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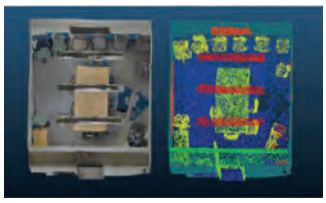
# Digital Transformation Works with Point Clouds



Digitising Reality: Automated 3D Point Cloud Data Processing Using AI

Downtown Dublin as a Lidar Point Cloud


Seeing the future: AI, BIM and Digital Twins

The Art of BIM Implementation

 SEE PAGE 3

GW GEOMATICS WORLD

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COVER STORY
The cover image shows a group of students on the Survey School Surveying course.

# CONTENTS



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**Next Issue:** 7 May
**Copy Date for Editorial:** 6 April
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*Grow your business!*

# TECHNICAL B2B MARKETING FOR SMART GEOSPATIAL COMPANIES

**WWW.GEOMARES-MARKETING.COM**

BY IAN DOWMAN

# The Spring Issue of GW Heralds Changes and Opportunities

**Welcome to the first issue of Geomatics World in 2020. As announced in the last issue of GW, we will be publishing only four issues in 2020, which will be designated Spring, Summer, Autumn and Winter. So, appropriately, this is the Spring issue, heralding, we hope, reinvigorated content and new opportunities for all readers. This does not imply that we necessarily believe that Brexit will bring a brighter future for geospatial, but we live in hope.**

This issue does, however, show what the future might hold. Three of our articles focus on artificial intelligence (AI) and the potential benefits of a digital transformation for businesses, which could be passed on to users. The vision was seen at the Digital Construction Week, reported here, which was dominated by terms such as digital twin, cloud computing and digital analytics, and, of course, BIM. In practice, the articles on Digitising Reality and Downtown Dublin as a Lidar Point Cloud show that AI can make extracting information from data more efficient when helped by the computing power available in the cloud, but it is important to remember that human involvement to check and provide quality control is essential.

James Gregory from Plowman Craven sets out the implementation of standards for BIM and discusses the advantages of BIM to a business; he also discusses the adjustment to the culture and practice necessary to get the maximum benefit.

As we write, the Coronavirus is rampant in China and spreading around the world; geospatial data and techniques are helping to map and visualise the spread of the virus and drones are being used to distribute medicine. In addition, analytics using AI and machine learning are being used to help organizations learn from past events and create new knowledge quickly from the millions of data points being generated in this outbreak. But, on the downside for our profession, we have to wonder whether restrictions on movement might affect conferences and other meetings planned in the next few months, especially as our Chinese colleagues now play such a large part in geospatial activities.

Coronavirus permitting, there are a number of international events to look forward to in 2020. In April, the Ordnance Survey is holding the 'Cambridge Conference', linked to the 6th High Level Forum on United Nations Global Geospatial Information Management (UN GGIM), to be located near London. This gathering will bring together leaders of national mapping organizations and other experts in the area of geospatial data. This will be followed in May by the FIG Working Week, near to home in Amsterdam, closely followed by GeoBusiness in London. The ISPRS quadrennial congress will be held in Nice, France, in June; another opportunity for UK involvement, without the need for a long-haul flight. In November, the COP26 climate conference will be held in Glasgow. In the context of looking after our environment and sustaining life on our planet, it is important to remember the role of the oceans, as noted by Gordon Johnston in his column. Data from and relating to the hydrographic sphere is an important component of geospatial data, subject to the same issues of access and management.

Ian Dowman, editor of Geomatics World

These events demonstrate the role of the UK in the international geospatial arena and, in some cases, provide the opportunity for UK practitioners and scientists to contribute to debates on the use of geospatial data and learn from reports on international activities.

During 2020, we will be continuing to publish a mix of articles and reports on topics of relevance to a wide range of people making use of geospatial data. We always welcome suggestions for articles and indeed offers of interesting articles and we also look forward to your comments on our content.

Ian Dowman, Editor

PLEASE NOTE OUR NEW ADDRESSES:
The editor welcomes your comments and editorial contributions by e-mail: i.dowman@ucl.ac.uk

## UK SATELLITES TO HELP LEAD THE FIGHT AGAINST CLIMATE CHANGE

The British government has announced backing for ground-breaking research analysing satellite images that will better predict the future impact of climate change in towns and cities and inform future government action. A new £5 million satellite data centre involving the Universities of Edinburgh and Leeds will use cutting-edge satellite technology to help combat climate change, including helping lower the risk of people being affected by flooding. The data centre will bring together 50 of the UK's brightest and best PhD researchers to help solve climate change. Measurements from satellites on rising sea levels, greenhouse gases and shrinking glaciers and forests will help provide policy makers, government and industry with the data and knowledge they need to better understand the impact of climate change and make future predictions.
https://bit.ly/2SCWEUP

▲ *Sentinel-1 amplitude image of ship tracks in the English Channel. (Courtesy: ESA)*

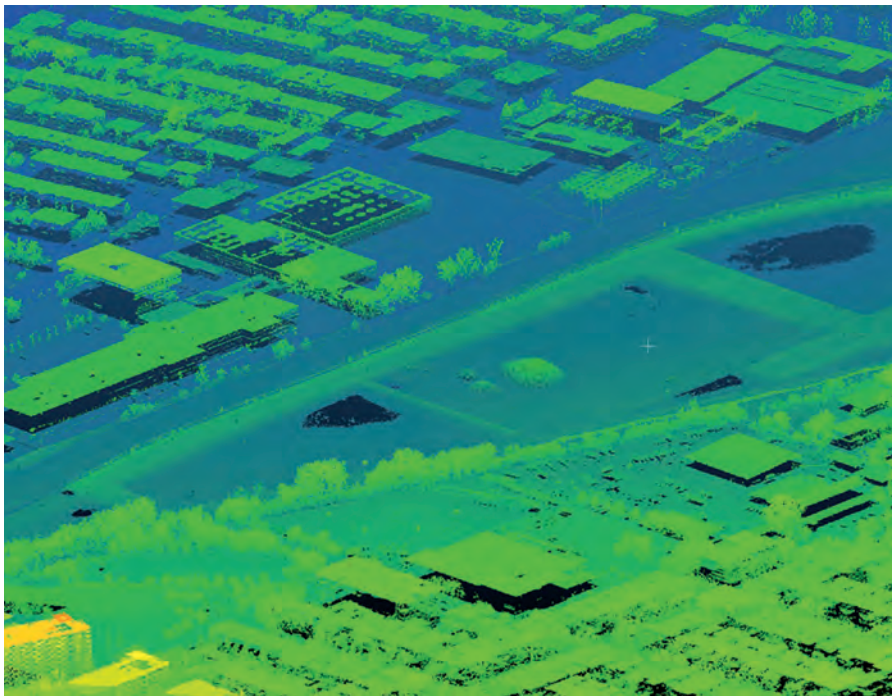
## PENN STATE-LED TEAM TO STUDY DIGITAL MODELLING ON CAPITAL PROJECTS

It takes a lot of data to move a large-scale, costly building project from design to reality. Digital modelling, otherwise known as Building Information Modelling, or BIM, increases construction efficiency and saves time and resources on building projects by compiling large amounts of project data into a well-organized central repository. John Messner, Charles and Elinor Matts Professor of Architectural Engineering at Pennsylvania State University (Penn State), is leading a US$240,000 Construction Industry Institute (CII)-funded project to study building projects that have utilised digital modelling and to compile recommended best practices for organizing, retrieving and analysing project data, which often includes a three-dimensional model and other disparate sources of facility information.
https://bit.ly/31HHBh3

▲ *Digital construction: Bentley's SYNCHRO XR and Microsoft HoloLens 2 bring the benefits of mixed reality to construction sites.*

## SIMACTIVE ADDS LIDAR TO POINT CLOUD PROCESSING SOLUTION

In response to the growing use of Lidar, photogrammetry software developer SimActive has integrated a new Lidar workflow in its Correlator3D product. The capability enables users to import a point cloud in the software and to perform registration with an image dataset. Using Lidar as control eliminates the need for traditional ground control points (GCPs) during image processing. Registration occurs during aerial triangulation, leading to a precise alignment of imagery with the Lidar data. Following this, Correlator3D can output colourised point clouds as well as seamless orthomosaics. "Removing the need to manually tag GCPs facilitates the integration of Lidar data with imagery," says Dr Philippe Simard, president of SimActive. "Our clients can benefit from different data sources, with perfect co-registration."
https://bit.ly/3bt5EER



▲ *SimActive has introduced a new Lidar workflow.*

## TESTING AREAS FOR DRONES NEEDED TO PREVENT 'BOTTLENECK' TO GROWTH

▲ *Examples of desirable drone technology testing locations also include forests, remote coastal areas and ports, through to residential areas and other dense urban environments.*

One of the UK's leading drone experts has urged British property owners and business leaders to leverage the opportunity of their under-used land for drone testing, to help accelerate the rate of growth of the UK drone industry, in the face of what he described as an emerging 'bottleneck' to growth. Robert Garbett, founder of the UK Drone Delivery Group, which is the first industry initiative to provide guidance on the steps required to enable accelerated commercialisation of the UK Drone Industry, stated: "There is a current unnecessary 'bottleneck' in the evolution of the drone industry and this primarily lies in the lack of controlled testing locations which can provide trial areas and safe environments to accelerate the development of drone technology, help to shape its standards, and ensure appropriate but non-constricting regulations".
https://bit.ly/2HdR9ac

## AERIAL PHOTOGRAPHY HELPS TO TRANSFORM POLICING IN NORTH YORKSHIRE

The latest aerial photography is helping the police in North Yorkshire, England, save time and resources and transform policing in the largest county in the UK. Supplied by Bluesky International and Getmapping under the Aerial Photography for Great Britain (APGB) contract with the Geospatial Commission, the high-resolution imagery is widely used across the force. Accessed via desktop GIS and mapping software, the up-to-date photography is benefiting operations and day-to-day services with applications including missing person searches, surveillance planning, anti-social behaviour management and crime investigations. Complementing existing mapping resources, including Ordnance Survey MasterMap data and the recently introduced what3words geocoding system, the APGB imagery provides additional detail and real-world context.
https://bit.ly/2UI8mR2

▲ *"The APGB imagery gives Control Room and frontline staff choices they did not have before."*

## PHASE ONE INDUSTRIAL AND AI-SURVEY SIGN PARTNER INTEGRATOR AGREEMENT

Phase One Industrial, a world-leading provider of medium-format metric cameras and imaging solutions for aerial applications, has signed an agreement with AI-Survey, a developer of UAS survey packages, services and tailor-made solutions. Together, these companies' high-end products are opening up new opportunities in drone-based high-accuracy mapping and inspection markets. Under this agreement, AI-Survey will support Phase One Industrial's iXM range of cameras in the UAV market for high-accuracy mapping and inspection. AI-Survey offers fast and efficient, simple and reliable UAS solutions tailored for geodesists with millimetre imaging results.
https://bit.ly/3bw4wAb

▲ *Phase One's Drone Solution.*

## BLUESKY LAUNCHES METROVISTA 3D CITY MODELS ONLINE

Highly accurate, UK citywide 3D models are now available to view and download from Bluesky's online Mapshop. The geographically accurate, photo-realistic MetroVista mesh models are available in a variety of formats ready for use in 3D GIS, CAD and other modelling software, as well as visualization, gaming and virtual reality workflows. Captured using Leica's, and the world's first, large format imagery and a Lidar hybrid airborne sensor and generated in Skyline's PhotoMesh software, the Bluesky MetroVista datasets of major UK cities are available online, offering a compelling alternative to traditional photogrammetrically-produced models.
https://bit.ly/2Skn3Ip

▲ *Highly accurate, UK citywide 3D models are now available to view and download from Bluesky's online Mapshop.*

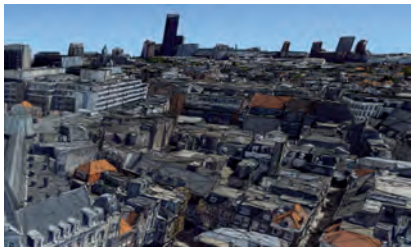
>

## NEW GUIDE HELPS FIND AND CLASSIFY GEOSPATIAL DATASETS ACROSS SEARCH ENGINES


▲ *Search Engine Optimisation (SEO) for publishers: Best practice guide.*

The UK Geospatial Commission and its six partner bodies have released 'Search Engine Optimisation (SEO) for publishers: Best practice guide' to make it easier to find and classify geospatial datasets across all search engines. This is the second in the series of guides to improve discovery and usability of geospatial data, after the publication of the 'Linked identifier schemes: Best practice guide' last year. The guide has been created because most users seek out geospatial data using common search engines and, at the moment, these are not necessarily finding or prioritising the authoritative national datasets. By following the tips in the guide, data publishers can make their data easier to find by users who can then devote more of their time to joining it with other data sets and carrying out analysis to provide insight and support better decision-making.
https://bit.ly/2w7TMYJ

## HEXAGON INTRODUCES VISUALIZATION PLATFORM FOR ACCURATE DIGITAL REPRESENTATION OF REAL WORLD

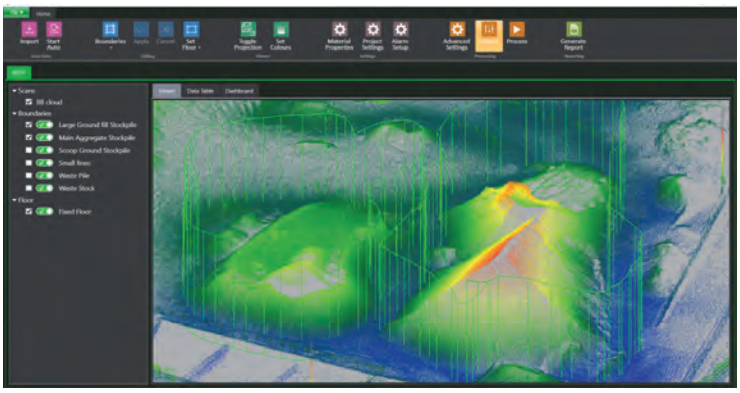


▲ *The HxDR Supermesh is the combination of multiple types of 3D datasets.*

Hexagon has announced the introduction of HxDR, a new cloud-based, digital-reality visualization platform. HxDR creates accurate digital representations of the real world through the seamless combination of reality capture data from airborne, ground and mobile sensors. Users can then leverage the complete, accurate and precise replicas to visualize and share their 3D design projects and models within a real-world context. For the first time, airborne imagery and laser scans, indoor and outdoor terrestrial scan data and mobile mapping data can be seamlessly combined using HxDR. Users simply drag and drop their reality capture files into HxDR and the automated meshing function does the rest. Or, they can license real-world replicas from Hexagon's exclusive and growing 3.6 petabyte collection of towns, cities and landscapes.
https://bit.ly/3byxaRx

## NEW GEOSLAM SOLUTION SIMPLIFIES STOCKPILE VOLUME ANALYSIS

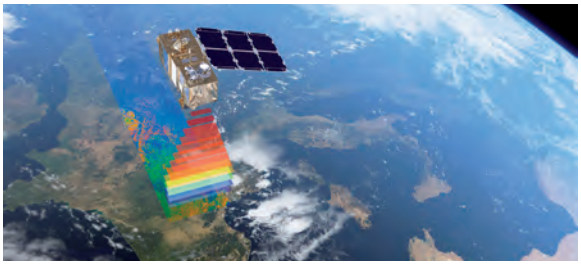
3D mapping and monitoring specialist GeoSLAM has announced a new and innovative product to enable mine operators to quickly and easily build high-density 3D volumetric models within minutes. GeoSLAM Volumes is an end-to-end way to calculate stockpile mass, instantly turning stockpile point cloud data into actionable 3D information for quick decision-making. This is achieved using the company's handheld Zeb Horizon SLAM (simultaneous localisation and mapping) scanner, which can be utilised on foot or with a UAV. Using lightweight scanners, the solution can capture and calculate complex data, such as the weight and bulk of stockpiles, up to ten times faster than traditional tools. GeoSLAM Volumes enables volume calculations to be calculated as frequently as required at all stages of the supply chain, without disruption to site activity or compromising employee safety. Designed for use in mines and quarries, but also suitable for use in a range of sectors such as agriculture, recycling centres or ports, GeoSLAM Volumes fully-mobile technology is adaptable for untrained staff to use in any environment. In addition, the technology does not require GPS, opening up hazardous or hard to reach areas that are ordinarily off-limits using traditional surveying methods.
https://bit.ly/2UNQLXX



▲ *GeoSLAM Volumes instantly turns stockpile point cloud data into actionable 3D information.*

## NEW SATELLITE SERVICES COMPANY PROVIDES SMART DATA FOR THE PLANET

Advances in technology for observing the Earth from space have resulted in the formation of a new company that will bring a range of innovative satellite intelligence and data services to market. 4 Earth Intelligence (4EI) has pioneered the use of satellite data for smart monitoring and analysis, creating city, region and countrywide data solutions for applications such as air quality, asset management, ecology and urban heat monitoring. With offices in Bristol, UK and in Abu Dhabi, UAE, 4 Earth Intelligence has been established to focus on new sectors and technical innovations using machine learning and artificial intelligence to provide smart data, in particular for global environmental applications. "Over the years, our technical team has been at the forefront of the development of new techniques in machine learning and artificial intelligence, used to process data collected by satellites that are equipped with increasingly sophisticated sensors," says David Critchley, CEO, 4 Earth Intelligence. "Having witnessed an exponential increase in the demand for new solutions to address a variety of issues affecting the planet, we will lead the way in the use of space and remote sensing technologies to address challenges such as climate change, pollution and population pressure."
https://bit.ly/31HyrAU



▲ *Copernicus Sentinel-2 satellite. (Courtesy: ESA/ATG medialab)*

## THE RACE TO RESURFACE SILVERSTONE

Lead contractor Tarmac, along with its industry leading road planing business, NRP, racetrack specialist Dromo and project partner Topcon Positioning Group, combined expertise with innovative surveying and measuring technology to ensure a smooth result at the UK's premier racetrack.
The Silverstone racetrack in Northamptonshire, England, has been a cornerstone of British motor racing for many years, having first hosted the British Grand Prix in 1948 and holding the title as its sole home since 1987. It was also the venue for the very first British motorcycle Grand Prix in 1977 and has retained the annual race for almost a decade.
Such a venerable history has earned the circuit high praise among some of the industry's most influential names. After Silverstone recently secured the British Grand Prix for a further five years, five-time world champion Lewis Hamilton called Silverstone "the ultimate race circuit", saying that if Formula 1 were to ever lose Silverstone, "it would lose a lot of its essence".
A first-class circuit deserves a first-class surface, and in the lead-up to the hotly anticipated 2019 Grand Prix and MotoGP races, it was time for Silverstone to be resurfaced for the smoothest ride possible. There needed to be no bumps whatsoever and no opportunity for standing water, which can lead to dangerous aquaplaning. However, with only a couple of weeks to completely replace the track's surface, it was clear that if the team were to get past the finish line on time, they would need to use the very latest paving technology.
https://bit.ly/320KjhT

▲ *Rather than simply replacing the top layer, the track required a complete redesign.*

BY JAMES KAVANAGH

# Consultations and New Information

James Kavanagh, Director of the RICS Land Group.

**Even during these dark early days of 2020, there are always some things to look forward to. For example, the traditional geo evening lecture session will feature an extra lecture on Thursday 21 May in conjunction with London Geospatial Week https://www.londongeospatialweek.com/. The January and February geo lectures featured What3Words (UK geo forum) and a joint offshore/marine lecture in February. All of the 2019/20 lectures have been well attended and I would encourage people to come along to the May lecture – more information at https://www.rics.org/uk/events/conferences-seminars/rics-geo-evening-lectures/.**

## NEW RICS 'INSIGHTS' LANDING PAGE

The RICS website has developed a bit of notoriety for being difficult to navigate and, although the most recent redesign (2018) has not helped matters, we have been working hard to iron out some of the more obvious failings. One recent change has been the re-establishment of sector landing pages and the building of an 'insights' landing page (separate from RICS Research) https://www.rics.org/uk/news-insight/research/insights/ RICS Insights are cross sector and delve into subject areas that require a bit more explanation to a broad professional readership. Although they do not carry regulatory weight they do offer RICS members, and others (they are free and open to all), an easy to access knowledge base. Geospatial surveying and related issues such as BIM and proptech are well covered with the latest output on Drones https://www.rics.org/uk/news-insight/research/insights/drones-applications-and-compliance-for-surveyors/ being joined by a new Blockchain insight in spring 2020.

Speaking of Drones, the Air Traffic Management and Unmanned Aircraft Bill [HL] 2019-20 https://services.parliament.uk/Bills/2019-20/airtrafficmanagementandunmannedaircraft.html is wending its way through the House of Lords. One to keep an eye on as this bill makes provision for airspace change proposals and the licensing regime for air traffic services under Part 1 of the Transport Act 2000, to confer police powers relating to unmanned aircraft and requirements in Air Navigation Orders and to provide for fixed penalties for certain offences relating to unmanned aircraft. Geospatial surveyors have fully embraced Drone/UAV technology and protocols, but it is always wise to make sure that you are fully compliant with regulations and CAA requirements.

The new RICS Imagery 6th edition Guideline Note is due for release in autumn 2020 and the open consultation is due in summer 2020. This new edition will encompass Drone/UAV output as well as traditional aerial imagery and Earth observation (EO) geospatial output. One to watch out for.

## PROFESSIONAL GROUPS PG2020

More information on this RICS initiative can be found at https://www.rics.org/uk/surveying-profession/global-professional-network/professional-groups/

PG2020 has reached its endgame and the RICS Geomatics Professional Group Board had its final meeting (of this incarnation) in late November 2019. RICS has 17 professional groups which will remain in place, but expert member boards will move to four (land which includes geomatics, property, construction and valuation) advisory forums. Working groups, panels, digital communities and forums will remain, and it is essential that RICS retains sector authority (the primary purpose of the RICS Royal Charter).

Geomatics members can join our new online digital communities by sending a quick email to kandrews@rics.org  A history of RICS land & hydrographic surveying (geomatics) and the various boards that have served RICS throughout the 72-year history of the division/professional group can be downloaded at https://communities.rics.org/connect.ti/Wikigeo/view?objectId=41995653

## GNSS

A very interesting development in the world of GNSS is the recently initiated EU Horizon 2020 project 'Galileo improved services for cadastral augmentation development on-field validation' (GISCAD-OV) and is focused on the use of Galileo GNSS capabilities and 'measured' cadastral surveying. The concept of a

'virtual' measured cadastre has been in the minds of many, almost since the advent of survey grade GNSS availability, and with Galileo offering cadastral level 'repeatability' survey accuracy, the need for physical monumentation has had its day. The 'measured' cadastre of most nations leaves a lot to be desired with a misconnect with national mapping (the cadastre can be quite localised) and non-alignment with GNSS/ Geodetic systems. This is an exciting initiative and has enormous regional and global potential.

The UK (even post Brexit) will have access to this system and GNSS is being increasingly used when determining boundaries during a dispute resolution process. GISCAD-OV received a € 3.4 million European Commission H2020 grant to research into ways to overcome current limitations within the system. In doing so, the project paves the way for the exploitation of further opportunities in cadastral land surveying. https://www.tudelft.nl/en/2019/bk/galileo-satellites-for-better-cadastral-land-surveys/ and https://www.clge.eu

## ORDNANCE SURVEY GEODESY CONSULTATION AND UPDATE

OS GB have started the geodetic conversation on future upgrades to the UK geodetic framework and coordinate reference systems (CRS). The full and very interesting document can be downloaded @ https://www.ordnancesurvey.co.uk/documents/resources/policies-geodesy-positioning-services.pdf and makes excellent reading. A brief extract from the document is given below and RICS (along with the Survey Liaison Group) will make sure to respond in due course.
The RICS GNSS 3rd edition 2020 Guidance Note review and upgrade is underway and we hope to be in open consultation during autumn 2020.

## BOUNDARIES

Our old favourite, the 'Property Boundaries (Resolution of Disputes) Bill [HL] 2019-20' – (Lord Lytton's bill), has been introduced into the House of Lords. The bill itself is at https://publications.parliament.uk/pa/bills/lbill/58-01/030/5801030.pdf and explanatory notes at https://publications.parliament.uk/pa/bills/lbill/58-01/030/5801030en.pdf

RICS Boundaries 4th edition 2020 Guidance Note is underway and is planned to launch at the traditional autumn/winter roadshows. The new edition will integrate the new 'boundaries dispute resolution protocol' https://www.propertyprotocols.co.uk/the-boundary-disputes-protocol and issues raised in recent case law (Lowe v Davis 2018, Murdoch v Amesbury 2018). There are also plans for a specific Scottish and Irish version.

## AGREEMENT BETWEEN RICS AND ACLS

The Royal Institute of Chartered Surveyors (RICS) and the Association of Canada Lands Surveyors have an agreement in place to allow direct entry for ACLS professional members to the MRICS designation. MRICS is an internationally recognized standard for surveyors and may be useful for our members working internationally.

For more information, please contact membershipamericas@rics.org or visit www.rics.org
With that, I'll sign off for now but do contact me on jkavanagh@rics.org if you need any further information. ◂

## COORDINATE REFERENCE SYSTEM DEFINITION AND REALISATION

CRS - 1. With the almost ubiquitous use of satellite-based positioning methods, there is a certain amount of appeal in having a mapping coordinate system that is directly compatible with ETRS89 and other global systems, i.e. one that no longer requires the OSTN15 transformation to link OS Net positioning with mapping. In addition, the integration of Building Information Models (BIM), GNSS, national mapping and engineering works, for example, is creating issues around compatibility. To this end, a consultation will start on the benefits and disadvantages to users of a possible OSGB36 National Grid replacement.

CRS - 2. There is a trend for national height systems to move away from "traditional" sea level / levelling based networks to ones based on GNSS measurements, in conjunction with an accurate geoid model and with a "W0" datum value that best approximates mean sea level and also aligns to regional and global height systems. The advantages of such a system to users in GB would be a single, consistent height datum available across the entire country, including on islands that currently have their own datum. Also, heights in this system would be compatible with others in Europe and maybe globally. A consultation will be carried out on the full benefits and disadvantages to users of implementing such a system. We aim to begin the initial consultation by the end of 2020.

CRS - 3. To assist users in the "metre / few decimetre" positioning arena, a clear policy and action plan will be produced to deal with the effects of the increasing WGS84/ETRS89 separation. The plan will be published by the end of 2020.

CRS - 4. Provide increased information to users on the quality of the ETRS89 realisation through time series, deformation analysis, etc.

CRS - 5. Refresh OS Net website to include a repository of technical/ geodetic information including historic documents.

CRS - 6. Improve user access to transformation through, for example, an RTCM broadcast version of OSTN15.

BY GORDON JOHNSTON

# Looking Forward to the Next Decade

Gordon Johnston, Chair of the RICS Geomatics Professional Group. Gordon welcomes your comments and thoughts so please email to the following address geochair.rics@gmail.com

**Welcome to a new decade. As the years progress towards 2030, the decade can bring a lot of challenges and opportunity for the profession across a wide spectrum of activities.**

The UN's growing awareness of the importance of our oceans and seas will hopefully develop further into real sustainable actions and outcomes, which should require further reliable and cost effective data acquisition and data management solutions. I believe the general levels of underinvestment in the offshore and hydrographic sector will be rectified in order to progress our knowledge of this least well-known frontier. Pressure is being brought to bear on countries and organisations to develop and implement serious and sustainable management plans for the seas and oceans. Our knowledge of these environments is increasing, but so too is the need to understand how the seas and oceans can sustain us. Some regimes are more reticent about sharing data and information as it is seen as an advantage and therefore of strategic value. Intellectual rights, inventions and data analytics will be put under pressure as new ideas and applications develop. So too will the release and access to spatial data itself which can often be withheld under the threat of some form of a security risk. Of course, the whole momentum of new technologies and their associated applications to enable their uptake, use and implementation of data and spatial data in particular will continue to emerge and challenge some of these perceptions. The new and exciting initiatives are being implemented across an ever widening community of users which I think offers many opportunities.

## DEMOCRATISING NEW TECHNOLOGY

Lidar, drones, satellite derived data sets for analysis and interpretation, BIM and GIS integration plus the appearance of Big Data and Analytics all feature in recent spatial and geospatial developments. Patents filed by numerous big technology companies have shown a trend towards spatial sensor and spatial-based data analysis which is probably a sign of how important and strategic spatial data and information has become. It is also likely that this interest and focus will not last, but tools and data will be socialized, tooled and integrated into various mainstream and general applications where they will be all but unrecognisable. Our profession's niche use of thermal imaging, Lasers, satellite imagery or 3D structure from motion will likely be surpassed through the broad use of these technologies for future applications.

## CREATING A SKILLED LABOUR FORCE

So for the developers and technologists there are, I believe, many opportunities. What I think will be much more of a challenge is the creation of a skilled labour force. Where will the surveyors, geospatial scientists, and spatial data specialists come from? The ongoing efforts to promote and develop a sustainable Geospatial education at tertiary level with apprenticeships, undergraduate and postgraduate courses must continue if the smaller boutique courses that offer real opportunities to the students and provide crucial skills are to survive. These specialist professional courses must be supported in order to provide our communities and society with the necessary skills to develop sustainable wealth. This will be a challenge for the decade ahead of us.

Around the world, the opening up of spatial data platforms, big data initiatives and internet and cloud-based Mapping as a Service (MaaS) can largely be seen as positive. The challenges of a skilled work force remain, as do the potential for cyber security breaches and nefarious acts based upon spatial data intelligence. How can we develop and promote on the one hand the access and availability of spatial data without somehow compromising on the other side our security? If spatial data really is that sensitive and of national importance, then national agencies and organisations would have to manage access and its use more closely. Some already do this across a number of industry sectors and data types, whilst often leveraging and adapting alternate technologies for their own use. Tracking, monitoring and identifying possible targets of interest, potential threats, suspicious acts or unusual movements could potentially be achieved through legitimate use of the spatial technologies. This is no longer surveying for traditional mapping purposes, but rather a more sophisticated monitoring of activities for protection of the environment, the economy and even perhaps society.

**POSITIONING, NAVIGATION AND TIMING**

Take the ubiquitous satellite-based Positioning, Navigation and Timing (PNT) as an example. It has generated billions in income and revenue for many companies and nations rely upon it for the ease and availability it offers. Whilst it is, for people in the street, a utility that allows them to get to where they wish to be. However, there is some concern that we are too reliant upon the US military controlled GPS. Europe developed and launched Galileo which, albeit rather slowly, is designed to be available if GPS is denied to the user. The Chinese are rapidly developing their satellite PNT system, Beidou. Recent launches of two more satellites last November strengthened its place in the PNT community. So these systems are surely a welcome addition to our toolset.

Just as early maps and charts were primarily created and designed with military use and strategic planning purposes in mind before being made available to the public, so we now have the Satellite PNT systems. Already they have developed far beyond their initial, somewhat limited, military use to the widest community of all - the public and society at large. So we have before us a challenge of increasing our access to spatial data and its widest availability, whilst preserving the strategic benefits for our nations' and society's protection.

*The last RICS geomatics PG board Nov 2019.*

The technology paradigm of expecting new things to always generate some improvement may not be sustainable in the geospatial world. We have good quality geospatial information but can we make it available for all, whilst preserving the strategic benefits of the analysis for ourselves? This will be another challenge for the decade ahead.

BY STEPHEN BOOTH

# Re-Branding, Re-Valuing and Groceries

Stephen Booth, former editor of Geomatics World

**'If at first you don't succeed... re-brand!' This motto has long served British industry. One thinks of the White Star Line (of Titanic fame), which became Cunard, which is now part of cruise line Carnival Corporation. For surveyors, more than 25 years ago the word geomatics was coming into wider use from its Franco-Canadian origins. It was seen as a way of making land surveying more exciting and interesting in university courses with the advent of GPS and GIS. Alas, there was competition. Geospatial was popularised by several US companies. In the UK, the then Institution of Civil Engineering Surveyors adopted the term geospatial engineering which gained recognition by the Institution of Civil Engineers.**

The RICS is busy revitalising its professional groups under the PG2020 programme, which will see the Geomatics Professional Group Board subsumed into the Land Board, comprising geomatics, property, construction and valuation. The final item on the agenda for the last meeting of the GPG, held at the end of last year, was to adopt the phrase 'geospatial surveying'. While geomatics may continue through 17 professional groups, it's easy to see that the word will diminish in use. Whilst many will argue it was doomed from the start and stuck to surveying, surely any major change of language and titling within any organisation requires serious promotion and marketing, which geomatics never had.

***The final item on the agenda ..... was to adopt the phrase 'geospatial surveying'***

## TIME FOR A REVALUATION?

Reader Martin Rickman drew our attention to an interesting article in The Times by Sky Economics correspondent Ed Conway. He suggests there might be change coming from the new government to raise more money through revaluation of properties for Council Tax. Readers with long memories will remember that the Council Tax, introduced in 1993, came about following the disastrous Poll Tax (trialled first in Scotland), which replaced the long- serving domestic rates system and attempted to impose a single tax on everyone - rich, poor or destitute. The Council Tax settled the argument but throws up some bizarre anomalies. A property in Westminster recently changed hands for £210 million, yet the owner will pay only £1507 per annum in council tax (wish mine was as low as that!). Undercurrents wonders if the appointment of the new Chief Land Registrar, Simon Hayes, last November might be the trigger to raise more money for the Prime Minister's plans. Conway seemed to think so, commenting, 'a rejig of property taxes is actually one of the more straightforward avenues for the new government to raise taxes'.

## GROCERIES ON THE X-Y AXIS

The Royal Geographical Society continues to provide thought-provoking material for this column. Paul Clarke, CBE is CTO at Ocado Technology. He talked about digital twins (something the GI community has been talking about for a while), geospatial and networked digital infrastructure. His lecture was illustrated with some excellent slides and video, showing how online grocer Ocado selects from a stock of over 50,000 items using robots in their warehouse which whizz about on rails in an x-y axis narrowly avoiding each other, whilst briefly hovering over bins and retrieving products to fulfil orders (watch at https://www.youtube.com/watch?v=4DKrcpa8Z_E).

## TWINNING'S THE WAY

One of the minor but important life-changing aspects of advancing years can be a nervousness to ensure reasonable proximity to toilets, whilst travelling. With the closure of many public toilets around London, one gets used to planning travel close to major buildings – museums, department stores and of course pubs. I strayed into the Central Hall Westminster recently and was intrigued to discover an image of a toilet in some far-flung part of the world above each urinal (doubtless there are similar images in the Ladies, but I didn't investigate).

The images are part of toilettwinning.org which encourages the twinning of toilets in the developed

world with those in places like the Democratic Republic of Congo. You can twin yours for £60 to cover the cost of building one elsewhere in the world. Our photo shows just such a toilet, Latrine No 11886 at Libero, North Kivu in DRC. For those needing final directions, Lats are -0.16656 and Longs 29.23178. You may need to bring paper.

## BEARD SECONDS, MOUNTWEAZELS AND PYTHONS

Undercurrents is always interested to learn of new units of measurement. An article on the BBC's website entitled "Twenty-six words we don't want to lose" caught our attention. One such word is "beard-second" – the approximate length a man's beard hair grows in one second. The unit was devised by Oliver Smoot, who used his own body length to measure a bridge and thus create the unit of the smoot.
Another word we like is "Mountweazel". It's one we're sure Ordnance Survey will be aware of, at least in spirit. It's the practice of placing spoof stories or items in publications to trap copyists and plagiarists. OS maps are reputed to contain small deliberate errors to trap such unscrupulous people. The word comes from the 1975 edition of the Colombian Encyclopaedia in which there is an entry for one Lillian Virginia Mountweazel, a specialist in early American mailboxes who died tragically in an explosion whilst working for Combustibles magazine. Fortunately, Mountweazel never existed.

Undercurrents is saddened at the death of former Python star Terry Jones. Monty Python's Flying Circus was a complete breath of very fresh air in late 60s Britain, then relying much on what today's younger generations will regard as weird entertainment like the Black & White Minstrel Show. Jones was responsible for many of the Python sketches. I particularly liked the Batley Townswomen's Guild's re-enactment of the Battle of Pearl Harbour: in a muddy field middle-aged women attacked each other with handbags. He also directed the controversial and irreverent Monty Python's Life of Brian, banned by 39 local authorities and several countries, including Ireland and Norway. Jones took the latter as a marketing opportunity in neighbouring Sweden through a poster campaign stating, "So funny it was banned in Norway".

A technique with lecturers I hadn't previously been aware of until pointed out by my partner, is to show the odd slide during a lecture with nothing but a nice, comforting and re-assuring image or video in between the important stuff, lest the audience drift off. One such recent lecture included a delightful video of otter cubs playing. I wanted more but alas we were quickly back on topic. ◂

▲ *Caught short in the Congo? Don't worry, help is on hand.*

Malcolm Draper is away. Stephen Booth, former editor of GW, is the author of this issue's Undercurrents. Do feel free to drop us a line with any (vaguely!) relevant surveying stories to rentamalc@aol.com or steve@pvpubs.com. For the sake of a good story, we are always prepared to change names, details etc to protect the innocent as well as the guilty!

# New Courses, Support and Qualifications

THE SURVEY SCHOOL RESPONDS TO HUGE DEMAND FOR MORE SHORT REVIT COURSES

**The new, short Revit courses run at The Survey School are proving to be a huge success and more have been scheduled to cater for the interest and demand. Bookings are now being taken for Revit Fundamentals for Surveyors Course 6, commencing on 9 March and Course 7 on 30 March. Visit the School's website for further information and to secure a place. http://www.surveyschool.org.uk/**

Places on the first Revit course sold out in two days and further dates also filled quickly. Survey School manager Alan Mansell explained that the popularity of the Revit courses is down to the uniquely tailored content. The existing Revit courses available in the public domain only really suited Revit end-users - those that would be working on the end product created by survey companies. The need for a course tailored to geomatics surveyors was seen to be necessary for the profession, so The Survey Association asked its members for feedback on what they would like to see in such a course.

Run in association with GCF Design, the two-day course was specifically developed with the geomatics surveyor in mind. Learners are shown how a surveyor transfers captured data, from laser scanning or measured survey into Revit, to generate, annotate and present 3D models and 2D outputs. The course covers Revit's interface, project set-up, export of data into Revit, coordinate systems, plus many more insights, useful for the surveyor.

In the meantime, and for the first time, a post-Revit course telephone support service is being offered to supplement and reinforce the learning experience.

## MANUFACTURERS SUPPORT THE TSA SURVEYING COURSE AT THE SURVEY SCHOOL

Students on the TSA Surveying Course at The Survey School benefit from using the latest technology, thanks to the continued generosity of the leading manufacturers. The School acknowledges and thanks Leica Geosystems, Topcon Positioning and Trimble distributor Korec, for their support with the loan and supply of survey equipment and the practical demonstrations and talks they give at the School.

Alan Mansell, the permanent manager of the Survey School.

Survey School manager Alan Mansell commented, "Both The Survey Association and the Survey School are extremely grateful for the support received from the manufacturers in regards to equipment loan and can now ensure that going forward, the latest instruments on the market form part of the courses held at the School."

"As an example, for 2020, The Survey School took delivery of six brand new Leica Geosystems TS07 Total Stations, along with the very latest in GNSS hardware – the Leica GS18-T 'tilting' GNSS system."

Course 54 begins on 2 March 2020 and Course 55 on 5 October 2020. Course costs are heavily discounted for TSA Member companies. For further details http://www.surveyschool.org.uk/the-course/

The TSA Course is now run alongside the ProQual Level 3 Diploma in Engineering Surveying. This provides a successful candidate with a recognised qualification and standard which is recognised by CSCS.

Qualifications for Industry (QFI) specialises in awarding qualifications for those who work in, or aspire to work in Construction, Engineering and Extractives. In addition, QFI provides apprenticeship services such as End Point Assessment (EPA) for English Trailblazer Apprenticeships. QFI has recently been approved as the End Point Assessment Organisation (EPAO) for the apprenticeship: Geospatial Survey Technician Level 3. Qualifications for Industry has joined TSA as a Supplier Member and The Survey School looks forward to working with them on apprenticeships for the Geospatial Sector.

*The Oast House - from field to classroom.*

*Revit Class at The Survey School.*

BY DAVID SELVIAH

# Digitising Reality: Automated 3D Point Cloud Data Processing Using AI

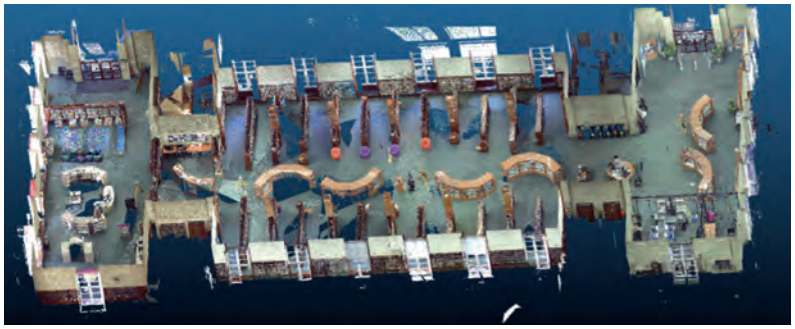
**Instruments for digitising the 3D real environment are becoming smaller, more lightweight, lower-cost and more robust and so are finding widespread usage, not only on surveying tripods for the highest accuracy, but also on mobile platforms such as autonomous vehicles, drones, helicopters, aircraft, robotic vacuum cleaners, trains, mobile phones, satellites and Martian rovers. Lidar uses laser scanning, while photogrammetry records images from one or more cameras which may be moving. Each laser scan records tens of millions of data point position and colour in a point cloud and hundreds of such point clouds may be combined. This article discusses the challenges, such as management, storage, registration, fusion, extraction of useful and actionable information that many companies and organisations face after obtaining vast 3D point cloud datasets.**

## CLOUD COMPUTING

The first challenges users face in performing 3D point cloud data processing include:

- Data Storage: The amount of data recorded grows exponentially with time, creating large data repositories.
- Processing: The computing power required increases as new algorithms with useful functionality are released and with the volume of data.
- Sharing: There are multiple stakeholders spread geographically around the world on mobile platforms who all need to view the most up-to-date data at the same time.

Previously, a software application ran on a dedicated server in a data centre but, if the computer hardware broke down, the user either had to find a backup (which had to be standing by and ready) or would suffer an interruption in service. Many companies guarantee a 24/7 level of service and so cannot tolerate this. However, cloud computing now gives users access, over a network, to applications running on a set of shared or pooled servers in a globally communicating network of data centres, giving speed and productivity improvements, resulting in increased competitiveness.



▲ *Figure 1: 30 Terrestrial laser scans of a central London library, fully automatically aligned using the Vercator® software.*

## BIG DATA ANALYTICS

Users face the difficult challenge of how to boil down the vast amounts of 3D point cloud data to generate useful and actionable information. Current methods for creating Digital Twin BIM models of buildings require users to inspect vast 3D point clouds to manually recognise and mark the outline positions of surfaces, straight edges, walls, floors, ceilings, pipes, and objects, which is time-consuming and susceptible to error. Some semi-automatic methods on laptops require users to recognise and mark part of these and the program finds the rest. Again, such objects can be mislabelled. Fully automatic methods are becoming available on laptops but do not find all the useful information, so users must add and correct what is found. Sometimes the automatic method makes so many mistakes it is quicker for the user to find and mark the structures manually.

"Useful information" in one application may be different from

that in another application. For example, in autonomous vehicles, it is an accurate 3D terrain model which can be used for safe navigation. In electricity pylon scanning, it is whether the pylon has its safety warning sign in place clearly visible and whether nearby vegetation is gradually encroaching on the power lines. In railway scanning, it is whether there has been any slippage or sag as well as an estimate of when gradually encroaching vegetation will become a hazard. Electricity supply companies and Network Rail are under UK government obligations to regularly inspect their assets and to perform preventative maintenance to ensure continuity of supply and travel.

## GEOMETRICAL OBJECT RECOGNITION

Correvate has developed a suite of machine learning geometric image processing methods for fully automated basic object recognition – walls, floors (figures 2 and 3), edges (figure 4) and pipes (see figure 5).

## ARTIFICIAL INTELLIGENCE (AI)

Artificial neural networks are extremely simplified models of living brains, which are trained and learn like people rather than being programmed by a master programmer. The learned knowledge or skills are stored in a distributed manner in the strengths or weights of the neuron interconnections. Some artificial neural networks learn on their own while others require a teacher or instructor to tell them when they are right or wrong. Gradually, they get better and better at performing a task during the iterative learning cycles which usually take a long time and require thousands of examples of the training data. Artificial neural networks are particularly good at recognition, classification and optimisation >

## BENEFITS OF USING THE CLOUD

**Auto-Application Updates:**
Applications are updated automatically, so the user always has access to the most up-to-date optimised software and bug fixes.

**Responsivity:**
Dedicated development support teams continuously monitor user experience to optimise and, if necessary, rewrite code.

**Scalability, flexibility and agility:**
Scalable elastic cloud environments on pools of servers, storage and networking resources scale up and down according to the number of users and the volume of their usage. They automatically scale up and down as users' needs change.

**Capital expenditure free:**
Users have access to the highest power computers. There is efficient use of hardware as users do not need to purchase, manage and maintain large amounts of computer and storage hardware, resulting in lower hardware, power, cooling and IT management costs. Users only pay for what they use as the cloud resources automatically scale, so it is easier for small businesses to manage their business at any time of day, from anywhere.

**High speed:**
Multiple computers run in parallel so many different parts of the same point cloud can be processed at the same time and many different users have no effect on speed or quality.

**Security:**
The data is stored and communicated securely with a level of encryption chosen by the user. If security is a paramount concern, the software can run on a private cloud without internet connections in-house. Clouds can be configured to make use of certain data centres, such as within one country if intercountry security is a concern.

**Availability:**
If one server is busy or not available then another server takes its place to provide full availability.

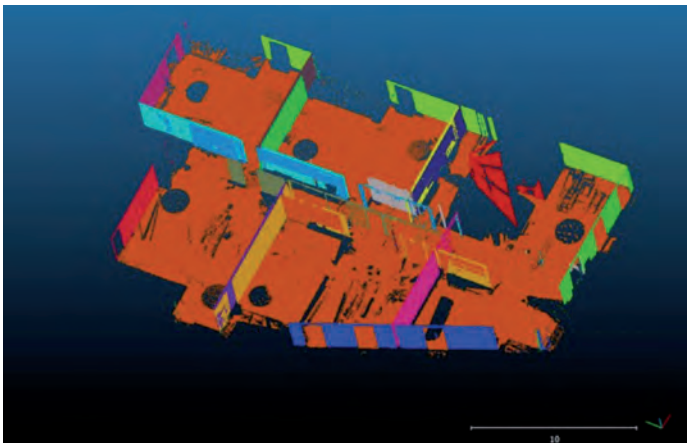
**Disaster Recovery:**
Data is stored in multiple locations at the same time so if storage hardware in one data centre breaks down, the calculation proceeds with little interruption as the data is backed up elsewhere. Data archiving facilities are automatically provided.
Latency: if latency is important, the cloud can be configured so that local clouds provide low latency to the user.

**Increased collaboration:**
Many users, located globally, and mobile users, can store, process, share and view datasets at the same time without any loss of speed or responsivity.

**Reliability:**
The application software can make use of resources on cloud computing infrastructure provided by different vendors in different global regions.

**Forward compatible:**
An open cloud architecture is forward compatible to match higher power computing resources as they are rolled out.

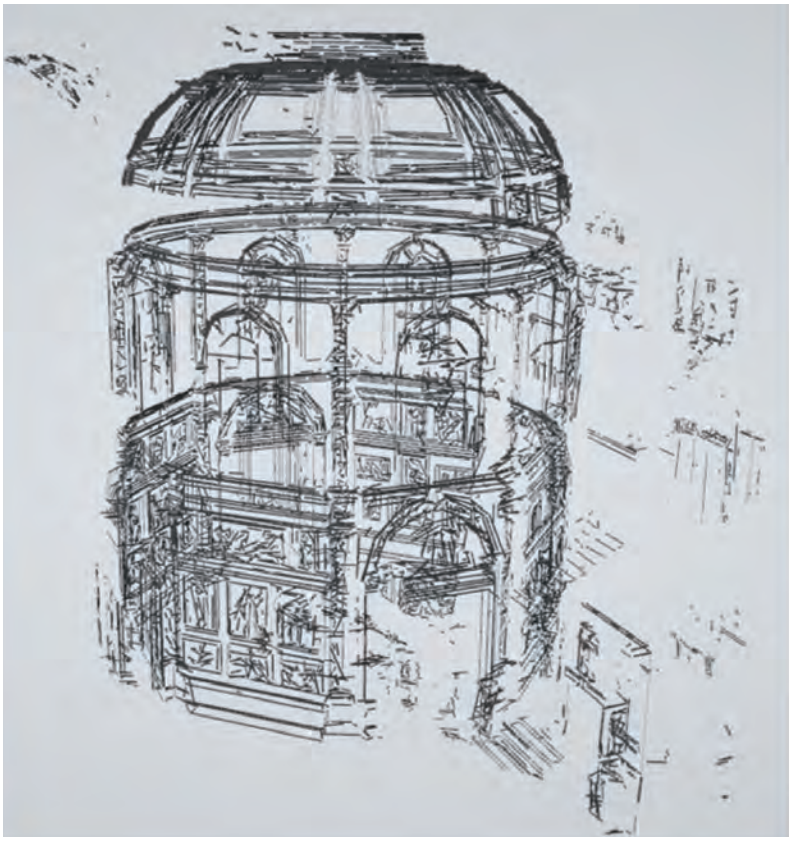
**Sharing:**
All point cloud datasets are secure in one place and accessible at any time from any place by any employee, improving collaboration.



▲ *Figure 2: Automatic Wall and Floor Recognition in a recently poured concrete shell of a building under construction in London (16 aligned scans).*

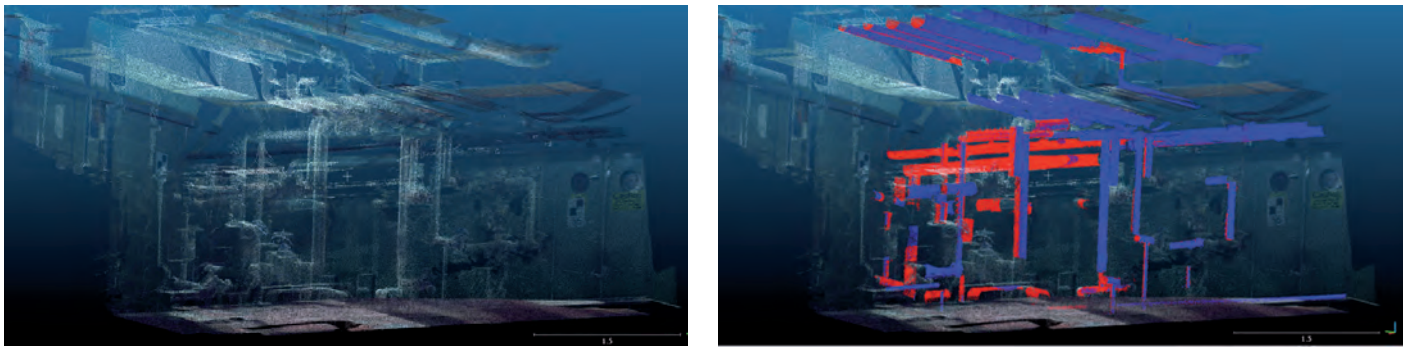
▲ *Figure 3: Automatic Wall Recognition in a recently poured concrete shell of a building under construction in London (16 aligned scans).*

tasks. However, their performance depends crucially on how they are trained, the types and the amount of training data. Many types of neural network have been developed and, most recently, Convolutional Neural Networks (CNN) used to perform Deep Learning have become very popular and achieve very good results. In the case of object recognition, if the neural networks are only trained with examples of objects one wants to find, then all input data will be classified as one of those objects, even if it is not one of those objects. So, the performance of the neural network is only as good as the way it was trained and the data that was used to train it. Neural networks are not as new as you might imagine given their current popularity in the media. Over 30 years ago, Selviah (1989) proved that the weighted interconnection layer of neural networks performs the same operation as a collection of correlators, operating in parallel, matching images from a database with input data and then the non-linear part of the neurons decide which image matches the input most closely. The clever part is the way in which the training automatically works out what images to store in the database in the first place.



▲ *Figure 4: Automatic Edge Detection followed by automatic fitting of straight-line segments in UCL circular/octagonal library under the iconic central dome (21 aligned scans).*

In the conference room image, figure 6, you see the impressive recognition results after training a new type of CNN with data from the Stanford Large-Scale 3D Indoor Spaces Dataset (S3DIS) using 70,000 3D objects of 13 types, structural objects: ceiling, floor, wall, beam, column, window, door, and movable objects: table, chair, sofa, bookcase, board and clutter in 11 types of room. Each category of object is marked in a different colour, for example, 'chairs'



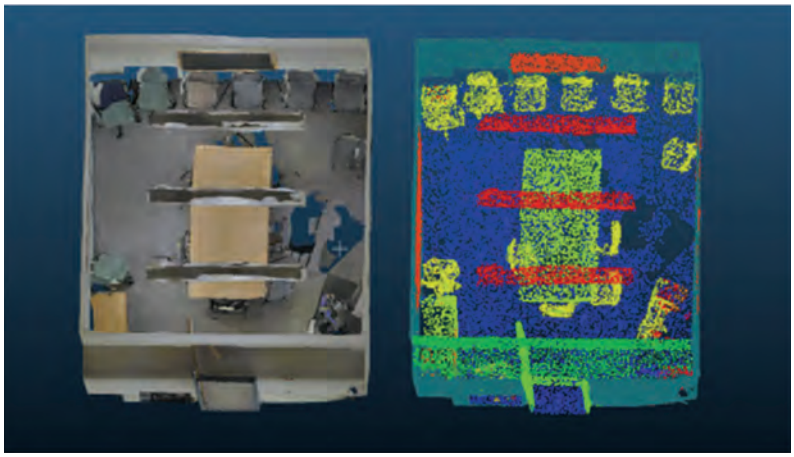
▲ *Figure 5a: Pipe scan. Figure 5b: Automatic Pipe Recognition in a Boiler Room 3.5 million point cloud; 98% cylinders correctly found (2 aligned scans red and blue).*

are marked in yellow, 'boards' are marked in orange, 'beams' are marked in red, 'door' is marked in green, 'walls' are marked in dark green, 'floor' is marked in blue, etc. The accuracy of classification of objects is around 93.5% comparable to human accuracy. The objects to be recognised can be chosen for each application simply by changing the training database.

## ARTIFICIAL INTELLIGENCE IN THE CLOUD

As the AEC sector embraces digital technology, the amount of data produced grows exponentially, creating large data repositories. To generate useful and actionable information from this 'big data' requires leveraging smart analytical tools such as AI that are becoming more accessible, especially when hosted from the cloud. Both the cloud computing infrastructure and artificial intelligence supply the tools to leverage and enable digital technology by providing convenient methods of working at scale, thus lowering the barriers to entry for users to these new ways of working. Artificial intelligence (AI) neural network and deep learning require vast databases of thousands of examples for training, which can be conveniently stored in elastic expandable cloud storage on demand. AI software requires highly parallel processing on many parallel processors to carry out the training in a reasonable time, again easily available in cloud computing infrastructures.

Intelligent combination and use of available techniques such as laser scanning, automatic alignment, cloud computing and artificial intelligence can not only speed up analysis of vast data sets but also improve accuracy and release human activity to ensure that a product is correct and useful. ◂



▲ *Figure 6: AI Automatic 3D object recognition. Plan view of original point cloud data for a conference room and 3D recognised objects. The ceiling was removed for clarity in viewing the inside of the room.*

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David R. Selviah is both a UCL academic at Reader level and CSO and Director of Correvate Ltd. For the last 33 years, he has been at the Department of Electronic and Electrical Engineering, University College London *UCL) carrying out research on AI, optical processing algorithms, devices, interconnects and systems and has over 250 publications to his name.

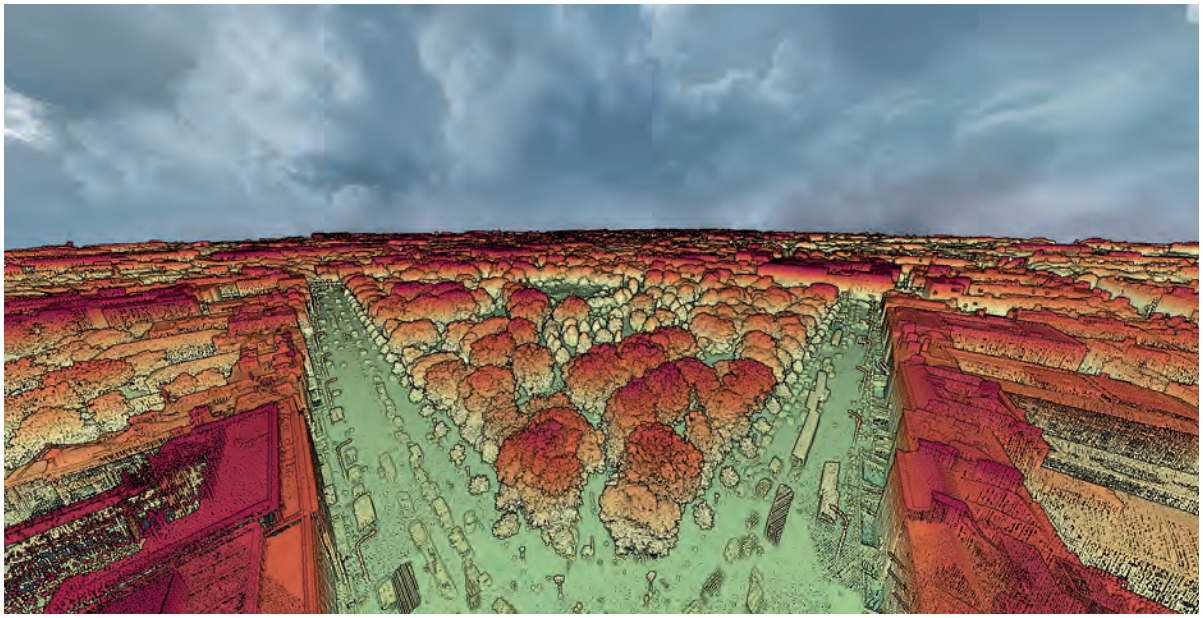
BY IMAN ZOLANVARI AND ATTEYEH NATANZI

*A Highly Accurate, Diverse and Dense Annotated Laser Scanning Dataset of a City Centre*

# Downtown Dublin as a Lidar Point Cloud

**The advance of Lidar data acquisition technologies is substantially increasing the amount of spatial data obtained and it is becoming cost-prohibitive to process it manually. Artificial intelligence (AI) has now started to offer cost-effective solutions to analyse and utilize those big datasets. AI can be employed for scene understanding, accurately detecting objects and classifying 3D assets. These are the significant fundamentals of several applications including autonomous navigation, intelligent robotics, urban planning, emergency management and even forest monitoring. The most popular types of 3D spatial information for such applications are Lidar and digital imagery. This article describes the dense annotated ground-truth Lidar dataset that was generated in 2019. The labelled dataset was produced from Lidar data of Dublin that was captured alongside aerial images of Dublin in 2015. Both datasets are publicly available and their URLs are included in this article.**

With two-thirds of the world's population already living in urban areas, and a further increase of two billion predicted by 2050, the number of megacities (i.e. with populations of more than ten million) is predicted to increase to 41 in the next decade (UN 2014). Most of these cities had less than 2 to 3 million inhabitants in 1950, which means that their infrastructure is totally unable to support such huge growth. To plan sustainable growth of such urban areas, geometrically accurate three-dimensional (3D) models are essential for city planning. Accurate spatial modelling and interventions related to city planning are especially challenging as most parts of cities are largely undocumented, and the cost of collecting the relevant data through traditional mapping methods is typically very high. In such cases,



▲ *Figure 1: Laser scanning point cloud of Dublin, Ireland's capital city.*

remote-sensing technologies offer cost-effective alternatives.

Laser scanning and photogrammetry are outstanding solutions amongst the current technologies. The latest Lidar scanners are able to capture around one million georeferenced points a second in the form of a point cloud. This point cloud can be acquired via three major sources: Terrestrial laser scanning (TLS), Mobile laser scanning (MLS) and Airborne laser scanning (ALS). TLS is able to collect most of the vertical facade data but little of any roofs, balconies and other horizontal planes, usually from the street point of view. MLS is obtained by cars or other vehicles (e.g. autonomous patrolling or even boats) to survey relatively short distances up to 300m with the same characteristics of TLS. ALS can contain full-waveform data with a good bird's-eye view but usually limited facade data. ALS is generally used for obtaining data for a large area (e.g. an entire urban region).

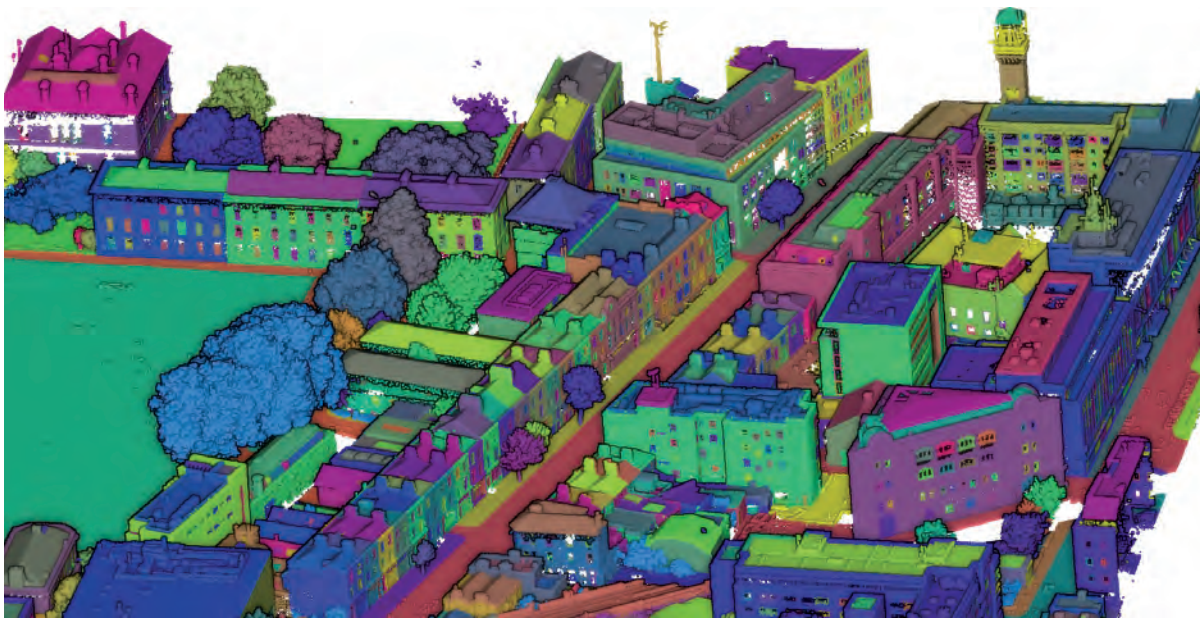
## THE DUBLIN DATASETS

In 2007 and later in 2015, the Urban Modelling Group at University College Dublin captured a massive urban dataset of the Republic of Ireland's capital city, Dublin, under supervision of Prof Debra (Laefer et al, 2015). The datasets include laser scanning point cloud (Figure 1) – as well as aerial imagery (i.e. vertical, oblique images and video data https://www.youtube.com/watch?v=qEi2Wo7Bcuk and https://youtu.be/iSRK1NIT-vA ). As the footage in the overview of the dataset shows, the density of the dataset was hugely improved in 2015 compared to the initial capturing in 2007. The 2015 dataset is one of the densest urban aerial Lidar point clouds that has ever been collected (over 1.4 billion points) with an average point density of 250 to 348 points per square metre. In this project, the initial dataset consisted of 5.6km2 of Dublin's city centre which was scanned with an ALS device carried out by a helicopter at an average flying altitude of 300m. The data was collected in March 2015, as there is usually minimum vegetation and hence shadows on the buildings at that time in Dublin.

While the primary output of the dataset was to generate a Lidar point cloud, the mounted cameras also captured imagery data during the flight. The imagery dataset consists of 4,471 images as georeferenced RGB images with a resolution of 9,000 x 6,732 pixels with a ground sampling distance of 3.4cm in TIFF format. The geographic information is given as GPS information in the EXIF metadata and the camera used for the capture was Leica RCD30. The dataset also includes 4,033 oblique JPEG images with a resolution of 7,360 x 4,912 that were captured by two NIKON D800E cameras. The total size of the imagery dataset is around 830GB.

▲ *Figure 2: A sample labelled tree that shows its trunk, branches and leaves have been precisely scanned.*

All Lidar and imagery data can be accessed at the NYU data >



▲ *Figure 3: A sample portion of the annotated dataset.*

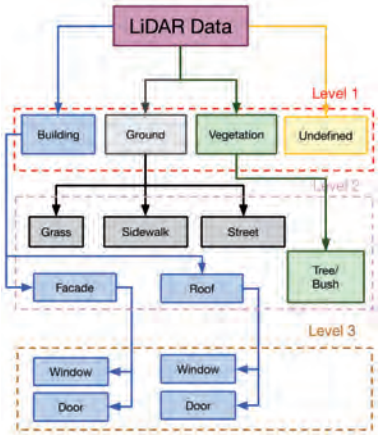
repository (https://archive.nyu.edu/handle/2451/38684) at New York University.

In addition to that dataset, in 2017 Dr Jonathan Byrne (Byrne et. al., 2017) also captured aerial images of Trinity College Dublin (TCD) campus at an average altitude of around 30m by drone and generated an image-based point cloud. The dataset would be interesting for comparison of the campus from 2015 to 2017.

## THE REASONS FOR ANNOTATION

The laser scanning data has no inherent classification information in the point cloud or any predefined relationships between its points. Consequently, in order to use these points in various applications, the data must be classified and the desired localized features must be extracted. Despite advances in the technology for accurately and rapidly capturing Lidar data on a large scale, automated analysis and understanding of the huge datasets obtained is still being developed.

The traditional methods of dataset processing usually use geometric fitting (e.g. RANSAC) or Region growing. These methods are for coarse segmentation as an initial step of classification of the dataset (e.g. buildings, streets, etc.). Coarse segmentation is typically followed by explicit feature extraction based on algorithms developed to extract smaller objects (e.g. windows, doors or chimneys) for specific applications. Despite the above-mentioned available techniques, machine learning (ML) and AI appear to be more efficient and cost-effective approaches. For example, neural networks (NN) can be trained to intelligently detect and classify 3D assets in the dataset with minimum manual intervention. However, the key point for training NN models is having an accurate, diverse and well-annotated ground-truth dataset. Therefore, it is significantly important to access a full-3D, dense and non-synthetic labelled point cloud at city scale that includes a variety of urban elements (various types of roofs, building facades, windows, trees and pavements). However, the generation of such detailed labelled datasets is difficult and expensive. While there have been several attempts to generate such a labelled dataset, including by using semi-automated photogrammetric or morphological methods, a review of the commonly available datasets shows that none of them can completely satisfy all requirements.




▲ *Figure 4: Order of labels and the hierarchy.*

## A NOVEL ANNOTATED MASSIVE POINT CLOUD

Zolanvari et. al. (2019) provided a novel labelled dataset (Figure 3) from the above-mentioned Lidar data of Dublin at Trinity College Dublin. In this project, over 260 million laser scanning points were manually labelled into 100,000 objects within

▲ *Figure 5: The white points show the differences between the 2017 and 2015 data of the TCD campus.*

13 classes. Those classes included a hierarchical level of detail, from coarse (i.e. buildings, vegetation and ground) to a refined level (e.g. windows, doors and trees).

The first level produced a coarse labelling that includes four classes: Building, Ground, Vegetation and Undefined. 'Building' refers to all shapes of habitable urban structures (e.g. homes, offices, schools and libraries). 'Ground' mostly contains points that are at the ground level. The 'Vegetation' class consists of all types of separable plants. Lastly, 'Undefined' points are those of least interest to include, such as urban elements (e.g. bins, decorative sculptures, cars, benches, poles, post boxes and non-static objects). Approximately 10% of the total points were labelled as undefined and they were mostly rivers, railways and construction sites. In the second level, the first three categories from Level one were divided into a series of refined classes. Buildings are divided into roofs and facades. Vegetation is classified into separable plants (i.e. trees and bushes). Ground points are divided into street, pavement and grass. The third level includes any types of doors and windows placed in the roofs (dormers and skylights) and facades. Each class could be extracted separately or in a combination of other classes for various applications. Figure 4 shows the labelling order of the dataset.

## LABEL GENERATION

To generate labels, the initial Lidar dataset was divided into 13 sub-tiles of around 19 million points for annotating. The process started with importing data into the CloudCompare 2.10.1 software. Points were then coarsely manually segmented using segmentation and slicing tools into three categories (i.e. building, vegetation and ground) and labelled accordingly. Next, the process continued to the third level of the finest details (i.e. windows and doors). Hence, this pipeline produced a unique label for each point. The process took over 2,500 hours with appropriate supervision and was carefully cross-checked multiple times to minimize the degree of error.

The annotated dataset includes diverse types of historic and modern urban elements in the city centre of Dublin. Types of buildings include offices, shops, libraries and residential houses. The buildings range from detached and semi-detached to terraced houses and date from different eras (from the 17th-century Rubrics building to the 21st-century George's Quay complex). This detailed labelled dataset is the first of its kind regarding the accuracy, density and diversity of classes, particularly regarding its city-scale coverage area. The hierarchical labels offer excellent potential for various classification and semantic segmentation applications in urban science.

## APPLICATIONS AND FURTHER INFORMATION

The main goal of the labelled dataset is to train convolutional neural networks (CNNs) for classification of urban elements in massive point cloud data. For example, the labelled dataset can be employed to train and use PointNet, PointNet++ and So-Net. These networks are able to classify urban elements for several important applications (e.g. robotic or autonomous navigation) based on semantic segmentation of the ground level which consists of streets, pavements and vegetation. These are essential elements for an autonomous navigation industry. Also, the vegetation class is highly beneficial for the detection of trees and it can be used to monitor the health of plants in an urban or even forest area. For example, a change detection technique applied to the drone and helicopter data from 2015 to 2017 clearly shows the location, size and number of removed trees. The white points (e.g. trees and the building) indicate what was removed after the 2015 scanning project (Figure 5). More information about the dataset (i.e. further description with video, link to the academic paper and a download link) can be found at bit.ly/GIM_magazine. ◂

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BY IAN DOWMAN AND WIM VAN WEGEN

*Digital Construction Week 2019*

# Seeing the Future: AI, BIM and Digital Twins

**Digital Construction Week was held at the Excel in London on 16-17 October 2019. DCW covers all aspects of construction with a large exhibition, seminar and conference sessions. There was one seminar stream on geospatial surveying and two specifically on BIM, but relevant topics such as artificial intelligence (AI) and visualization, as well as BIM, cropped up in many of the other sessions. The most used buzzword was digital twin which was heard in many talks and in the exhibition booths.**

The term digital twin is used quite flexibly, but essentially it implies that an object must have a digital representation which can be presented visually, i.e. a virtual object. At a more advanced stage, the components of the object, represented digitally, can be controlled and updated and can be interrogated in real time. They can be linked to the Internet of Things (IoT) and analysed with artificial intelligence (AI), usually operating in the cloud.

So, what are the main developments and what is their impact on construction and, in particular, geospatial practice?

A presentation on the Main Stage by Anne Kemp (Atkins and the UK BIM Alliance) gave an excellent summary of the current position.

BIM is clearly a driving force and new publications from the UK BIM Alliance set out the framework (https://www.ukbimalliance.org/stories/ukbimframework/) and stress the need for a common framework and for standards. The relevant publications are the second edition of Guidance Part 2: Processes for Project Delivery with additional insight on the activities associated with ISO 19650-2 clause 5; and the updated Guidance Part 2. The UK BIM Framework is also releasing revised guidance for the public sector on applying BS8536 parts 1 & 2 – Government Soft Landings.

## NATIONAL DIGITAL TWIN

It is essential that all partners in the construction/build/maintenance cycle speak the same language and avoid confusion and this becomes even more important when we consider the ambitions of a digital twin. The objective of a (UK) National Digital Twin involves connected digital twins creating an ecosystem, embracing transport, energy and the built environment. https://www.cdbb.cam.ac.uk/system/files/documents/TheGeminiPrinciples.pdf.

The Gemini principles support this through requiring a clear purpose, being trustworthy and functioning effectively. The concept of the Golden Tread, linking all changes in a building, was held up as an ideal which could have saved lives in the Grenfell Tower disaster.

All of this is promoted and developed by The Centre for Digital Built Britain (CDBB) which is a partnership between the Department of Business, Energy & Industrial Strategy and the University of Cambridge, to deliver a smart digital economy for infrastructure and construction for the future and to transform the UK construction industry's approach to the way we plan, build, maintain and use social and economic infrastructure. https://www.cdbb.cam.ac.uk/. CDBB was presented as an organization to develop this digital nirvana which could help reduce our carbon footprint and reduce air pollution.


▲ *A typical seminar session at DCW.*

## ARTIFICIAL INTELLIGENCE

AI was another major topic in the conference and seminars and an important rhetorical question being asked was 'what can robots do?' There were few answers to this. A concrete example of successful AI was the UK start-up Vercator (Geomatics World March/April 2018). David Selviah from Vercator discussed the problems of extracting information from scans and the challenge of processing big data. He did, however, show that AI could identify features from point clouds such as planes, edges and specific objects such as chairs. He also painted an optimistic picture of future research and stressed the value of the cloud to speed up processing and store large volumes of data. Selviah's presentation is published on page 18.

Matt Armstrong-Barnes from HPE stressed that AI needs to be used appropriately and that it is particularly good at finding anomalies and for identifying safety issues on construction sites. It has been shown to be very effective at spotting defects in aluminium. A survey has shown that 40% of digital companies see AI as essential. He said that much work has been done but that it needs to be put together to solve problems.

## InSAR AND BIM

Maria De Farago from Telespazio presented developments in the use of SAR interferometry. GW has published an article on this showing InSAR for monitoring land subsidence (Geomatics World March/April 2019). De Farago demonstrated how InSAR from satellites could be used for Structural Health Monitoring (SHM) and asset management using a development site near Excel. The InSAR data can be integrated into a BIM model. This involved no in-situ instrumentation and can measure building deformation to centimetre level. InSAR monitoring can also be used to predict landslips.


▲ *Robots are everywhere, but how useful are they?*


▲ *A key message repeated around the hall.*

Many geospatial companies were present at the exhibition including Bentley, Bluesky, Faro, GetMapping, Hexagon, Korec, Leica, Murphy Surveys, Plowman Craven and Skanska. Less well-known companies such as Royal Haskoning DHV offered services in the fields of aviation, buildings, energy, industry, infrastructure, maritime, mining, transport, urban and rural development and water, and set great store by the digital transformation and supporting a sustainable environment.

## VIRTUAL, AUGMENTED AND MIXED REALITY

Virtual Reality and Augmented Reality were centre stage during the Visualization Track of the seminar programme, proving that both technologies are more than just a buzzword. VR can be a fantastic tool for training purposes; however, the isolated nature of VR headsets is not always a very suitable solution. Igloo Vision demonstrated a different way: shared VR in projection domes or cylinders, allowing for whole teams to be immersed not just in training scenarios but also in BIM.

While many professionals are getting familiar with VR and AR, mixed-reality is less mainstream. Augmented reality is delivered through a handheld mobile device (a smartphone or a tablet); mixed reality is delivered through head-mounted see-through glasses. Mixed Reality is a fusion of real and virtual worlds, enabling the production of new environments and visualizations where physical and digital objects co-exist and interact in real time.

Keltbray, a leading UK civil engineering group, demonstrated how they incorporated Microsoft HoloLens mixed-reality headsets into their planning and proposal stages of development. Thanks to this forward-thinking approach, they are able to enhance and optimize the process, reducing costs and inefficiencies at early stages, allowing a collaborative environment between developer and services provider.

## CONCLUSION

Overall, the exhibition and presentations at Digital Construction Week can be seen as a dichotomy between the here and now, characterized by instrument companies and survey companies aiming to make money from supporting the construction industry, and those looking to make money in the future by exploiting digital technology. Since many contractors in the Architecture, Engineering and Construction (AEC) industry are lagging behind when it comes to embracing the digital transformation, there are still many opportunities ahead for the geospatial world. ◂

BY JAMES GREGORY

*The Past, the Present and the Future of the New International BIM Standard*

# The Art of BIM Implementation

**Building Information Modelling (BIM) is a means of creating a data-rich digital representation of an asset, be that buildings or infrastructure. The processes behind BIM form the foundations for smart information production (digitisation) and management through the lifecycle of a project. BIM encourages all project parties to work collaboratively, aiding project efficiency, de-risking project cost models and programmes, and enabling use of the model to inform operations and maintenance decision-making in the future.**

Standards exist to inform end clients and project teams about how to implement BIM in the delivery and management of projects and assets. In the UK, the adopted standard for BIM was the PAS 1192 suite which was published by BSI (British Standards Institution) and was released back in February 2013. These standards have since been widely adopted as a BIM project 'framework', encouraged by the Government BIM mandate in 2016. This standard, however, was founded on a predominantly 'UK-centric' view and did not necessarily align with the design and construction processes undertaken outside of the UK. The natural progression of this BIM Standard was therefore to not only make it an official British Standard but also make it more internationally applicable. Out of this, as of January 2019, the BS EN ISO 19650 standards (Parts 1 & 2) were born.

The BS EN ISO 19650 still holds many of the key principles scribed within the PAS 1192 suite; however, a number of key areas have been enhanced, including the formal introduction of the 'lessons learnt' initiative, as well as a focus on removing specific UK terminology.

To ensure an international balance, the standard was appraised by representatives from a collection of national standards bodies as set out in Adjacent Digital Politics (2019). "The ISO 19650 series has been developed by an international working group with the aim of enabling teams to minimise wasteful activities and increase predictability around cost and time. Designed to be achieved through a common

▲ *A BIM model of Olympia.*

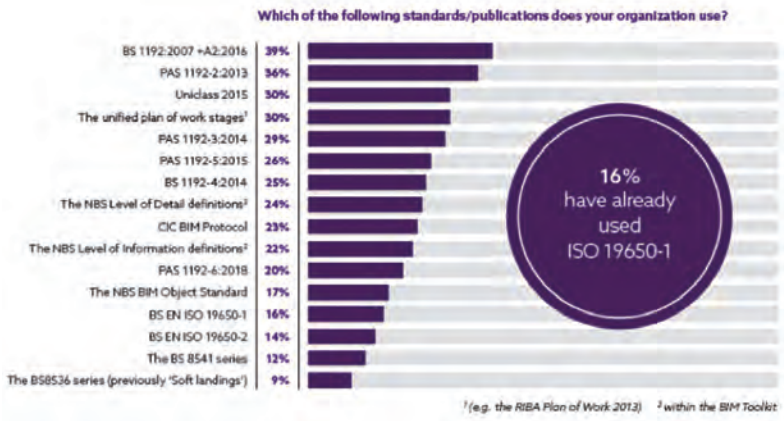
and collaborative approach to the management of information."

The latest National BIM report (2019) has indicated 14 - 16% of organisations have already adopted the new BS EN ISO 19650 standards. (NBS, 2019)

Whilst the standards for BIM now provide a unified approach to working, they are built in a way that allows countries to have a good degree of flexibility to meet their own national information requirements. This is exercised through a National Annex (attached to the BS EN ISO 19650 standards). The UK was the first country to develop its own National Annex and other countries are now following suit.

The National BIM report, (NBS, 2019), states "To give you an example: there's a requirement within ISO 19650-2 for information to be classified. In the UK National Annex, it states that the classification system is to be Uniclass 2015, and we would expect the US National Annex to state that the classification system to be used is Omniclass. This enables the ISO 19650-2 requirement for classified information to be met, but in a way that allows flexibility for each region to use standards that are already in place."

A decade ago, it was normal to challenge the concepts and values of BIM. We are now, however, in a very different phase. BIM is widespread across the industry, with its benefits being recognised by many and in a vast number of ways. The BIM era has been driven not only by the 2016 government mandate but also a general momentum from organisations throughout the industry, for example design teams and contractors using their own initiative to recognise efficiencies through the adoption of BIM.




▲ *Use of BIM standards.*

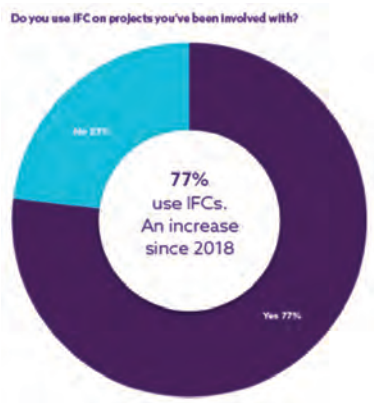
It's time for everyone to start (or continue) their BIM journey and craft the direction and pace of these to benefit the company and clients. This, however, is easier said than done!

Though these standards have been produced to drive us forward into a new era of information production, exchange, management and delivery; all should be aware that meeting the requirements will not be simple. The BIM process stimulates change, an uptick in process management, an increased need for competent and trained personnel, and a wider awareness and consideration of one's position within the wider project lifecycle. As such, implementation of BIM requires leadership, a team with common and clear goals, and a mechanism to celebrate progression.

Aside from the normal barriers for implementing change within a business, additional barriers exist when implementing BIM. One of the key barriers relates to the creation of a new 'alien' information workflow and its associated protocols and documents, as well as hundreds of 'TLAs' (Three Letter Abbreviations!) It's completely normal for the glossary of a typical BIM document, such as a BIM Execution Plan, to be two or three pages long; therefore, aside from encouraging all to progressively become familiar with the terminology, it is prudent to have BIM champions within a company to provide support for wider business.

Paul Shillcock, co-author of the PAS 1192-2 standard (and accompanying UK National Annex) has stated that "there will be a need for both the providers and receivers of information to transform the way in which they produce, exchange and use digital information, whilst aligning their business process to the latest industry standards and best practice." (BIMPlus, 2019)

In our experience at Plowman Craven, one of the most effective ways of progressing along the >




▲ *Use of the IFC format.*

BIM journey is to practise it. As each project progresses, lessons are learnt (in line with BS EN ISO 19650 vision), and best practice is progressively developed. Progression on the BIM journey can be seen in many ways, whether that's the evolution of a common data environment, the optimisation of an internal workflow, the appropriate allocation of roles and responsibilities, or even the 'back-to-basics' technique of communication!

Compared to traditional projects, BIM advocates an increased frequency of information exchange throughout the project lifecycle. The challenge is that many disciplines work in many applications and therefore information interoperability is not always easy. This is, however, possible with open format file types like IFC. These can be exported and imported into most authoring and reviewing platforms and therefore provide a key information link between specific task teams.

For example, when a design has been detailed and the subcontractor then takes ownership of it, the designer can collaborate cross-platform, therefore enabling the subcontractor to pick up from where they left off. This alone provides a significant programme saving as the subcontractor no longer needs to recreate the design intent information.

The BS EN ISO 19650 strongly advocates the importance of interoperable data formats, like the IFC.

As per clause 5.1.6 of BS EN ISO 19650-2:2018, "using open data standards whenever possible to avoid duplication of effort and interoperability issues." (BSI Standards Limited, 2018)

The NBS National BIM report 2019 indicates that 77% of individuals use the IFC format within their project. (NBS, 2019). This illustrates a key step not only in industry mindset progression but also the start of a new, next level, collaboration era.

Continuing on from the mindset of increasing collaboration between parties within the project lifecycle - and exploiting the latest technological advances - it would be rude not to mention the latest BIM buzzword, the 'Digital Twin'.

Through the correct adoption of BIM Standards and Processes, in alignment with BS EN ISO 19650, a BIM project can be appropriately developed to enable an accurate virtual representation of the as-built asset.

The information model (accurate virtual representation) can then be stripped down and passed through to a facilities management platform, where the asset information model (AIM) is built up, developed and further enhanced by adding additional asset data. Utilising appropriate maintenance forecasting procedures within the facilities management system, one can use the AIM to inform decision-making during the operational phase. At this point, it becomes a digital twin. Harris (2019) describes the digital twin: "The digital twin concept is more than just an evolution of a BIM or 3D model. More advanced digital twins use two-way interactions with their physical counterparts; this theoretically allows for the physical asset to be controlled remotely – or even autonomously maintained – by its digital twin. For example, through the use of devices and sensors and machine learning linked to the internet of things, a building's digital twin could use its collected data to react to anomalies without the requirement for humans to interact."

Of course, all of the above is only possible with a solid information management structure, an eagerness to innovate and a drive for industry best practice. The BS EN ISO 19650 series provides us with a framework to do this, and it is accessible to all. Valuable guidance documentation is available through the UK BIM Alliance website and it is there to help you. So, no matter where you currently stand on your road to BIM - whether yet to embark or with plenty of miles under the belt - there is plenty of learning for all and an exciting journey ahead. ◂

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