

## Scanners for Permanent Monitoring and Their Integration Capabilities

Permanent 3D Data Acquisition of Geotechnical Structures  
Using Web-based Applications



**3D MODELLING OF BUILDINGS USING TLS TECHNOLOGY**

**RECONSTRUCTING 3D BUILDINGS USING DEEP LEARNING**

**DEEP LEARNING FOR GROUND AND NON-GROUND SURFACE SEPARATION**



# e-survey E800

- ▶ Comprehensive and Mighty
- ▶ All Terrain Survey
- ▶ Powerful US-Designed **Engines**
- ▶ Affordable Top Quality
- ▶ Sales in +50 countries, Guaranteed Satisfaction

GNSS RECEIVER



[www.esurvey-gnss.com](http://www.esurvey-gnss.com) [info@esurvey-gnss.com](mailto:info@esurvey-gnss.com)

Copyright © Shanghai eSurvey GNSS Co., Ltd. All rights reserved.



## DIRECTOR STRATEGY & BUSINESS DEVELOPMENT

Durk Haarsma

**FINANCIAL DIRECTOR** Meine van der Bijl

**TECHNICAL EDITOR** Huibert-Jan Lekkerkerk

**CONTRIBUTING EDITORS** Dr Rohan Bennett,  
Frédérique Coumans

**HEAD OF CONTENT** Wim van Wegen

**COPY-EDITOR** Lynn Radford, Englishproof.nl

**MARKETING ADVISOR** Myrthe van der Schuit

**BUSINESS DEVELOPMENT MANAGER** Jurjen Visser

**CIRCULATION MANAGER** Adrian Holland

**DESIGN** ZeeDesign, Witmarsum, [www.zeedesign.nl](http://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: [myrthe.van.der.schuit@geomares.nl](mailto:myrthe.van.der.schuit@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](mailto:wim.van.wegen@geomares.nl).

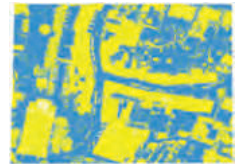


Geomares  
P.O. Box 112, 8530 AC Lemmer,  
The Netherlands  
T: +31 (0) 514-56 18 54  
F: +31 (0) 514-56 38 98  
[gim-international@geomares.nl](mailto:gim-international@geomares.nl)  
[www.gim-international.com](http://www.gim-international.com)

No material may be reproduced in whole or in part without written permission of Geomares.  
Copyright © 2022, Geomares, The Netherlands  
All rights reserved. ISSN 1566-9076

## P. 11 Deep Learning for Ground and Non-ground Surface Separation

Precise ground surface topography is crucial for 3D city analysis, digital terrain modelling, natural disaster monitoring, high-density map generation and autonomous navigation, to name but a few. Deep learning (DL), a division of machine learning (ML), has been achieving unparalleled success in image processing, and recently demonstrated huge potential for point cloud analysis. This article presents a feature-based DL algorithm that classifies ground and non-ground points in aerial laser scanning point clouds.



## P. 14 Scanners for Permanent Monitoring and Their Integration Capabilities

Climate change and the expansion of urban habitats, for example in the alpine region, make it increasingly important to obtain spatially and temporally detailed high-quality datasets that can be integrated into a comprehensive risk management system as an early warning system. A recently published white paper examines this issue and proposes an appropriate solution.



## P. 18 Reconstructing 3D Buildings Using Deep Learning

Automated classification and object detection in Lidar and imagery data is essential for minimizing production costs. While the optimization of traditional methods using rule-based algorithms has enhanced geospatial applications, significant manual intervention is still required to obtain a high-quality dataset. This article outlines how artificial intelligence (AI) can lead to a robust process for 3D city modelling and discusses some of its challenges.



## P. 25 Three Candidates for FIG President

In this article, *GIM International* and FIG ask the three President candidates – Abbas Rajabifard (Australia), Diane Dumashie (UK) and Orhan Ercan (Turkey) – six questions about their views of the surveying and geospatial profession, the future and their visions if they were the next President of FIG.



## P. 34 3D Modelling of Buildings Using TLS Technology

The developments taking place in software and technology in many spheres of everyday life and business mean that higher and higher standards are being set in terms of quality and time. In the field of the 3D modelling of buildings too, there is an increasing emphasis on obtaining a highly detailed, high-quality 3D model in near real-time. As a result, the TLS (Terrestrial Laser Scanning) method is becoming increasingly important.



## P. 36 Representing 3D Point Cloud Data

The 3D data jungle in today's computerized ecosystem — primarily populated by reality capture devices — presents forms that vary in both structure and properties. As a kind of visual guide, this article provides an overview of the main 3D data representation methods — 3D point clouds, meshes, parametric models, depth maps, RGB-D, multi-view images, voxels and more — to help users understand the main differences and choose the best method for their specific applications.



P. 5 Editorial

P. 6 Headlines

P. 40 Organizations

To subscribe to *GIM International* go to [www.gim-international.com/subscribe](http://www.gim-international.com/subscribe)

## COVER STORY

This issue's front cover shows the Leica ScanStation P40 being used to capture 3D data around the entrance of a cave at the base of the Perito Moreno glacier, Argentina. This edition of *GIM International* contains multiple articles that zoom in on terrestrial mapping. While terrestrial mapping is a traditional survey method, it still often proves to be the most accurate solution for many mapping projects. (Image courtesy: Alessio Romeo)



# PENTAX

Focusing on true  
performance

## G7N

### GNSS Receiver

An all-constellation GNSS Smart  
Antenna with a MEMS sensor for  
Tilt Compensation.



## R-2500NS Series

### Total Station

A reflectorless Total Station  
from 1" accuracy with dual  
display panels for precise  
angles and ranges.



[www.pentaxsurveying.com/en/](http://www.pentaxsurveying.com/en/)

Tel.: +81-48-793-0118

Fax: +81-48-793-0128

E-mail: [International@tiasahi.com](mailto:International@tiasahi.com)

**TI Asahi Co., Ltd.**

International Sales Department

4-3-4 Ueno Iwatsuki-Ku, Saitama-Shi  
Saitama, 339-0073 Japan



## May the best candidate win!

From 11-15 September, the surveying world will gather in Warsaw, Poland, where FIG and the Polish Surveyors are organizing the 27<sup>th</sup> FIG Congress. Surveyors from all over the globe will finally be able to meet one another again in person after having only seen each other 'on screen' for the past couple of years. Therefore, it will undoubtedly be a festive celebration of the surveying profession! And FIG has always stood up for this profession, looking out for its interests to the best of the association's ability.

These are hectic times, with uncertainty whether the pandemic is really over, a war on European soil, climate change accelerating faster than ever and economic challenges looming over us once again. The geospatial sector has a key role to play in tackling many of these challenges, and the FIG Congress will shed light on all kinds of circumstances affecting the surveying world and the professionals at its core: the surveyors.

This issue of *GIM International* includes interviews (see page 25) with the three candidates in the running for the FIG presidency for the next four years: Diane Dumashie from the United Kingdom, Orhan Ercan from Turkey, and Abbas Rajabifard from Australia. Read what they have to say about the changing nature of the profession, the role of the surveyor and the surveying industry, and how FIG should support that role in the near future. They also share their views on the cooperation that FIG seeks with many other organizations worldwide to secure the implementation of the SDGs, and how surveyors could play a vital part in this process.

It is a privilege for us at *GIM International* to carry these interviews with the candidates for the FIG presidency. All three candidates have proven themselves over the years and have established a long track record of ambassadorship for both the surveying profession and the organization that represents it. As a sector, we can be thankful that these renowned ambassadors are willing to dedicate themselves to the hard work that lies ahead of them. It is a sign of the heartfelt commitment and involvement that is part of our community, both within and across borders.

I am sure that they would all make a terrific FIG president, and whether they are ultimately chosen or not, Diane, Orhan and Abbas will undoubtedly continue to devote themselves to FIG and the surveying profession as a whole. I would like to take this opportunity to wish them a fair battle and all the best in the campaign that lies ahead. Good luck to all three candidates and may the best one win!



Durk Haarsma,  
director strategy & business  
development  
[durk.haarsma@geomares.nl](mailto:durk.haarsma@geomares.nl)

### Advertisers

CHCNAV	30, 32	FOIF	43	Pix4D	16	TI Asahi	4
ComNav	10	Gintec	38	RIEGL	9		
eSurvey	2	NavVis	21	SOUTH	30, 44		



## Share Your Experiences of Challenging Survey Projects!

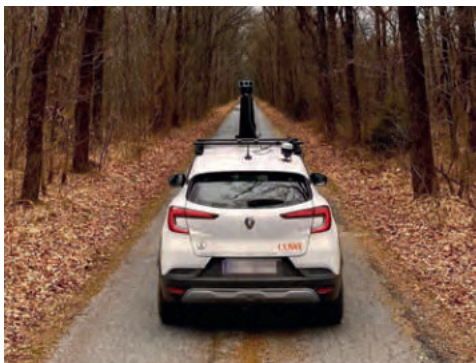
Have you been involved in a challenging surveying project, and would you be willing to share details of your experience with other *GIM International* readers? The diverse nature of surveying – and its relevance for so many aspects of the future advancement of society – means that industry professionals work in all kinds of environments, often under very difficult circumstances or with spectacular results. If you have an impressive or informative story to tell about how you and your surveying team overcame challenging conditions, Wim van Wegen is keen to hear from you!



▲ Iceland's dynamic geodetic situation can be challenging for surveyors, but it also presents opportunities for interesting and exciting projects.

## Mosaic Integrates Mobile Mapping Camera with External GNSS for RTK

The Mosaic 51, a 360-degree mobile mapping camera, is now fully integrated with external GNSS to easily achieve real-time kinematic (RTK). Thanks to these extended capabilities, Mosaic's solution offers centimetre-level accuracy for customers with a high demand for precise position data. It also helps with gathering position with absolute accuracy in challenging conditions like urban canyons, which can pose a huge challenge for standard GNSS positioning systems. In its three years in production, the Mosaic 51 has already gained recognition as the go-to mobile mapping solution for street-level truth with its best-in-class ground level imagery, thanks to its 72MP resolution with 6x12MP image sensors, granting full 360-degree image capture. It is among the highest resolution mobile mapping cameras available.



◀ Mosaic 51, a robust 360-degree mobile mapping camera, now is fully integrated with external GNSS to easily achieve RTK.

## Woolpert to Provide Topographic Map of Part of Nigeria



▲ Parts of Nigeria seen from Space by NASA's Aqua satellite.

Woolpert has been selected to collect, process and deliver topographic mapping across more than one quarter of Nigeria, or roughly 258,000km<sup>2</sup>, under a US\$4.4 million contract with the Ministry of Mines and Steel Development (MMSD). The project is part of the Mineral Sector Support for Economic

Diversification Project, also known as MinDiver, and is funded by the World Bank. Woolpert will supply the labour, materials and equipment needed to develop 340 complete topographic mapping sheets and corresponding Multinational Geospatial Co-production Program (MGCP) data. The firm will provide 1.5m processed satellite imagery, digital elevation models, ground truthing, feature extraction and topographic map data. The company also will implement a streamlined MGCP mapping and cartographic finishing workflow through Esri ArcGIS Pro with Defense Mapping and Production Manager. Additionally, Woolpert has deployed a fully-fledged, cloud-based enterprise geospatial data hosting platform coupled with multi-user virtual desktops through Microsoft Azure and Woolpert's raster service, STREAM:RASTER, to allow for easily managed, cross-continental geospatial production.



## Qatar Completes Aerial Photography Survey to Update Digital Maps



▲ Dhows against the backdrop of the Doha skyline.

The aerial survey system for upgrading digital maps of Qatar has become operational. Under the aerial surveys project for Qatar, the mission of aerial photography covering all parts of the country and Halul Island to take 20cm-accurate evaluative aerial photographs has been completed as the basis for

updating the digital linear maps of the country. The photography work took place from 30 March to 20 April 2022. The project is being implemented by the Geographical Survey System (GIS) Center of the Ministry of Municipality. It is planned to provide all state institutions with aerial photographs and updated digital maps during July 2022, to be used within the activities and projects of the FIFA World Cup Qatar 2022 events. They could be used later in all other projects of the state in various fields such as planning, education, health, Ministry of Interior services, supporting decision-making and infrastructure development of the country, among others.





## FARO Launches 3D Digital Reality Capture and Collaboration Platform



▲ **The combination of the new Focus Scanner, Stream and Sphere is set to significantly reduce scanning and processing time.**

FARO Technologies has launched a new data capture and collaboration platform providing an efficient cloud-based workflow combining three innovative new solutions: the FARO Sphere digital ecosystem for the most effective exchange of data possible, the FARO Focus Premium Laser Scanner for fast, accurate and complete field capture, and the FARO Stream

mobile app for real-time data verification. "With FARO Sphere as its backbone, our new end-to-end 3D capture platform provides customers with industry-leading ease of use, accuracy and speed," said Michael Burger, FARO president and CEO. "Real-time data capture validation and remote collaboration will transform how customers generate, access and utilize 3D data models. For our shareholders, Sphere is expected to generate meaningful high-margin Software as a Service (SaaS) recurring revenue over time as customers increasingly realize the benefits of our cloud-based solution."



## Finnish Geospatial Research Institute Moves into New Facilities



▲ **Many innovative research and business facilities are located at Otaniemi, Espoo. (Image courtesy: Espoo.fi)**

The Finnish Geospatial Research Institute (FGI) of the National Land Survey of Finland (NLS) has moved into new facilities in Otaniemi in Espoo. Roughly 130 FGI employees started working in the new facilities on 1 May 2022. FGI is a renowned international research organization and specialist in the field of geospatial data. In addition to geospatial data

research and technologies, its research fields include satellite positioning, space geodesy, laser scanning, and geodata science and computing. For example, the Geodesy and Geodynamics Department is responsible for ensuring that Finland's coordinate, elevation and gravity systems are up to date. The building is also home to the Geological Survey of Finland (GTK). A new section has also been built in conjunction with the building, housing FGI's research equipment and other special functions. The facilities were selected by partly applying multifunctional spaces to make them ideal for the research organization's needs.



## NASA Develops Lidar Backpack Technology for Moon Explorers

NASA researchers and their industry partners have developed a remote sensing mapping system to aid explorers in the most isolated wilderness imaginable: the airless wastes at the South Pole of the Moon. Now the astronauts, who are like 'hikers on a mountaineering expedition' in a wholly uncharted environment, will be able to generate a real-time 3D map of the terrain. The Kinematic Navigation and Cartography Knapsack (KNaCK) is a mobile Lidar scanner that is worn like a hiker's backpack. It makes use of an innovative type of Lidar called frequency modulated continuous wave (FMCW) Lidar in order to provide Doppler velocity and range for millions of measurement points per second. These measurement points instantly create a real-time navigation system, delivering to the explorer a 3D point cloud or high-resolution map of the surrounding terrain. Using KNaCK during rover excursions and when travelling on foot, explorers could precisely map the topography of the landscape, including deep ravines, mountains and caves. Lidar even works in pitch blackness, relieving astronauts of the need to haul cumbersome lighting rigs everywhere they go.



▲ **Michael Zanetti, a NASA planetary scientist, testing the backpack-sized prototype.**



## PhaseOne Unveils Aerial Solutions with Near-infrared Capabilities



▲ **The PAS 880i covers a wide swath across-track: more than 20,000 pixels in nadir and 14,000 pixels in each of the obliques.**

Phase One, a leading developer of digital imaging technologies, has announced its next-generation aerial mapping solutions. The Phase One PAS 880 oblique and PAS 280 nadir systems have been enhanced with 150MP near-infrared (NIR) sensors and the most productive workflow with the launch of the latest iX Suite SW solution. The new PAS 880i offers the same image quality and image capture rate (2 frames/second) that gained its forerunner a reputation for reliability and productivity. The PAS 880i covers a wide swath across-track: more than 20,000 pixels in nadir and 14,000 pixels in each of the obliques, operated at a variety of airspeeds, altitudes and lighting conditions. It is

one of the few solutions in the market that can capture the highest-resolution, blur-free images under the same flying altitude and speed conditions for nadir and oblique simultaneously.



## Advanced Navigation Acquires Vai Photonics



▲ **Chris Shaw and Xavier Orr, the CEOs and co-founders of Advanced Navigation.**

Advanced Navigation, one of the world's most ambitious innovators in artificial intelligence (AI) robotics and navigation technology, has acquired Vai Photonics, a spin-out from the Australian National University (ANU) developing patented photonic

sensors for precision navigation. Vai Photonics and Advanced Navigation share a similar vision to provide technology to drive the autonomy revolution. Together, they will commercialize their research into exciting autonomous and robotic applications across land, air, sea and space. "The technology Vai Photonics is developing will be of huge importance to the emerging autonomy revolution. The synergies, shared vision and collaborative potential we see between Vai Photonics and Advanced Navigation will enable us to be at the absolute forefront of robotic and autonomy-driven technologies," said Xavier Orr, CEO and co-founder of Advanced Navigation. "Photonic technology will be critical to the overall success, safety and reliability of these new systems. We look forward to sharing the next generation of autonomous navigation and robotic solutions with the global community."



## Leica Geosystems Launches New Mobile Mapping System



▲ **Leica Pegasus TRK reality capture mobile mapping system.**

Leica Geosystems has launched a reality capture mobile mapping system called Leica Pegasus TRK, introducing artificial intelligence, autonomous workflows and intuitive interfaces. The Leica Pegasus TRK solution utilizes artificial intelligence capabilities to transform mobile mapping. The advanced dynamic

laser scanning and expandable imagery system for recording, measuring and visualizing environments increases productivity with automated, intelligent workflows. Due to its low weight, the Pegasus TRK can easily be operated by one person, making mapping projects more efficient and cost-effective. Because of the system's user-friendliness, it is suitable for professionals who are new to the technology. At the same time, its reliable, high-quality deliverables serve the needs of technical experts in various industries, including surveying, transportation and utilities. The Pegasus TRK solution features an AI-enhanced camera and automatic camera calibration. To comply with privacy regulations, its artificial intelligence (AI) can identify and blur identifiers, such as people and vehicles, in real time.



## CHC Navigation Introduces Airborne Lidar Series



▲ **A BB4 UAV equipped with the AA2400 scanner for a city mapping task.**

CHC Navigation (CHCNAV) has released the AlphaAir 1400 (AA1400) and AlphaAir 2400 (AA2400) Lidar systems. Both solutions are compact airborne laser scanners that are easily installed on various UAV platforms or small survey aircraft and helicopters. They are

ideally adapted to high-density point corridor mapping applications, day or night, under leaf-on and leaf-off conditions or with dense vegetation to provide reliable results. "Nowadays, it is critical to obtain the highest data quality for the majority of aerial survey projects. In addition to state-of-art GNSS and IMU sensors, the AA1400 and AA2400 also integrate RIEGL's VUX Lidars with their unique Waveform-Lidar technology, allowing echo digitization and online waveform processing. Multi-target resolution is the basis for penetrating even dense foliage," said Andrei Gorb, product manager of CHC Navigation's Mapping and Geospatial Division. "The continuously rotating polygonal mirror wheel enables scanning speed of up to 400 lines per second, allowing for effective coverage of large areas when used from fast drones or aircraft."



# Juniper Systems Launches Next-generation GNSS Receiver

Juniper Systems has introduced the all-new Geode GNS3 GNSS receiver. It enables users to easily collect real-time GNSS data with sub-metre, sub-foot and decimetre accuracy options – without the huge price tag or complexity of other precision receivers. This scalable platform allows users to purchase the level of accuracy they need now while having the option to increase accuracy in the future. The Geode GNS3 GNSS receiver is now available worldwide in both single-frequency and upgradable multi-frequency antenna configurations so that users have the level of accuracy needed to get the job done. The Geode GNS3S offers superb sub-metre accuracy with a single-frequency antenna. The GNS3M allows for scalable accuracy, with its multi-frequency antenna including support for all constellations on L1, L2 and L5 frequencies. Multi-frequency signal tracking, together with Atlas L-Band correction subscriptions, allow for up to decimetre accuracy. As with previous Geode devices, SBAS corrections are available for sub-metre accuracy in certain regions. Both models also support local differential GNSS RTK/CORS network corrections through the Geode Connect NTRIP Client.



▲ A surveyor using the Geode GNS3 GNSS receiver in the field.

## RIEGL VZ-i Series TERRESTRIAL 3D LASER SCANNERS



Vienna Prater Main Alley: point cloud, true colored

### RIEGL WAVEFORM-LIDAR TECHNOLOGY FOR EXTREMELY FAST ACQUISITION OF HIGHLY ACCURATE SCAN DATA

- » up to 50 high resolution scan positions per hour – *extremely fast data acquisition*
- » suitable for highly complex and extensive environments (e.g. buildings, narrow tunnel systems, forested areas) – *practicable versatility*
- » 1 TByte SSD memory for more than 1000 scan positions – *on-board storage for comprehensive projects*
- » automatic, reflectorless, extremely robust, and highly precise registration of scan positions – *highest accuracy of scan data*
- » "RIEGL VZ-i Series" and "Project Map" Apps on mobile devices – *remote scanner control and real-time visualization of the scan project for smooth scanning*



Explore the full RIEGL product portfolio at [www.riegl.com](http://www.riegl.com)





# CORS Solution



Full Constellation



High Accuracy



Million-User



Strong Compatibility



Consisting of M300 Pro Receiver, AT600 Choke Ring Antenna, and CDC.NET Software, ComNav CORS Solution is widely used in public infrastructure, providing high precision positioning service for terrestrial mapping.



@ComNav Technology Ltd.  
Sales@comnavtech.com

## A FEATURE-BASED SEMANTIC SEGMENTATION ALGORITHM FOR POINT CLOUD CLASSIFICATION

# Deep Learning for Ground and Non-ground Surface Separation

Precise ground surface topography is crucial for 3D city analysis, digital terrain modelling, natural disaster monitoring, high-density map generation and autonomous navigation, to name but a few. Deep learning (DL), a division of machine learning (ML), has been achieving unparalleled success in image processing, and recently demonstrated huge potential for point cloud analysis. This article presents a feature-based DL algorithm that classifies ground and non-ground points in aerial laser scanning point clouds.

Recent advancements of remote sensing technologies make it possible to digitize the real world in a near-automated fashion. Lidar-

based point clouds are a type of remotely sensed georeferenced data, providing detailed 3D information on objects and the environment, and have been recognized as one of the most powerful means of digitization. Unlike imagery, point clouds are unstructured, sparse and of irregular data format. This creates many challenges, but also provides huge opportunities for capturing geometric details of scanned surfaces with millimetre accuracy. Classifying and separating non-ground points from ground points greatly reduces data volumes for consecutive analysis of either ground or non-ground surfaces, which consequently saves costs and labour, and simplifies further analysis.

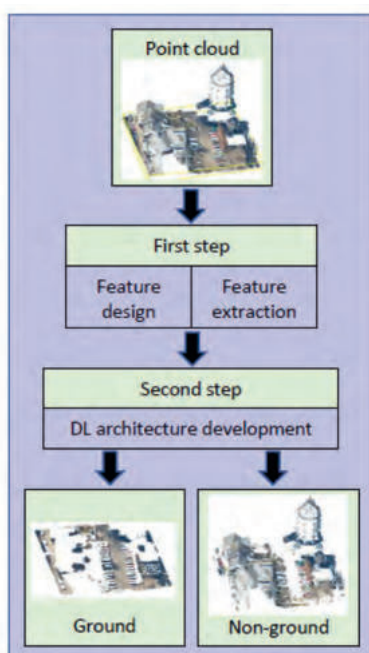
### MACHINE LEARNING AND DEEP LEARNING

Machine learning methods with a long history of automatic classification include well-known methods such as Support Vector Machines and Random Forest. However, they are often criticized for their limited generalization capability due to the use of shallow architectures. On the contrary, artificial neural networks with several hidden (internal) layers use a so-called deep architecture

which has been applied in recent years with unprecedented success. The main challenge of implementing a supervised DL method is that it requires a sufficient amount of labelled training and validation data to tune a successful classification model. Many researchers believe that the end-to-end DL approach can extract useful features automatically from raw data, and therefore no feature engineering is required, but this is not always true. This article argues that the use of appropriate features can solve classification problems more efficiently while using fewer resources, i.e. a small number of layers and less training data. However, implementing a feature-based DL method needs a clear understanding of both problem and data structure to extract powerful features. The architecture presented in this article, which was originally proposed in the paper by Nurunnabi et al. (2021), is a feature-based DL classification approach that labels ground and non-ground points in airborne laser scanning (ALS) point clouds.

### FEATURE EXTRACTION

The proposed algorithm consists of two steps. The first step performs feature design and



▲ Figure 1: Workflow of the DL algorithm.



extraction, while the second step develops the DL architecture (Figure 1). Based on an extensive review of state-of-the-art literature, the authors selected the most promising and successful features used for defining the characteristics of points based on their local neighbours. Features are derived using spherical and cylindrical neighbourhoods of each point of the data. A spherical neighbourhood with a user-defined radius is used to obtain 3D geometric features (GFs) based on the covariance matrix generated by the coordinates of the neighbour points (x, y, z). Principal component (PC) analysis is performed to estimate eigenvalues and eigenvectors from the covariance matrix that are used to derive the necessary features. The most common 3D GFs, also known as covariance features (CovFs), are: point normal, curvature, first PC, three eigenvalues, linearity, planarity, scattering, omnivariance, eigentropy, plan offset and verticality. Vertical infinite cylindrical neighbourhood (with the same radius as the spherical neighbourhood) is used to obtain cylindrical features that relate to the heights of the points (z values). These are the minimum, range, mean, and variance values of z, and the relative position of the point of interest  $p_i$  within its neighbourhood. Additionally, point density, return number, intensity, positive openness and echo ratio are used.

## DEEP LEARNING ARCHITECTURE

The proposed architecture develops a binary classifier and follows a straightforward artificial neural network (NN) workflow. The inputs for the network are the feature

vectors, and the outputs are the labels of ground (1) or non-ground (0). Fully connected network layers are used with a rectified linear unit (ReLU) activation function for the hidden layers, and a Sigmoid function is used for the output layer. Binary cross entropy is used as loss function, while the use of an Adam optimizer speeds up the model training process. A so-called He initialization strategy and Batch normalization are used to reduce the influence of vanishing and exploding gradients. Evaluation of the model is needed to fine-tune the necessary hyper-parameters. The network consists of five hidden layers with 50 neurons per layer. Inputs are processed with a mini-batch size of 128. The network is trained with 50 epochs and the one that achieves the highest accuracy is selected as the final model. L2 regularization with a learning rate of  $\gamma=0.01$  is used to avoid overfitting. The relevance of the features is studied in several groups (Models) to identify the optimum ones producing the best results.

## OPEN-ACCESS AIRBORNE LIDAR DATASET

The newly developed algorithm can be demonstrated based on an open-access airborne Lidar dataset provided by the Administration du Cadastre et de la Topographie (ACT) of Luxembourg. Average point density, horizontal and vertical precision of the data are  $15/\text{m}^2$ ,  $\pm 3\text{cm}$  and  $\pm 6\text{cm}$ , respectively. The data is organized into  $500\text{m} \times 500\text{m}$  tiles, each of which contains on average 5-7 million points. The points are labelled into classes, e.g. soil, vegetation,



▲ Figure 2: 3D aerial laser scanning point cloud of Dudelange, Luxembourg, used as test dataset. The dataset is coloured with RGB values.

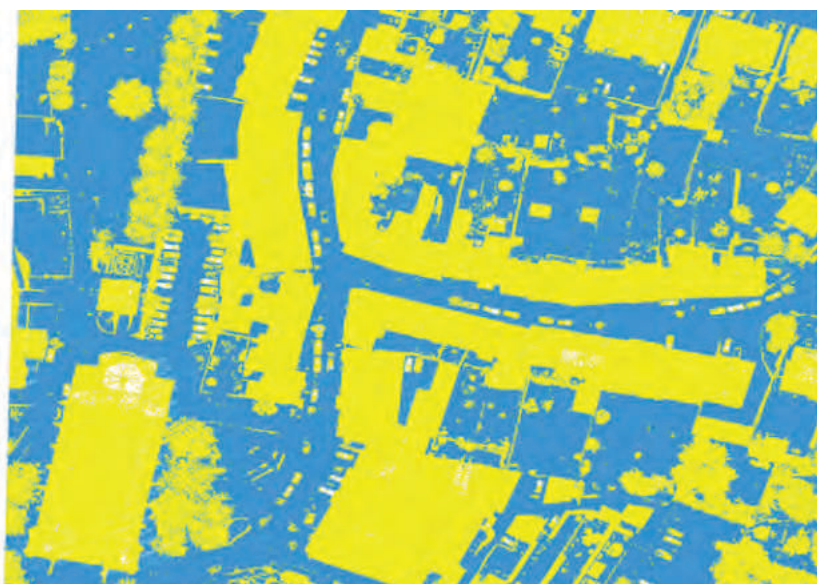
buildings, water, bridges, power lines and unclassified. Additional manual editing was performed to obtain more accurately classified data as ground and non-ground points (Figure 3). Two tiles from a semi-urban area (Dudelange, Luxembourg) were selected for use with the algorithm. The test dataset has a height difference of around 20m between the highest and the lowest points.

## DEMONSTRATING THE ALGORITHM

From the selected tiles, one tile was used for training and validation, while part of the other tile was selected as test data (Figure 2). The training-validation tile was sliced into five segments, and one of them was randomly selected as the validation set. The training, validation and test sets consist of 3,481,758 points, 650,764 points and 970,387 points, respectively. The required input vectors were generated with a neighbourhood size of 100cm radius and the proposed algorithm was applied using different combinations of features. Model 3 was identified as the best group of features as it achieves the highest accuracy among the three considered models. It consists of a set of 17 feature vectors: point normal, curvature, linearity, planarity, scattering, omnivariance, eigentropy, plane offset, verticality, point height z, range-z, mean-z, variance-z, point density, positive openness, echo ratio and intensity. Model 3 achieved the highest precision of 99.77% for ground surface extraction, an F1 score of 97.5% and 97.8% for labelling ground and non-ground points respectively, and an overall model accuracy of 97.7% (Figure 4).

## SEPARATING GROUND FROM NON-GROUND

The algorithm for pointwise classification (also known as semantic segmentation) of point



▲ Figure 3: 2D plot of ground truth for the test dataset, showing ground (sky-blue) and non-ground (yellow) points.

clouds used three models which are three different combinations of extracted pointwise local features. The inputs for the networks are point features, rather than the raw point coordinates (x, y, z). It can be concluded that accurate estimation of the height values of the points has significant impact on results. The discussed approach could be successful as a so-called work-horse method to efficiently separate ground from non-ground points. It combines a high accuracy with relatively low computational load. This distinguishes this method from recent end-to-end deep learning point cloud methods, which typically require heavy and extensive training and are therefore more difficult to perform on a standard desktop computer. The non-end-to-end approach described here accepts more information-rich input (i.e. the feature vectors) and therefore requires fewer internal layers. As a consequence, fewer parameters (i.e. the weights of the neuron connections) have to be determined, which makes the method much lighter and more efficient.

### CONCLUDING REMARKS

The proposed feature-based DL algorithm classifies ground and non-ground points in ALS point clouds with a high rate of accuracy. It presents a fully connected deep neural network approach to develop a binary classifier. The authors showed in the original paper that, unlike most feature-based algorithms, the new algorithm does not require multi-scale neighbourhoods. Hence, it can reduce a significant amount of the computational complexity and saves time when compared to many existing feature-based algorithms. The new classification algorithm is simple but efficient to perform. This is because the architecture is shallow but powerful, which reduces the computational burden, and extracts both ground and non-ground points efficiently in the presence of steep slopes, non-smooth terrain and with significant height variability. However, the proposed feature-based DL algorithm requires a thorough understanding of both the saliency features used as input vectors, and the data

properties for tuning the hyper-parameters in the model-building process in order to achieve the highest classification accuracy. ◀

### ACKNOWLEDGEMENTS

This work is supported by the Project 2019-05-030-24, SOLSTICE – Programme Fonds Européen de Développement Régional (FEDER)/Ministère de l'Economie of the GD of Luxembourg.

### ABOUT THE AUTHORS



**Abdul Nurunnabi** is a researcher at the Department of Geodesy and Geospatial Engineering, University of Luxembourg, Luxembourg. He gained his PhD in Spatial Sciences from Curtin University, Australia, with a government scholarship. He did postdoctoral research at the University of Tokyo, Japan, with a scholarship from the Japan Society for the Promotion of Science. He has authored over 60 peer-reviewed research papers. His research interests include statistics, pattern recognition, machine learning (ML), deep learning, data science and feature extraction.

✉ [abdul.nurunnabi@uni.lu](mailto:abdul.nurunnabi@uni.lu)



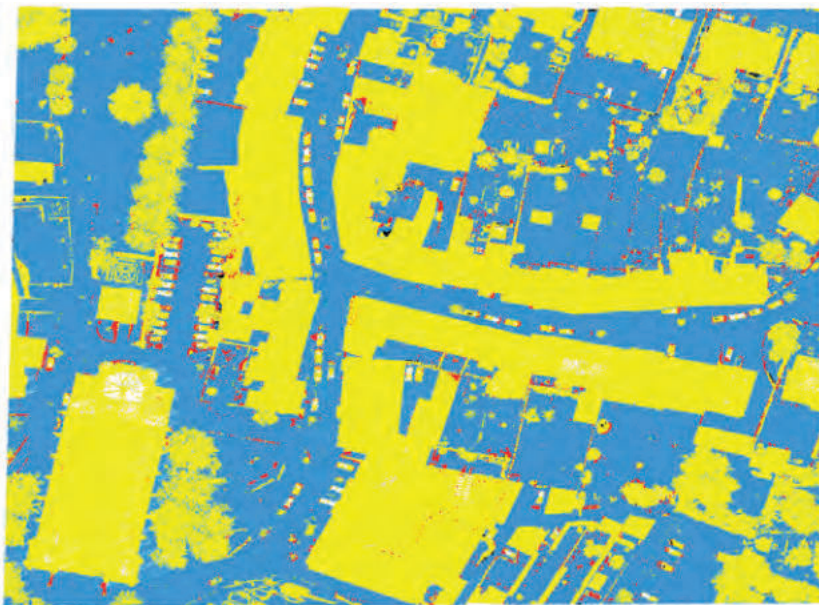
**Roderik Lindenergh** is an associate professor at the Department of Geoscience and Remote Sensing, Delft University of Technology, the Netherlands. He obtained his PhD in Mathematics from Utrecht University, the Netherlands. His main research interests are the properties, processing and applications of laser scanning point clouds and digital terrain analysis using satellite remote sensing data. Lindenergh has (co-) authored more than 170 peer-reviewed research publications. He has served as chair, PC member, associate editor/board member and organizer for various conferences, workshops and journals.

✉ [r.c.lindenergh@tudelft.nl](mailto:r.c.lindenergh@tudelft.nl)



**Norman Teferle** is a professor of Geodesy and Geospatial Engineering in the Faculty of Science, Technology and Medicine at the University of Luxembourg. He is well known for his contributions to GNSS, in particular PPP ambiguity resolution, high-precision monitoring and the sensing of the troposphere. More recently he worked on aspects of photogrammetry and point cloud analysis using ML methods as well as BIM for sustainable construction.

✉ [norman.teferle@uni.lu](mailto:norman.teferle@uni.lu)



▲ Figure 4: 2D plot of the classification results for the test dataset, showing correct ground points (sky-blue), correct non-ground points (yellow) and misclassified points (red and black).

### FURTHER READING

ACT/Dudelange data: <https://data.public.lu/en/datasets/lidar-2019-releve-3d-du-territoire-luxembourgeois/>

LeCun, Y., Bengio, Y., Hinton, G., 2015. Deep learning. *Nature*, 521(7553): 436-444.

Nurunnabi, A., Teferle, F. N., Li, J., Lindenergh, R. C., Hunegnaw, A., 2021. An efficient deep learning approach for ground point filtering in aerial laser scanning point clouds. *The Int. Arch. of the Photogramm. Remote Sens. Spat. Inf. Sci.*, XLIII-B1-2021, 31-38.



# Scanners for Permanent Monitoring and Their Integration Capabilities

Climate change and the expansion of urban habitats, for example in the alpine region, make it increasingly important to obtain spatially and temporally detailed high-quality datasets that can be integrated into a comprehensive risk management system as an early warning system. A recently published white paper examines this issue and proposes an appropriate solution.



▲ Figure 1: System installation in Vals.

## OVERVIEW

Based on the latest developments at RIEGL and DMT, the comprehensive possibilities of integrating a laser scanner into a monitoring system are demonstrated on the basis of an example project in Vals Valley in Tyrol, Austria. The focus is on the proper integration (ensuring reliability, accuracy and integrity) of a long-range laser scanner into a continuous web-based monitoring system, from an engineering geodetic perspective.

be recorded at a single observation object. In addition to the technical requirements for the sensor system itself, the conditions for data integration, data storage and visualization must also be met as part of a comprehensive risk management system.

## ULTIMATE LIDAR TECHNOLOGY

In 2016, the RIEGL VZ-i series of 3D terrestrial laser scanners was introduced. The hardware includes a data processing board, which

## THE CONDITIONS FOR DATA INTEGRATION, DATA STORAGE AND VISUALIZATION MUST BE MET AS PART OF A COMPREHENSIVE RISK MANAGEMENT SYSTEM

Permanently installed in the surroundings of a monitored object, the system permits high temporal and spatial resolution in the acquisition of measured values. The installation of a monitoring system based on laser scanning does not require any prior knowledge of the expected motion characteristics, so different processes can

enables multiple processing tasks to be performed on board. In addition, an open LINUX operating system allows the scanner to be customized for special purposes by running apps in C++ and Python scripts on the scanner. Thus, specialized apps can be programmed that provide just-in-time results on the scanner for specific applications.

These features make it practical to use the hardware within a monitoring system. Reliability is supported by the compact and robust design in a dust-proof and splash-proof housing (IP64).

### SITE DESCRIPTION OF VALS VALLEY

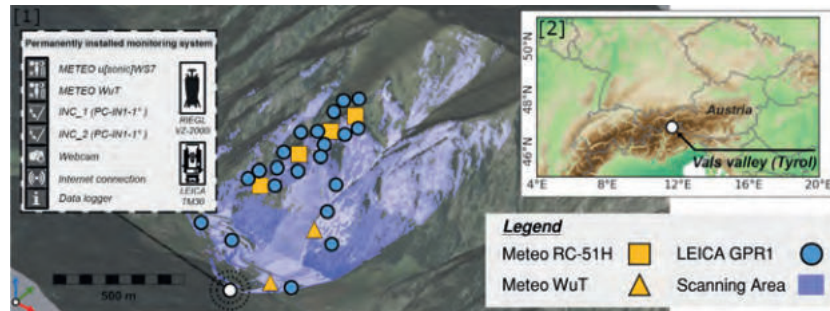
The study area is the Vals Valley in Tyrol, Austria [1]. A rockfall occurred in this area on 24 December 2017. Although this caused no human casualties or significant damage to buildings, a road located directly below the rockfall slope was covered with 8m of debris and a total volume of 116,000m<sup>3</sup> of rock was relocated [2].

Point cloud data was recorded during three campaigns in 2020 and 2021 using the RIEGL VZ-2000i laser scanner permanently installed on a survey pillar in a shelter (to protect the scanner from the influences of rain, sun, wind, etc.) on the opposite slope, about 800m from the area affected by the rockfall (see Figure 1).

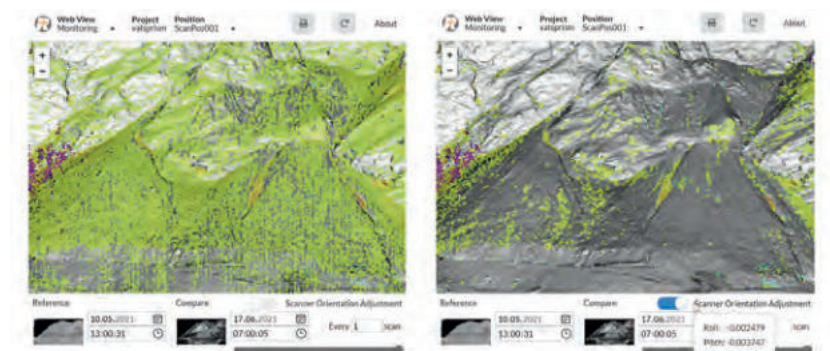
The rockfall area itself was scanned every three hours with an angular resolution of 0.015°, resulting in a point spacing of approx. 14cm in a 500m range. In the time between, consecutive fine-scans of 21 corner cube prisms were performed every 20 minutes. In addition to the laser scanner, inclination sensors on the surveying pillars (PC-IN 1-1° from POSITION CONTROL) and various meteorological sensors were installed in the shelter and in the area of the rockfall. The additional measurements serve to verify daily and seasonal systematic effects on the results (see Figure 2).

### THE MONITORING APP

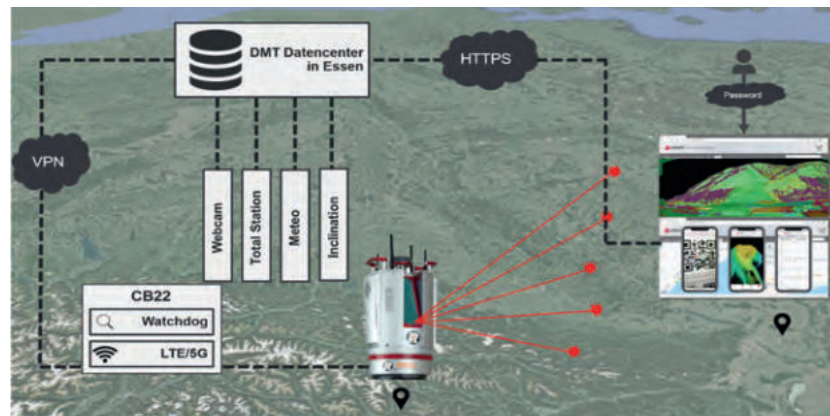
An essential component of the integration of this permanently installed laser scanner is the monitoring app from RIEGL. Each scan has a storage requirement of about 250MB of raw data, which is detrimental to near-real-time data transmission. For each measurement, the monitoring app processes the point cloud in the polar coordinate system of the scanner and converts the data into a compressed 2D representation. All 3D Lidar points are rasterized on a regular grid in azimuth angle and polar angle. All data points within a raster cell are then statistically analysed to generate a 2D image with range and surface orientation information. As a result, the memory requirement is only about 25MB, which is 10% of the memory required for the raw data.



▲ Figure 2: 3D overview of the test site in the Vals Valley including applied sensor technology and overview of the geographical situation of the Vals Valley. (Data Source: Land Tirol - data.tirol.gv.at and <http://ows.mundialis.de/>)



▲ Figure 3: Monitoring App - Scanner Orientation Adjustment disabled (left) and enabled (right).



▲ Figure 4: The installation of DMT SAFEGUARD Lidar in schematic view.

The local surface normal vector information is stored in the alpha channel of the image. The scalar product (a value between 0 and 1) between the local normal vector and the laser beam direction is calculated. The more the surface normal is tilted against the beam direction, the lower the alpha value. The comparison of two scenes can be done 'on-the-fly', so that any scenes can be compared within seconds. This development enables use in any monitoring platform (see Figure 3).

Optionally, a roll/pitch/yaw correction of the actual scan with respect to the reference scan is executed. This important feature allows

the handling of slight movements of a few millidegrees of the scanner mounting caused by physical or atmospheric inputs. Such a small impact can result in massive errors over a longer range.

### INTEGRATION OF THE SCANNER INTO A WEB-BASED MONITORING SYSTEM

The integration of area-based sensor technology intends to provide all stakeholders with a comprehensive set of advanced tools for monitoring, measurement and analysis to determine the effects of a rockfall in terms of ground and slope movement and to deliver important information on the condition of the ground surface. In Vals, a communication box





viDoc®

# RTK surveys from your phone

Attach the rover to your mobile device to scan your site  
or digitize objects with ease

- **Handheld RTK rover**
- **Centimeter grade accuracy**
- **Fast and safe site documentation**

Use viDoc and the free terrestrial scanning app PIX4Dcatch for data capture

Process your data with Pix4D software to create digital twins of your site and  
immediately calculate precise volumes and measurements

"High-quality 3D scans, geospatially accurate and easy to share. Workflow is intuitive and seamless, at a fraction of the cost of other multi-part solutions available on the market."

Shane Shi, HSC Pipeline Engineering, Singapore

Learn more & book a free demo at:  
**[pix4d.com/vidoc](https://pix4d.com/vidoc)**



is connected to the scanner via LAN. The box provides a corresponding power supply and internet connection; in Vals Valley, it is based on an LTE connection. The data connection to the DMT servers is realized via a secure VPN connection (IPSec), so that the scanner itself is initially only available to selected users via the DMT network. The scanner can be used worldwide and is available to many different users within a project.

After initialization, the scanner is able to operate and monitor automatically, although scans can also be started manually via the web application. Initialization of the measuring programme includes the preparation of the monitoring workflow, and the parameterization of the monitoring app and of the scheduler app on the scanner. As a first result, data from the monitoring app and the time series of the prism detection are available on the scanner as CSV. In the next step, data is synchronized to the servers in Essen using RSYNC via the secure data connection. The Monitoring App is integrated into the DMT SAFEGUARD interface and is available to users from anywhere in the world via a password protected login (see Figure 4).

Dashboard functionality in DMT SAFEGUARD enables intuitive and interactive visualization of the time series from the prism detection (see Figure 5). In addition, all sensors can be displayed in a spatial context on a map. The platform allows decision makers to quickly obtain relevant information, while multiple users can work simultaneously with the platform, enabling collaborative teamwork at any time and in real time. In Vals, Lidar data is complemented by integrating various inclinometers and weather stations and a webcam.

### CONCLUSION

The open architecture of the VZ-i series scanners makes it possible to customize the scanner for complex data acquisition and processing tasks using Python scripts and Python-based apps. The online-waveform processing technology used ensured high-quality data, even under harsh environmental conditions, and 24/7 and fully remote system operation were proved. Laser scan data was processed by integrated apps in real time on the scanner and the final results were visualized via a web-viewer tool running on all standard web browsers. ◀



For more information on this project, scan this QR Code and have a look at the “Permanent Monitoring” white paper by RIEGL and DMT.

### REFERENCES

- [1] Schröder, D., Anders, K., Winiwarter, L. & Wujanz, D. (2022). Permanent terrestrial Lidar monitoring in mining, natural hazard prevention and infrastructure protection – Chances, risks, and challenges: A case study of a rockfall in Tyrol, Austria. In Proceedings of the 5<sup>th</sup> Joint International Symposium on Deformation Monitoring (JISDM), Valencia, Spain.
- [2] Hartl, S. (2019). Analyse der Felslawinen Frank Slide und Vals mit Hilfe des Computercodes r. avaflow (Doctoral dissertation, Vienna).

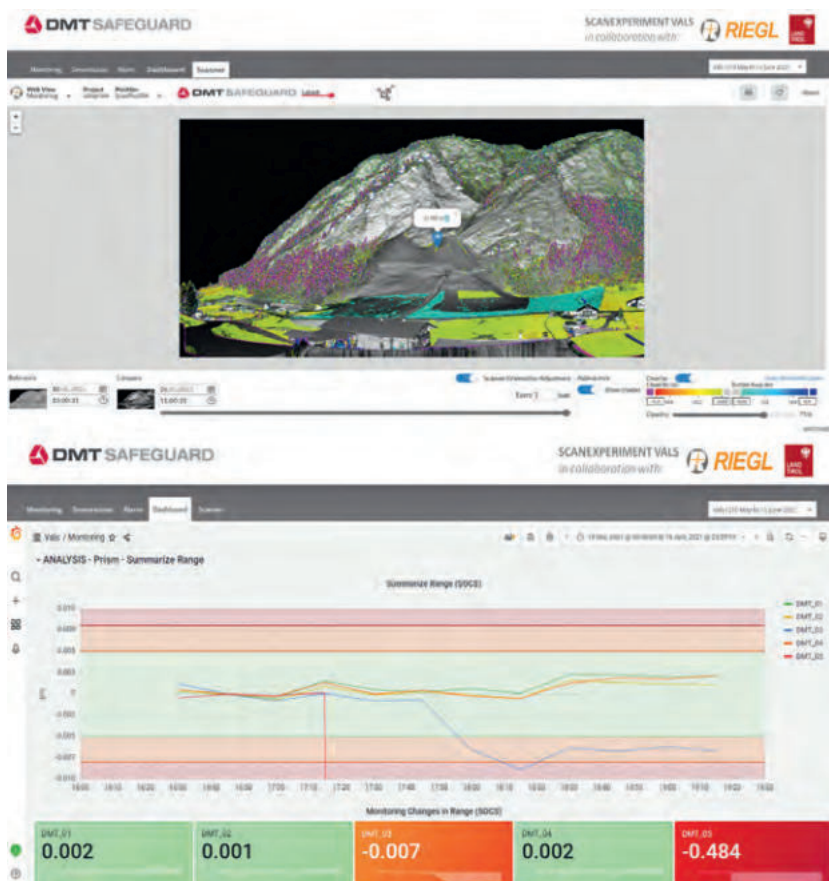
### ABOUT THE AUTHORS



**Thomas Gaisecker** holds a Master's in Geography with a focus on Geoinformatics from the University of Salzburg. He was CEO of ICRA between 1995 and 2003 and also a partner at NextGIS between 2000 and 2003. He joined RIEGL in 2003, where he is now Mining Business Division Manager for RIEGL International. He is an expert in terrestrial laser scanning/UAS-based laser scanning and applications in mining and monitoring.



**Daniel Schröder** received his Master's in Geoinformatics and Engineering Surveying from the University of Applied Sciences in Mainz in 2016. Since then, he has been working as a Senior Project Manager at DMT GmbH & Co. KG. The main field of his work is automated geodetic monitoring in mining, natural hazard prevention and infrastructure. He focuses on the use of long-range laser scanners from RIEGL and the integration of GNSS technology from various manufacturers.



▲ Figure 5: RIEGL Monitoring App integrated in DMT SAFEGUARD.



# Reconstructing 3D Buildings Using Deep Learning

Automated classification and object detection in Lidar and imagery data is essential for minimizing production costs. While the optimization of traditional methods using rule-based algorithms has enhanced geospatial applications, significant manual intervention is still required to obtain a high-quality dataset. This article outlines how artificial intelligence (AI) can lead to a robust process for 3D city modelling and discusses some of its challenges.

## ARTIFICIAL INTELLIGENCE FOR REMOTELY SENSED DATA

With recent advances in the field of remote sensing, the use of AI has increased significantly among the geospatial community. Extracting meaningful information from an enormous amount of data, now being collected every day, is crucial and requires a workflow that is both efficient and accurate.

There are several articles and case studies in which deep learning (DL) methods are used for aerial Lidar classification and object detection; however, utilizing a DL method for industry-level and large-scale applications is a demanding task and incorporating it into the production workflow is a challenge. Extracting information through the integration of Lidar and ortho is usually done using

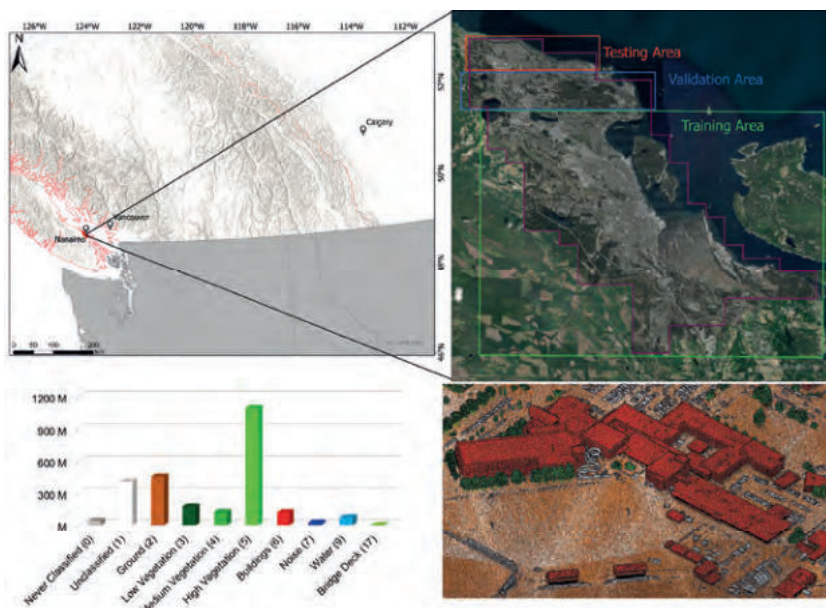
automatic methods that involve either colourizing Lidar points using images or concatenating RGB-NIR channels with extracted feature layers from Lidar, such as the digital terrain model (DTM) or the digital surface model (DSM). As a result of these fusions, either the 3D geometrical information of point clouds degrades when transformed into a 2D raster file, or the quality of point cloud colourization deteriorates due to reasons such as shadows, obstacles, edges, and so on.

Nevertheless, integrating Lidar and imageries provides an opportunity to improve the AI results for many applications.

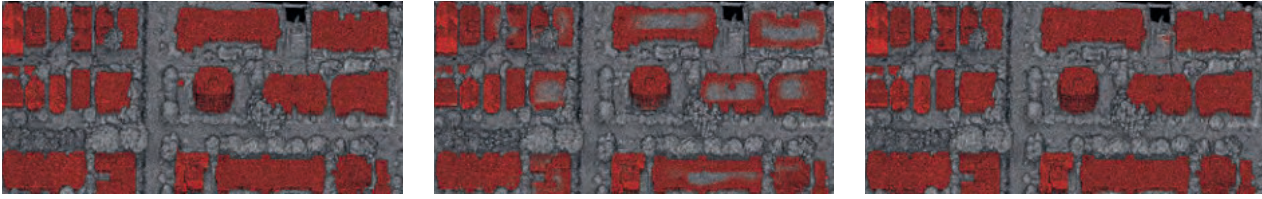
## AUTOMATIC 3D CITY MODELLING VS DEEP LEARNING MODELS

In automatic methods of 3D modelling that use a programmatic approach to extract the features and digitize the outlines manually, large-scale Lidar datasets must go through a multi-step routine to be classified.

An automatic classification routine would usually include classifying ground points, separating points above ground into classes, and grouping and classifying buildings based on their planar features and other attributes, such as echo. However, various components of the buildings may not be properly classified, such as edges, hips, chimney



▲ Figure 1: Nanaimo Lidar dataset used for training the deep learning model.



▲ Figure 2: (a) Vancouver Lidar dataset, (b) the predictions of the deep learning model before fine-tuning and (c) after fine-tuning.

flashing and walls, depending on the texture complexity and Lidar point density. Adjacent objects to buildings such as trees might also be misclassified. This is why manually editing Lidar points is usually required to achieve high-quality data. As a result, the process of automatic Lidar data classification becomes 'semi-automatic' and labour-intensive.

Deep learning methods, on the other hand, can perform classification and object detection tasks much faster once trained. One of the main requirements of DL methods and their use in real-world scenarios is the necessity of high-quality training data and the ability to easily differentiate the existing classes in the data from each other. For example, traditional methods tend to eliminate the noisiness of the data by limiting ground points in small triangles. This would leave points with similar characteristics in two different classes, which would cause the DL model to not converge.

### TRAINING MODEL AND DATA PREPARATION

To train and test a DL method, we used 186km<sup>2</sup> of aerial Lidar from Nanaimo, BC, Canada, with approximately 30,000 roof segments that were automatically classified using TerraSolid and manually digitized by human editors (Figure 1).

The dataset has an average point density of approximately 19pts/m<sup>2</sup> and was originally classified into the classes: Never Classified (0), Unclassified (1), Ground (2), Low Vegetation (3), Medium Vegetation (4), High Vegetation (5), Building (6), Noise (7), Water (9) and Bridge Deck (17). Since the objective of this work was mainly 3D city modelling and because the buildings were the objects of interest, we reclassified the data into Never Classified (0) and Building (6), so that the DL model could better differentiate buildings from other points. We used 80% of the Nanaimo data as the training set and 13% for validation. The remaining 7% was used to test the model.

We used the PointCNN model for this purpose and the Lidar data was prepared and fed to

the network in block sizes of 50 x 50m with 8,192 sample points per block. Intensity and return numbers were considered in the process as extra features. The coordinates of Lidar points were normalized in the range of the defined block size, and intensity values and return numbers were normalized between 0 and 1.

Table 1 shows the precision, recall and F1 scores obtained for the Never Classified and Building classes for our training dataset. It indicates that, despite having imbalanced data (with buildings being just under 5% of the total dataset), the model was able to properly differentiate buildings from other points.

Evaluation Metric	Never Classified code (0)	Building code (6)
Precision	99.33%	97.13%
Recall	99.53%	95.95%
F1 score	99.43%	96.53%

▲ Table 1: Precision, recall and F1 score values obtained for Nanaimo test dataset.

### CHALLENGES IN AUTOMATION

One of the major limitations of deep learning models is that performance is considerably affected when they are tested on a new dataset or on a dataset with different characteristics, which frequently occurs because of different project specifications (e.g. density level) and varying geographic sites (e.g. urban, forested, mountainous). Therefore, to automate the classification procedure while obtaining acceptable results in various scenarios, it is necessary to make sure that the DL model is generalized and can predict datasets with different characteristics. The new dataset must however have similar feature attributes to the dataset with which the model was trained.

After training the model with the above Nanaimo dataset and achieving highly accurate results, we tested the model on a Vancouver dataset. The Vancouver dataset had an average point density of nearly 45pts/m<sup>2</sup>, which is noticeably higher than the Nanaimo dataset. As expected, the primary



▲ Figure 3: Calgary dataset, classified with the deep learning model trained on Nanaimo, and fine-tuned by the Vancouver datasets.



prediction results did not have the same accuracy as the Nanaimo dataset and the model failed to correctly classify a significant portion of the building points (as represented by a recall value of 67.43% for buildings in Table 2).

To improve the performance of the model on the Vancouver dataset, a small amount of the Vancouver dataset (ten 1km x 1km tiles in total) was used to fine-tune the pre-trained model. As can be seen in Table 2, the performance of the model significantly increased and building points were classified with an F1 score value of 96.50% (Figure 2).

After fine-tuning the model with the Vancouver dataset, it was tested on a new dataset from the City of Calgary. The Lidar data for Calgary had an average point density of approximately 38pts/m<sup>2</sup>. As can be seen in Figure 3, the buildings in the Calgary dataset were classified with a high accuracy and the model was able to distinguish buildings from adjacent objects such as bushes, trees and cars.

### REFINING BUILDING CLASSIFICATION WITH IMAGES

One of the major requirements of Level of Detail (LoD) 2.2 building model generation is building footprint layers. Primarily, the building footprints were extracted from Lidar data in a multi-step process including rasterization, polygonization and regularization. To refine the building footprints layer, as well as benefit from another data source to perform a quality check on both the extracted building footprints and the Lidar classification, we used a pre-trained Mask-RCNN model to detect buildings from aerial images.

Building footprints extracted from the imagery were overlaid on Lidar data, and both the misclassified Lidar points and the building footprints were modified accordingly (Figures 4 en 5).

### CONCLUSION AND RECOMMENDATION

Employing AI-based methods in industry-level projects requires a well-constructed workflow with robust datasets. In this article, we first trained a deep learning model to classify building points in aerial Lidar data using a very



▲ Figure 5: Extracted building vectors from Lidar data overlaid on the same ortho.

high-quality dataset from Nanaimo. Although the trained model obtained acceptable results on a dataset from the same area that the model was trained with, it failed to achieve a high accuracy prediction due to different characteristics of the new dataset. This poor performance of the deep learning model on the Vancouver dataset meant that the model was not sufficiently generalized. It is therefore recommended to improve the generalization and transferability of the trained model to enhance the Lidar prediction quality on various structure types by providing more training data. ◀

	Before fine-tuning		After fine-tuning	
Evaluation Metric	Never Classified code (0)	Building code (6)	Never Classified code (0)	Building code (6)
Precision	85.69%	98.94%	98.35%	96.26%
Recall	99.63%	67.43%	98.09%	96.74%
F1 score	92.14%	79.99%	98.22%	96.50%

▲ Table 2: Precision, recall and F1 score values for the Vancouver dataset before and after fine-tuning the model.

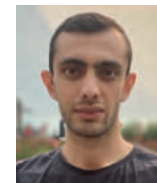


▲ Figure 4: A fragment of the ortho from the Nanaimo dataset.

### ACKNOWLEDGEMENT

The authors would like to thank the cities of Nanaimo and Vancouver, and McElhanney Ltd, for providing Lidar data.

### AUTHORS



**Morteza Esfandiari, MSc**, is a geospatial technician with McElhanney Ltd. Morteza received his MSc in Geodesy and Geomatics Engineering from the University of New Brunswick in 2021. His research interests cover applications of machine and deep learning in geospatial datasets, with emphasis on methods for the segmentation and classification of point cloud and raster data.  
✉ mesfandiari@mcelhanney.com



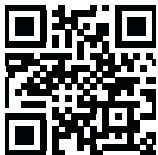
**Dr Azadeh Koohzare, PEng, CMS**, is a division manager with McElhanney Ltd. Dr Koohzare obtained her PhD in Geomatics Engineering from the University of New Brunswick. She is an industry advisor for several national, government and academic committees. Having managed more than 150 geospatial projects over her 20+ year career, Dr Koohzare's expertise in geospatial projects and Lidar / airphoto surveys is hard to match. Dr Koohzare is recognized for her work in North and South America, Africa, the Middle East and Southeast Asia.  
✉ akoohzare@mcelhanney.com

NavVis Reality Capture Solution

# The new standard in reality capture



NavVis has the most accurate mobile mapping systems on the market. Used together with NavVis IVION, professionals in the laser scanning, surveying and AEC industries have an end-to-end reality capture solution.



Scan me and  
discover more

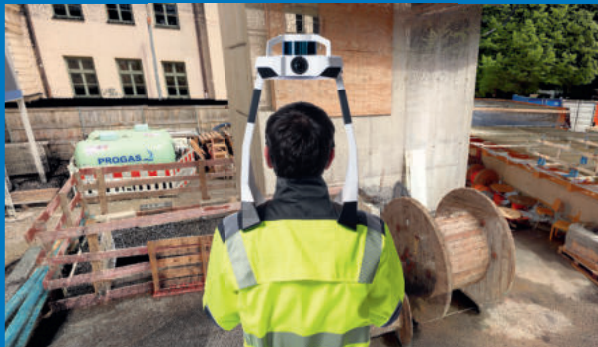
[www.navvis.com](http://www.navvis.com)



# Get it done

## NavVis VLX

With regular software updates to the SLAM algorithm, NavVis VLX 2nd generation is optimized for outdoor environments and will continue to evolve long into the future. It also boasts IP42 for protection against solid objects larger than 1 mm and vertically dripping water, and a carbon-fiber frame that's super strong and reduces overall weight.



**Dynamic scanning.** Capture everything from complex indoor spaces to outdoor environments.



**Superb accuracy.** NavVis VLX is powered by precision SLAM technology entirely in a class of its own.



**All-in-one reality capture.** Take high-res scans and images in every direction for complete 360° coverage.



**Live mapping feedback.** Monitor your scanning progress in real time with a built-in touchscreen interface.



**Precision meets ergonomics.** A wearable device where operators can scan at the speed of walking.



**Geo-registration.** NavVis VLX can capture control points for precise geo-registration and alignment of datasets.



## Survey-grade point clouds

NavVis system software contains a unique SLAM algorithm that's been specially developed to overcome the challenges of capturing high-quality point clouds with a mobile system.



### **Preserve original details**

Point cloud surface reconstruction preserves details while removing noise for more efficient use in 2D drawings and 3D models.



### **Highly realistic texturing**

Highly detailed point clouds include color and realistic texturing.



### **Detect and remove dynamic objects**

Objects that move through the scan are automatically detected and removed from point clouds during post-processing, resulting in less manual work.



### **Robust SLAM**

Robust SLAM algorithms can accurately capture the entire building including the facade and surroundings.



Scan me and  
discover more



# NavVis Reality Capture Solution Workflow



## Data capture

NavVis VLX captures high-quality point clouds with survey-grade accuracy 10x faster than a terrestrial laser scanner. NavVis VLX can be used on its own or in combination with third party hardware depending on your project requirements.

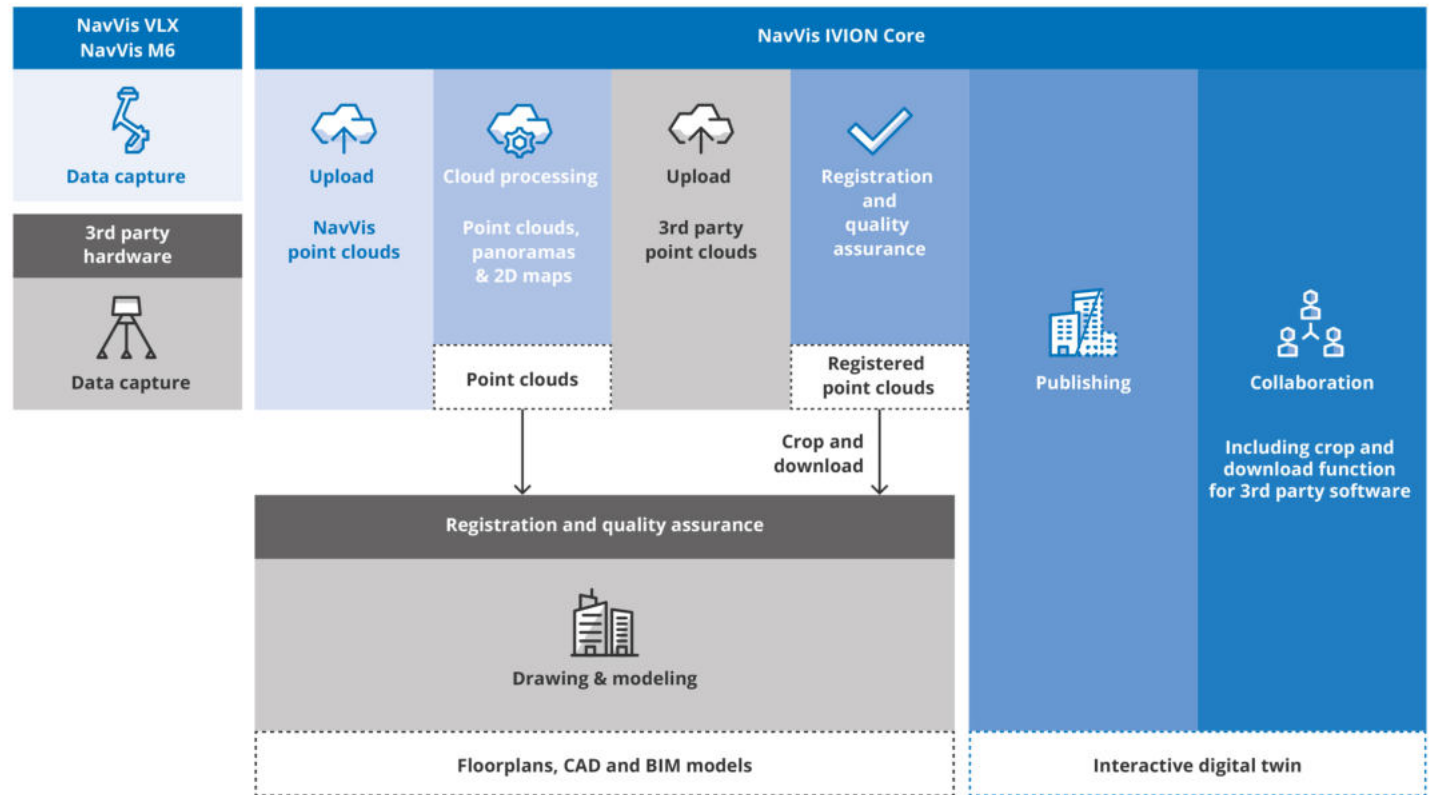
*"For an intersection survey, it would usually take six or eight hours. But with NavVis VLX, I can collect the entire intersection in 10 minutes. I can have all that contextual information to make measurements, and even build existing conditions models to give to the design engineers."*

BEN SHINABERY  
QK4



## NavVis IVION Core

A reality capture platform for laser scanning and AEC professionals. Manage your 3D scans with intuitive tools for creation, collaboration, and publication. NavVis IVION Core makes mobile mapping workflows more efficient, speeds up model creation and delivery, and adds value to your data.



*"NavVis IVION Core is a great tool that we use to provide our clients with a viewer, giving the end user the most efficient visuals to understand any building."*

EAMON LYNCH  
360 Energy



## Registration and quality assurance

Quickly and easily register NavVis point clouds as well as 3rd party data in NavVis IVION Core. Use the alignment tool to complete quality assurance of your data.

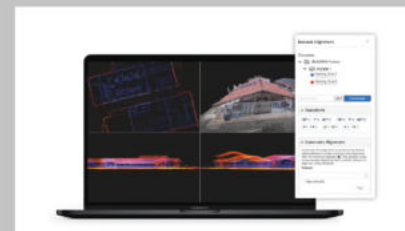


## Cloud Processing

With the Cloud Processing add-on for NavVis IVION Core you can efficiently process laser scan data captured by NavVis devices anywhere with an internet connection. Easily set up and start processing multiple datasets onsite, ready for when you're back to the office.

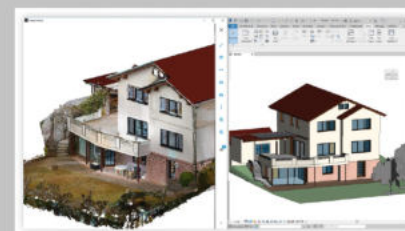
*"With the NavVis' Cloud Processing Add-on, we're able to dial up more processing cores when we need it and dial them down when we don't. And we can still have the flexibility to do smaller projects on premises."*

**MARK HANNA**  
Precision Point



## Process, align and geo-register

Process, geo-register and automatically align scan data from NavVis devices and other data sources with survey-grade accuracy.



## As-built documentation

Using NavVis IVION Core, simply crop and download sections of a point cloud for modeling in third-party CAD or BIM software applications. And with the NavVis IVION Add-in for Autodesk Revit, you can directly compare or verify your BIM model with the up-to-date conditions at any stage of your project.

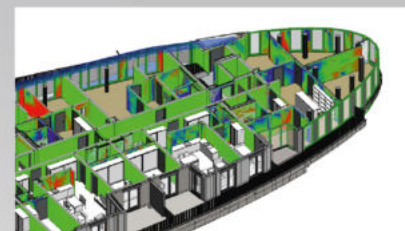


## Collaboration

With NavVis IVION Core you can Inspect, plan and measure with a building visualization that's incredibly easy to navigate. Improve efficiency by giving your team and clients access to the full point cloud data from anywhere. With NavVis IVION Core you can optimize construction verification and boost your scan-to-BIM workflows.

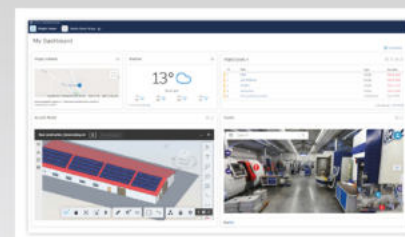
*"We're able to minimize software costs by maximizing the usage of an individual instance. The multi-site feature together with the intuitive web interface makes new project setup fast and easy. And the updated user management in NavVis IVION Core means administrators have more security control; it greatly simplifies the process of providing access."*

**AARON HUNT**  
TruePoint



## Construction verification

NavVis data is perfectly suited for the comparison of BIM models and point clouds in third party software for construction verification purposes. This enables AEC professionals to have complete transparency before construction has even started or during construction.



## Collaboration and handover

From project managers to building owners, make important information accessible in any standard browser to the right people at the right time. Collaborate intuitively and visually from start to finish.





# NavVis

## Visit our website and book a free demo today!

Bridging the gap between the physical and digital world, NavVis enables service providers and enterprises to capture and share the built environment as photorealistic digital twins.



Scan me and  
discover more

[www.navvis.com](http://www.navvis.com)

**WHO WILL SET THE SCENE FOR FIG OVER THE NEXT FOUR YEARS? WHO WILL REPRESENT THE SURVEYING PROFESSION AND COMMUNITY? WHAT WILL BE ON TOP OF THE AGENDA?**

# Three candidates for FIG President – Five questions on the future of surveying and surveyors

The International Federation of Surveyors, FIG, has since 1878 represented surveyors and the surveying profession globally. Today, it does so in the broadest sense, by including geospatial experts, valuers, construction economists, hydrographic surveyors, land surveyors and so on.

2022 is a special year for FIG, as the FIG General Assembly will elect a new President to take over from President Rudolf Staiger. Two new Vice Presidents will also be elected. This will all take place at the FIG Congress 2022, which will be held in Warsaw, Poland, from 11–15 September. The President and Vice Presidents will be elected for four years, starting from January 2023 and running to December 2026.

So, who are the candidates? This is the first time that the names of the candidates have been announced so early, which gives us the possibility to get to know the candidates a little better.

In this article, *GIM International* and FIG ask the three President candidates – Abbas Rajabifard (Australia), Diane Dumashie (UK) and Orhan Ercan (Turkey) – five questions

about their views of the surveying and geospatial profession, the future and their visions if they were the next President of FIG.

## **Candidates for President for the term 2023–2026:**

- Abbas Rajabifard, Surveying & Spatial Sciences Institute SSSI, Australia
- Diane Dumashie, Royal Institution of Chartered Surveyors RICS, UK
- Orhan Ercan, Turkish Chamber of Survey and Cadastre Engineers HKMO, Turkey

## **Candidates for two Vice Presidents 2023–2026:**

- Brian Davies, Canadian Institute of Geomatics CIG, Canada
- Daniel Steudler, GEOSUISSE, Switzerland
- Qin Yan, Chinese Society for Geodesy Photogrammetry and Cartography CSGPC, China
- Winnie Shiu, National Society of Professional Surveyors NSPS, USA

## Abbas Rajabifard

### **How do you foresee the surveying profession changing?**

We are living in an increasingly complex and interconnected world and a very fast-growing digital market, and the use of location information in everyday life is growing dramatically. In this context, digital transformation, and our response to global challenges (e.g. population growth, urbanization, climate change, sustainability, resilience and pandemics such as COVID-19), are increasingly altering all aspects of our societies and our economic stability. Technological advancements are offering

new ways to design, produce, consume and manage by providing a 'live' system to model, measure and monitor changes. In this environment, the dependency of projects on land and geospatial information are becoming more crucial compared to the past. Therefore, I see surveying professions playing a more important role, but at the same time the changing directions and new requirements I see for surveying profession are more obvious, and risks are real in this context, in terms of quality of skills, market concentration and external geopolitical factors.

### **How will FIG continue to represent the interests of surveyors in the future?**

The role I see for professional associations such as FIG to represent the interests of its members is becoming more strategic in this very fast-changing world. For FIG to maintain its international leading role and to improve its standing, it needs to re-examine its values and vision and develop a smart plan and strategic activities. It also needs to develop a roadmap that ensures that FIG remains relevant and connected and continues to serve the needs of the market





and the interests of surveyors for the world we have today and into the future.

In response to the fast-growing market and global challenges, we see several strategic initiatives from different authorities and global entities (e.g. United Nations, World Bank). These agencies mostly have initiated major work around new frameworks or roadmaps (SDGs, IGIF, NUA) to assist global communities, as well as to improve the efficiency and effectiveness of our actions in response to the global challenges. In these initiatives, land and geospatial information are crucial components for decision-making processes to enable us to effectively respond to the challenges and improve sustainability. This is due to an inter-relationship between the market trends and the global challenges. We need to understand these relationships; therefore, FIG has a major role to play, and we as surveyors, spatial and land practitioners can play a strategic role in this transformation process.

***How would FIG contribute to the implementation of the SDGs under your presidency? How can surveyors and geospatial experts worldwide be encouraged to become actively involved in these goals?***

FIG has a major role to play in today's emerging markets and in empowering Member States to implement SDGs, and we as surveyors, spatial and land practitioners can play a strategic role in this transformation process. Urbanization, natural and human-induced disasters, migration and technological advancements

are among some of the most potent forces that are increasing the connectivity and complexity of the challenges highlighted in the SDGs. The SDGs' dependency on geospatial information and enabling technologies are mainly due to the primary roles that data and tools play in relating people to their location, place and environment, and in measuring 'where' progress is, or is not, being made, particularly at the sub-national and local levels. However, in the pursuit of sustainable development, many countries continue to face a series of impediments that limit their ability and opportunity to participate fully in the implementation of the United Nations 2030 Agenda and to support national development and economic prosperity, and through that, a global and thriving information economy. In response to this, and as part of our strategy, we will focus on improving our closer collaboration with the UN, the World Bank and international agencies and play a very active role in all FIG Commissions to facilitate SDG implementation. This is an area in which FIG can take a strategic role to empower the global community and sustain future skills and human resources.

***What do you think of the current developments in land administration, fit-for-purpose, IGIF, FELA and so on? How can FIG play a role in this?***

Professional associations are not only important to the professions they represent, but they are becoming an increasingly important source of science and

knowledge-based advice to governments and institutions with global responsibilities. My leadership of FIG would ensure that FIG is on a very positive trajectory for future relevance, sustainability and growth.

***Which main goals would you hope to see achieved during your presidency?***

Should I have the support to serve FIG as president, I will bring a very strong strategic vision that will increase the relevance of FIG in the future. My focus will be on FIG today and in the future – opportunities and challenges, and strategic pathways to nurture strong collaborative partnerships with government, industry and academia, to ensure the next generation of professionals is equipped to meet the needs of the emerging markets and industry. I will bring a vision for FIG that aligns its aim, objectives and mission with all the changes taking place in the market. My motto is:

Connect Local Challenges to Global Action  
/ Connect the Global Market to Local Opportunities

For FIG to continue to be relevant, it must be more actively engaged with the key international institutions to ensure that surveying and geospatial knowledge and technologies are fully utilized when dealing with the major global challenges. I will focus on:

- Global Agenda: SDGs, IGIF, COVID-19, digital transformation, power of location, climate change, digital economy, digital

Professor Abbas Rajabifard is a surveyor and internationally recognized scholar and engineer, and an active leader in land administration modernization, sustainability and resilience and the development of digital twins. He is a strategic thinker who is passionate about driving innovation and change within the surveying and geospatial profession. He understands the complex environment that we work in and the need to build collaborative partnerships to maximize opportunities for growth. Abbas has proven experience in leading and chairing professional organizations and executive science panels, such as the Global Spatial Data Infrastructure (GSDI) Association and the UN-GGIM Academic Network. He is currently Director of Smart and Sustainable Development and Geomatics Discipline Leader at the University of Melbourne. He has more than 30 years of experience working at various state, national and international levels in industry, government and academia, in a career path that has always been in surveying, land administration and spatial. He has been nominated by the Australian Surveying & Spatial Sciences Institute (SSSI).

twins, opportunities for surveyors/practitioners;  
- FIG Commissions and interrelationships (cross-cutting collaboration);

- FIG diversity and inclusion;  
- Regional focus (needs, challenges and opportunities);  
- Young surveyors and women in surveying

(supporting digital surveyors/engineers);  
- Capacity-building (human capacity and organizational capacity) and providing new digital skills.

## Diane Dumashie



### ***How do you foresee the surveying profession changing?***

As the biggest international society representing the geospatial and surveying profession, FIG offers a global platform of exchange and influence for our stakeholders. Over recent years, I've had the pleasure of holding the Council remit on some of the strategic stakeholder engagements and I can see that above all our profession needs to remain relevant, serve the public interest and leave no one behind in a world of rapid and dramatic change.

To continue to provide leadership in society we must be ready to innovate, to adapt and to lead the response to change. To remain impactful over the coming decades, our work will be shaped by the major global forces affecting societies. These include climate action, rapid urbanization, environmental and resource stewardship, technology revolution and demographic influences. By way of example on the how, I'll draw on two of these forces.

First, the ongoing digital transformation. Our profession has been in transition

for some time, but we can't stand still; we must be prepared for the future by adapting now. Our societies are more connected than ever and geospatial is underpinning a lot of what we do as real-time services become society's expectation and demand is growing across all our FIG professional disciplines. We do not have a monopoly over this abundant data that is richer and more complex than ever before, and we have to better appreciate that the increasing convergence between our sector and tech sectors is happening now and we must claim our relevance.

Second, adaptive organization and adaptive skills. Crucially, our profession crosses four generations. Those of us already in the workforce are now employed in ways we could have hardly imagined. Inevitably for our younger people, their work view has already changed. This was demonstrated in the round table of young professionals that I chaired at the FIG WW 2021 entitled 'Reimagining the future of the surveying profession post 2020'. We are stepping-up to meet the challenge, but we need to do much more and we have to attract and develop talent with the key people skills to take up the ambassadorial, collaborative and engaging leadership roles of the future.

### ***How will FIG continue to represent the interests of surveyors in the future?***

FIG brings together the broad and diverse field of survey disciplines. Drawing on my history of senior roles in FIG, the best means to represent the diverse interest of surveyors is to ensure that FIG leads, listens and collaborates.

It is an imperative to bring positive changes to the built and natural environments in the face of global forces; we must be trusted by our stakeholders and society and as

a sustainable 21st-century professional body. This raises the question whether our profession is prepared and resilient to engage in developing a better world for society and the planet.

Foremost, having chaired the FIG Governance Task Force 'Our profession: Fit for the future in how we work and organize' (FIG WW 2021), I have listened and learnt first-hand from FIG members about the increasing need and desire for resilience and sustainability within our profession. I can see that the ongoing geopolitical changes mean that our profession needs to maintain an influential voice at all levels to continue our beneficial society impact. It is imperative that FIG leads and advocates to raise awareness for our members to step up and respond to this impetus for change.

### ***How would FIG contribute to the implementation of the SDGs under your presidency? How can surveyors and geospatial experts worldwide be encouraged to become actively involved in these goals?***

The 2030 Agenda (SDGs) united global policy to transform the social, economic and environmental dimensions of humanity and our planet. Importantly, the UN mantra – to leave no one behind – highlights our own professional expertise in land and geospatial data seen in many of the SDGs.

2030 will soon be upon us, and meeting the goals requires ambition and leadership and a clear pragmatic plan. Taking action using the SDGs along with climate change action is underpinning everything we need to do now; to walk the path to climate equity we need action in cities and to secure and manage our planet's natural resources.



Sustainability and resilience are not business as usual; there are readily accessible options with emerging innovative technology. Having been involved in the 2030 Agenda for over a decade, my presidency would advocate for an Environmental, Social and Governance (ESG) agenda. I'd seek to build on the very good work of the FIG Task Force on the SDGs2 to encourage speed and scaling up into our professional activities and to adopt a fresh view of the SDG project. Understanding the big agendas and proactively advocating issues allied to professional excellence is important, as explained in my webinar in the RICS Value the Planet series3 which concludes with actions that individual members can take in their own professional work.

***What do you think of the current developments in land administration, fit-for-purpose, IGIF, FELA and so on? How can FIG play a role in this?***

Land administration is at the heart of all FIG activities. As former Commission Chair and Chair of ACCO, I've seen clearly how this is addressed in various ways in all the FIG Commissions. Land Administration is the operational engine within Land Governance and is rooted in the cadastral area.

The recent developments in land administration are significant for managing the built and natural environment. The fit-for-purpose concept has been developed in recent years by some prominent members of the FIG community and provides an approach to closing the cadastral gap, especially in developing countries, by building frameworks that meet today's societal needs. FIG promotes this, thereby supporting poverty alleviation, empowering the poor, and meeting the SDGs. The surveying profession will be the key custodians of maintaining and constantly improving such nationwide systems.

In the same way, FIG supports the work of UN-GGIM. The IGIF provides an operational framework for building such interactive data management systems, along with supporting the efforts of the UN-GGIM and the World Bank to develop the practical guidelines for implementation and economic impact assessments. FELA is a more general framework building on the same structure as the IGIF. FELA is a great framework for referencing and FIG encourages the building of comprehensive land administration systems.

***Which main goals would you hope to see achieved during your presidency?***

My agenda for action is underpinned by sustainability and resilience in the professional sphere and society space, to enable our professionals to take action on the most important issues of our time. To navigate the decade of transformation, one thing is certain; we must act together. Given FIG's unique structure with a GA of member associations, my overriding goal is to respond to the global challenges at both the council and national level. I'd also emphasise professional development, to be filtered back to the individual member associations for local implementation.

What is clear to me is the certainty about context and connectivity. I foresee this is a time of opportunity if we embrace the adaptability mindset. My headline goals include:

Climate action and the SDGs: Sustainable development is at the heart of developing resilience to climate change and achieving net zero emissions; Build on the importance of SDGs, poverty alleviation and social equality

Digital transformation: Claim our relevance in data and technology; Advance the role of the Geospatial Knowledge Infrastructure (GKI) in society and economy; Provide user-friendly, low-cost land administration and property systems

Community diversity and inclusion: Resilience of our profession for attracting new recruits, encouraging succession plans and upskilling all generations

Governance in the FIG organization: Member communication, collaboration and value added

As a global professional body, we need to respond to these challenges if we are going to ensure that our members deliver confidence in the years ahead. My tenure will work for. My tenure will work for clarity and collaboration, purpose and reliability, and action and courage.

**Dr Diane A Dumashie. FRICS, CEDR, Director of Dumashie Ltd; FIG Vice President; Trustee of LionHeart Benevolent Fund, RICS Standards and Regulation Board**

A fellow of the RICS, Diane delivers strategic projects that have a clear social, economic livelihood agenda linked to land. Works in the UK and internationally helps the public sector and donor multilateral and bilateral agencies to generate benefits to society. Adept at enabling, facilitating and bringing people and resources together to achieve organizational objectives. Diane leads and innovates to manage change, energizes and resolves complex issues in the areas of land management, land administration, gender rights, land and coastal property regeneration. A passionate ambassador of professional development, Diane has throughout her career held voluntary roles to serve the profession worldwide.

## Orhan Ercan

***How do you foresee the surveying profession changing?***

The FIG definition of surveyor, from 2003, identifies the broad scope of surveyors and

importantly advises that surveyors must consider the relevant legal, economic,



environmental and social aspects. Surveying is a long-established profession, but it is also at the forefront of change, which also must include technological change. We live in an increasingly complex and interconnected world and the expertise of the surveying and geospatial professions has never been more important. Although the traditional roles of surveyors continue, albeit with delivery and outputs revolutionized, the roles are also now far wider given the increasing challenges of climate change, disasters, conflict and pandemics. The profession remains more relevant to society than ever before and it must continue to do so.

#### ***How will FIG continue to represent the interests of surveyors in the future?***

Global factors, new technology, societal demands, external factors, surveyors' expectations and young surveyors are triggering the need for change, both in geospatial and land management. Artificial intelligence, the internet of things and big data technologies are changing industries, societies and our way of life.

From a small survey I conducted in the scope of the campaign, I have induced that the needs of countries and continents differ substantially. A typical example is that NSDI sets the agenda for Central Asian countries, while Asia Pacific countries focus on digital twins, smart cities, international cooperation and knowledge transfer within the scope of digital transformation. Interestingly, African countries keep land policy frameworks, land registry, initial cadastre, geospatial

data production, technical standards, institutional strengthening, capacity building and modern technology usage on the agenda, while Balkan countries are more interested in cadastre, land consolidation and automation issues. In addition, some European countries are also working on SDI needs, quality improvement of land registry system and records, cadastral renewal, more automation, smart cities, sustainable business models, citizen-oriented land projects, innovation, international networks, cooperation and knowledge transfer.

As a global society, FIG provides an international forum for continuous discussion and development aiming to promote better scientific, technical and professional knowledge, standard and practices. FIG publications, which have become a tradition, are very important sources that guide our member associations and practitioners as a synthesis of science and practice.

FIG will take care to develop and share new knowledge and practical experience among surveyors from various regions. FIG will work more closely with regional and local associations and coordinate with them in addressing major professional challenges. FIG will continue to contribute and collaborate through knowledge transfer with member associations using both face-to-face and virtual tools. Finally, FIG will develop linkages with grassroots surveyors and young surveyors in as many countries as possible and encourage diversity.

#### ***How would FIG contribute to the implementation of the SDGs under your presidency? How can surveyors and geospatial experts worldwide be encouraged to become actively involved in these goals?***

The SDGs are intended to be a blueprint for a better and more sustainable future for all and surveying professionals have a key role to play in this. It is therefore of crucial importance that FIG member organizations and surveyors are aware of how their work contributes to the achievement of the SDGs and vice versa.

The SDGs, which run from 2015 to 2030, are already near the mid-point of the cycle. FIG should develop advanced hybrid tools for community engagement and building sustainable partnerships. Good spatial monitoring of the SDGs will enable the better planning and development of what will follow post-2030. However, such engagement should be professional and objective and add value rather than just providing fora for promotional engagement.

The SDGs document, which is being prepared by the Task Force, will be considered as a practical guide in my term.

#### ***What do you think of the current developments in land administration, fit-for-purpose, IGIF, FELA and so on? How can FIG play a role in this?***

Regarding land administration, Cadastre 2014 has been FIG's most influential publication in the history of FIG. It has influenced fit-for-purpose and has been especially significant in that it has called out the over-engineering of spatial/

**Orhan Ercan was FIG Vice President for the 2017-2021 period and previously worked in the General Directorate of Land Registry and Cadastre in Turkey.**

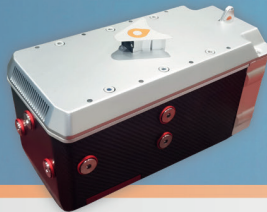
Since retiring, he has worked in the private sector and is currently a member of the Faculty of Applied Sciences in the Department of Real Estate Development and Management at Ankara University. During his private-sector studies, he carried out various national and international surveying projects, thus gaining private-sector experience as well as widening his professional spectrum. He has participated in all three corners of the academic/public-sector/private-sector cooperation framework or 'industry triangle'. He crowned this experience with the association experience he gained from his HKMO and FIG activities.



CHCNAV

## PREMIUM LONG-RANGE AIRBORNE LiDAR

The **AlphaAir 1400 & 2400** are long range, lightweight airborne laser scanners designed for use on various UAV platforms, helicopters or small airplanes for high-density corridor mapping applications.



DEALERSHIP OPPORTUNITIES AVAILABLE



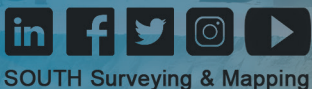
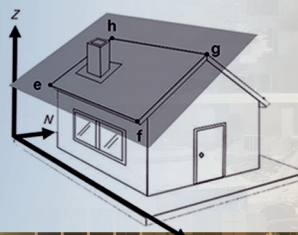
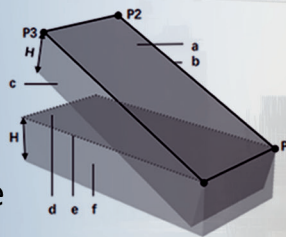
Mapping & Geospatial | [www.chcnav.com](http://www.chcnav.com)

## 2D + 3D AREA & VOLUME

**SOUTH**  
Target your success

### N40 Total Station

Freely projected onto the horizontal plane (2D) or reference plane defined by 3 points (3D).



E-mail: [mail@southsurvey.com](mailto:mail@southsurvey.com)  
[www.southinstrument.com](http://www.southinstrument.com)

surveying accuracy of the cadastre for land registration. Much of the over-engineering is attributable to vested interests in the surveying profession. It was through FIG collaborating initially with WB that led to FIG Publication #60. Further FIG collaboration with UN-Habitat GLTN enabled the preparation of detailed guidelines. FIG will continue to engage and provide fora to share, discuss and evaluate best practices. After that, the role of FIG should be to promote these achievements and build upon experience sharing in the various regions.

FIG will continue to promote the important principles of VGGT to encourage accessible, transparent and sustainable land administration around the globe and to support the attainment of the 17 SDGs that are directly or indirectly related to land management.

***Which main goals would you hope to see achieved during your presidency?***

Developing smart solutions for building strong partnerships within the global geospatial society and improving

engagement among developed and developing member associations, academic and corporate members to overcome new emerging challenges and turn those challenges into opportunities.

Based on my answer to the second question, it is among my goals to work more closely with member associations to better understand their needs and to produce solutions together.

Another important issue is to develop more effective cooperation opportunities with regional bodies such as the Council of European Geodetic Surveyors (CLGE), the Africa Regional Network (ARN), the Federation of French Speaking Surveyors (FGF), Arab Land Initiatives, the Mediterranean Union of Surveyors (UMG), Asia Pacific CBN, RICS, NSPS, CAGIS and Latin American Surveyors.

We will take the necessary initiatives to activate academic members and make them more productive within the FIG. We will also work with the Young Surveyors Network (YSN) to promote wider participation and encourage and mentor the next generation of FIG leaders. Furthermore, we will continue to give

special importance to the issue of women in surveying.

As the Vice President of FIG, I succeeded in making the countries with a population of about one quarter of the world a member of the FIG in various categories during the 2017–2021 period. However, the world map on the FIG web page shows that some countries are not yet members of the FIG.

I and my colleagues will do our best to embrace the whole world by making FIG the 'World Federation of Surveyors'.

We will also make the necessary attempts to publish the peer-reviewed papers presented at FIG events as a 'FIG Special Issue' in one of the journals within the scope of the WoS/SCOPUS indexes.

Strengthened engagement with international development agencies will be ensured, including the World Bank Group (including IFC and the Annual Conference on Land and Poverty), UN-FAO, UN-Habitat including GLTN, UN-Stats including UN-GGIM (global and regional), IFAD, key development agencies and NGOs/CSOs and the Global Donor Platform for Rural Development.



**geomares**  
MARKETING

*Grow your business!*

**TECHNICAL B2B MARKETING FOR SMART GEOSPATIAL COMPANIES**

**WWW.GEOMARES-MARKETING.COM**



# CHC Navigation

*One of the geospatial industry's fastest growing companies is expanding the reach of its navigation and positioning solutions in Europe and the world*

CHC Navigation is expanding its reach throughout Europe and the world, with more dealers and customer support and advanced training and service points. The Shanghai-based company has been a player in the mobile mapping industry for almost two decades. Founded in 2003, initially as a provider of GNSS technologies for the domestic market in China, the company's evolution has since tracked the stellar expansion of the GNSS navigation and positioning industry.

CHCNAV now offers end-to-end precision positioning solutions encompassing both hardware and software for applications in land and airborne surveying, conventional GNSS surveying, 3D mass data acquisition, unmanned navigation and robotics, precision agriculture and more.

## **CUSTOMER-CENTRIC, TECHNOLOGY-DRIVEN AND THE HIGHEST QUALITY STANDARDS**

Having a large domestic market as a testing ground for new products and platforms has been a huge advantage for the company, which employs more than 700 engineers at its four R&D centres. Moreover, CHCNAV reinvests 15% of its revenues in R&D, including fundamental research. This has yielded a fusion of technologies able to provide positioning accuracy in the millimetre or centimetre range, as well as precision ultra-high-speed long-range scanners. Its hybrid positioning systems merge the

strengths of GNSS, MEMS, IMU, Lidar and optical data. CHCNAV's steady output of ruggedized, reliable technologies and workflow solutions has earned the company a growing following of users in Germany, France, Hungary, Romania, the U.S. and elsewhere.

Recognizing the importance of reliable logistics, the highest quality standards and service and training within customers' reach, CHCNAV has made management systems another hinge of the business. It has proven systems in place – adapted from leading international high-tech companies – spanning product development, manufacturing and human resource planning. These are designed to get customers the solutions they need to solve the geospatial positioning challenges they face in their applications. CHCNAV develops leading-edge technologies, but always with the goal that the technologies remain affordable.

The APACHE 4 autonomous hydrographic

survey marine drone and the AlphaAir 450 Lidar system are just two of the products recently released to the international market that are solidifying CHCNAV's position as a leader in the geospatial industry.

## **APACHE 4 MARINE DRONE**

The APACHE 4 marine drone, released to the international market in May 2021, is a compact unmanned surface vessel (USV) featuring a combination of an ADCP (Acoustic Doppler Current Profiler) for cross-sectional flow measurements and a single-beam echosounder. It eliminates the high construction and maintenance costs of the traditional ropeway towing systems used to carry ADCP for cross-section water flow velocity and discharge measurements. The APACHE 4 offers an unattended operation solution with a shallow draft, high navigational accuracy and stable hovering. It is compact, easy to launch and handle on-site, and can be conveniently transported by car.

## **KEY FEATURES OF THE APACHE 4**

**Integrated adaptive water flow straight-line and hovering technology.** As water flow and turbulence change, the APACHE 4 autonomously follows the defined profile, navigating in a straight course along the cross section. The hovering technology improves flow estimation accuracy and ensures that the APACHE 4 hovers stably in turbulent flow at the start and endpoint of the ADCP observation.

**GNSS+IMU.** The on-board GNSS+IMU module provides uninterrupted positioning and heading data even during transient GNSS signal loss. The obstacle avoidance radar system and live video feed guarantee safe operations in case of loss of visibility or difficult environmental conditions.



▲ AlphaAir 450 mounted on CHCNAV BB4 drone.



▲ APACHE4\_Autonomous Hydrographic Survey USV.

**Built-in single-beam echosounder.** This allows the user to verify and compensate for the ADCP bottom tracking data accuracy, while providing water depth profile data associated with the flow velocity profile measurement.

**Compatible with most ADCPs.** The APACHE 4 can embed different types of ADCP sensors, such as the M9, RTDP 1200, RiverPro or RiverRay while providing them with positioning, orientation, power, waterproofing, local network and 4G transmission.

#### ALPHAIR 450, A BREAKTHROUGH IN AIRBORNE LIDAR AFFORDABILITY

The AlphaAir 450 (AA450) Lidar system is another product that is generating huge interest in CHCNAV innovations. Lidar scanning is an ideal technology for capturing 3D data, but it has long been overly costly and complex to operate. Andrei Gorb of CHCNAV's Mobile Mapping Division characterizes the AA450 as "a breakthrough Lidar scanner that delivers user-friendly and high-accuracy capabilities at a reasonable price". The AA450 is the lightest, most accurate and cost-effective Lidar UAV system in its class. Released to the international market in March 2021, the AA450 integrates a high-performance laser scanner with an industrial-grade professional 26MP camera and a high-precision inertial navigation system. It is widely used for power line inspection, topographic mapping, emergency response, agricultural and forestry surveys and more.

#### KEY FEATURES OF THE AA450

**Lightest in its class.** The AA450 weighs 1kg, making it perfectly suited to drone payload requirements.

**Advanced accuracy.** The combination of

industrial-grade GNSS with a high-precision IMU means the AA450 easily achieves an absolute accuracy of 5cm (vertical) and 10cm (horizontal) for small survey areas. For even more precision and accuracy, users can apply adjustment algorithms in the CHCNAV CoPre software.

**Industrial reliability.** High-level IP64 protection means the AA450 can withstand the challenges of field environments, with operating capability in temperatures from -20°C to +50°C. This provides more field survey days in a year, increasing users' return on investment.

#### BUILDING A SMART WORLD WITH PRECISE SPATIO-TEMPORAL INFORMATION

CHCNAV offers products, services and end-to-end solutions across seven major industries:

- Surveying & Engineering
- Mobile Mapping & Geospatial
- Marine Surveying
- Navigation & Infrastructure
- Precision Agriculture
- Machine Control
- GNSS OEM

In precision farming, for example, CHCNAV automated steering retrofit kits for tractors are experiencing a phenomenal uptake. Their affordability and ease of use put the efficiencies of precision positioning in the reach of all farms, whatever their size. Powered by local, network or satellite RTK corrections, the GNSS+INS terrain compensation technology provides a hands-free accuracy of  $\pm 2.5$ cm over any terrain. Digital 3D twins is another area where CHCNAV technologies are pushing frontiers. The purchase of a 3D mobile mapping system is too often constrained to a specific purpose, such as airborne or ground survey.

CHCNAV customers expressed a need for a professional Lidar solution that can be used in different scenarios, offering optimal adaptability to their current and future needs. The AlphaUni series is an innovative multi-platform Lidar system that can be used with an aerial or marine drone, on a vehicle or carried as a backpack to provide sophisticated and comprehensive 3D models.

#### DIGITAL CONSTRUCTION BREAKTHROUGHS ON THE WAY

Moving from GNSS Lidar to digital construction is a major next step for CHCNAV. It has a range of technologies for contractors, including machine control for equipment such as excavators and graders, as well as its surveying and site monitoring solutions. At INTERGEO 2022, it will present a full line of solutions that stand out in affordability, while providing dramatic improvements in productivity across work processes and delivering exceptional return on investments.

To find out how CHCNAV's integrated positioning and navigation solutions can make your work more efficient, contact us at: [marketing@chcnav.com](mailto:marketing@chcnav.com). ◀

# CHCNAV



▲ AlphaUni Multi-Platform Lidar system.



# 3D Modelling of Buildings Using TLS Technology

The developments taking place in software and technology in many spheres of everyday life and business mean that higher and higher standards are being set in terms of quality and time. In the field of the 3D modelling of buildings too, there is an increasing emphasis on obtaining a highly detailed, high-quality 3D model in near real-time. As a result, the TLS (Terrestrial Laser Scanning) method is becoming increasingly important.

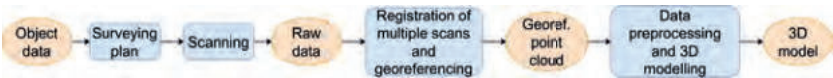
TECHNOLOGY

TLS technology involves the use of a laser scanner mounted on a static tripod. A beam is emitted from the laser sensor, reflected from the object and returned to the laser sensor. During this process, the laser travel time is measured. Therefore, the distance travelled by the laser beam can be calculated. By combining this distance with the known position of the laser scanner, a large number of points can be obtained, leading to a point cloud that represents the surrounding space in three dimensions. When surveying buildings and similar spatial entities, a laser scanner can be placed at multiple stations to cover the entire object. It is important to ensure an appropriate overlap between the scans obtained at successive stations, based on which individual scans are imported and processed into a complete 3D representation of the building.

ADVANTAGES

TLS has many advantages compared to traditional surveying methods. For example, it increases productivity, as a large amount of high-density data can be collected in less time and with fewer resources. Much more information is also obtained: apart from 3D positional information, the obtained data includes reflected intensity values and colours if the TLS has an integrated RGB camera. This makes it easy to create an accurate geometric model and to extract the required data such as dimensions, spatial positioning and structural characterization.

TLS is also an easy-to-use technology; it is a fairly automated surveying procedure and learning how to use the instrument does



▲ Figure 1: TLS surveying and creation of 3D model of building.



▲ Figure 2: Surveyed building.

Facade	Basement	Ground floor	1st floor	2nd floor	3rd floor	4th floor	5th floor
16	21	7	15	17	13	10	12

▲ Table 1. Number of scans per floor

not take much time. Furthermore, it is a non-contact technology, enabling surveying in hard-to-reach areas and improving safety in hazardous environments. Finally, it has a relatively high accuracy. Although the single point accuracy of TLS is usually lower than traditional techniques, it can be improved through adjustment techniques and the accuracy achieved using this method is satisfactory for most applications.

TLS SURVEYING AND CREATION OF 3D MODEL

The process of TLS surveying and the creation of a 3D model of a building as implemented in this article is shown in Figure 1.

Survey planning includes defining the area to be surveyed; defining the expected resolution and accuracy of the point cloud; selecting the scanner to be used; choosing optimal locations for the scanning stations; and choosing types of targets for registration and georeferencing, places for their location and their geometric configuration.

In the field, the operator must first set up the instrument at the defined location, define the 3D section of the scene to be captured and select the necessary options in the software (e.g. sampling resolution, accuracy mode, number of scans, first or last pulse

measurements). Once scanning has started, the operator can follow the process on the screen of the TLS or remotely on a laptop, mobile phone or tablet. When the scanning is complete, the data is saved in a specified project file. As mentioned earlier, large objects need to be surveyed from several locations. The scans obtained at each station are referenced to the instrument-fixed, in other words internal coordinate system of the scanner. This is unnecessary. This procedure is called registration, following which the registered scans are combined into a single dataset. After this, the point cloud can be georeferenced and further 3D models and views can be created.

### SURVEYED BUILDING

The surveyed building presented in the article is located in the vicinity of Frankfurt, Germany. The building consists of a basement, ground floor and five floors (Figure 2).

Scanning using TLS was performed to obtain a 3D model of the building for the needs of reconstruction (to design a new interior and exterior) and as a basis for the development of a BIM (Building Information Model).

### LASER SCANNER

The laser scanner used for surveying was the Trimble X7.

### DATA PROCESSING

A total of 111 scans were performed, with the number of scans per floor given in Table 1.

After collecting data in the field, the scans were imported into the Trimble Business Center software and registered (Figure 3).

Based on the obtained point cloud, the 3D modelling of the facade and all the surveyed floors of the building was performed using Revit software. The result of 3D building modelling is a .ifc (industry foundation classes) file. Figure 4 shows the whole 3D model of the building, while Figure 5 shows the part of the 3D model that represents the interior of the building.

### CONCLUSION

The impact of the development of technology and software in recent decades is evident and has consequences for geodetic engineering and the 3D modelling of buildings. TLS is a modern method that is increasingly being used to create 3D building models. This technology enables the collection of large amounts of high-density and detailed data in a much shorter time and with fewer resources. The data collection and processing are largely automated and allow for additional analyses, updates and changes to spatial data. Finally, artificial intelligence and virtual reality are

also increasing in importance in many areas of life and work, and it is only a matter of time before we see the further expansion and development of geodetic methods that incorporate these modern concepts. ◀

### FURTHER READING

- M. Rashidi, M. Mohammadi, S.S. Kivi, M.M. Abdolvand, L. Truong-Hong and B. Samali, A decade of modern bridge monitoring using terrestrial laser scanning: Review and future directions, *Remote Sens.*, vol. 12, no. 22, pp. 1–34, 2020.
- C. Wu, Y. Yuan, Y. Tang and B. Tian, Application of Terrestrial Laser Scanning (TLS) in the Architecture, Engineering and Construction (AEC) Industry, *Sensors*, vol. 22, no. 265, 2022.
- T. Kuzmić, M. Marković, M. Batilović and V. Bulatović, Application of Terrestrial Laser Scanning Technology for the Purpose of Creating 3D Models of Objects, *FIG e-Working Week 2021 – Smart Surveyors for Land and Water Management – Challenges in a New Reality*, 21–25 June 2021.

### ABOUT THE AUTHORS



**Marko Marković** is assistant professor at the Faculty of Technical Sciences (FTS), University of Novi Sad (UNS), Serbia. He received a PhD in geodesy from the FTS in 2018. His current research interests include engineering geodesy, geographic information systems, digital photogrammetry and laser scanning.



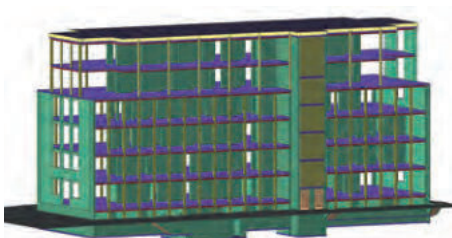
**Mehmed Batilović** is assistant professor at the FTS, UNS, Serbia. He received a PhD in geodesy from the FTS in 2021. His areas of interest are deformation measurements and deformation analysis of building structures, optimization of geodetic networks, engineering geodesy and laser scanning.



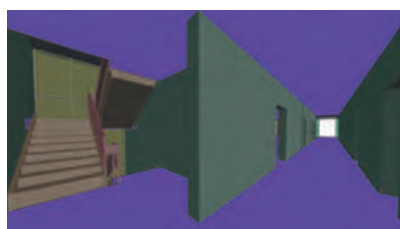
**Tatjana Budimirov** is a teaching assistant at the FTS, UNS, Serbia. She received an MSc in geodesy from FTS in 2016. Her research interests are GNSS surveying, the Internet of Things and laser scanning. Her latest research focuses on the GNSS PPP method and its positioning errors.



▲ Figure 3: Registered point cloud of scanned building.



▲ Figure 4: 3D model of building.



▲ Figure 5: Part of 3D model of building interior.



# Representing 3D Point Cloud Data

The 3D data jungle in today's computerized ecosystem – primarily populated by reality capture devices – presents forms that vary in both structure and properties. As a kind of visual guide, this article provides an overview of the main 3D data representation methods – 3D point clouds, meshes, parametric models, depth maps, RGB-D, multi-view images, voxels and more – to help users understand the main differences and choose the best method for their specific applications.

## 3D POINT CLOUDS

A point cloud is a set of data points in a three-dimensional coordinate system defined by X, Y, Z coordinates. Reality capture devices and techniques such as photogrammetry and Lidar usually enable the external surface to be described in its three dimensions by a generated point cloud. Point clouds are simple yet efficient 3D data representations. While fast rendering and transformations make a direct inspection of a point cloud handy, they are often not perfectly integrated into commonly used 3D applications with sophisticated functions. However, recent developments show a trend towards better support, even within pure mesh-based rendering platforms such as the Unreal 5 game engine. Still, a standard process is

to derive a mesh using a suitable surface reconstruction technique.

## 3D MODELS

Almost all 3D models can be divided into two categories:

- 1) Solid: These models define the volume of the object they represent. Solid models are mainly used for engineering and medical simulations and are usually built with constructive solid geometry or voxels assemblies.
- 2) Shell or boundary representations (B-Reps): These models represent the surface, i.e. the boundary of the object, not its volume. Almost all visual models used in reality capture workflows, games and film are boundary representations.

Solid and shell modelling can create functionally identical objects. Differences between them are primarily variations in how they are created and edited, conventions of use in various fields, and differences in types of approximations between the model and reality. 3D models can describe a point cloud based on three main strategies: constructive solid geometry, implicit surfaces (+parametric modelling), and B-Reps. The most common 3D models are B-Reps such as 3D meshes.

## 3D MESH

A mesh is a geometric data structure that allows the representation of surface subdivisions by a set of polygons. Meshes are mainly used in computer graphics to represent surfaces, or in modelling to discretize a continuous or implicit surface. A mesh is made up of vertices (or a vertex), connected by edges making faces (or facets) of a polygonal shape. When all faces are triangles, this is called triangular meshing. Triangular meshing is most common in reality capture workflows.

Quadrilateral meshes are often obtained through mesh optimization techniques to achieve more compact representations. These meshes are based on the boundary representation, which depends on the wire-frame model (3D lines simplify the object; a line represents each object's edge in the model). The boundary representation of 3D models is mainly composed of two parts: the topology (organization of elements) and the geometry (surfaces, curves and points). The main topological items are faces, edges and



▲ Figure 1: A 3D point cloud of an abbey acquired in 2014 using photogrammetry or Lidar.

vertices. See Figure 3 for schematization of a simple B-Rep for a cube.

Meshes are a great way to make the geometry of a point cloud explicit, and often enable a significant reduction in the number of points needed as vertices. Besides that, they give a sense of the relationship between objects through the connectivity between the faces. However, meshing is an interpolation of the base point cloud geometry and can only represent the data to a certain degree, linked to the complexity of the mesh. There are many strategies for meshing a point cloud, but they often require users to have some theoretical background and to know which parameters to adjust for an optimal result.

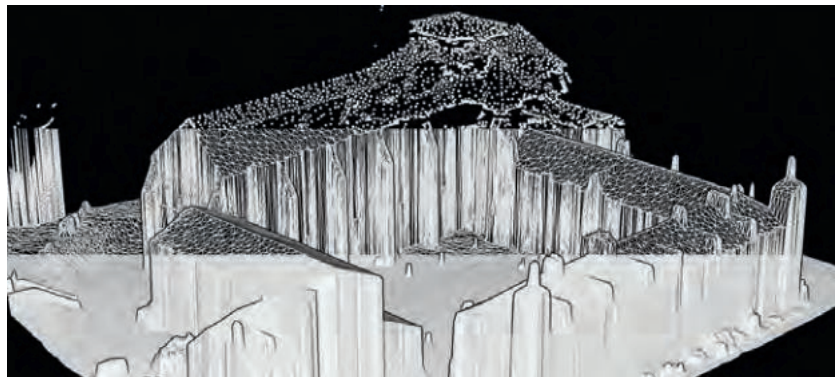
### VOXEL-BASED MODELS

A voxel can be seen as a 3D base cubical unit that can represent 3D models. Its 2D analogy is the pixel: the smallest raster unit. A voxel-based model is a discretized assembly of '3D pixels' and is most often associated with solid modelling. In the case of point cloud data, one can represent each point as a voxel of size  $X$  to obtain a 'filled' view of empty spaces between points. Voxels are mainly associated with data structures such as octrees and make it possible to average a certain amount of points per voxel unit, depending on the level of refinement needed (see Figure 4).

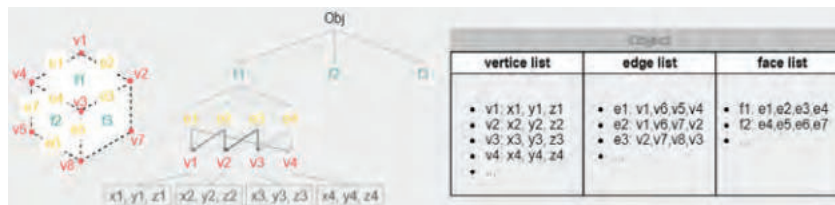
While this is practical for rendering and smooth visualization, it approximates the initial geometry coupled with aliasing artifacts and can give false information if the volume information is used incorrectly. However, the very structured grid layout of voxel models can be convenient for processing tasks such as classification through 3D convolutional neural networks.

### PARAMETRIC MODEL (CAD)

'Parametric' is used to describe a shape's ability to change by setting a parameter to a targeted value that modifies the underlying geometry. This is very useful if you want to model 'walls' merely by setting up their orientation, length, width and height, for example. So parametric modelling is suited to using computing capabilities that can model component attributes with real-world behaviour. Parametric models use a composition of feature-based, solid and surface modelling to manipulate the model's attributes. One of the essential features of parametric modelling is that interlinked attributes can automatically change values. In other words, parametric modelling allows



▲ Figure 2: From top to bottom – the vertices of the mesh, the edges linking the vertices together, the faces formed by vertices and edges (primarily triangular).



▲ Figure 3: The schematization of a simple boundary representation for a cube.

the definition of entire 'classes of shapes', rather than just specific instances. However, this often demands the underlying point cloud geometry to be structured very smartly to break down the model entity into sub-entities (e.g. segments) aggregated in classes.

Parametric models are time-consuming to create but can add a lot of value to the 3D point cloud data, through massive semantic enrichment and additional triggers on the relations between objects constituting the scene.

### DEPTH MAP

The depth map is one type of raster-based point cloud representation. A depth map is an image or an 'image channel' containing information relating to the distance of the points constituting the scene from a single viewpoint. A depth image visualizes the distance of objects from the camera based on the colour of the pixels. Although most geospatial professionals are used to working with RGB images, the simplest form of expressing the depth is to colour-code intensity values on one channel, with bright pixels having the highest values and dark pixels having the lowest values.

This form of point cloud representation is sufficient if superficial information is needed linked to a known point of view. This is the case for autonomous driving scenarios, for example, in order to quickly map the environment at each position through a

360-degree projected depth map. However, the major downside is that it is only possible to work with 2.5D data rather than 3D data, since a depth map cannot represent two different values for one line of sight.

### RGB-D

RGB-D data provides 2.5D information about the captured 3D object by attaching 2D colour information (RGB) to the depth map. Besides being inexpensive, RGB-D enables effective representations of 3D objects for various tasks such as identity recognition, pose regression and correspondence. The number of available RGB-D datasets is vast compared to other 3D datasets such as point clouds or 3D meshes, and RGB-D is the preferred way of training deep learning models through extensive training datasets.

### PROJECTIONS

Projecting 3D data into another 2D space is another representation of raw 3D data where the projected data encapsulates some of the key properties of the original 3D shape. Multiple projections exist where each converts the 3D object into a 2D grid with specific information. Projecting 3D data into the spherical and cylindrical domains has been typical for representing the 3D data in such a format. Such projections help the projected data be invariant to rotations around the principal axis of the projection and ease the processing of 3D data due to the Euclidean grid structure of the resulting projections. However, such representations are not optimal



# GINTEC

NEW CHOICE NEW FUTURE



G20



G30



G30Pro



G20M



M8

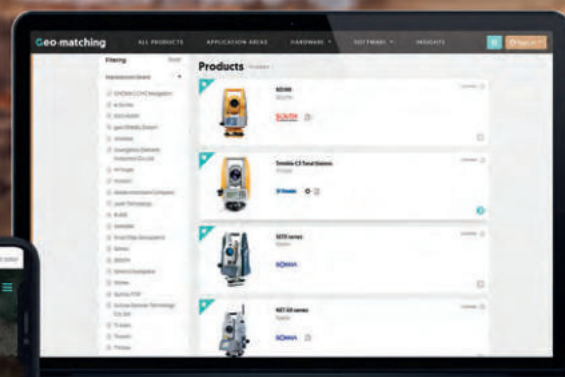
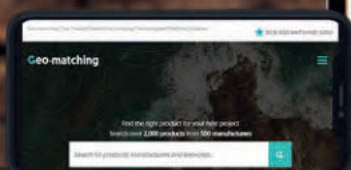


<http://www.gintec.cn>  
E-mail: [overseas@gintec.cn](mailto:overseas@gintec.cn)

# Geo-matching



Your Product Platform for Surveying,  
Positioning and Machine Guidance



✓ Search and compare

✓ Get insights

✓ Connect

[www.geo-matching.com](http://www.geo-matching.com)

for complicated 3D computer vision tasks such as dense correspondence due to the information lost in projection.

### IMPLICIT REPRESENTATION

Implicit representation is the lesser visual component of point clouds. It is a way to represent point clouds by a set of shape descriptors that can be seen as a signature of the 3D shape to provide a compact representation of 3D objects by capturing some fundamental properties to ease processing and computations (e.g. expressed as a .CSV file). For example, global descriptors provide a concise yet informative description for the whole 3D shape, while local descriptors provide a more localized representation for smaller patches in the

shape. Implicit representation is convenient as part of a processing pipeline and eases data transfer among different infrastructures. It is also beneficial for advanced processes that benefit from informative features that are difficult to represent visually.

### MULTI-VIEW

A multi-view image is a 3D representation in which information is accessed by matching several 2D images of the same object from different points of view. Representing 3D data in this manner can lead to learning multiple feature sets to reduce noise, incompleteness, occlusion and illumination problems on the captured data. However, there is no definitive rule for how many views are enough to model the 3D shape. It is important to avoid

incomplete capture of the shape properties while preventing overfitting. Both volumetric and multi-view data are more suitable for analysing rigid data with minimal deformities.

### CONCLUSION

To summarize, when choosing the ideal 3D data representation method for your application, it helps to bear the following in mind:

- 3D point clouds are simple and efficient but lack connectivity
- 3D models such as 3D meshes, parametric models and voxel assemblies provide dedicated levels of additional information but approximate the base data
- Depth maps are well known and compact but essentially deal with 2.5D data
- Implicit representation encompasses all of the above and is beneficial for advanced processes that benefit from informative features that are difficult to represent visually
- Multi-view is complementary and leverages raster imagery but is prone to failure due to suboptimal viewpoint selection. ◀



▲ Figure 4: Example of voxel generalization based on an octree subdivision of the space occupied by the point cloud data.



▲ Figure 5: Depth map of a point cloud based on a top-bottom view.

### FURTHER READING

F. Poux and R. Billen, Voxel-based 3D point cloud semantic segmentation: unsupervised geometric and relationship featurizing vs deep learning methods, *ISPRS International Journal of Geo-Information*, vol. 8, no. 5, p. 213, May 2019.

F. Poux, *The Smart Point Cloud: Structuring 3D intelligent point data*, Liège, 2019.

G. Karara, R. Hajji, and F. Poux, 3D point cloud semantic augmentation: Instance segmentation of 360° panoramas by deep learning techniques, *Remote Sensing*, vol. 13, no. 18, p. 3647, Sep. 2021.

### ABOUT THE AUTHOR



**Florent Poux** is a lecturer, senior scientist (University of Liège) and a mentor in data sciences & machine learning (OpenClassrooms), and spearheads innovation for the French Tech 120 (Geosat). He holds an award-winning PhD in sciences and was decorated with the 2019 ISPRS Jack Dangermond award. Poux aims to transmit knowledge and solve automation problems through various forms of communication and development.

✉ [fpoux@uliege.be](mailto:fpoux@uliege.be)



# Setting the Scene for the Coming Four Years

FIG Congress 2022 marks the end of term for the current 2019–2022 leadership for the President, two Vice Presidents and all ten Commission Chairs. It has been an unusual – and digital – term of office. The last time we could all meet in person was at the FIG Working Week 2019 in Hanoi, Vietnam. This was the first event of the current leadership – and the only one that was held on-location, at least so far. Now we are looking forward to meeting again in person, this year in Warsaw, Poland on 11–15 September 2022.

Last year, the General Assembly was held online. This had both advantages and disadvantages. One advantage was that many members were able to attend. Although the travel situation looks much better this year, the FIG Council has decided to hold one of the General Assembly sessions online to make it possible for many members to attend. This online session will be held most likely on a Sunday a few weeks before the Congress and will include the President's report, commission reports, the financial report and other FIG matters.

After that, it is time to meet in person. The second session will be held in the afternoon of 11 September 2022 in Warsaw, and we cannot wait to meet everyone again in person. This on-site session is called 'Get to know your candidates'. The FIG Council has received nominations from the following candidates:

## Candidates for President for the term 2023–2026:

- Abbas Rajabifard, Surveying & Spatial Sciences Institute SSSI, Australia
- Diane Dumashie, Royal Institution of Chartered Surveyors RICS, UK
- Orhan Ercan, Turkish Chamber of Survey and Cadastre Engineers HKMO, Turkey

## Candidates for two Vice Presidents 2023–2026

- Brian Davies, Canadian Institute of Geomatics CIG, Canada
- Daniel Steudler, GEOSUISSE, Switzerland
- Qin Yan, Chinese Society for Geodesy Photogrammetry and Cartography CSGPC, China



▲ Busy time at the registration desk in 2019, Hanoi, Vietnam – three years ago, and the last time the main FIG event was held in person.

- Winnie Shiu, National Society of Professional Surveyors NSPS, USA

The elections for the two Vice Presidents will start immediately after the second General Assembly session. The election for President will start on Tuesday 13 September 2022. All member associations eligible to vote will appoint an official delegate and the voting will, like last year, be held online.

The opening ceremony followed by the welcome reception will be held immediately after the General Assembly session. Three further days of intensive learning, exchange and networking in a variety of technical, special and other sessions await all attendees.

The highlight of each day will be the keynote sessions that will cover the following topics:

- Geospatial Excellence for Better Living – Digitalization and Modern Surveying and Cadastre in a Post-COVID-19 Era
- Urban Rural Land Linkages
- Land Governance in support of the 2030 Global Agenda

- Our Next Generation – on Mentoring and Women's Land Rights
- Mapping the Plastic
- Technology and Visualization for the Future

The third and final General Assembly closes the Congress on 15 September with a final session in which the result of the elections will be published.

Do not miss this opportunity to meet your international colleagues and new peers and friends – finally again after three years of screen presence.



**More information**  
[www.fig.net/fig2022](http://www.fig.net/fig2022)



# Lasers and Cold Atoms in Space and on the Ground

The International Association of Geodesy (IAG) launched the Novel Sensors and Quantum Technology for Geodesy (QuGe) project in 2019. This project aims to ensure that the Earth and planetary sciences benefit from the vast potential of novel technologies based on quantum mechanics and relativity. In particular, ultracold atom accelerometry, high-precision laser ranging between satellites and relativistic geodesy with optical clocks are very promising approaches that will overcome problems of classical gravimetric Earth observations. With such advances, we will have the best tools available not only to understand geophysical processes, but also to better navigate on Earth and in space and to discern the fundamental physics that underlie our world.

QuGe fosters synergies in technology development, space mission requirements and geodetic and geophysical research by organizing workshops and conference sessions and by providing a platform where experts from different fields can collaborate. QuGe emphasizes three pillars of development.

The first focuses on investigations of ultracold atom technologies for gravimetry on the ground and in space. Recent achievements should enable the production of cold atom gravimeters on a large scale, making it possible to establish dense networks of absolute gravimetric instruments for continuous monitoring, for example of aquifer and volcanic systems. Measuring Earth's gravity field from space requires precisely monitoring the changing distance between paired orbiting satellites – as in the GRACE-FO mission. However, the satellites undergo forces other than changes in Earth's gravity field, including aerodynamic drag. Currently, these other forces acting on the satellites are measured using less accurate electrostatic, suspended-mass accelerometers. Quantum accelerometers could greatly support navigation and inertial sensing on the ground and in space, and will serve as a basis for developing the next generation of gravity-monitoring space missions.

The second pillar of QuGe focuses on improving technology for laser interferometric

ranging between spacecraft to achieve nanometre-scale accuracy, which will become the standard for future geodetic gravity-sensing missions. High-precision laser ranging has been applied successfully in the current GRACE-FO mission, demonstrating the superior performance for intersatellite tracking of laser interferometry over traditional microwave-based ranging methods used in the original GRACE mission.

The third pillar focuses on applying general relativity and optical clocks to improve measurement reference systems. By comparing ticking rates of accurate clocks placed at different locations on Earth, chronometric levelling could realize a global height reference with one-centimetre

consistency. Optical clocks could also ensure better results in GNSS, Very Long Baseline Interferometry experiments, or gravitational wave detectors. They could also allow the testing of the constancy of the fundamental constants of physics, and even make it possible to redefine the second.

## More information

- <https://quge.iag-aig.org/>
- Van Camp M., Pereira dos Santos F., Murböck M., Petit G., Müller J., *Lasers and Ultracold Atoms for a Changing Earth*, EOS, 103(1), 32-37, doi:10.1029/2021E0210673, 2022.



▲ This absolute gravimeter developed by the SYRTE (Time and Space Reference Systems) department at the Paris Observatory uses ultracold atom technology to make high-precision measurements of gravity. (Credit: Sébastien Merlet, LNE-SYRTE)



# Actionable Map Ethics



Map ethics may seem a strange topic for a column. After all, should we not expect that ethics, and – in the case of cartography – map ethics, be the most common thing in the world? Something that would automatically be, due to the professional attitude of cartographers. Isn't this what makes maps so authoritative?

Well, times have changed, to the extent that it is necessary to devote a column to map ethics. The most important change is that making maps, and more importantly distributing maps, has become so much easier. These days, simple tools exist that allow anyone to make a map and disseminate it through social media, reaching millions.

This democratization of cartography is positive, but there are two sides to every coin, and the message of a map can also be designed in a negative way. Maps have been and still are used for propaganda purposes, and Monmonier's book *'How to Lie with Maps'* present other issues. Of course, no single map is perfect. Maps present only a particular perspective of reality, because they are selections and abstractions of this reality. Map-makers, even when following cartographic design guidelines, must still make many choices, which usually lead to informative and authoritative maps.

As we witness in today's society, people create their own arguments when they believe that their own perspective is not well represented. This now affects cartography too, where politicians draw their own truth. Remember Trump's 'Sharpiegate' in 2019, when he 'annotated' a weather map showing the track of Hurricane Dorian to strengthen his own arguments. Not all manipulations are as easily recognizable, however. Today, it is even possible to use tools to create deep fake maps and satellite imagery. However, maps do now and then contain fake elements that are introduced to be able to prove that the map was illegally copied, but these are usually minor elements that do not affect the map user.

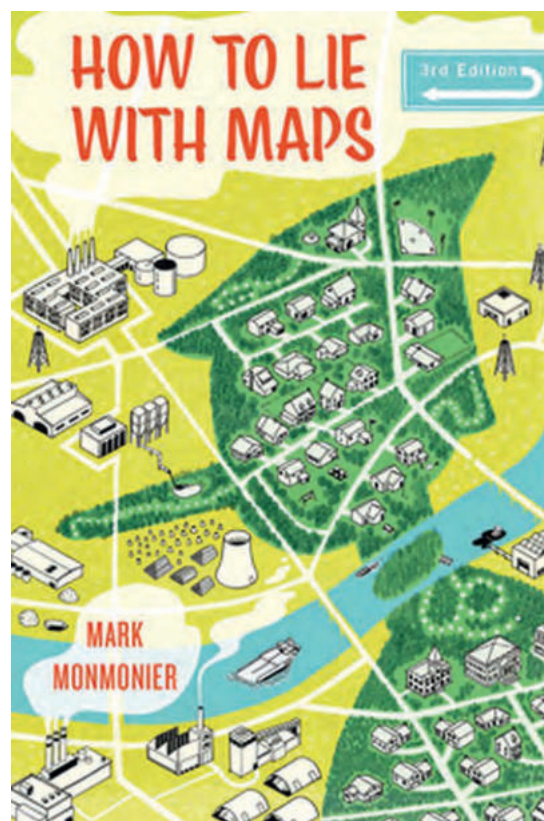
Can we still trust maps? Do maps actually represent the truth? And what has ethics to do with this? According to Wikipedia: "Ethics seeks to resolve questions of human morality by defining concepts such as good and evil, right and wrong, virtue and vice, justice and crime."

However, it is important to realize that context, culture and time influence these. So, while ethics may not provide answers, awareness is important, which is why ethics is currently high on the agenda of the ICA-endorsed conferences EuroCarto and AutoCarto.

A group of Esri cartographers recently proposed the 'Mapmaker's Mantra'. They suggest that cartographers should consider four points to ensure that maps remain authoritative: 1. Be honest and accurate (communicate information correctly and clearly); 2. Be transparent and accountable (open about sources and decisions); 3. Minimize harm and seek to provide value (aim at equity, inclusion and empathy, and design maps to increase understanding); 4. Be humble and courageous (admit when you are wrong or lack knowledge). While these cartographers are not the first to pay attention to ethics, messages spread easier and wider today. For instance, in 2017 the British Cartographic Society incorporated a code of conduct using words such as honesty, integrity, competence, respect and responsibility.

It is impossible to disagree with the Mapmaker's Mantra, and cartographers should keep these points in mind while working. The question is: how? Agreeing is not enough, although creating awareness among colleagues and, just as importantly, incorporating the Mantra into curricula would be a step forward. But how can we make the Mantra actionable? I have a suggestion. The first, second and third points of the Mantra could be incorporated in a map by means of annotations. This would allow map readers to experience the decisions made during the design process, and therefore improve their understanding of what they see. It would therefore make our cartographic knowledge available to the user.

The annotation should be available on call, similar to a legend. The illustration, a map of Africa representing one of the SDG indicators, shows how it might work. One suggestion is to use five categories: the data, the visual representation or map type, the story the maps intends to tell, the functionality of the visualization environment, and ethics. Selecting the data label could show the highest, lowest, average or median values. The representation label could explain the map type and point to



▲ Cover art from *How to Lie With Maps* by Mark Monmonier/University of Chicago Press.

its strengths and weaknesses. The story label could provide background and explain the distribution. The functionality label could help to guide the user to the interactivity options, and the ethics label could point to the data source (here UN data) and explain the effect of the map projection, for instance.

These are experimental ideas on how to make the Mapmaker's Mantra more actionable. Its implementation in practice requires more discussion and user research, but in the end it should lead to map users who can decide for themselves whether or not to trust a map.

**More information**  
[www.icaci.org](http://www.icaci.org)



# A60 Pro

## IMU-RTK GNSS Receiver

- Multi-channel technology (GPS, Glonass, Galileo, Beidou)
- Built-in premium IMU for calibration-free tilt survey (up to 60°)
- Supports WebUI wireless management, including settings, upgrading, downloading, etc.
- Smaller, lighter, and more portable
- Professional FOIFPad Android field software





# Compact. Powerful. Durable.



## Galaxy G3

Almighty Pocket RTK.

- A pocket-size but powerful receiver
- 18 working-hour makes recharge effortless
- Fixed in seconds with superb satellites tracking
- BDS-PPP enabled to work without real-time correction



SOUTH Surveying & Mapping  
[www.southinstrument.com](http://www.southinstrument.com)

**SOUTH**  
Target your success