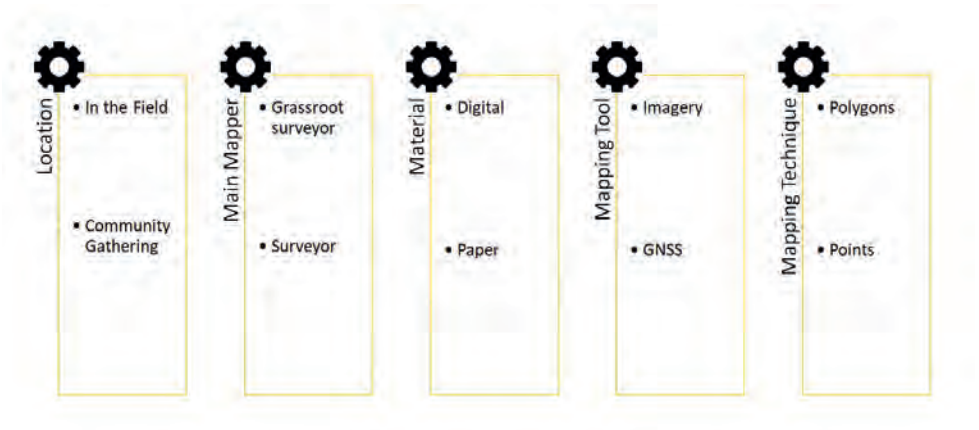
▲ *Christiaan Lemmen during a mission in Nepal (image courtesy: Jan van Roekel).*

The Land Administration Domain Model is actually an international standard (ISO 19152). Why is it important to have a worldwide standard for land administration purposes?

ISO 19152 defines a reference Land Administration Domain Model (LADM) covering basic information-related components of land administration. To understand its importance, this standard should be looked at as a knowledge model in which the semantics of the land administration domain are defined, but in a descriptive way rather than a prescriptive way. The people designing land information models, which are the core of a land administration system, are the brains of the land administration organization. They are faced with the question of what to include and how to structure a data model at conceptual level. To start from scratch is far more difficult then starting with an existing, conceptual model which can be adapted to local needs. LADM meets these needs by defining such a model and can be regarded as the common denominator in land administration. LADM supports system design, system development and system implementation. LADM is also aimed at facilitating communication between organizations and governments on various levels.

There are many different land administration systems worldwide, which often consist of a conglomerate of divisions which may even belong to different ministries and agencies. Would standardization help in such a diverse world?

Yes, definitely. In many countries, land administration is fragmented between many institutions which often operate from silos and under mandates that do not support cooperation and coordination. Some institutions may cover one part of the country while others cover adjacent administrative units; some institutions operate at central level, others at regional or local level. The types of tenure the institutions register may also differ. Countries with well-developed land administration show that proper land information models are desperately needed. However, reforming established institutions is very complex and requires political willingness, particularly to ensure good cooperation and workflows. Not only are there many inconsistencies among institutions at the operational level, but the data is also inconsistent and incomplete in many countries. Standards do help here and also enable GIS and database providers as well as open-source communities to develop and offer consistent products and applications. Today, this solution has been initiated in the Open Geospatial Consortium (OGC) with the domain working group for land administration. I expect this initiative to greatly help developing countries arrive at well-functioning land administration. Additionally, only paper-based approaches are legally valid in many countries; paper-based systems may have backlogs and as a result they are sensitive to 'motivation' fees. A completely digital system may eliminate this. Since a transition from paper to digital may affect the 'business model' of officials and civil servants, objections to renewals will be met all along the winding road.



▲ *Mapping and recording options can be combined in data collection applications in many ways – but all should be supported by standards in exchange (source: Lemmen, Unger and Bennett).*

Would a non-corrupt land administration system supported by a proper legal system and population registration be able to contribute to the first two Sustainable Development Goals (SDGs): to end poverty and to end hunger?

Tenure security means that there is no risk of land grabbing, forced evictions or expropriation without compensation in the form of money or land. If land rights are documented or perceived to be secure, people do not live in fear of such risks and are therefore more willing to invest in improving housing and starting businesses. All such initiatives induced by tenure security do indeed contribute to poverty eradication. Ending hunger may require large-scale industrial food production. This can, for example, be achieved through consolidation and readjustment of land where existing land rights are respected. Existing land rights may be used to organize shares in the profits and benefits from large-scale agriculture. One benefit may be that women can be exempted from heavy work in the fields, enabling them to exploit their talents and skills in a more sophisticated way in more comfortable environments. In all cases, proper land information systems are needed to support documentation of land rights and reallocation of them where needed.

Why is it important that individuals – young and old, rich and poor, male and female – can own land?

It is not only about ownership or freehold, but additionally about perceived security of tenure as is also formulated in the SDG indicators. Tenure may be related to all kinds of personal rights and to informal or customary land rights. The people should feel safe and enjoy the reassurance of tenure security. By the way, it is not only about secure people-to-land relations, but also the other way around: land-to-people relations – i.e. it is not just what the people harvest from the land and what the land can give to the people, but also about what the people can give to the land and what the land can get from the people. If all land rights are documented, then it is easier to stop new human footprints outside the territories with documented land rights.

From a philosophical point of view, one may question whether individuals should be allowed to own land since there are good reasons to state that land belongs to all people or – viewed from another perspective – the divine. What are your thoughts on this?

That is why customary land rights need to be recognized, documented and protected.

factrics

marketing by facts

TECHNICAL B2B MARKETING

for smart engineering companies

www.factrics-marketing.com

Many land administration systems are not designed for these important tasks. At global level, there is agreement that change is needed. On the other hand, I believe that many people really prefer individual ownership above state-owned land.

Does the right to own land not result in an adverse effect, namely to drive land into the hands of the rich and well-off? This process has been going on in Africa for decades and even seems to be accelerating due to the power shift from the West to the East.
The principle of tenure security is understood everywhere, but there is indeed a risk in relation to land markets and land being viewed as a collateral. People understand and sometimes even experience that land can be grabbed... but maybe it is not understood everywhere that land rights can be bought and sold. I think there are cases where it may be wise to introduce land markets separately from establishing tenure security. Again, this is about good information models; it should be clear to investors where markets apply.

It is fair to say that the LADM standard is in continuous development. On which aspects will the focus lie in the coming years?
The second edition, which has been in development since 2018, includes a series of proposals on new or extended LADM functionalities. Apart from management of property rights, attention will be paid to valuation, inclusion of land value and even taxation. Restrictions to land and changes in responsibilities resulting from spatial planning and land management in a broader sense are also being considered. All these amendments have to be underpinned by proper data, which should not only exist but also be well maintained. Initial data acquisition for land administration will be key in many countries over the next decade. Blockchain may be implemented for land rights transactions, for example, or for conversion from social to legal tenure. The second edition will also pay attention to maritime limits and boundaries, 3D and 4D, indoor and building information modelling (BIM) and indicators for the SDGs. This huge standardization effort requires agreement among professionals, scientists, NGOs, governments and global organizations. We will work in teams. One very important benefit is that I can cooperate with Peter van Oosterom from Delft University of Technology and his team.

In a nutshell, what action is needed for the successful implementation of LADM standards over the coming decades?
The OGC members have drafted a charter for a land administration domain working group which describes how to improve the effectiveness and efficiency of land administration systems by optimizing the use of OGC standards and complementary open standards. This development will enable land administration based on LADM to be operationalized and implemented in systems. OGC is really ambitious in this – it brings together experts and the geospatial industry. UN-GGIM is also very supportive here, as are FIG, UN Habitat, FAO and the World Bank.

The proper protection of ownership rights requires a well-functioning cadastral system in which property boundaries are accurately mapped. Recording and georeferencing boundaries is a time-consuming endeavour. Which measures and modern techniques could avoid a recording process which would otherwise take a century or more?
More flexibility will indeed be needed in initial data acquisition. Data may be collected in the field or gathered in the village, using aerial or satellite images or GNSS devices. Using imagery, the boundary surveys may be done by professional surveyors and legal experts or by supervised grass-roots surveyors and paralegals who are trained in subsidiary legal matters but not fully qualified. The process workflow may be fully digital or with interfaces to paper-based approaches. In GNSS-based approaches, the surveys can be done by the people themselves by walking along the perimeters of their parcels with a handheld device; points can be measured using an app with a very simple interface (see Diagram on previous page). Therefore volunteer-based land administration and crowdsourcing needs support in LADM and in general processes apart from just data.

You were a contributing editor of* GIM International *for nearly 20 years. What was your drive to contribute to this professional journal besides also being active in science and regularly publishing scientific papers?
GIM International is a great magazine, renowned all over the planet. I'm active in the projects from my first employer, Kadaster International, with research and education at the University of Twente/ITC and also within Commission 7 of the International Federation of Surveyors (FIG). *GIM International* provides a very nice communication channel for sharing knowledge. I like the format as it gives readers a quick impression of the topics thanks to the attractive titles, summaries, headers and figures. The articles are very informative and to the point, but it's not a time-consuming read. ◂

ABOUT CHRISTIAAN LEMMEN

After completing his geodesy degree at Delft University of Technology (TUD), the Netherlands, in 1982, Christiaan Lemmen worked at the Dutch cadastre, first as information manager until 1999 and subsequently as senior land administration advisor until present. In 2012 he received a PhD from TUD after defending his thesis on 'A Domain Model for Land Administration'. In 2017 he was appointed part-time professor of land administration modelling at Faculty ITC, Twente University, where he had held positions as a part-time assistant professor and visiting researcher in cadastre and land management since 1999. Since 1995 he has conducted more than 60 short-term and long-term assignments in Central, Eastern and Southern Europe, South America, Africa and Asia. He was a contributing editor of *GIM International* for nearly 20 years (2000-2018). His life's work is the design of the Land Administration Domain Model (LADM), which has been an ISO standard since 2012. He is an honorary member of the International Federation of Surveyors (FIG) and an internationally renowned expert in the field of land administration.

COMMUNICATING FOREST MANAGEMENT PLANS THROUGH VIRTUAL REALITY

Building a 3D Virtual Forest

Forest management planning is a delicate process. Environmental, economic and social aspects need to be taken into account in order to achieve sustainable development. In Quebec, before a plan can be implemented, local communities have to be consulted for their feedback and concerns. Instead of just expecting citizens to decipher complex maps, this project is aimed at sharing a realistic view of the potential changes through a 3D virtual experience. This application is based on GIS data that consists of a shapefile with information derived from a Lidar survey, as well as a digital elevation model.

In the province of Quebec, Canada, the Ministry of Forests, Wildlife and Parks (MFFP) is in charge of the sustainable development of the forests. As part of its duties, the MFFP devises forest management plans. The initial plan has to be submitted for public consultation with the local population before any action can be taken. By holding such meetings, the ministry strives to keep the public informed, while taking into account citizens' interests and opinions. In what is commonly known as the 'harmonisation process', the MFFP takes the feedback into consideration and, if possible, adjusts the forest management plan accordingly.

A COMMUNICATION PROBLEM

However commendable this process may be, it does not always make it easy for citizens to form an opinion. Using the current technology, it is hard to visualise the real impact of the forest harvesting plans. This presents a communication problem for the forestry experts who are responsible for conveying the information to the residents taking part in the consultations. For example, maps offering an aerial perspective of the territory are currently being used to illustrate the various forestry operations. These maps are difficult to understand for anyone who is not familiar with this field of expertise. As such, for the vast majority of the population, these documents are not particularly helpful when it comes to visualising the final result in a practical manner – and yet how the end result will look matters immensely to many attendees of the consultation meetings.

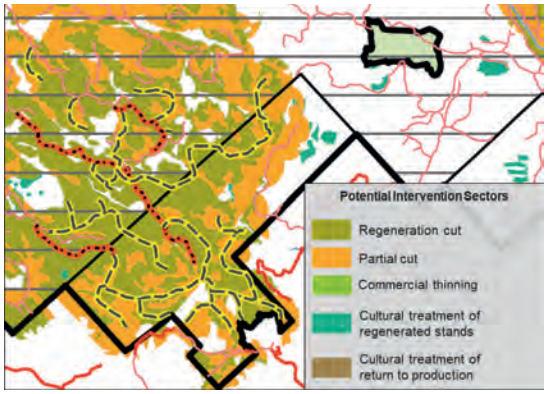
A VIRTUAL SOLUTION

In an attempt to provide an answer to this communication issue, FPInnovations and the Centre en Imagerie Numérique et Médias Interactifs (CIMMI) joined forces to develop a virtual reality application called the Virtual Forest. An immersive and concrete way of visualising the result of forestry operations on a territory was created in the space of just two months. The application depicts a precise representation of the forest: each tree is in the right place and is the right height. The generation of the forest tree-type (or 'essence') diversity follows a precise set of rules which has been configured to represent the forestry management plan presented to the public as accurately as possible.

Area before forestry operations.

▲ *Area after forestry operations.*

Instead of relying entirely on confusing 2D maps and written documents, the residents can now explore an immersive and accurate three-dimensional (3D) environment in which they can navigate at will thanks to teleportation mechanics. From a user's point of view, the app showcases two major features: 1) it shows the before and after state of the forest (allowing the user to switch from one state to the other), and 2) it can be experienced in either a first-person or a top-down perspective. Consequently, for the population of an area targeted for a forestry operation, the Virtual Forest app provides a great tool to observe how it will visually affect their region. The intention is for the application, along with the forestry management plans and documents, to be available to the public during the consultation process. Although the Virtual Forest app is still a prototype for now, ramping it up to an operational app is not an insurmountable challenge.



▲ *A complex forest management plan (details).*

AN IMMERSIVE AND INTUITIVE 3D VR APPLICATION MIGHT BECOME AN IMPORTANT PART OF THE PUBLIC CONSULTATION PROCESS IN THE FUTURE

FROM GIS DATA TO 3D MODELS

Geospatial data is at the root of the Virtual Forest's creation. In this case, the dataset available was:

- a shapefile showing the height and location of each tree in the area extracted from a Lidar survey
- a digital elevation model (DEM) of the terrain in Esri ASCII raster format with each cell value representing the elevation.

The main objective was to represent these geospatial datasets in a realistic way in virtual reality, using the game engine Unity.

Starting with the DEM, a point was created at the centre of each cell with an elevation attribute. Using Blender's plugin BlenderGIS, those points were imported and a Delaunay triangulation process was applied to create faces between the points. Once that was done, the resulting surface was exported in the Unity-friendly FBX format. As for the trees, the initial shapefile was converted into CSV format. Then, a Unity plugin was built to read the file and, for each line, instantiate a 3D model of a tree at the right location. Those 3D models could then be scaled according to the corresponding height in the CSV file. The Unity plugin can take into account many types of trees, as well as the percentage of each of them on the terrain. The information available for the area was that the tallest 70% of the trees were white pines and the remaining 30% were broadleaves. In this scene, a lake and a forest road were drawn manually for visual purposes, but the process could have been implemented to add them from geospatial data as well. Also, all the steps could be fully scripted and automated, providing that the input comes in a standardised format.

PRELIMINARY FINDINGS

The main objective was for the app to be easily usable by anybody without extensive tutorials or prior gaming experience. Indeed, the application was showcased multiple times to diverse audiences and their feedback helped to provide an understanding of how people relate to their environment and how small details can make a huge difference. For example, when foresters tested the app, two users argued that the tree type depicted in the area was not a white pine as it was supposed to be, but some kind of oak. The 3D model used correctly showed the forest essence, but one user explained that the dead leaves on the ground did not

▲ *A user wearing a virtual reality headset.*

correspond to what is commonly found in a pine forest. This misunderstanding arose from the fact that the ground texture used was completely unrelated to the type of forest. People's perspectives are clearly affected by their personal background; the developers focused on trees and models, while the foresters looked at the forest as a whole. In light of this experience, one should also expect local citizens to look for familiar features to orient themselves, such as the right texture on the ground or landmarks such as a pier, a small cabin, some huge boulders, etc.

User feedback led to many improvements to the app. The texture on the ground was added, then the sun in the sky casting shadows accurately. People in general seemed to prefer a realistic approach and attention to small details. But even after some flowers and grass had been added to the environment, something still felt static and unrealistic. To bring things to life even more, the branches were made to sway softly as if in a breeze and an audio track reinforced the immersive feeling. In 3D applications such as this, it is important to keep enhancing the realism until it becomes almost the same as the real world. Everyone should be able to relate to the environment immediately in order to focus on discussing the main issue: the planned forestry operations.

CONCLUSION

Building a virtual forest puts geospatial data to use at a human scale. Replacing unclear 2D maps with an immersive and intuitive 3D virtual reality application might become an important part of the public consultation process in the future. The next step of this project could be to define the metrics to measure the efficiency of the virtual reality application compared to the current way of conducting public consultations. This would reveal the extent to which virtual reality can improve communication between the MFFP and the people using the forest. ◀

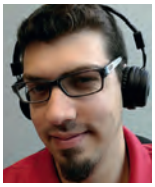
FURTHER READING

Consultation on integrated forest management plans: https://mffp.gouv.qc.ca/les-forets/amenagement-durable-forets/consultation-public-partenaires/consultation-plans-damenagement-forestier-integre/ (in French)
The Virtual Forest app on YouTube: https://youtu.be/5sua2SCOYkk

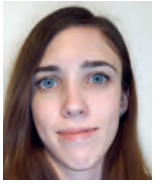
ACKNOWLEDGEMENTS

The authors would like to thank Francis Charette of FPInnovations, Marie-France Arsenault and Maxime Grandmont for their help.

ABOUT THE AUTHORS



Jean Boissonneault is a web developer converted to 3D software development at CIMMI, as well as a multimedia technologist, programming whizz and all-around geek.
✉ jboissonneault@cimmi.ca



Alicia Lamontagne is an intern developer at CIMMI working on augmented and virtual reality applications, and is currently studying computer sciences at Laval University.
✉ lamontagne.alicia@gmail.com

Vincent Thomas is a geomatics engineer at CIMMI and is working on 3D and virtual/augmented reality applications.
✉ vthomas@cimmi.ca

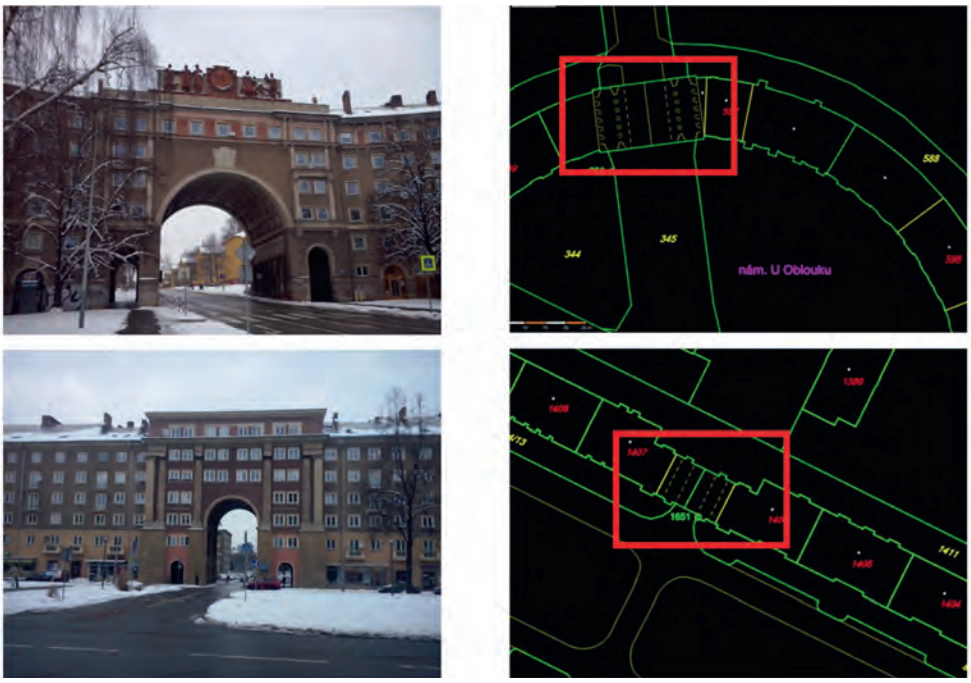
Geospatial Data in Support of 3D Cadastre

The urbanization trend is leading to an increasing number of people living in cities, thus also placing new demands on cadastral registration. To be able to register the complex infrastructures and built-up areas properly, the cadastre will need to consider the third spatial dimension. The 3D cadastre is based on 3D parcels (spatial units) which are single volumes (or multiple volumes) of space. Although the technology offers numerous possibilities for implementation of the 3D cadastre, there are still some open issues, as this article explains.

We live in a three-dimensional world. Over the past decades, there have been an increasing number of 3D situations in which different property units (with possibly different types of land use) are located on top of each other or constructed in even more complex structures (see the examples in Figures 1 and 2). The traditional cadastres based on the 2D parcel paradigm do not provide sufficient tools to register and display such situations efficiently.

LADM

The international standard ISO 19152:2012 Land Administration Domain Model (LADM), which brings support for 3D parcels, defines a conceptual model covering basic information-related components of land administration (including those over water and land, and elements above and below the surface of the Earth). The LADM provides a reference model which serves to provide an extensible basis for the development and refinement of efficient and effective land administration systems, based on a model-driven architecture (MDA), and to enable involved parties, both within one country and between different countries, to communicate based on the shared vocabulary (i.e. an ontology) implied by the model.



▲ *Figure 1: Buildings (left column) and their portrayal on a 2D digital cadastral map (right column, highlighted in red rectangles). The cadastral map shows only the outlines of the buildings (at the surface level).*

LADM provides an abstract, conceptual model related to parties (people and organizations), basic administrative units, rights, responsibilities and restrictions (ownership rights), spatial units (parcels, and the legal space of buildings and utility networks), spatial sources (surveying) and spatial representations (geometry and topology). Furthermore, LADM provides terminology for land administration, based on various national and international systems. The terminology allows a shared description of different formal or informal practices and procedures in various jurisdictions. Last but not least, LADM provides a basis for national and regional profiles and enables the combining of land administration information from different sources in a coherent manner.

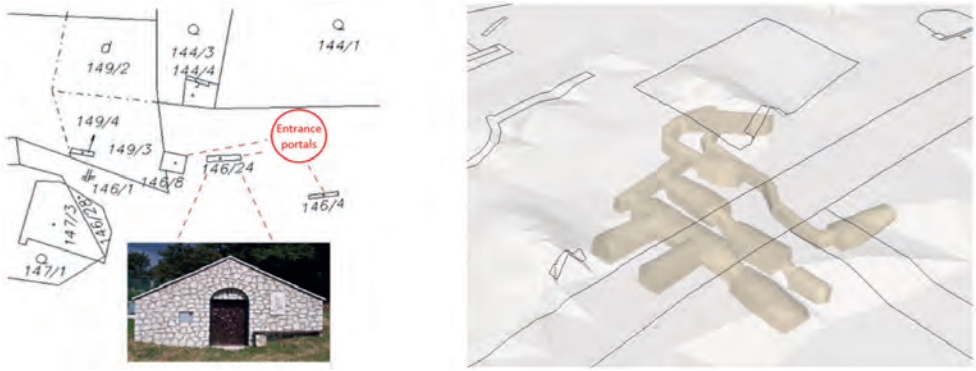
3D CADASTRAL INFORMATION MODELLING

Cadastral data models (e.g. LADM) including 3D support have been developed for legal information modelling and management purposes. The various aspects of 3D cadastral information modelling need to be addressed, e.g. the possibilities of linking 3D

legal rights, restrictions and responsibilities (RRR) spaces, modelled with LADM, with the physical reality of 3D objects (described via CityGML, IFC, InfraGML, etc.). This is closely related to the legal framework and initial registration of 3D spatial units (3D parcels).

An initial categorization of 3D parcels was set up (Thompson et al., 2015) and formed the starting point for the further investigations into suitable corresponding database representations, exchange formats and data capture encodings. Figure 3 displays a general 3D spatial unit which can be defined by boundaries other than horizontal and vertical.

Two remaining challenges that depend on country-level decisions are the definition of what are acceptable (valid) 3D cadastral object representations, and how to create their 3D geometries (even non-2-manifold geometries). The non-manifold 3D representations (self-touching in edge or node) are not well supported by current GIS, CAD and DBMS software nor by generic ISO standards such as ISO 19107 (Van Oosterom, 2013).



▲ *Figure 2: Left – the entrance portals of wine cellars (Tokaj vineyard, cadastral unit Vel'ká Tŕňa, Slovakia) and their representation on the existing 2D cadastral map. Only the entrance portal can be seen on the map. In this case, every entrance portal is established on a separate building parcel. Right – a possible visualization of the underground wine cellar as a 3D parcel together with digital terrain model and existing 2D parcel boundaries.*

3D SPATIAL DATABASE MANAGEMENT SYSTEMS

The 3D spatial database management system (SDBMS) should support a data model to handle a variety of 3D objects, 3D geospatial data quality control, 3D analysis, high-performance dissemination of 3D geospatial data and real-time rendering. It should also support the related 3D standards. Although a lot of work has been completed on defining a 3D vector geometry in standards by the OGC and the ISO, it is still insufficient to define 3D cadastral objects. 3D objects have a more rigorous definition for cadastral purposes. For a volumetric 3D cadastral object, for example, the polyhedron needs to satisfy characteristics such as closeness, interior connection, face construction and proper orientation.

As with 2D geometry, 3D volumetric primitives would need to satisfy the adjacency and incidence (gaps and overlaps) relationship so that they are mutually exclusive and spatially exhaustive in the domain. While standards and definitions for solids exist, such as the PolyhedralSurface in the SQL Geometry Types of OGC as well as other definitions for solids, they are currently not well utilized and do not comply sufficiently with standards. It is highly problematic to validate such solids and exchange datasets between formats and platforms. This does not usually follow any standards, and error reports are usually cascading rather than in a single report, thus making it very cumbersome to deal with errors individually.

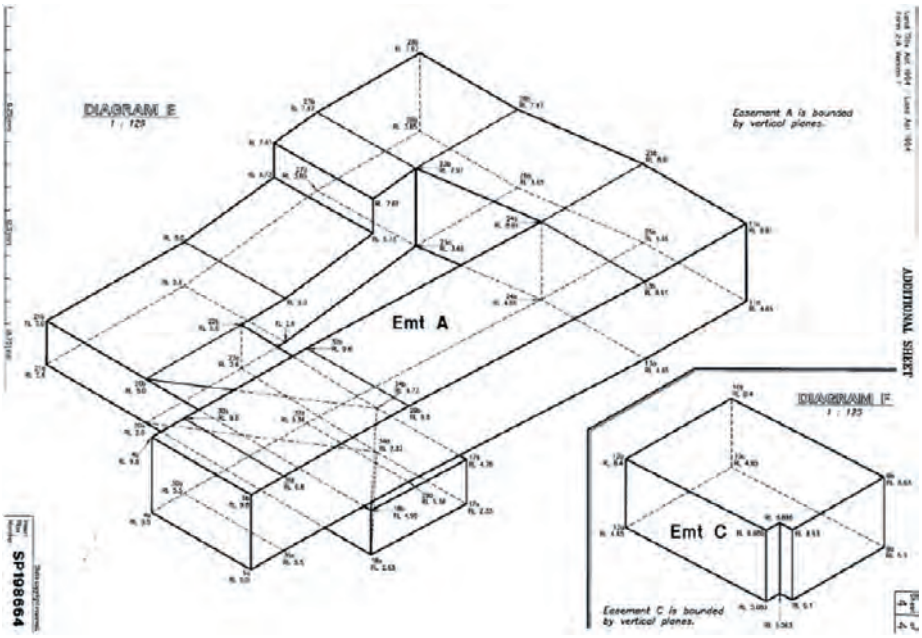
LADM addresses many of the issues in 3D representation and storage of 3D data in a DBMS. It allows in-row storage of 3D data in a mixed 2D/3D database allowing for fast retrieval and analysis; it allows for 3D data to be stored in different levels of detail, overlapping 2D footprint of 3D objects, and supports liminal parcels; and it allows attribution of different boundary lines and faces. However, one identified issue is the duplication of the definition of boundaries for separate spatial units.

Three-dimensional objects can also be represented using voxels (volumetric pixels). This brings advantages in object representation, object count and volume, 3D operations and simple analysis, and represents 3D as a solid instead of point, line and polygon. The challenges to this are the storage and efficient handling by current spatial databases. However, some GIS systems are working towards creating a column store structure to accommodate voxels.

Another possibility is to represent 3D objects as a point cloud. Lidar point clouds could assist in terms of being a reference framework of as-constructed features, or a 3D data acquisition tool for 3D physical objects, or a verification tool for pre-existing building information modelling (BIM) or other models. Point cloud data can be used for data such as administrative, vector, raster, temporal, etc., and SDBMSs should be able to combine this data for a point cloud data type with characteristics such as xyz values, attributes per point, spatially coherent data organization, efficient storage and compression, data pyramid support for multi-scale or vario-scale support, temporal support, query accuracy over a range of dimensions, analytical functions and parallel processing.

LIDAR POINT CLOUDS COULD ASSIST IN TERMS OF BEING A REFERENCE FRAMEWORK OF AS-CONSTRUCTED FEATURES, OR A 3D DATA ACQUISITION TOOL FOR 3D PHYSICAL OBJECTS

Spatial indexing is used by SDBMSs to improve search speeds. Of the three types of indexes, namely B-Tree, R-Tree and GiST, the latter two are found to be useful for 3D GIS data. Operations on and amongst 3D objects have been described by OGC, such as 3D architecture (Envelope(), IsSimple(), Is3D(), etc.) and spatial relationships (Equals(), Intersects(), Touches(), etc.). However, existing SDBMSs often implement them differently.



▲ *Figure 3: A general 3D spatial unit (Thompson et al., 2015).*

3D topological structures are an important consideration in a 3D cadastral SDBMS. Topological relationships between neighbouring parcels can be between two objects or between many of the object's neighbouring parcels. While 3D topological structures have been defined, they are not fully compliant with standards such as LADM. LADM not only provides a conceptual description of a land administration system, but also provides a 3D topology spatial profile. LADM also stipulates that geometrical information along with an associated topological primitive help to describe 3D spatial units. LADM volumes can be bounded or unbounded at the top or bottom which is a reflection of real-world situations where there may be limited or unlimited rights or restrictions on the ground or in the skyward direction of a volumetric property. The approach based on the Tetrahedral Network (TEN) model is a suitable 3D topological model for volumetric parcels and is proposed as an alternative to boundary representation. The 3D topology model based on TEN synchronized with LADM specifications and the development of conceptual and physical model seems to be suitable for 3D cadastre and 3D registration. This topological model would utilize surveying boundaries to generate 3D cadastral objects with consistent topology and rapid query and management.

TO ENABLE THE EFFECTIVE FUNCTIONING OF THE 3D CADASTRE, THE 3D DATA MUST BECOME AN INTEGRAL PART OF THE CADASTRAL SPATIAL DATABASE

VISUALIZATION

The example in Figure 3 shows how difficult it can be to grasp the geometry of a 3D object represented as a 2D drawing. Even trained experts might have difficulties to assess the vertical gap between the two ends of the object. This might prevent people untrained in geometry or CAD – like lawyers or managers – from understanding complex situations. A possible solution could be the use of mixed reality (MR) technology which allows visualization of models in 3D. Special glasses blend digital information, e.g. the representation of a 3D model, into the user's field of vision. Since each eye observes the model from a slightly different perspective, the user perceives the model in 3D. Importantly, the reality is still visible for the user in MR, which minimizes virtual reality sickness and enables the user to avoid collisions while moving around.

Figure 4 shows MR in action at the TH Vienna Spatial HCI Lab. Wearing special glasses, the user sees the model shown on the computer screen. The model is a 3D representation of an apartment building, with the apartment ownership visualized as a holographic model. Different floor colours represent differences in ownership in this model (Navratil et al., 2018). The glasses include sensors for hand detection, thus allowing interaction with the model – in this case, grabbing a floor and relocating it in the space. The interaction is more intuitive than in 3D CAD because it imitates interaction with real desktop objects, e.g. moving a book. This reduces the frustration level among users.

REVISION OF ISO 19152:2012

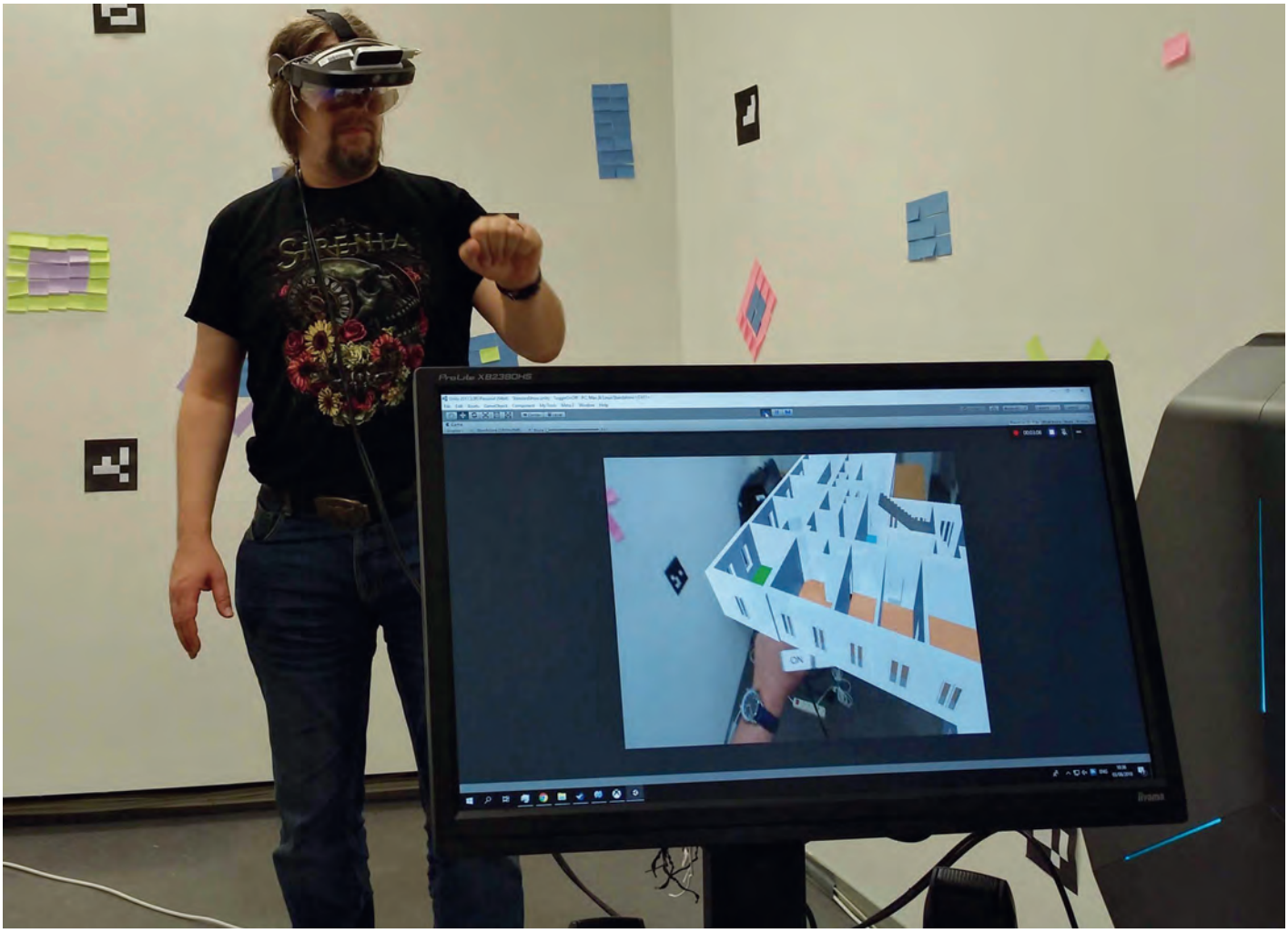
During the 47th ISO meeting week in Wuhan, China, in November 2018, the scope of the revised ISO 19152:2012 standard was agreed. The new version of the ISO 19152 is going to be significantly extended for new packages and annexes. For example, the new ISO 19152 will also consider the spatial planning information because it is necessary to integrate legal and spatial planning information, e.g. spatial planning regulates the total height of a building on a parcel. The ISO 19152 package dedicated to spatial planning information supports geometry objects which represent spatial planning hierarchy and geometric characteristics, facilitates information in spatial planning zoning and describes communities and their role in spatial planning.

FURTHER READING

Navratil, G., Schwai, M., Vollnhofer, S., Konturek, P., Giannopoulos, I. (2018). From Floor Plans to Condominium Rights Through an Augmented Reality Approach. 6th International FIG Workshop on 3D Cadastres. Delft, The Netherlands.

Thompson, R., van Oosterom, P., Karki, S., Cowie, B. (2015). A Taxonomy of Spatial Units in a Mixed 2D and 3D Cadastral Database. FIG Working Week 2015 – From the Wisdom of the Ages to the Challenges of the Modern World. Sofia, Bulgaria.

Van Oosterom, P. (2013). Research and Development in 3D Cadastres, Computers Environment and Urban Systems (2013), https://doi.org/10.1016/j.compenvurbsys.2013.01.002.



▲ *Figure 4: Working with mixed reality. (Photo courtesy: Philip Konturek)*

Legal spaces and legal objects have their own geometries, which in many cases are not aligned with physical spaces and physical objects. The legal space should be linked to physical objects. BIM/IFC or CityGML offer options in this respect. Therefore, the revised version of ISO 19152 should contain the examples of LADM technical encodings in BIM/IFC and CityGML respectively. BIM is important in order to establish a link between BIM and land administration in relation to spatial planning and the whole lifecycle of a building.

CONCLUSION

Over the last 20 years, researchers and professionals have paid significant attention to the 3D cadastre. Nowadays one can find examples of legislation supporting the registration of 3D spatial units around the world (Sweden, the Netherlands, Queensland, Victoria and big cities in China like Shanghai). The registration of 3D spatial units can be seen as the first step towards the 3D cadastre. However, the organizational and technical aspects also have to be addressed. Although some countries already support the registration of 3D spatial units, this is done mostly using 3D drawings (e.g. a survey sketch capturing the 3D geometry of the object or a 3D PDF file showing the legal extent of 3D spatial units). To enable the effective functioning of the 3D cadastre, the 3D data must become an integral part of the cadastral spatial database. To meet this condition, the necessary steps are standardization in the field of 3D cadastre (ISO 19152 LADM), 3D information modelling (e.g. 3D LADM-based country profiles) and further development of 3D spatial databases. Another important technical aspect of the 3D cadastre is in relation with other initiatives like BIM. The capturing of 3D data is often seen as the most expensive phase of establishing the 3D cadastre. Re-usage of data like BIM could help to resolve this issue. The usage of BIM for 3D cadastre purposes has already been addressed in the literature. ◀

ABOUT THE AUTHORS

Karel Janečka is a senior researcher at the University of West Bohemia in Pilsen, Czech Republic. His research activities are spatial data infrastructures, geographical information systems, spatial databases, spatial data mining and 3D cadastre. He has been the president of the Czech Association for Geoinformation since 2012.
✉ kjanecka@kgm.zcu.cz

Gerhard Navratil is a senior researcher in the geoinformation research group of the Department for Geodesy and Geoinformation at TU Vienna, Austria. His research activities are land administration & cadastre, data quality and navigation.
✉ gerhard.navratil@geo.tuwien.ac.at


EOS
Positioning Systems
ARROW SERIES™
High Accuracy Field Mobility
Submeter with SBAS, 1cm with RTK
SafeRTK™ for poor cell coverage areas
GPS/Glonass/Galileo/BeiDou, L1/L2/L5
4cm real-time accuracy anywhere in the world
www.eos-gnss.com


Geo-allen®
GEO-ALLEN CO., LTD.
Punctuality / Quality / Rigor / Service
(Found in 2002)
New
Patent No.
ZL 2013 2 0115329.3
www.geoallen.com e-mail:geoallen@vip.163.com
Fax:+86-512-6862-9776 Tel:+86-512-6802-6320

EXTRACTING VISIBLE BOUNDARIES FROM UAV DATA THROUGH IMAGE ANALYSIS AND MACHINE LEARNING

Towards Cadastral Intelligence?

The inability to access formal land registration systems fosters insecure land tenure and conflicts, especially in developing countries. This calls for low-cost and scalable mapping solutions aligning with fit-for-purpose land administration. The work presented in this article supports the UAV-based mapping of land tenure inspired by state-of-the-art approaches from remote sensing, geoinformatics and computer vision. The guiding question is how to develop an automated approach that promotes the paradigm shift towards cadastral intelligence which integrates human-based expert knowledge with automatically generated machine-based knowledge.

Cadastral mapping contributes to the creation of formal systems for registering and safeguarding land rights. According to the World Bank and the International Federation of Surveyors (FIG), 75% of the world's population do not have access to such systems. Furthermore, they state that 90 countries lack land registration systems, while 50 countries are in the process of establishing such systems. In these countries, cadastral mapping is often paper-based (Figure 2) or delineated from partly outdated maps or low-resolution satellite images which might include areas covered by clouds. The definition of boundary lines is often conducted in a collaborative process among members of the communities, governments and aid organizations. This process may be referred to as 'community mapping', 'participatory mapping' or 'participatory GIS'. Numerous studies have investigated cadastral mapping based on orthoimages derived from satellite imagery or aerial photography, and recently also from imagery from unmanned aerial vehicles (UAVs or 'drones'). The average geometrical precision is shown to be the same, or better, compared to conventional terrestrial surveying methods. As a consequence, UAVs are increasingly proposed as a tool for fast and cheap spatial data capture enabling the production or updating of cadastral maps.

VISIBLE BOUNDARIES

Cadastral surveying techniques can be divided into (i) direct techniques, in which the accurate spatial position of a boundary is measured on the ground using a theodolite, total station or global navigation satellite system (GNSS), and (ii) indirect techniques, in which remotely sensed data such as aerial, satellite or UAV imagery is used (Figure 3). Indirect techniques rely on the existence of visible boundaries demarcated by physical features such as buildings, hedges, fences, walls, roads, footpaths, crop types or water bodies. These features can be extracted by means of image analysis, as demonstrated by studies in remote sensing. Visible boundaries are assumed to make up a large portion of all cadastral boundaries.

AUTOMATED CADASTRAL MAPPING

To investigate the potential of using UAV data coupled with image-based automatic feature extraction for land tenure mapping, a tool was designed that facilitates the delineation of visible cadastral boundaries from UAV data to support indirect cadastral surveying. In contemporary indirect surveying approaches, the operator creates nodes by clicking along a boundary. In the proposed approach, the operator has multiple options to create a boundary making use of the automatically extracted features along visible boundaries. One option consists of selecting nodes from a set of proposed nodes that are then automatically connected along visible object outlines derived from the UAV data. A machine learning approach is applied to learn which object outlines demarcate cadastral boundaries at the specific local scale.

AUTOMATED DELINEATION WORKFLOW

(a) Image segmentation delivers closed contours capturing the outlines of visible objects in the image. Multiresolution combinatorial grouping (MCG) has shown to be applicable to high-resolution UAV data and to deliver accurate closed contours of visible objects.

(b) Boundary classification aims to learn which lines from (a) are useful for cadastral boundary delineation. This is achieved by training a machine learning algorithm that takes into account the lines and their context. After being trained on a set of lines, it can then predict a boundary likelihood for lines from (a) that represents each line's usefulness for cadastral mapping.

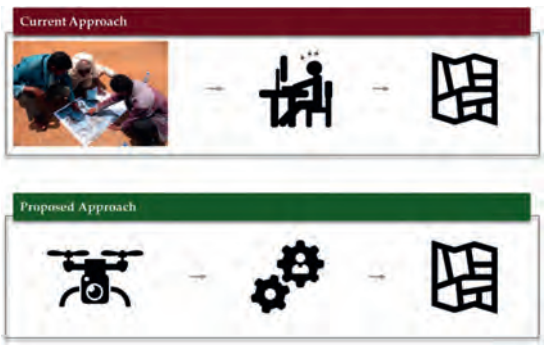
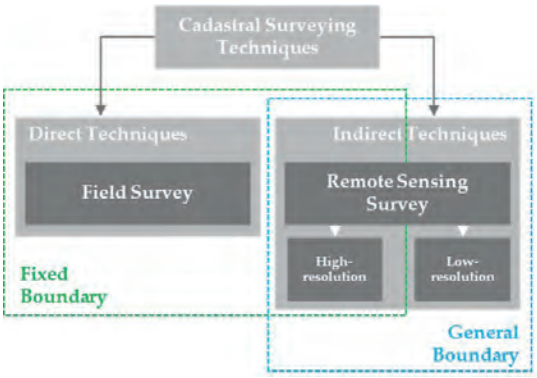
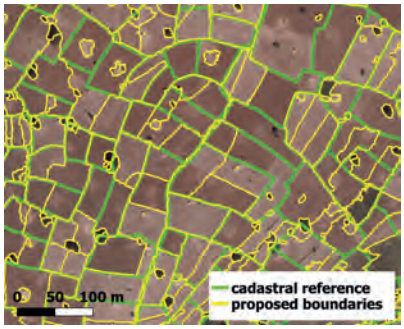


Figure 1: Improving current indirect surveying by coupling high-resolution UAV imagery with automated feature extraction for cadastral mapping.

▲ *Figure 2: (a) Paper-based cadastral data storage in Kajiado (Kenya), and (b) a paper-based map used in local land administration.*



▲ *Figure 3: Direct and indirect techniques for cadastral surveying.*



▲ *Figure 4: Boundaries derived with the described approach overlaid on cadastral reference data from Ethiopia. For these automatically generated boundaries, a boundary likelihood is predicted to be used during the interactive delineation when generating final cadastral boundaries.*

(c) Interactive delineation allows a user to start the actual delineation process: the RGB orthomosaic is displayed to the user, who is asked to create final boundaries making use of the automatically extracted boundary features and their boundary likelihoods. (c) is implemented as a publicly available QGIS plug-in (BoundaryDelineation).

CHALLENGES

The proposed delineation workflow, which is entirely open source, has been evaluated on different UAV data, e.g. from Rwanda, Kenya, Germany and France. Given the complexity of cadastral boundaries, automating boundary delineation remains challenging; the variability of objects and extraction methods reflects the problem's complexity, consisting of extracting different objects with varying characteristics. These circumstances impede the compilation of a generic model for a cadastral boundary and thus the development of a generic method. No standardized specifications exist for boundary features, and boundaries are often not marked continuously and/or maintained poorly.

ONGOING WORK

The authors are currently revising the workflow steps (b) boundary classification and (c) interactive delineation. For (b), they are investigating a deep learning based approach, and for (c), they are improving the usability and effectiveness of the plug-in by adding further delineation functionalities, speeding-up the processing and allowing the creation of polygons.

EXTRACTABLE BOUNDARIES

To further develop automated cadastral mapping in indirect surveying, the authors suggest considering the extractable boundary rather than the visible boundary alone. Instead of focusing on the visible boundary comprising of outlines of physical objects, automated cadastral mapping should focus on the extractable boundary that incorporates local knowledge and context. Local knowledge helps in identifying boundaries, e.g. between two beacons. Context helps when closing an open gateway in a fence as

FURTHER READING

1. Crommelinck, S.; Bennett, R.; Gerke, M.; Nex, F.; Yang, M.Y.; Vosselman, G.: Review of automatic feature extraction from high-resolution optical sensor data for UAV-based cadastral mapping. *Remote Sensing* 2016, 8, 1-28.
2. Crommelinck, S.; Bennett, R.; Gerke, M.; Yang, M.Y.; Vosselman, G.: Contour detection for UAV-based cadastral mapping. *Remote Sensing* 2017, 9, 1-13.
3. Crommelinck, S.; Bennett, R.; Gerke, M.; Koeva, M.; Yang, M.Y.; Vosselman, G.: In SLIC superpixels for object delineation from UAV data, International Conference on Unmanned Aerial Vehicles in Geomatics, Bonn, Germany, 4-7 September 2017, IV-2/W3, pp 9-16.
4. Crommelinck, S.; Höfle, B.; Koeva, M.N.; Yang, M.Y.; Vosselman, G.: In Interactive boundary delineation from UAV data, ISPRS TC II Symposium, Riva del Garda, Italy, 4-7 June 2018, IV-2, pp 81-88.
5. www.github.com/SCrommelinck/Delineation-Tool
6. www.its4land.com

a boundary, for example. This information is not inherent in the concept of the visible boundary, but it is extractable from remote sensing imagery.

CONCLUSION

The delineation cannot be fully automated at the current state since the extracted outlines require (legal) adjudication and incorporation of local knowledge from human operators to create final cadastral boundaries. Image-based approaches hold potential to automatically extract use rights, which do not necessarily represent legal rights. These circumstances limit the scope of automated approaches. The authors observed that automating cadastral mapping dealing with sensitive land rights can only be successful when the interactive part that bridges the gap between automatically generated results and the final cadastral boundary is designed and implemented in correspondence to user needs.

ACKNOWLEDGEMENTS

This research was funded within its4land, which is part of the Horizon 2020 programme of the European Union, project number 687828.

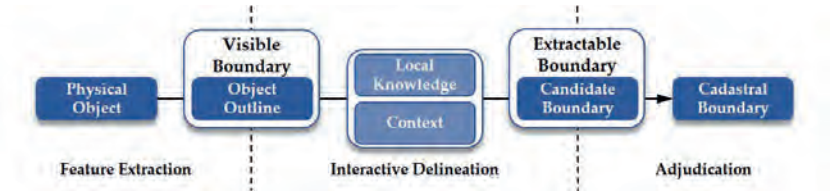


Figure 5. From physical object to cadastral boundary: reformulated boundary concepts for indirect surveying.

ABOUT THE AUTHORS

Sophie Crommelinck gained a BSc in geography and MSc in geoinformatics at the University of Heidelberg, Germany. Currently, she is pursuing her PhD at the Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente, the Netherlands. In her PhD research, she is investigating automated image-based mapping of land tenure through image analysis and machine learning with supervision from Mila Koeva, Michael Yang and George Vosselman.
✉ s.crommelinck@utwente.nl

Dr Mila Koeva gained her doctorate from the University of Architecture, Civil Engineering and Geodesy, Sofia. She is an assistant professor in 3D land information at UT, co-chair of ISPRS WG IV/10 and project coordinator of its4land.
✉ m.n.koeva@utwente.nl

SUZHOU FOIF CO.,LTD.

It's professional

NEW CHANCE
NEW SUCCESS!

A90

Cutting-edge RTK receiver

- Up to 555 channels
- Smart design, maximum productivity
- Third-generation incline measuring: Perfectly achieves precise measurements
- WiFi connection: Realizes WebUI control which is designed to modify settings and monitor the receiver status
- Multiple softwares(including Android) bundled, third-party softwares (FieldGenius, SurvCE) optional

FOIF® since 1958

www.foif.com

High-quality Aerial Imagery Helps to Unlock **5G Networks**

Telecommunication operators are working at full speed to bring a 5G network to life in the early 2020s. Most operators are currently at the signal propagation planning stage and are defining optimal locations for the network nodes. Although widely used for the planning of 3G/4G networks, digital surface models generated from satellite images are insufficient for 5G antenna positioning. Another source, with required high-resolution data, is now available for the USA and large parts of Europe and Canada.

5G is the next generation of wireless network technologies. For 5G to become a reality, however, significant and fundamental changes need to be made to current network architecture. Presently, most telecom operators are therefore preparing their signal propagation planning. This cannot be done effectively without high-resolution spatial data. The vital importance of high-resolution geographical 3D datasets is due to the characteristics of 5G (for the basics, see page 32). To realize the benefits of the new network, it is necessary to amplify the spectrum and to operate primarily in the less occupied high- to very-high-frequency domains. However, operating in high-frequency bands, especially when it comes to signal propagation, can pose the following challenges: 1) high-frequency signals are easily blocked by obstacles, especially (reinforced) concrete, and 2) high-frequency signals attenuate faster over distance (attenuation proportional to the square of signal frequency). A new network architecture forms the heart of a successful signal propagation setup, and it requires digital surface models (DSMs) and digital terrain models (DTMs).

TO OPTIMIZE SIGNAL PROPAGATION PERFORMANCE OF THIS VAST NETWORK OF SMALL ANTENNAS, A DETAILED OVERVIEW IS NEEDED OF THE GROUND SURFACE AND TERRAIN

5G ANTENNA POLES EVERYWHERE

Instead of centralized and expensive 'station-like' antennas, scattered and agile antenna poles will be used to 'guide' signal waves around obstacles and act as signal 'pit stops' to decrease attenuation. These active

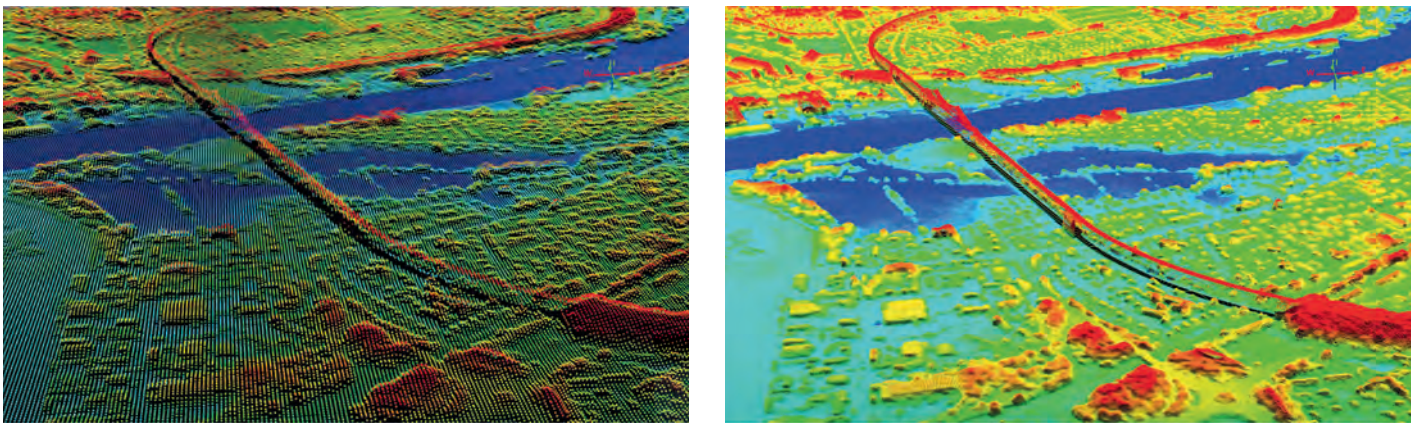


Figure 1: Comparison of 5m (left) and 80cm (right) DSMs.

BASIC CHARACTERISTICS OF 5G

5G is the next generation of wireless network technologies that will revolutionize mobile communication systems, raising the norm for wireless network speed to 10Gb/s. 5G also means a revolutionary change to the entire architecture of cellular networks. The network will have none of the 'blind spots' currently experienced, e.g. in tunnels or inside elevators. A better network architecture not only means much lower latency (fewer delays and lags), but also creates better communication paths. The previously centralized communication (with everything passing through base stations) will be scattered, allowing direct device-to-device communication. More devices can be connected without interfering with central data traffic, which will be a significant step towards advancing the Internet of Things (IoT) and cyber-physical systems. In another major improvement, 5G networks are expected to decouple energy consumption from data volume/traffic thanks to higher signal transmission efficiency and lower signal attenuation.

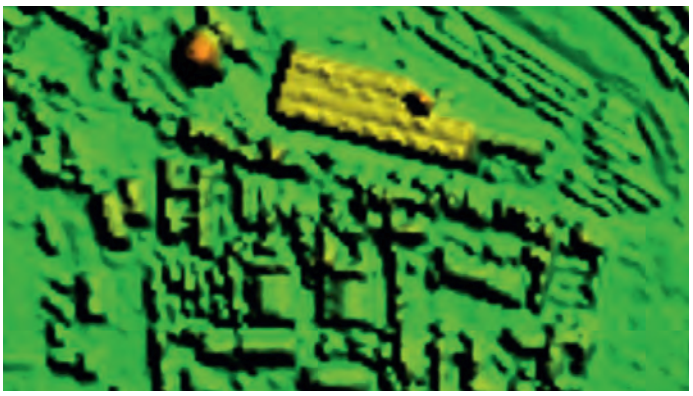
antennas will be much smaller than current antennas and will outnumber them several hundred times. We will see 5G antenna poles being installed everywhere – on buildings, at bus stations and even in shops.

In order to optimize signal propagation performance of this vast network of small antennas, a current and detailed overview is needed of the ground surface and terrain. This means the use of DSMs (as-built surface information with buildings and vegetation) and DTMs (processed surface information with all vegetation and structures removed). So far, 3G/4G network operators have planned and implemented their network using relatively rough and simple DSMs, generated from satellite data with a spatial resolution of 5 x 5 metres or worse. This is simply insufficient for the planning of a 5G network. In most countries, however, better datasets are only available 'in pieces', with inconsistent accuracy and specifications. Network providers would have to acquire a patchwork of non-homogeneous and expensive existing data, or be confronted with costly data acquisition. Additionally, access to better datasets is often restricted and administratively complex. It is therefore perhaps interesting to know that there is an alternative approach in many regions of the world.

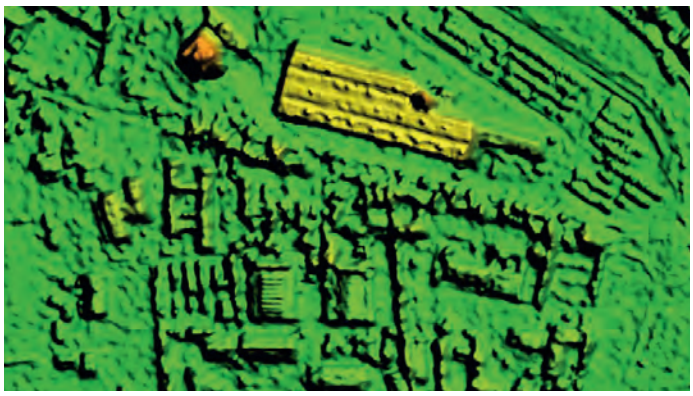
IN MOST COUNTRIES, HIGH-RESOLUTION DATASETS ARE ONLY AVAILABLE 'IN PIECES', WITH INCONSISTENT ACCURACY AND SPECIFICATIONS

REGIONWIDE 3D IMAGERY

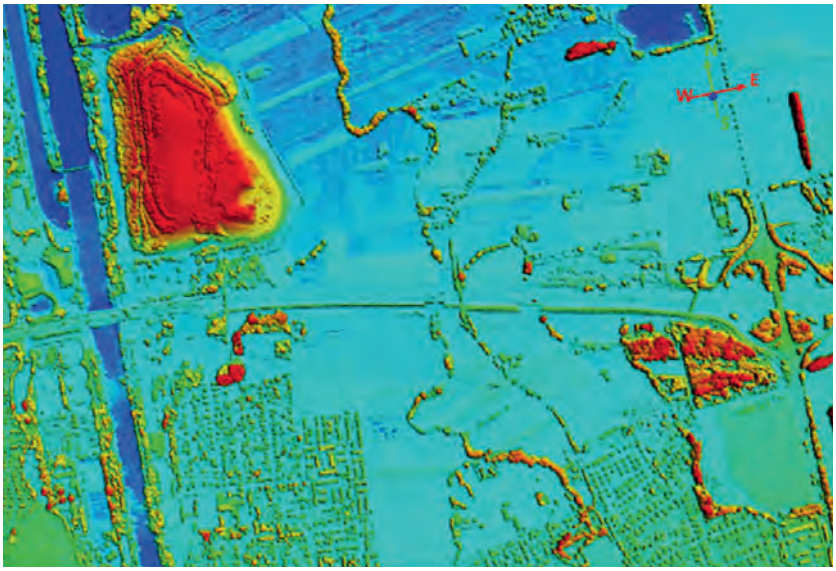
For the USA and large parts of Canada and Europe, the Hexagon (HxGN) Content Program provides seamless 15-30cm resolution orthophotomosaics and elevation data, as well as an 80cm-resolution DSM. In its work to acquire Europe-wide homogeneous aerial imagery coverage since 2014, COWI has discovered the benefit of the HxGN Content Program compared to traditional satellite imagery for professional use. The solution has brought radical improvements to the aerial imagery industry thanks to its high geometric accuracy, radiometric consistency and its ability to capture images in areas with difficult weather conditions, covering entire countries and regions. The Leica cameras used within the programme capture light in four bands: three visible bands for a colour image and the invisible near-infrared, which can be used later to detect vegetation automatically. This combination makes it very suitable for a wide-area semi-automatic mapping task at high speed. Due to the continuous capture of the data in stereo models, high-resolution terrain models can be calculated and all important obstacles mapped in 3D. The digital surface models have a spatial resolution of 80cm, which is much better than almost any satellite dataset used today for radio propagation.



▲ *Figure 2a: 5m-resolution DTM. Detailed structures are generalized and disappear in the surroundings.*



▲ *Figure 2b: 80cm-resolution DTM. Detailed structures are clearly visible.*



▲ *Figure 3: HxGN DSM at 40cm resolution.*

The HxGN DSM can be further improved by combining mapping with the height model and adding land cover information, e.g. the discrimination between buildings, building types and vegetation such as forest and agriculture. The DSM will inherently contain the information about the height of buildings and vegetation, both of which are crucial for 5G antenna planning. If the resulting high-resolution datasets would pose challenges for local data storage and management of large-area coverage, that can be addressed through easy and secure cloud-based storage and access. ◀

FURTHER READING

www.cowi.com/solutions/planning/the-hexagon-content-program

ABOUT THE AUTHORS

Simon Musaeus is senior vice president of mapping at COWI A/S. He holds an MSc in geodesy from the University of the Armed Forces, Munich, Germany, and a doctor of business administration from Walden University, Minnesota, USA. Before taking responsibility for the COWI mapping business, he led various projects and local companies in Latin America, Eastern Europe and India.
✉ SIMU@cowi.com

Michaela Neumann is director of geodata and mapping at COWI A/S. She holds an MSc degree in geography from the University of Bonn, Germany, and has more than 20 years of experience in the use of geodata for a multitude of applications and markets across Europe and beyond.
✉ MENE@cowi.com

A PLEA FOR A BOTTOM-UP, BRUTE-FORCE SOLUTION

Land Administration Census

The battle against poverty in developing countries has always been associated with the issue of land. Since the turn of the millennium, the focus has been on facilitating the official registration of land rights by the poor and the vulnerable. Many countries in sub-Saharan Africa still lack a well-functioning land administration system, notwithstanding many dedicated aid programmes. Such programmes were designed by Western institutions and often copied Western land administration architectures. In this article, the author advocates a bottom-up approach using census-taking as a paradigm. First the capabilities of advanced technologies are identified, then the way aid is brought to the vulnerable is explored and lastly an approach based on conducting population and housing censuses in sub-Saharan Africa is considered.

It is generally recognized that the right of individuals or groups to own land and to reap its fruits is a key driving force for prosperity of a society as a whole. Ownership brings the obligation of custody and stewardship. Owing land is a fundamental human right. Article 17 of the Universal Declaration of Human Rights – adopted and proclaimed on 10 December 1948 – declares that (1) everyone has the right to own property alone as well as in association with others, and that (2) no one shall be arbitrarily deprived of his property. But how do others know of an individual's or a group's rights to land?

▲ *Figure 1: Trimble TDC100 handheld data collector combines smartphone and GNSS technology.*

INNOVATIVE LAND TOOLS

To avoid conflicts, it is essential that the types of right, the subjects who hold the rights and the objects themselves, i.e. the pieces of land, are clearly identified and registered, and the rights are acknowledged and protected by the authorities. This is where land administration comes in. It is a complex process with many actors and stakeholders. It involves the generation of legally valid documents, measurement of the parcel boundaries and (georeferenced) documentation of these measurements. Many developing countries do not have a well-functioning land administration system in place, notwithstanding many aid programmes which are focused on securing land tenure. These programmes were designed by Western institutions and often copied Western land administration architectures. In sub-Saharan Africa progress is modest, leaving farmers and others vulnerable to land disputes, land grabbing and decreasing yields.

To speed up the process of safeguarding property rights, much hope is focused on the abilities of advanced technologies and innovative land tools related to the concepts of 'pro poor', 'fit for purpose' and continuum of land rights. However, technology is just one side of the coin. The other side concerns matters such as the architects of the solution and the design principles. The solutions are often based on a template that has been designed in a developed part of the world. However, because conditions vary from country to country, the implementation of a template derived from systems which work well elsewhere has been proven to be inappropriate.

TECHNOLOGIES

The individual parcel is the key entity in any land administration and cadastral system. A boundary survey of individual parcels actually means measuring the coordinates of the points along the edges of the parcel where the direction of the border deviates from a straight line. Next, a continuous boundary is reconstructed by connecting the corner points. In the wake of the advancements in microelectronics and computational power, land surveying technologies have changed drastically since the 1950s. Total stations and high-end GNSS receivers – the workhorses of land surveyors – have been accompanied by multiple sensor systems which can be mounted on nearly all types of moving platforms, including

Figure 2: UAS equipped with camera as tool for cadastral boundary survey (courtesy: M. Lemmens).

human backs and hands. The main sensor systems are based on cameras and laser scanners (Lidar) supported by GNSS and miniaturized inertial navigation systems. Produced at low costs, consumer-grade smartphones are increasingly being equipped with such sensors. This opens up new possibilities to involve land owners and other rightsholders more intensively in the land administration process; currently, their role entails merely pointing out the corners of parcels, after which a land surveyor carries out the time-consuming boundary survey job. Indeed, the possibilities and capacities to capture cadastral boundaries are huge today. Smartphones equipped with high-accuracy GNSS capabilities are becoming increasingly affordable and user-friendly, potentially enabling millions of laymen to become amateur surveyors (Figure 1). Optical satellite images have such a high ground sample distance (GSD) that boundaries can be delineated with a relative precision at decimetre level. Unmanned aerial systems (UASs or 'drones') can be equipped with cameras, making it possible to create accurate ortho images of a village and surrounding fields within a couple of days using dense image matching software (Figure 2). The local population, supported by a trained person, can delineate property boundaries on these images. The data can be processed in temporary offices thanks to the internet, wireless communication and the opportunities of cloud computing. Research conducted all over the world has shown that high-resolution optical satellite images, UASs and smartphones can all help to speed up the land administration process.

HANDHELDS EQUIPPED WITH GNSS AND GIS COMBINED WITH IMAGERY SUPPORT THE IDENTIFICATION OF LAND RIGHTS AND BOUNDARY DELINEATION

PARTICIPATORY LAND ADMINISTRATION

The above-mentioned sensors and new capabilities enable what is called participatory land administration (PLA). This means that the owners come together and agree about who owns which piece(s) of land. They then record the boundaries with devices including smartphones and data sources such as ortho-rectified satellite images or orthomosaics created from images captured by UAS-mounted cameras. The initial establishment of a land administration system requires the existing land rights to be officially recognized and recorded. This process, called adjudication, does not concern vesting land rights – they already exist – but focuses instead on authoritatively ascertaining the rights. A carefully conducted adjudication process creates security of rights. An early study of the role of PLA in speeding up the adjudication process was conducted by Lamptey (2009) in Ghana. She found that the use of handhelds equipped with GNSS and GIS software combined with satellite imagery effectively support the identification of land rights and boundary delineation (Figure 3). Later research conducted by Asiama et al. (2017), also carried out in Ghana, confirmed the findings, although the exact delineation on satellite images sometimes faced difficulties because of occlusion by vegetation. Figure 4 shows the results of boundary surveys carried out using smartphones (red) and high-resolution satellite images (blue).

TOP-DOWN APPROACH

Securing land tenure helps to reduce poverty among farmers and other entrepreneurs because it stimulates custody and stewardship. Who should design, develop and implement the necessary measures and


GINTEC
NEW CHOICE NEW FUTURE
Surveying and Mapping Fly Towards Higher Efficiency
http://www.gintec.cn
E-mail: overseas@gintec.cn


Capture topography in less than HALF the time.
LiDAR USA
Fagemate Technologies Inc.
Email sales@lidarusa.com to purchase
DJI M200/210 SNOOPY LiDAR Package

provisions to arrive at secure land tenure? How should it be organized and who should be in charge? How should the endeavour be financed? Time after time, it has been demonstrated that solutions conceived by developed countries and often based on Western concepts do not achieve the intended improvements. The main reasons are that legal systems and the relationships between humans and land are embedded in a historical and cultural context. The technologies and workflows that work well in one society cannot necessarily be copied and directly applied to another. The idea that such a transfer would work is a long-standing misconception.

The effects of foreign aid on improving the living conditions of the poor in developing countries has been intensively investigated. Despite the best of intentions, aid often does more harm than good. This is because the aid-giver not only provides financial support and contributes expertise, but also defines the aid and determines the manner in which it is executed in line with the adage, 'he who pays the piper calls the tune'. Based on his research Easterly (2006), who spent most of his career as an economist at the World Bank, criticizes foreign aid delivered by the rich part of the world to the poor part. He argues that "aid does not work since it is provided in the context of ambitious plans based on generosity; a planner thinks he already knows the answers". Planners take a top-down approach, whereas the poor need bottom-up solutions. Since the poor themselves know best in terms of what they need, they should be allowed to come up with the solutions; they do not need Western architects who devise solutions on a drawing board somewhere in the USA or Europe. Up to now, the sum of all plans is negative, he states, and that is because aid money does not actually reach the poor, and when goods and services purchased with donor money do reach them they are not used properly.

AID DOES NOT WORK SINCE IT IS PROVIDED IN THE CONTEXT OF AMBITIOUS PLANS BASED ON GENEROSITY; A PLANNER THINKS HE ALREADY KNOWS THE ANSWERS

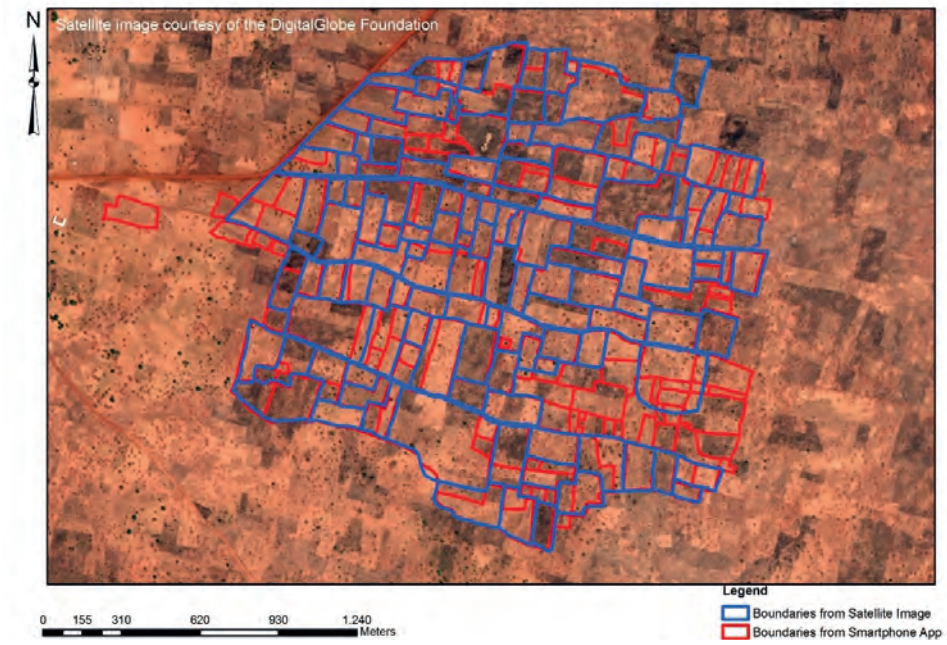
MOZAMBIQUE

A recent example of a top-down approach in the context of land administration is the Terra Segura (Secure Land) Mozambique Land Administration Project, which is financed by the World Bank Group with a loan of US$100 million issued at the end of 2018. In Mozambique, land rights for about 90% of the total occupations have not been formally registered. The project is aimed at improving tenure security as well as the land administration system. This requires institutional upgrading and capacity building. The project will cover 1,200 communities across the country and benefit 700,000 rural rightsholders, equating to around 12% of the country's rural population (Figure 5). In addition to the construction of provincial and regional offices, ICT equipment will be procured, high-resolution orthorectified satellite images acquired, and parcel demarcation and boundary surveys outsourced. Task team leadership and technical aspects will be managed from the World Bank's office in Washington, USA, in close collaboration with the country office in Maputo, Mozambique's capital. The overall risk of the project has been classified as substantial. The urgent need for this project has arisen due to the eagerness of foreign investors to acquire large pieces of land, an interest which is stimulated by the national government and the agricultural industry. Confronted with irreversible deprivation, the rural population is putting up fierce resistance but is unaware of the underlying processes. It is hoped that increasing tenure security will prevent such land-grabbing activities by foreign investors. This four-year project is not only being controlled from an office in the West, but is actually involving 12% of the

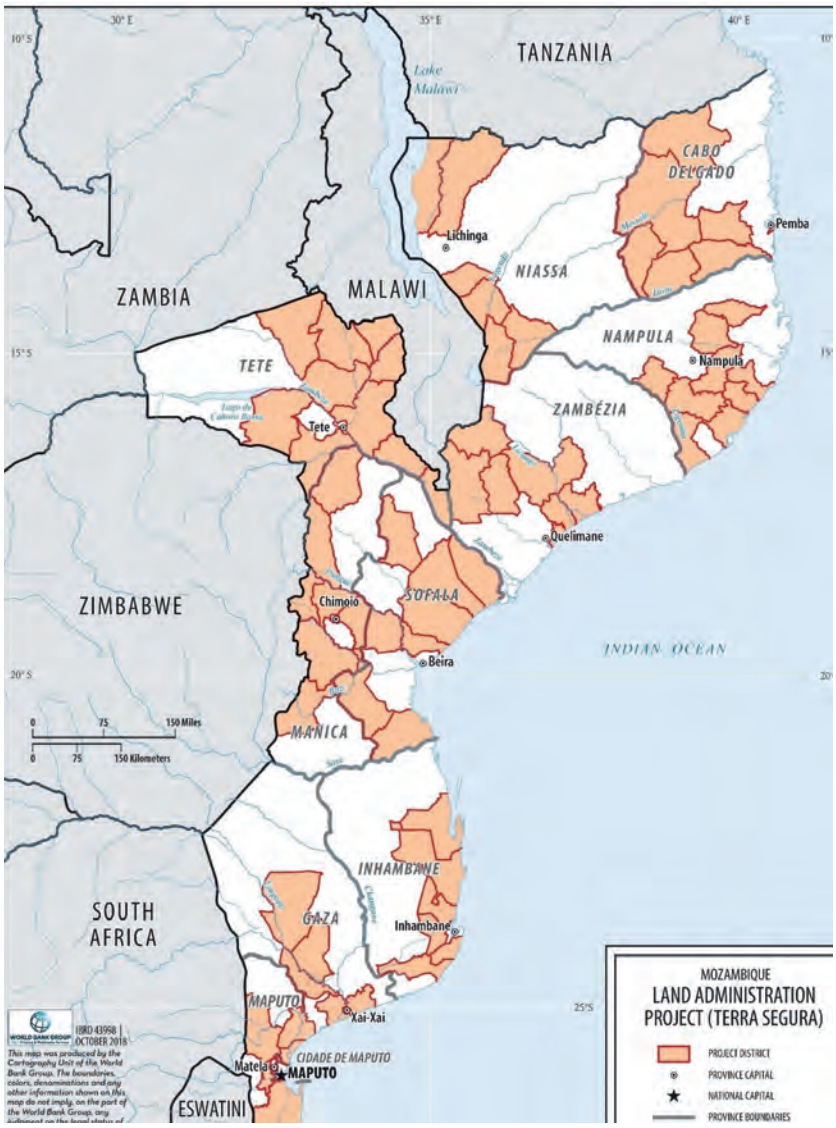
AMENABILITY

The ideas proposed in this article go back a long way. The first notions originate from a land administration project carried out in Estonia in the 1990s. Related issues have featured regularly in the nearly 200 columns I have written for this publication since then. Some readers might even have thought that I've become philosophical – but it has always been about injustice, the imbalance of power and unjustifiable poverty.

Figure 3: Boundary survey using a handheld (left) and satellite map (source: Lamptey, 2009).



▲ *Figure 4: Parcel boundaries collected from satellite map and by smartphone (source: Asiama et al., 2017).*



▲ *Figure 5: Terra Segura project districts in Mozambique (source: World Bank, Report No: PAD2919, 2018).*

rural population, as mentioned above . As a result, it is expected to take 30 to 40 years to cover the entire country.

CENSUS

The Mozambique example outlined above shows that covering an entire country with tenure security may take decades, even when using advanced technologies such as aerial or satellite imagery or smartphones equipped with positioning apps. In many sub-Saharan countries, however, other huge projects involving the entire country have been undertaken rather successfully within time spans of less than a decade. These projects are closely related to population and housing censuses. A census is a large-scale, comprehensive and complex undertaking as preparing for, collecting and processing the massive amount of data places huge demands on resources in terms of manpower, training, technology and funding. It is said to be one of the biggest peacetime operations in terms of planning, funding, logistics and execution, affecting as it does the entire population living within the territory. Producing detailed statistics for small areas and small population groups is the foundation of any population and housing census, and to arrive at such statistics it is necessary to collect data concerning composition, characteristics, spatial distribution and organization.

The different census methods can be subdivided into: (1) group assembly method; (2) self-response method; (3) direct interview/canvasser method; and (4) virtual census. In developing countries, the canvasser method is usually used, because the other methods require a high level of literacy among the population. The canvasser method is a de facto method whereby every individual physically present in the country is interviewed face to face. This is the most reliable but also the most expensive and demanding method because it requires extensive preparation, training of hundreds of thousands of enumerators, adequate communication and a fine-grained command hierarchy.

BOTTOM-UP APPROACH

Adjudication carried out in sub-Saharan countries is often criticized because of limited transparency and lack of participation of the land owners and other stakeholders. In line with the ideas of Easterly, the success rate depends on a bottom-up approach in

which the main stakeholders are convinced that officially registering land rights brings benefits to the owners and society as a whole. Being convinced is maybe not enough; people should also be enthusiastic and willing to make sacrifices. Census-taking provides a paradigm for the manner in which such a huge endeavour can be organized and streamlined. A first requirement is that the endeavour should be organized bottom-up, with the financial support and expertise of donor organizations. A second requirement is a sophisticated publicity programme addressing the entire population. A third requirement is that hundreds of thousands of indigenous literates are trained for fieldwork. As the example of Mozambique shows, organizations are willing to provide financial support. Of course, all the solutions proposed and investigated in the past should not be thrown in the waste bin. For example, capacity building is a key pillar for success. Participatory land administration has proven to be effective for motivating and inspiring land owners. Today, information and publicity can reach every nook and cranny of a country. The technology is in place. Now it is all about bundling the abilities, converging energy and creating a willingness to undertake the mission. A bottom-up approach of such dimensions and impact will require a 'brute-force approach' – but that does not mean that it should be accompanied by military missions or physical force. Furthermore, the endeavour can be founded on three sound concepts: pro poor, fit for purpose and continuum of rights.

CONCLUDING REMARKS

The proposed approach will be confronted with many complex factors which may be beyond the scope of control. However, the main pillar for success will be the bottom-up approach in which governments, land owners, traditional leaders and other stakeholders join forces in the firm conviction that everyone will benefit and that their efforts will mark a turning point for a new era, a better future. If it is possible to organize a nationwide population and housing census, with all the painstaking preparation and setbacks it entails, surely it is also possible to organize a nationwide land administration census? It is worth at least considering the opportunities. ◂

FURTHER READING

Asiama, K., Bennett, R., Zevenbergen, J. (2017) Participatory Land Administration on Customary Lands: A Practical VGI Experiment in Nanton, Ghana, *ISPRS International Journal of Geo-Information*, 6, 186.

Easterly, W. (2006) *The white man's burden: why the West's efforts to aid the rest have done so much ill and so little good.* The Penguin Press, New York, NY, 436 p.

Lamptey. F. (2009) Participatory GIS tools for mapping indigenous knowledge in customary land tenure dynamics: case of Peri-urban Northern Ghana. MSc thesis, International Institute of Geo-information and Earth Observation (ITC), Enschede, The Netherlands (Supervisors: M. Lemmens, A. Tuladhar, A. Arko-Adjei).

Lemmens, M. (2011) *Geo-information: Technologies, Applications and the Environment*, Chapter 13 (Census Taking) & Chapter 15 (Land Administration), Springer.

ABOUT THE AUTHOR

Mathias Lemmens is director of MSc Geomatics for the Built Environment, Delft University of Technology, the Netherlands, and an independent geomatics consultant. As team leader and GIS advisor he has conducted major EU and World Bank projects in Estonia, Nigeria and Kenya.

✉ m.j.p.m.lemmens@tudelft.nl

Transiting Cartographic Meetings

The last ICA column in this magazine highlighted the biennial International Cartographic Conference in Tokyo, in July 2019, and the many pre-conference events being held in association with this. All listed in the ICA Calendar, these events are supplemented by a full programme of other meetings also listed there.

It is clear that there is ongoing activity in the discipline of cartography, complementing the formal major conferences. For example, the ICA Commission on Cartographic Heritage into the Digital has organized an extensive programme for its 14th conference, which is being held in Thessaloniki from 8-10 May 2019. The major focus of this meeting is the contribution of 'cartoheritage' to the developing field of digital humanities, including basic topics such as digitization, georeferencing and content analysis. Further investigation of contemporary issues such as derived studies of landscape change, connection between map and textual data, and thematic portals for visualization of cartoheritage, are also included. As previously, the proceedings of the Commission's conferences can be obtained online through the web pages of its excellent journal of record, e-Perimetron, which presents an extraordinary range of scholarship in this important area of cartographic activity. A recent meeting which was organized on an initiative outside formal ICA Commissions, but which was similarly potentially important, was the 2nd Workshop on Schematic Mapping (11-12 April), held in Vienna, Austria. This meeting brought together disparate groups of researchers and practitioners working on various aspects of schematic maps, including cartographers, computer scientists, graphic designers, psychologists and transport professionals. Formal presentations on usability, automation and history of real-world applications were enhanced by attention to some practical contemporary scenarios. The use of novel algorithms for creating metro maps was demonstrated by several researchers, notably from Germany, whilst some applications of schematic maps in non-transport arenas were considered. It is noteworthy that some longer-standing algorithmic approaches (e.g. from ESRI) are still valid and effective. Novel designs were presented and discussed by a number of attendees, with the influence of previous masterpieces of design and execution (e.g. metro maps of London, Berlin, Sydney and Tokyo) being evident. The re-design of the Vienna metro map, due to a proposed new line, was considered, and the possibilities of dynamic map displays in newly commissioned metro carriages were explored.

The local transport operator, Wiener Linien, graciously offered its informative exhibition centre within one of the Vienna U-Bahn stations as the location for a social/poster venue.

More information
https://icaci.org/calendar/
http://cartography.web.auth.gr/ICA-Heritage/Thessaloniki2019/programme.html
www.e-perimetron.org

Poster event at the U2/U5 information centre, Volkstheater U-Bahn station. (Image courtesy: Ken Field)

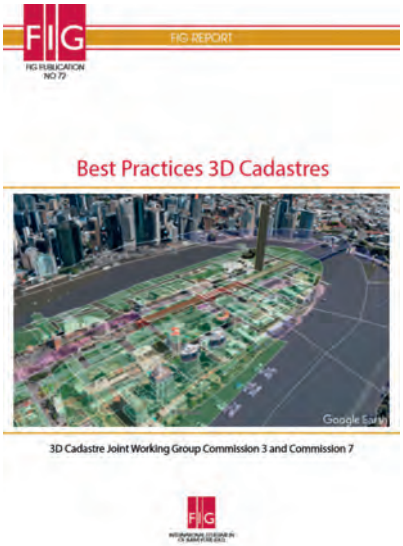


FIG Publication No. 72, Best Practices 3D Cadastres.

New FIG Publication on 3D Cadastres

Two recent publications on 'Best Practices 3D Cadastres' give a comprehensive overview of research, developments and implementations relating to 3D cadastres. Professor Peter van Oosterom, an authority and expert in this field, has been working in this domain for two decades. The first International Workshop on 3D was organized under his chairmanship in 2001, and the sixth edition of that workshop was held last year. Prof Van Oosterom has also chaired the FIG Working Group on 3D Cadastres – a joint Working Group of FIG Commissions 3 'Spatial Information Management' and 7 'Cadastre and Land Management' – for many years. At the end of the two most recent four-year terms (2010-2014 and 2014-2018) of the Working Group, it was decided to collect the best known practices in a single FIG publication. Key authors were invited to produce a chapter on a specific topic, as follows:

- Chapter 1: Legal foundations (Dimitrios Kitsakis)
- Chapter 2: Initial Registration of 3D Parcels (Efi Dimopoulou)
- Chapter 3: 3D Cadastral Information Modelling (Peter van Oosterom)

- Chapter 4: 3D Spatial DBMS for 3D Cadastres (Karel Janečka)
- Chapter 5: Visualization and New Opportunities (Jacynthe Pouliot)

The lead authors each teamed up with a group of authors to produce their chapters. A lot of inspiration was found in FIG's earlier 3D cadastre activities. Based on the long version, a shorter version of about 80 pages has also been produced and published. The short version is available as a FIG publication both as a hard copy (paper) and soft copy (online PDF). The long version is published in soft-copy format and in the style of the FIG proceedings.

In the preface, Chryssy Potsiou, FIG president 2015-18, writes: "This publication is a further contribution of FIG in this ongoing process of improving land administration systems. It responds to the need for international research in building effective land administration infrastructures with modern information technology that will support the 2030 global policy goals for sustainable development. This study takes into account the recent developments that have taken place, and I hope that it will lead to a better understanding of the concept of a 3D cadastre".

More information
FIG Publication No. 72, Best Practices 3D Cadastres, is available at:
http://www.fig.net/resources/publications/figpub/pub72/figpub72.asp
The extended version is available at:
http://www.fig.net/resources/publications/figpub/FIG_3DCad/figpub_3DCad.asp

21st International Workshop on Laser Ranging

The 21st International Workshop on Laser Ranging was held at the Australian National University in Canberra, Australia, from 5-8 November 2018. The theme of the workshop, 'Laser Ranging for Sustainable Millimetre Geoscience', afforded presentations on a wide range of topics highlighting SLR contributions to research, with sessions on the following topics:

- SLR Contribution to Global Geodetic Observing System – A 2020 Perspective
- Improvements in the SLR Product Quality and Precise Orbit Determination
- Satellite Missions and Techniques for Geodetic Applications
- Characteristics of Retroreflector Arrays
- Sources of Systematic Errors
- Network Operations and Site Upgrades
- Developments in SLR Techniques and Technologies
- Developments in Software and Automation
- Lunar Laser Ranging and Deep Space Missions

Over 175 registrants from 23 countries participated in the workshop. The workshop programme included 80 oral presentations and over 60 posters. All abstracts, presentations, posters and summary papers are available within the 'Program' section of the workshop's proceedings website.

One issue that particularly stimulated discussion was the SLR policy in tracking GNSS satellites. The ILRS routinely prioritizes satellite targets by altitude (LEO through geosynchronous), with occasional adjustments to enhance tracking on new satellites, typically with active systems aboard. Within the GNSS regime, several satellites may be given high priority at the request of the constellations to provide better pass coverage for special directed applications. Of the remaining GNSS satellites (currently ~ 60), a subset is identified for non-prioritized tracking on an 'as time permits' basis. The ILRS will work with the IGS and the contacts from the GNSS constellations for their advice.

The 21st International Workshop on Laser Ranging concluded with a general discussion on the format of the workshop, planning for future workshops, and improvements to the clinic content and organization. The community looks forward to the next opportunity to meet, the 22nd International Workshop on Laser Ranging, which is planned for the 2020 timeframe in Kunming, China.

More information
https://cddis.nasa.gov

Participants at the 21st International Workshop on Laser Ranging. (Photo credit: Exclusive Images, Canberra, Australia)

ISPRS 2020 Congress: Nice is Nice!

The XXIV ISPRS Congress will take place in 2020 in the French city of Nice from 14-20 June. Nice is the capital of the French Riviera and is an outstanding location on the Mediterranean Sea, bordered by the Alps, Italy and the countryside of Provence.

The venue of the congress, the Acropolis Convention Centre, is in the heart of the historical city, just 5 minutes' walk from the Vieux Nice (the old town) and 10 minutes' walk from the beach. The Acropolis is also less than a 20-minute tram ride from the airport, so it is extremely convenient!

Held every four years, ISPRS congresses are major scientific and technical events in the geospatial community. The ISPRS 2020 Congress in Nice will host over 3,000 participants from 100 countries and will gather leading specialists in the fields of photogrammetry, remote sensing and spatial information sciences, coming from universities, mapping and cadastre agencies, space agencies, public organizations and private companies. The ISPRS Congress is the opportunity for participants to learn the state of the art on the current trends in science and technology and also to network with a very large number of experts from within the community and from neighbouring fields.

More than 2,000 papers will be submitted for the 2020 Congress, many of which will be presented in the various tracks. Six of those tracks will be science-oriented, devoted to the presentations of new high-quality contributions in the scope of the five ISPRS Technical Commissions (sensor systems, photogrammetry, remote sensing, spatial information science, and education and outreach).

In addition to these, a fora track will discuss hot topics for the geospatial community (global mapping and resource monitoring for Sustainable Development Goals, smart cities, digital globes, data cubes and geoplatforms, autonomous navigation and open science) in order to study the role that the community could play in them.

A technology track will be dedicated to specific presentations of new technologies, products and services developed by the industry but also by academia (science-oriented platforms, products and services). It will be associated with a large industrial exhibition that will give attendees the unique opportunity to get updated on the advances of new geospatial technologies and solutions, and their applications.

More information
http://www.isprs2020-nice.com

The Acropolis Convention Centre.

SinoGNSS®
By ComNav Technology Ltd.

To make your work
easier is our original motivation

T30 GNSS
Receiver

T30 GNSS Receiver featuring full-constellation tracking capability, tilt compensation, 4G/WiFi/Bluetooth® connection, and easy survey workflow with Android-based Survey Master Software, Dustproof&Waterproof design makes T30 GNSS Receiver perfectly and effectively work even in harsh environments. Collect more accurate data easier and faster no matter for beginners or professional surveyors.

Features

- L-BAND — Support L-Band and PPP
- Two 3400mAh Hot Swap Batteries
- Rugged Al-mg alloy Housing
- All Constellations
- Tilt Compensation
- 4G Tx & Rx — Built-in 4G/ TX & RX
- 67 — IP67

Perfectly Works with:

Survey Master

Google play
Download for free

SinoGNSS®
By ComNav Technology Ltd.

Sales@comnavtech.com
www.comnavtech.com

THE **ONE** THAT STARTED IT ALL

“ THE SX10 IS OPENING UP
A WHOLE NEW RANGE OF POSSIBILITIES.

- Even Sellevoll, Geomatikk Survey

“ WE COULD KEEP OUR FEET ON THE GROUND AND
SAFELY MEASURE REMOTE OBJECTS.

- Joel Cusick, U.S. NPS

“ WE HAVE WITNESSED
BETTER RETURNS THAN ANY OTHER SYSTEM.

- Terry Nygaard, Tx RPLS

“ THE HIGHEST TECH PIECE OF EQUIPMENT
I'VE EVER USED.

- Paul Biehl, Aztec

“ QUICKER ROI THAN ANY TWO INSTRUMENTS
WE'VE HAD IN THE PAST.

- Matt Bryant, NTT DATA

“ ADAPTING TO THE SX10 WAS NO PROBLEM.

- Niels Balens, BAM Contractors

“ FASTER IN THE FIELD
AND MUCH MORE ROBUST.

- Steve Sharron, WSP

“ WILL DEFINITELY
REVIVE THE WHOLE INDUSTRY.

- Lennårt Gimring, AF Consultants

The Trimble SX10 Scanning Total Station is the single must-have piece of equipment that masters surveying, imaging, and high-speed 3D scanning in one powerful solution. Two years and thousands of customers later, the reviews are in: the SX10 remains the first and the best of its kind.

Trimble SX10

See how others are using the SX10 at **Trimble.com/SX10_Stories**