Engineering surveying *showcase* 2013

ISSUE ONE

FEATURES:

Monitoring banks and structures with the EA

Machine control for complex nature reserve

Class of Your Own counters perceptions

BIM and the Land Surveyor's role

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Engineering surveying*showcase*2013 ISSUE ONE

Engineering Surveying Showcase is a twice-yearly window into the surveying industry. It is published for the benefit of the industry and for the professionals who work in it.

Our mission is to show to the survey industry's customers, clients and employers, whether as individual surveyors, managers or other professional disciplines, such as engineers or architects, the latest developments and applications in surveying technology and techniques.

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*Don't miss the next issue of Showcase with our review of software for Geomatics. Issue No 2 for 2013 is out 30 September 2013**

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COVER STORY

All of the images featured on the cover are from articles and features in this issue of Showcase and reflect the wide ranging editorial coverage.

• *Our thanks and acknowledgements to Spectra Precision, Clem Rutter, Class of Your Own, and the Environment Agency.*

Showcase is published for the benefit of those who work in, or supply, the geomatics industry. Our aim is to raise awareness of the new opportunities which technology is bringing to the traditionally narrow field of surveying.
Showcase is currently published twice yearly (March and October) and distributed to over 6,000 surveyors, engineers and professionals who use spatial data in the built environment.

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Raising awareness to change perceptions

Welcome to the first issue of Showcase for 2013. Showcase exists to raise awareness amongst surveyors and engineers of what today's surveying and mapping equipment and techniques can do, and to reach a wider readership working in construction and the built environment, who may need the services of professional survey and geospatial specialists or just need to know more about our side of the industry.

This issue has several interesting articles that help inform our aims. The importance of monitoring cannot be overstressed. Things like unstable natural features such as cliffs as well as structures such as buildings likely to be affected by adjacent work like tunnelling, or manmade river banks and dams, all need a watchful eye to protect the public and key infrastructure. The previous issue (*Showcase 2012 No 2* – "Monitoring system helps save lives") demonstrated vividly what might have happened without monitoring. Turn to page 22 to read how the Environment Agency uses monitoring.

"Professional institutions invariably work within their own bubble to further their own interests. . ."

For those unaware of the advances in machine control we look at how a highly complex earthworks project for a nature reserve would probably have been all but impossible using traditional setting out with batter rails etc. We also take another look at BIM, building information modelling (or management, depending on where you are in the process I suppose). **Chris Little** is a land surveyor with plenty of experience in both practical surveying and teaching and training. He poses the fundamental question of what the surveyor's role should be in BIM. Turn to page 12 to find the answer.

But perhaps the most challenging topic we've explored this time is the importance of changing negative perceptions about working in construction, which are endemic amongst school teachers who play a pivotal role in shaping young people's career destinations. **Alison Watson**, a land surveyor, and partner **Dan Gibson**, an architect, are behind Class of Your Own (COYO), a scheme that reaches out to schools and engages with pupils by giving them a chance to "design, engineer and construct" something. The shear enthusiasm of the youngsters has to be experienced as I did at a House of Lord presentation in March. They just loved telling us about how they used the software, developed their design skills and thought about sustainability and green issues.

COYO has had strong backing from Mott MacDonald, Autodesk and Topcon. But why haven't the professional bodies been doing this sort of thing? They will probably answer that they have regular links with schools. But too often those links rely on passive activities like speaker visits, leaflets and videos. Professional institutions usually work within their own bubble to further their own interests (which may not necessarily be their members' interests) and don't reach across the various construction disciplines as COYO does. They need to step out of those bubbles and step up to the plate that an opportunity like COYO offers. Read more on page 28.

Finally, if you're interested in capturing 3D geospatial data and laser scanning our feature (begins page 16) looks at the latest developments in what is becoming a ubiquitous technology. Scanners play a key role in capturing geospatial data, from monitoring, to heritage, to BIM they provide a quick and economic option. We review the latest offerings from the manufacturers and **Richard Groom** argues for a standard format for point clouds.

*The next issue of Showcase will be autumn 2013. Copy date for editorial is **9 September** for publication on 30 September. Copy date for advertisers is **18 September**.*
• Call 01438 352617 for more details

Editor

**If you know of engineers and project managers who would benefit from a copy of Showcase, please drop us a line and we'll earmark them for a free copy.*

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The autumn and early spring are traditional times when manufacturers of survey and mapping equipment launch new products, update software and refresh their ranges. 2012/13 is no exception with the October Intergeo exhibition in Hanover seeing several innovations.

Zebedee, a handheld laser scanner could be ideal for facilities management.

AERIAL MAPPING AND LiDAR

Large format aerial cameras continue to be in demand for wide area mapping projects. Microsoft company Ultracam announced the **Falcon**, a digital airborne camera system with image footprints of 14,430 or 17,310 pixels and the ability to change storage units in flight. Image capture varies depending on footprint but up to 5,200 images can be stored.

Another aerial camera system was unveiled by Optech using SOMAG AG Jena's GSM 3000 gyro-stabilization mount with a multi-sensor frame and platform for its line of airborne laser terrain mappers and digital metric cameras. The mount is compatible with all of Optech's Orion lidar sensors and CS-series digital mapping cameras.

Pegasus flys high

Capable of altitudes up to 5000m, Optech's new **Pegasus HA500** system can collect multi-beam lidar data throughout its entire operating envelope with maximum cloud density and accuracy at any altitude. A twin-laser configuration ensures the same data fidelity and measurement precision irrespective of the number of beams.

80% efficiency gain

Optech has more recently announced the **CS-6500** aerial camera system, a highly efficient camera that offers a fast cycle time, an electronic shutter, panchromatic or colour CCD sensors, interchangeable lenses, and a metric-quality dataset. The camera's new 29-Mpx interline CCD increases the operational window, makes data collection 80% more efficient, and reduces read-out leakage output, enabling operators to gather high-quality imagery even faster. The camera also features simplified operations, high versatility, and a large 6500×4300 pixel footprint that enables integration with Optech's ALTM lidar sensors and CS-series of thermal and multispectral cameras.

Real-time orthos

From Trimble, the **DSS 500** is a medium-format, directly georeferenced imaging system. Capable of producing full-resolution, ortho-rectified imagery in real time, the digital sensor system (DSS) is designed as a high-productivity, mapping-grade solution for colour orthophoto and vertical mapping applications. The DSS 500 is also compatible with Trimble's INPHO 5.5 photogrammetric software for unmanned aerial systems and aerial LiDAR data production. New versions of eCognition image analysis and Trident Analyst office software for remote sensing were also announced. The DSS 500 is also available as an OEM board set for custom integrations.

60Mpx multi-spectral

The latest development from Leica is the **RCD30 Oblique**, a medium format camera for high accuracy 3D urban mapping and 3D corridor mapping applications. Based on Leica's RCD30, the world's first 60Mpx multi-spectral medium format camera, the Leica RCD30 Oblique allows a trio and penta head configuration for corridor mapping and urban mapping applications. Customers have a choice of CH61 RGB only and CH62 multispectral RGBN camera heads. For highest image quality the RCD30 Oblique provides multi-directional motion compensation.

20k pixel swath

Leica has also announced a new generation of its airborne digital sensor, the **Leica ADS100**. Introducing a unique focal plate design, the ADS100 offers a swath width of 20,000 pixels for all multispectral bands (RGBN) and multispectral capability in forward, nadir and backward. The ADS100 provides the world's first large format CCD line with TDI (Time Delay and Integration) to increase sensitivity despite a smaller pixel size. By doubling the cycle rate, high resolution images can now be acquired at much higher ground speeds. To provide the best stabilization performance, the new Leica PAV100 gyro-stabilized mount is equipped with revolutionary adaptive control technology. In addition to the PAV100, the ADS100 shares all aircraft installation components such as camera controller, operator displays and flight control software with Leica's RCD30 medium format camera.

TERRESTRIAL LASER SCANNERS

Compact mobile mapping

Topcon introduced a new vehicle-mounted compact 3D mapping system that can accurately measure objects even in adverse weather conditions and enclosed job sites such as tunnels and mines. The IP-S2 Compact+, incorporates high-precision GNSS receivers, IMU (inertial measurement unit), vehicle wheel encoders, 360° camera and laser scanners.

Product manager Sander Jongeleen said, "The full-colour, high-resolution, high-density point clouds dramatically increase efficiencies for example in GIS asset management such as utilities, and transportation work such as roads, highways, tunnels, and overpasses."

The system is available in two configurations: a three-scanner standard model or a five-scanner system. The three-scanner gives a 360° vertical

Right: Topcon's new IP-S2 Compact+ 3D mobile mapping system can be easily mounted on a car or vehicle.

field of view. The five-scanner system increases cloud density, minimizes scanning shades, and collects 150,000 points per second with a range of 40-50m. two IMU options are available, either high grade commercial or tactical units.

Mobile mapping, indoors

An interesting data-gathering device seen very much in action at Intergeo, was the **Viametris I-MMS** indoor mobile mapping system. Housed in a simple three-wheel trolley, it comprises two high density LiDAR sensors with a range of 50m and an optional panoramic camera. An onboard processor and real-time data capture display are included. There is no GNSS or INS; the user simply completes data acquisition by returning to the start point to ensure closure. Centimetre level accuracy is aided by the Viametris SLAM algorithm, developed from gaming applications.

Zebedee springs in

The indoor market for measured surveys and facility management is set to grow. Earlier this year 3D Laser Mapping announced the arrival of Zebedee, a handheld laser scanner licensed from Australia's national science agency. Mounted on a simple spring mechanism (hence the name, which older readers may recognise from the BBC TV's *Magic Roundabout*), the scanner loosely oscillates about the spring producing a rotation that converts 2D measurements into 3D fields of view. Its ability to locate itself makes Zebedee ideal for use indoors, underground and in enclosed environments, where GNSS won't reach.

Surveyors targeted

The Intergeo saw the launch of Leica Geosystems' latest scanner, the **ScanStation P20**. Targeted at surveyors, Leica are claiming three world firsts: onboard check & adjust functionality, sub-millimetre range noise at 120m, and by combining time-of-flight range measurement and modern waveform digitizing (WFD) technology the P20 can deliver 1 million points per second.

Trimble opts for Faro

The launch towards the end of 2010 of the Faro Focus laser scanner certainly set the industry humming. Described as a 'game-changer', the scanner weighed in at only 5kgs and a price half that of erstwhile competitors. The Focus has been selling well. So well in fact that the big boys want a slice of the action. Sensibly Faro, with a limited distribution network, has responded. Trimble is now offering the scanner re-badged as the Trimble TX5. For specs see our Laser Scanners feature but you'll need to look under Faro.

Underground scanner

Maptek has released the **I-Site 8200** laser scanner designed for underground survey applications. The scanner can be coupled with a range of accessories to provide a complete scanning system for underground drives, tunnels and stopes, as well as surface stockpiles and silos, while processing of scan data can be undertaken in I-Site Studio and I-Site Void software. The I-Site 8200 has a vertical scan window of -35 to 90° and 360° horizontally. Whatever the orientation of the scanner, integrated levelling automatically corrects scans before processing.

The I-Site 8200 scanner is designed for underground work.

GNSS

For GIS applications Leica Geosystems has launched the **Zeno CS25 GNSS**, a 7" screen tablet computer running Windows 7 with full GNSS functionality and incorporating a compact L1/L2 antenna.

Leica also launched earlier this year the **Viva GS14 GNSS** receiver. With Leica's SmartTrack and SmartCheck technology integrated, the GS14 tracks signals with the highest quality and constantly evaluates and verifies the RTK solution using Leica's xRTK technology to deliver positions in difficult environments.

Premier GNSS system

Launched at Intergeo the

High-accuracy aerial surveys help visualise HS2

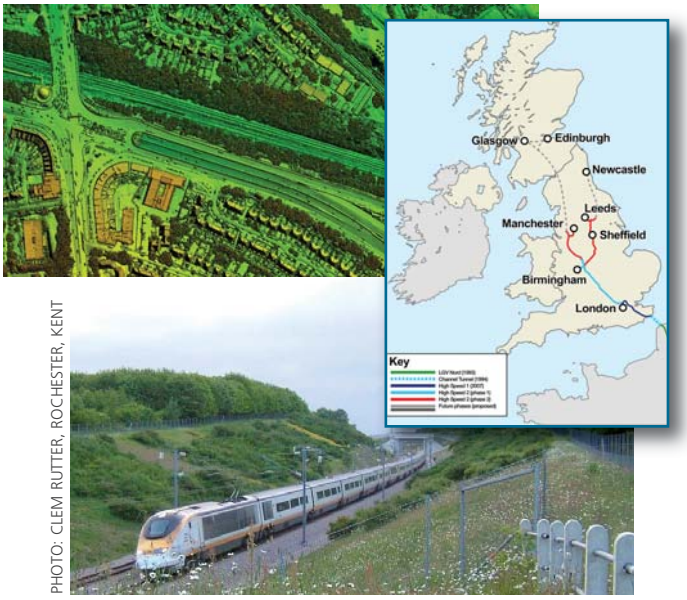

PHOTO: CLEM RUTTER, ROCHESTER, KENT

Detailed planning is under way for the UK's largest ever infrastructure project, the new high speed rail network HS2. The project is designed to connect Britain's major midlands and northern cities to the European high-speed network. While commencement of construction is some way off (2017 or later), the promoters HS2 Ltd, have needed aerial imagery and mapping with advanced visualisation tools. With experience of working on projects like the Channel Tunnel Rail Link, they turned to Blom.

Utilising wide-format aerial cameras and LiDAR Blom captured high-resolution aerial imagery and laser data along the entire 225kms of the first phase of the proposed HS2 route to provide a complete 3D overview. The high-resolution 4cm imagery can also be used for subsequent 1:2500 topographic mapping and provides a permanent time-stamped photographic record along the route.

Simon Kraeter, commercial director for Blom UK explains "Our survey data is a valuable asset for route design and geotechnical assessment, helping HS2 Ltd to design a better railway that minimises the impact along the route. The models can also be used to create sound propagation simulations, making it possible to devise where sound reduction steps might be necessary."

Many planning decisions will require more than just a vertical view and mapping to be able to put the site in context with the surrounding area. Blom supports this need by capturing oblique aerial photography and video, giving a 'bird's eye' perspective to any location on the route.

"Plans that are sympathetic to the surrounding area are important to everyone but can only be made if a contextual view of the area is available, which is what our oblique imagery and aerial video provide" adds Kraeter. "Hyperspectral imagery, used to show vegetation cover, is also provided, allowing planning decisions to be made with environmental aspects in mind."

Although it maybe another 20 years before the project is fully completed, current plans are for the link to first reach Birmingham then split into two lines, one for Manchester and the other to Leeds. If construction begins as planned in 2017 then Birmingham could be connected by 2026 and the remainder by 2032.

Trimble R10 GNSS system is the company's premier solution of its integrated survey receiver portfolio. Designed to increase productivity, the R10 provides powerful functionality, including Trimble 360 receiver technology, precise position capture with Trimble's SurePoint technology and xFill, a bridging technology that "fills in" for RTK corrections when there are radio or internet connection outages.

Topcon in the vanguard

Showcase covered in the last issue (October 2012) recent updates to Topcon's GNSS range including the ultra lightweight **HiPer SR** RTK system. At Intergeo they announced the inclusion of a GNSS patented chipset known as Vanguard. With Universal Tracking technology and 226 channels available, all current and upcoming GNSS constellations can be tracked.

Topcon believes that he architecture behind this new chipset is superior to any available on the market. Fraser Smith, director of GNSS product management for Topcon Positioning Systems (TPS), said, "The new Vanguard GNSS technology uses the most advanced GNSS signal tracking and processing architecture available in the marketplace."

Vanguard includes several exclusive solutions; Quartz Lock Loop for superior signal processing in heavy vibration applications, Universal Tracking channels for all in view tracking, and Intelligent Tracking Optimization for selecting the best combination of satellites.

Trimble's Spectra Precision ProMark 220 GNSS has the latest Ashtec chipset.

The technology is being integrated into additional Topcon and Sokkia GNSS receivers.

Updates across Trimble's GNSS range

Following the launch of the R10, Trimble has updated its entire GNSS survey receiver portfolio adding increased functionality and capability. Models affected include the Trimble R4, R6 and R8. The updates include increased satellite tracking and RTK performance. The improvements follow the introduction of the "next generation" Trimble R10 GNSS system explained Erik Arvesen, vice president of Trimble's Survey Division, adding, "We felt it was an ideal opportunity to modernise the complete integrated receiver portfolio. The additional functionality in the Trimble R4, R6 and R8 provide surveyors with more capability, flexibility and additional receiver options to meet their ever-changing business needs."

ProMark 700 for network RTK apps

Trimble's Spectra Precision brand has introduced the **ProMark 700 GNSS** receiver specifically for network RTK applications. Weighing only 650 grams, the ProMark 700, with all operations performed from the data collector, is possibly the lightest GNSS RTK smart antenna available on the market. It features a long battery life (typically over 10 hours) for all-day operation without the need for recharging or replacement. The waterproof unit is designed for harsh outdoor environments and a wide operating temperature range.

The new receiver is equipped with 220 GNSS dual-frequency and dual-constellation channels that allow tracking of all available L1/L2 GPS/Glonass satellite signals. The ProMark 700 has been designed as an intuitive, simple and easy-to-use receiver. Add-ons include the low-cost MM10 data collector or the new T41 data collector with a smart phone design.

Trimble again added to the brand's portfolio earlier this year with the launch of the **EPOCH 50 GNSS** system, with 220 channels to make effective use of the GPS L1/L2/L2C/L5 and Glonass L1/L2 signals. The receiver uses proven technology to provide an extremely stable phase centre and tracking of the new stronger L2C and L5 signals.

Ashtech lives on inside

Another brand acquisition by Trimble is Ashtech, now only featuring as the engine in Spectra Precision's GNSS offerings. The new **ProMark 120** and **ProMark 220 GNSS** receivers launched at Intergeo replace the ProMark 100 and ProMark 200 models. Both come with an updated hardware platform that includes the latest Ashtech GNSS chipset with Z-Blade GNSS-centric technology. Both models have updated software and the ProMark 220 is dual-frequency and dual constellation with Glonass L2 capability. In addition, both come with the MS windows embedded handheld 6.5 professional operating system.

Gorilla glass for controller

Trimble has also recently introduced an all-in-one device for mobile communications and surveying data collection. The **Trimble Slate Controller**

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Leica's new Rugby 840 includes Smart Targeting and a Smart Lock feature that continuously monitors the laser plane for any errors.

comes with a 4.3" capacitive touch Gorilla glass display covering the entire front surface that increases readability without sacrificing durability. The controller combines the convenience and ease-of-use of a smartphone with rugged durability, optimised field software and the **Trimble R4 GNSS** receiver.

Rugged mobile

Handheld Group has launched the Algiz 10X rugged mobile device. It weighs 1.3kgs, is 32mm thick and can withstand tough weather and harsh handling. Its 10.1" touch-screen can display detailed maps and other visuals even in bright sunlight. It comes with IP65-rating and meets stringent MIL-STD-810G military standards for protection against dust, water, vibrations, drops, extreme temperatures and varying altitudes. The tablet is GPS enabled, with Bluetooth, fully integrated modem and antennas for wireless connectivity.

TOTAL STATIONS

Nikon-Trimble has launched a new series of mechanical total stations. The **Nikon NPL-322** series includes instruments with 2" and 5" angular options. The 2" model offers dual-displays and both models feature a reflectorless EDM with 200 metre range. The series feature two rechargeable long-life Li-ion batteries to support the longest of working days.

UAVs

In the fast growing market for UAVs SenseFly updated its UAV range at Intergeo. The hand launched **eBee** offers a 45min flight time with a range that can capture 1.5–10 sq kms. The unit weighs 630g at take off and carries a 16Mpx camera enabling it to capture images with a ground resolution as low as 3cm per pixel.

CONSTRUCTION LASERS

Touch down for new Rugby range

A new line of construction lasers from Leica promises to be the toughest in the market with the highest environmental standard (IP68) for water and dust protection. The **Rugby 800 series** accessory options include a unique solar power battery charger.

Designed from the ground up and to military spec MIL-STD 810G, the four-model range includes the Rugby 840, a multipurpose horizontal/vertical laser for all levelling, aligning and squaring applications and with an automatic calibration feature.

A 'Smart Targeting' function allows users to tie-in slopes (in single and dual axis) and to align the beam automatically in the vertical. Once the laser is set up on the starting point, the second point can be positioned automatically by using the new Leica Rod Eye laser receiver without the need to walk back to the laser or a separate remote control.

With 'Smart Lock' the laser plane is continuously monitored in real-time eliminating errors. Should the laser plane move out of tolerance, the laser will indicate the movement with an alarm. This functionality is ideal for batter board and facade applications that require a fixed installation of the system and the laser plane to stay exactly in place all day long. Additionally, the 'Maximum Temperature Stability' technology provides the highest accuracy throughout the day over the entire working range without drifting.

The lasers come with new generation unbreakable Lithium-Ion batteries. Throughout the new Leica Rugby family, the battery packs (Alkaline and Li-Ion) are interchangeable and can be charged anywhere anytime on site. The lasers come with a five-year no cost warranty.

SOFTWARE

Z/I goes for PureColor

Hexagon company Z/I Imaging and Leica stablemate, has a new release of its Z/I Sensor software PPS V 6.6 that introduces PureColor Technology. As part of a

continued over page

Nikon total station levels Polish aircraft

One of the world's most successful military training aircraft, the PZL-130 TC Orlik, is now being levelled with the aid of a Nikon Nivo 5M total station.

Levelling, both longitudinal (forward and aft) and lateral (left to right), is performed in the final stages of aircraft assembly. Accurate levelling on the ground is required before precise alignment and symmetry checks can be performed to confirm that the geometry of the aircraft is to specification.

Prior to using the Nivo total station, levelling was done with a theodolite and precision levelling rod and whilst easy to use, distances could not be measured. Manual calculation was also required for the height differences and calculation errors, and manual entering of the values into a computer.

Manufacturer EADS PZL "Warszawa-Okecie" SA, Poland's oldest aircraft manufacturer, sought a more efficient solution – one that would be easy to use and could automatically collect and transmit data to an integrated computer. ImpexGEO, one of Poland's largest suppliers of measuring equipment, suggested and demonstrated the Nivo 5M total station for the task.

Equipped with reflectorless technology, the Nivo 5M eliminates the need for a levelling staff, and all height differences are checked using both distance and vertical angle measurements. All data are automatically stored in the internal memory of the total station for later export in ASCII format to a PC. In addition, the Nivo's coaxial laser pointer speeds aiming and often eliminates the need to optically point the unit. Other features include full CoGo functionality and Bluetooth comms to external data loggers.

Although Orlik's technicians had never used a total station, they required only two hours of training on the easy-to-use Nivo with its shortcut customisable user-defined keys to enable access to the most important features with just a single keystroke. The lightweight, small size of the instrument, its two independent hot-swappable batteries, and full-day battery life are also valued features of the new unit.

broader focus on radiometric enhancements and simplified processing, PureColor boosts the dynamic range of the output image and protects all information collected even in high illuminated and shadow areas. In addition, PPS V 6.6 will reduce the time needed for manual adjustments and provide a significantly higher automation level for post-processing parameter settings.

Additional features and enhancements include automated colour balancing for perfect radiometric image quality and a new atmospheric correction model to reduce haze and dust.

New apps and software update for Leica's iCON

A new '**Roading**' application and an enhanced version of its iCONstruct field software for the iCON construction portfolio have been announced by Leica Geosystems. iCONstruct field v1.5 significantly improves and optimises construction workflows with the iCON CC50 and CC60/61 field controllers and the iCON gps 60 and iCON robot 50 positioning sensors.

The Roading application is an option for the iCON build and iCON site software. It is also available for the Leica iCON CC60/61 7" inch large display controller. Roading enables setting out of individual road lines and slope elements. A new cross-section view gives users a good visual impression of the road profile at the current measured position. Together with the split screen option, it is possible to achieve the best possible overview of the current position and the road model. Roading allows contractors to use the same data on the machine and on the field controller.

The latest software improves and simplifies the setting-out workflow of points and includes a new arrow view with different orientation options. With these new guidance options users can select their favourites to increase the speed when staking out design points. GPS users can also now receive coordinate systems via the RTCM v3.1 message format using SmartNet RTK service.

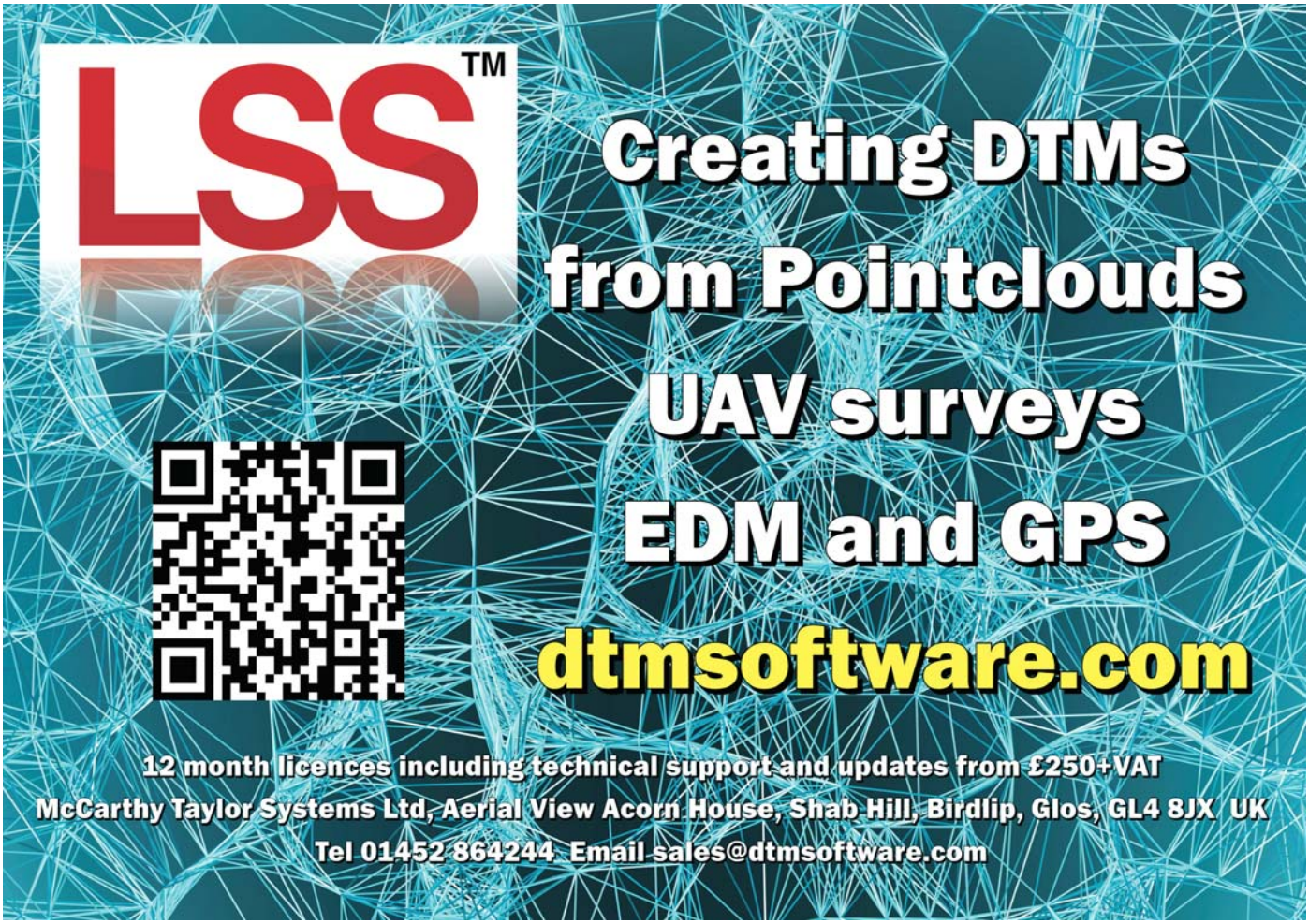
Leica's latest cable locator offers Bluetooth connectivity for seamless integration with mobile mapping technology.

BRIEFS

Applanix has introduced the POS LV 120, a small, light-weight micro-electro-mechanical (MEMS) inertial measurement unit (IMU) that provides continuous positioning and orientation.

New additions to Leica's **Digisystem** range of cable locators and transmitters use the latest digital signal processing technology with frequencies of 512Hz and 640Hz giving users a greater tracing range as well as the ability to locate sewer-camera inspection systems. The Digicat 550i xf and 650i xf also gives depth estimation as well as a 32Mb memory and Bluetooth connectivity for integrating with mobile data loggers and devices.

Trimble has acquired the **Penmap** suite of software for office and data collection in the cadastral and surveying markets.



Engineering surveying and **Geomatics** World - have you been missing something?

Over the years our publication *Geomatics World* and its predecessor *Surveying World*, have published many articles on engineering projects. From the Channel Tunnel, the Burj tower in Dubai, the Auckland telecoms tower to Libya's Great Manmade River project and the Thames Barrier, we have kept surveyors informed of the special techniques used by their colleagues on these challenging projects.

WE HAVE ALSO published detailed accounts of structural monitoring and deformation as well as the techniques used for high-resolution close-range data capture by laser scanning or photogrammetric imagery for heritage and historic documentation, through sites such as Stonehenge, Easter Island and Iron Bridge.

In addition, Geomatics World regularly reports on new measurement technologies and their application. We also keep readers up to date on industry-wide initiatives likely to affect their professional practice, like BIM, new publications and regulatory affairs.

We are invariably the first to report on new technologies like 3-D GIS, laser scanners, UAVs or 360-degree panoramic cameras. During the last year we have reported on techniques as diverse as using kites to capture high-resolution imagery and a new GPS technique, precise point positioning, that could greatly reduce the cost of positioning. We regularly review and analyse the complex analysis associated with getting the very best positional data from equipment such as laser scanners and GNSS receivers.

For hydrographic surveyors we also keep a watchful eye on offshore positioning and underwater survey systems.

Geomatics World is the leading English language publication for surveyors and measurement specialists working in the UK and throughout the English-speaking world.

The following is just a sample of some of the articles we have published during last year and to date in 2013.

Pebble tracking

Measuring beach movement is not a precise or static science. One solution involves installing 2400 tiny RFIDs in pebbles.

Surveying Stonehenge: Part II

After the data capture and processing comes the analysis and interpretation. Paul Bryan takes us through the results.

Oil, Gas and Geomatics

The International Association of Oil and Gas Producers (OGP) Geomatics Committee has launched four documents that will be essential reading for those working in the industry, reports Richard Groom.

Blue oceans, IMUs and Oceanology

Richard Groom reports on a hydrographic technology forum run by R2Sonic and concurrent with the Oceanology event.

Just how safe is GNSS from interference?

Simon Canning examines the many potential sources of interference for GNSS signals, from seagulls to malicious jamming.

Laser scan launch for Belfast Titanic venue

A spectacular light show heralded the opening of Titanic Belfast but it was only possible due to some complex scanning and modelling.

Kite Aerial Photography

A venerable technique harnessed to high-resolution digital cameras is providing great results, explains Bill Blake, but watch out for the wind!

Precise Point Positioning v GNSS

Chris Rizos and colleagues analyse whether this technique is a viable alternative to differential GNSS and network RTK.

Combining laser scanning and sonar

An award-winning project ingeniously combines scanning and multibeam sonar to fabricate and install an underwater spool piece.

Micro UAVs: useable survey tools?

Andrew Blogg explains the pros and cons of this new survey tool.

Too many points?

In the first of two articles Dan Schnurr analyses the options for producing point clouds from aerial survey systems.

BIM: what's in it for survey?

Richard Groom talks to two leading survey companies about BIM and reports from a recent RICS event and asks, can we define BIM?

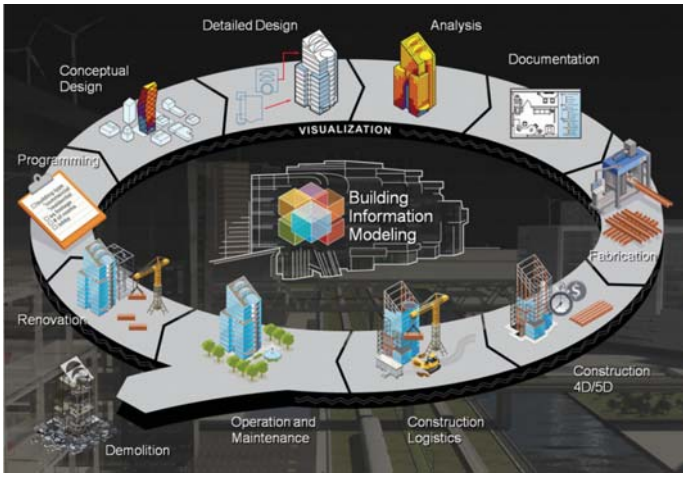
Scanning Easter Island's mysterious statues

Laser scanning has enabled archaeologists to record and assess erosion on these strange human artefacts, explains Rachel Dalton-Taggart.

• To become a regular subscriber to Geomatics World go to: http://www.pvpubs.com/magazine.php?id=1 or call 01438 352617.

BIM – what is or should be the role of the surveyor?

Someone needs to be at the heart of the BIM process for it to operate smoothly, argues **Chris Little**. That person should be the Land Surveyor.



Above: BIM – or Building Information Modelling – is aimed at the whole life cycle of an asset, including conception to design and build and even to demolition.

BIM IS THE current buzz-word or should I say TLA (three letter abbreviation) in the Construction world and will continue to affect all of those connected to the industry for the next few years. Many people will already be aware of what it is, but there are many others for whom the term will be totally new.

There is no one accepted definition of the term BIM. It is often taken as standing for Building Information Model, or Building Information Modelling. If anything, these are a little simplistic as it covers more than just the 'model' of a building. It is really concerned with the process of managing all data associated with a building during its whole lifecycle. This encompasses not only the building geometry, but all the quantities and properties of the building from concept, planning and design, through construction, operation and finally de-commissioning. So, possibly BIM should stand for 'Building Information Management'. It is the information that becomes vital centrally for a project, with the aim of access by all who need information about the building.

BIM is being pushed by governments worldwide as a means of creating a leaner and more cost effective form of construction and facility management. In the UK, the government expects all its funded projects to fulfill BIM requirements by 2016. This will have a major impact on the Construction and associated industries.

Is it a database? Is it CAD? Is it software?

At the heart of BIM is the 'model', but what is it? A database, a CAD model, or a software program? It will certainly be dependent on software for allowing access to the data, but will it be standalone programs, or more like the Internet with shared access? The data types and formats will vary and continue to grow with the life of the project, so what will hold the data/information together? This is where the term 'model' creates problems. Many in the construction and surveying industries will think of the 'model' as a 3D CAD model based on surveyed and design data. Those involved with cost management and facility usage etc are more likely to consider the 'model' to be a combination of spreadsheets and databases related to rooms or reference numbers rather than to geographical location.

Where will the 'model' come from? The designers (architects, structural and MEP engineers etc.) implementing concepts laid out by the 'owners'? Will it be based on new survey data, or from existing plans? How will this data fit together, what forms of quality control will be in place? Do the 'modellers' understand the different datasets, the concepts of scale and accuracy and how these affect the drawings and CAD models? **Andy Roberts**' article, "Survey Drawings – an Oxymoron?" in the March/April 2006 edition of *Geomatics World* is still very relevant today, with many professionals not understanding that 'the accuracy of survey data in digital drawings is not linked to the zoom factor of the mouse wheel'. Many think that digital survey drawings are at a scale of 1:1 and that dimensions taken from a CAD drawing are correct to 3 decimal places of a millimetre!

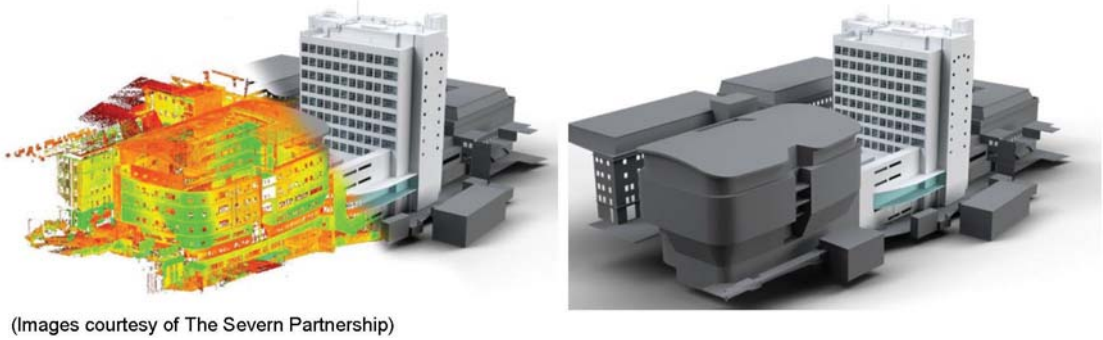
… unless they grasp the basics of geometry and surveying the results… can be disastrous. . .

Understanding 3D geometry is essential

So, who should be involved in the creation of these BIM 'models'; the Land Surveyor? For decades they have been creating the floor plans, elevations and sections from pencil plots, through digital plots to full 3D digital models, and ensuring that everything 'fits' within the building correctly. It is the land surveyor who understands the 3D geometry of buildings and how survey data from different sources (tapes, total stations, laser scanners etc.) can be integrated to create a true representative model.

Survey technology today makes it very easy - possibly too easy - for anybody to collect survey data and create plans/models, but unless they grasp the basics of geometry and surveying the results, without anyone realising, can be disastrous and expensive.

BIM is not just about buildings but also Infrastructure. This increases considerably the size and complexity of the database and will involve many more mapping data formats (satellite, aircraft and UAV imagery, LiDAR point clouds, GPS/GNSS positioning) and other data sources such as existing maps/plans (paper and digital), services records and images from GPR (ground penetrating radar) etc. Will all this data be compatible and accessible within the BIM environment and its software? Data exchange and compatibility

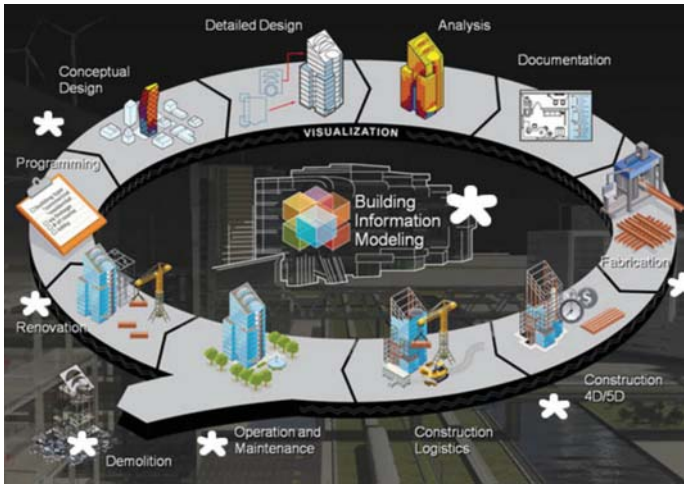


(Images courtesy of The Severn Partnership)

problems, along with the management of vast quantities of varied data, are nothing new to the surveyor. Surveyors have been able to combine and make accessible datasets for many years, ensuring that digital data is properly available. How many times has digital data been supplied as a .pdf rather than a .dwg drawing making it impossible to extract the information digitally?

BIM and Crossrail

With BIM being applied to infrastructure, not just buildings, it introduces the issue of coordinate systems. Will the BIM 'model' be based on a plane or a national coordinate system? A very large number of engineers, architects and other professionals know nothing about scale factor, so what hope is there for the BIM modeller? Crossrail's data strategy, for instance, from the beginning had "the aim of creating an integrated design, facilitating multidisciplinary collaboration throughout the life of the project, becoming the base for an asset management system". A BIM project before the existence of BIM. The coordinate system for the mapping was originally



Land Surveyors should be involved at almost every stage of BIM - not just the initial stages.

Ordnance Survey National Grid, but due to the potential problems of scale factor a totally new system (London Survey Grid) was devised to ensure what was effectively a scale factor of unity for the tunnelling section through the centre of London. Will other major BIM infrastructure projects be as enlightened?

The ones with the knowledge

Land Surveyors ought, should. No, must. . ! be involved in BIM projects. They undertake initial surveys on which most of the models will be based. They understand coordinate systems, scale, accuracy, the nature of errors, and the necessity of quality control at all stages of a project. They can manage and ensure compatibility of large and varied datasets. They have always worked in 3D and understand geometry, CAD and 3D modelling.

So what is the land surveyor's role in BIM at present? The BIM circle does not mention the land surveyor at all! Their skills are required at the initial stages, for dimensional control, setting out and checking during site construction, to maintain the model during its life, and then closing the circle after demolition.

The Land Surveyor's knowledge and skills are vital for the BIM model to work, and for the BIM process to operate smoothly. They should become part of the building management process and not just supply data. The land survey industry needs to sell the benefits of its skills and become involved in all parts of BIM, and be there to ensure that all the pieces of the BIM jigsaw are the right size, in the right place and fit together successfully.

• *Chris Little is a highly experienced trainer and educator and has worked in both industry and academia. Nowadays he is an independent consultant specialising in assisting small and large companies to develop their personnel in the fields of data management, storage and transfer; survey instrumentation and other geospatial technologies.*

More at
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2013: the Year of the Point Cloud

BIM has been the talk of the year to date and, thanks to BIM, the term 'point cloud' is gaining wider usage outside the world of laser scanning. Perhaps one day, like GPS, it will eventually be understood by everyone, wonder Richard Groom.

***Right**: a laser scanner calibration room.*

TRADITIONALLY, and I am hesitant to use the word for a technology that is not much over ten years old, laser scanners have been the standard means of producing point clouds. But in 2013 relentless advances in computing science have made production of point clouds using photogrammetric techniques an attractive alternative. Add to that the prospect of capturing aerial photography using UAVs and web-based point cloud generators, like 123D Catch and it is no longer just a question of selecting the most appropriate scanner but also of which technology will give the best result. For more detail on the options see the Jan/Feb 2013 issue of *Geomatics World*.

Time for a standard

Of course, the difference between 'laser scanning' and 'point clouds' is that one is a technology and the other is a product. A shift of thinking from the technology to the product carries with it a change of emphasis. If you are presented with a point cloud, what do you want to know about it? The method used to survey the point cloud is important because it will help the point cloud user to understand the quality of the point cloud data. Without that information, measures of accuracy and precision take on greater significance. Point cloud data should be stored with metadata that retains the quality information that gives the data provenance. The laser scanning world has come up with various formats over the past decade, but laser scan data is simple stuff and it is time for a standard format to emerge. We will be covering this in *Geomatics World* later in the year.

Beware long range noise

Precision is a measure of the consistency of the points. If you repeat the same point observation many times and calculate the mean, precision is a measure of how close each individual observation is likely to be to the mean. If a single observation has low precision, there is a greater risk that it will deviate further from the mean observation. Laser scanner manufacturers use the term 'noise' to mean precision. In terms of laser distance measurement the precision of a point depends upon the distance to the point and upon its surface characteristics. Longer distance means lower precision. Black surfaces absorb energy which limits the range and weaker return signals result in lower (in some cases, much lower) precision. Conversely, white surfaces reflect energy and therefore have higher precision and longer range.

The accuracy of the distance to the scanned point is a measure of how close the mean of an infinite number of repeated distances is to the actual distance. Few would deny that accuracy is a more important than precision, because a precise instrument can be constantly wrong. It is important to know how accurate the scanner is, and to do this is a calibration exercise. One method is to set up a calibration room with targets on the walls, ceiling and floor. We referred to this in the Nov/Dec issue of *Geomatics World*. This method can be used to calibrate scanners for angular as well as distance measurement. Note also that when discussing laser scanners we tend to concentrate on distance accuracy and ignore angular accuracy, but clearly they are of equal importance.

. . . it is time for a standard format to emerge.

The scanner manufacturers provide precision and accuracy information about their products, but it tends not to be consistent. It is worth asking questions of the manufacturers, particularly where they may appear not to have provided information – for example up to the full specified range of the instrument.

Check and adjust

The past few years have seen a race to observe more and more points per second. The phase-based scanners seem to have reached a plateau of one million points per second. Time-of-flight scanners typically operate an order of magnitude more slowly but the new **Leica Geosystems P20** is a time-of-flight scanner with a scan rate that matches the phase-based scanners. The company also quotes an angular accuracy of 8" and 3D point accuracy of 3mm at 50m and 6mm at 100m. However perhaps of even greater interest is the 'check and adjust' facility, which allows the operator to check the instrument himself at any time, rather than waiting to send it to the workshop for service.

The Leica 8800 was introduced last year and this year is joined by the shorter range 8400. Both instruments are aimed at the mining market, as are three instruments from **Maptek**. The i-site 8200 is intended for underground surveys of drives, tunnels and stopes. The company's website states that it is safe for use underground but does not expressly state if it is explosion-proof. Again, in the mining corner of the market, **Riegl** have launched the VZ-6000 with an incredible range of 6000 m. However, note that its laser is class 3B. In another exciting development, Z+F have launched the 5010C scanner, which incorporates an integrated high dynamic range (HDR) camera to produce full panoramic images of up to 80Mpixel per scan.

Last year **Trimble** announced a deal with FARO to sell the Focus 3D laser scanner as a Trimble OEM product. The Trimble TX5 3D, apart from some software changes, is in all respects the same as the Faro Focus 3D-120.

Mobile mapping

Mobile scanning is a fast developing area with position-fixing of the scanner the central problem. Outdoor

systems use closely-coupled GNSS and inertial measurement units to control the position and attitude of the sensor. Sensors have been mounted on road vehicles and boats for some years but we are now starting to see them mounted on other forms of transport, including pedestrians – see *Geomatics World* Nov/Dec 2012.

If outdoor mobile laser scanning is difficult, mobile scanning indoors, without GNSS for position-fixing, has to be the next big challenge. There are three indoor mobile laser scanning systems currently on the market. Two use laser scanners and other sensors mounted on a trolley that the operator pushes around the building but the most exciting prospect is perhaps a system called Zebedee. This is a sensor on a pole that the operator carries. It uses its own measurements to navigate and, according to the brochure, promises a 3D accuracy of 30mm. We expect that Zebedee will be appearing live at Geo-South on 1st/2nd May.

. . .and next a mobility scooter?

LASER CLASSES

Class 1 lasers are safe under all conditions of normal use.

Class 1M lasers are safe under all conditions of use except when passed through magnifying optics such as telescopes.

Class 2 lasers operate in the visible part of the spectrum and protection is provided by the blink reflex which limits exposure to 0.25 seconds at the power rating of the laser. Clearly, they can become dangerous if the blink reflex is suppressed.

Class 2M is safe, due to the blink reflex, if not viewed through optical instruments. The amount of light permitted through the pupil is limited by using a large diameter beam or large beam divergence.

Class 3R lasers are considered safe if handled carefully, with restricted beam viewing. The risk of damage is reduced by limiting the laser to a sufficiently low power rating.

• *Note: none of the scanners in our tables has a higher rating than 3R. For more, see standard IEC 60825-1.*

Time of flight v. phase-based scanning

Time-of-flight measurement technology is based upon the principle of sending out a laser pulse and observing the time taken to reflect from an object and return to the instrument. Scanners using this technology can operate over long ranges at rates of up to about 50,000 points per second. Waveform analysis is the detailed investigation of the return signal. For example, where the pulse hits ground that is obstructed by a shrub there is likely to be a first return from the outer leaves, intermediate returns from branches and a last return (possibly) from the ground.

Phase-based scanning involves measuring the difference in phase between the laser pulse emitted by the scanner and the pulse returning to the scanner. Typically, these scanners are able to measure points at a much faster rate than time-of-flight scanners – up to a million points per second. However, their range is severely limited by the wavelength of the signal: for some models the maximum range is 80m.

In both cases, the measured distance is combined with angle encoder measurements to provide the three-dimensional location of a point.

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TERRESTRIAL LASER SCANNERS

Company	FARO	FARO	Leica Geosystems	Leica Geosystems	Leica Geosystems
Model	Focus 3D - 120	Focus 3D - 20	ScanStation C10	ScanStation P20	ScanStation C5
Type	Phase	Phase	Pulse (time of flight)	Pulse (time of flight)	Pulse (time of flight)
Laser Class (IEC 60825-1)	3R	3R	3R	2	3R
Wavelength (Visible /IR)	905	905	Green Visible 532nm	808nm (invisible)	Green Visible 532nm
Power (mW) / (mJ)	20mw	20mw	Maximum average radiant power 1.5 mW Maximum peak radiant power 120 W Pulse duration 250 ps Pulse repetition frequency 50 kHz	Max. single pulse energy 8.5nj Pulse duration 3ns Pulse repetition 1MHz	Maximum average radiant power 1.5 mW Maximum peak radiant power 120 W Pulse duration 250 ps Pulse repetition frequency 25 kHz
Minimum operating range (m)	0.6	0.6	0.1m	0.4m	0.1m
Maximum operating range (m)	153.49	20	300m	120m	35m
Horizontal field of view	360	360	360	360	360
Vertical field of view	300	300	270	270	270
Max and min scan rate (pts/sec)	976,000/ 122,000	976,000 / 122,000	up to 50,000 pps	up to 1,000,000 pps	up to 25,000 pps
Maxi resolution (min pt spacing)	1.5mm at 10m	1.5mm at 10m	<1mm min	0.8mm at 10m/8mm at 100m	0.8mm at 10m/8mm at 100m
Dual axis compension (Y/N)	Y	Y	Yes, real time. S electable on/off	Yes, Real time. Selectable on/off	No
Accuracy @10m 90% reflectivity	0.6mm	0.6mm	_	_	_
Accuracy @10m 10% reflectivity	1.2mm	1.2mm	_	_	_
Accuracy @25m 90% reflectivity	0.95mm	-	_	_	_
Accuracy @25m 10% reflectivity	2.2mm	-	_	_	-
Accuracy @50m 90% reflectivity	-	-	6mm	3mm	6mm
Accuracy @50m 10% reflectivity	-	-	6mm	3mm	6mm
Accuracy @100m 90% reflectivity	-	-	_	6mm	-
Accuracy @100m 10% reflectivity	-	-	_	6mm	-
Accuracies quoted are r.m.s.e.	-	-		-	-
Scanner weight (kg)	5	5	13	11.9	11.9
Case weight (kg)	9	9	10	10	10
Power source	-	-	2 x Internal batteries (4 supplied) giving > 6 hours of scan time, Optional External Battery or AC Power	2 x Internal batteries (4 supplied) giving up to 14 hours of scan time, Optional External Battery or AC Power	2 x Internal batteries (4 supplied) giving up to 6 hours of scan time, Optional External Battery or AC Power
Resolution of integrated camera	70 megapixel	70 Mpx	Max 1920x1920 mage size, 260 images for a full dome	Max 1920x1920 image size, 260 images for a full dome	Max 1920x1920 image size, 260 images for a full dome
Weatherproofing	N	N	IP54 (IEC 60529)	IP54 (IEC 60529)	IP54 (IEC 60529)
Data storage	sd card	sd card	80GB internal SSD or to USB stick	256GB internal SSD or to USB sttick	80GB internal SSD or to USB stick

TERRESTRIAL LASER SCANNERS

Leica Geosystems	Leica Geosystems	Maptek	Maptek	Maptek	Company
HDS8800	HDS8400	8810	8400	8200	Model
Pulse (time of flight)	Pulse (time of flight)	Pulse (time of flight)	Pulse (time of flight)	Pulse (time of flight)	*Type*
1	1	1	1	1	*Laser Class (IEC 60825-1)*
1545nm	Near IR	Near IR	Near IR	Near IR	*Wavelength (Visible /IR)*
–	–	5 microjoules	5 microjoules	5 microjoules	*Power (mW) / (mJ)*
2.5m	2.5m	2.5m	2.5m	1m	*Minimum operating range (m)*
2000m	1000m	>2000m	>1000m	200m	*Maximum operating range (m)*
360	360	360	360	360	*Horizontal field of view*
80	80	80	80	125	*Vertical field of view*
up to 8800pps	up to 8800pps	8800	8800	8800	*Max and min scan rate (pts/sec)*
–	–	–	–	–	*Maxi resolution (min pt spacing)*
Yes	Yes	Yes	Yes	Yes	*Dual axis compension (Y/N)*
8mm	20mm	8mm at 200m	20mm at 200m	8mm at 200m	*Accuracy @10m 90% reflectivity*
8mm	20mm	8mm at 200m	20mm at 200m	8mm at 200m	*Accuracy @10m 10% reflectivity*
8mm	20mm	8mm at 200m	20mm at 200m	8mm at 200m	*Accuracy @25m 90% reflectivity*
8mm	20mm	8mm at 200m	20mm at 200m	8mm at 200m	*Accuracy @25m 10% reflectivity*
8mm	20mm	8mm at 200m	20mm at 200m	8mm at 200m	*Accuracy @50m 90% reflectivity*
8mm	20mm	8mm at 200m	20mm at 200m	8mm at 200m	*Accuracy @50m 10% reflectivity*
8mm	20mm	8mm at 200m	20mm at 200m	8mm at 200m	*Accuracy @100m 90% reflectivity*
8mm	20mm	8mm at 200m	20mm at 200m	8mm at 200m	*Accuracy @100m 10% reflectivity*
					Accuracies quoted are r.m.s.e.
14	14	14	12	11.9	*Scanner weight (kg)*
10	10	31	29	28.9	*Case weight (kg)*
Interchangeable Li-Ion Battery gives up to 4.5 hrs operational time	Interchangeable Li-Ion Battery gives up to 4.5 hrs operational time	24V / 33W	24V / 33W	24V / 33W	*Power source*
70Mpx Line Scanning camera	70Mpx Line Scanning camera	70Mpx	N	N	*Resolution of integrated camera*
IP65 (IEC 60529)	IP65 (IEC 60529)	IP65	IP65	IP65	*Weatherproofing*
Via supplied Tablet PC	Onboard or via optional rugged tablet PC	On USB plus wireless controller tablet	On USB plus wireless controller tablet	On USB plus wireless controller tablet	*Data storage*

TERRESTRIAL LASER SCANNERS

Company	Optech	Optech	Optech	Riegl	Riegl
Model	ILRIS-HD	ILRIS-HD-ER	ILRIS-LR	VZ-400	VZ-1000
Type	Pulse	Pulse	Pulse	Time of flight	Time of flight
Laser Class (IEC 60825-1)	1	1M	3	1	1
Wavelength (Visible /IR)	1535nm	1535nn	1064nm	IR	IR
Power (mW) / (mJ)	<10mW	<20mW	-	-	-
Minimum operating range (m)	3m	3m	3m	1.5 m	2.5 m
Maximum operating range (m)	1250m @ 80%	1800m @ 80%	3000m @ 80%	600 m	1400 m
Horizontal field of view	360°	360°	360°	360°	360°
Vertical field of view	-20 to +90deg°	-20 to +90deg°	-20 to +90deg°	100°	100°
Max and min scan rate (pts/sec)	10,000	10,000	10,000	122 000 / 42 000	122 000 / 29 000
Maxi resolution (min pt spacing)	1.3mm at 100m	1.3mm at 100m	1.3mm at 100m	3	5
Dual axis compension (Y/N)	-	-	-	Y	Y
Accuracy @10m 90% reflectivity	All accuracies quoted as 7mm single shot at 100m (reflectivity not specified	All accuracies quoted as 7mm single shot at 100m (reflectivity not specified	All accuracies quoted as 7mm single shot at 100m (reflectivity not specified	5 mm	8 mm
Accuracy @10m 10% reflectivity				5 mm	8 mm
Accuracy @25m 90% reflectivity				5 mm	8 mm
Accuracy @25m 10% reflectivity				5 mm	8 mm
Accuracy @50m 90% reflectivity				5 mm	8 mm
Accuracy @50m 10% reflectivity				5 mm	8 mm
Accuracy @100m 90% reflectivity				5 mm	8 mm
Accuracy @100m 10% reflectivity				5 mm	8 mm
Accuracies quoted are r.m.s.e.				-	-
Scanner weight (kg)	14	14	14	9.6	9.8
Case weight (kg)	8	8	8	8	8
Power source	AC or DC	AC or DC	AC or DC	11 - 32V DC	11 - 32V DC
Resolution of integrated camera	Internal	Internal	Internal	-	
Weatherproofing	IP64	IP64	IP64	IP64	IP64
Data storage	Extl via USB port	Extl via USB port	Extl via USB port	int. 31Gb or via USB	int. 31Gb or via USB

TERRESTRIAL LASER SCANNERS

Riegl	Riegl	Topcon	Trimble	Trimble	Company
VZ-4000	VZ-6000	GLS-1500	FX	CX	Model
Time of flight	Time of flight	Hybrid	Phase shift	WAVEPULS	*Type*
1	1	1	3R	3R	*Laser Class (IEC 60825-1)*
IR	IR	1535nm IR	690nm	660nm	*Wavelength (Visible /IR)*
-	-	10mW (Stop Beam), 100mW (Scan Beam)	15mW		*Power (mW) / (mJ)*
5 m	5 m	1m	1.5m	~80m	*Minimum operating range (m)*
4000 m	4000 m	500	~80	360	*Maximum operating range (m)*
360°	360°	360°	360°	300°	*Horizontal field of view*
60°	60°	70	270°	-	*Vertical field of view*
222 000 / 23 000	222 000 / 23 000	30,000	216,000	54,000	*Max and min scan rate (pts/sec)*
10	10	1mm @ 20m			*Maxi resolution (min pt spacing)*
Y	Y	Y			*Dual axis compension (Y/N)*
15 mm	15 mm	4mm	1-4mm		*Accuracy @10m 90% reflectivity*
15 mm	15 mm	4mm	n/a		*Accuracy @10m 10% reflectivity*
15 mm	15 mm	4mm	n/a	4.5mm	*Accuracy @25m 90% reflectivity*
15 mm	15 mm	4mm	n/a		*Accuracy @25m 10% reflectivity*
15 mm	15 mm	4mm	n/a	7.3mm	*Accuracy @50m 90% reflectivity*
15 mm	15 mm	4mm	n/a		*Accuracy @50m 10% reflectivity*
15 mm	15 mm	4mm	n/a		*Accuracy @100m 90% reflectivity*
15 mm	15 mm	4mm	n/a		*Accuracy @100m 10% reflectivity*
-	-				*Accuracies quoted are r.m.s.e.*
14.5	14.5	16	11	11.8	*Scanner weight (kg)*
8	8	8.5	6	12	*Case weight (kg)*
11 - 32V DC	11 - 32V DC	7.4V	18-24V/100-240V	24 V nominal: 90–240V ,50–60 Hz	*Power source*
2560 x 1920 pixels, 5 Mpx in FOV 7.2x5.5°	2560 x 1920 pixels, 5 Mpx in FOV 7.2x5.5°	2Mpx			*Resolution of integrated camera*
IP64	IP64	IP52	IP53	IP64	*Weatherproofing*
int. 78 Gb or via USB	int. 78 Gb or via USB	SD Card or PC	PC	PC	*Data storage*

TERRESTRIAL LASER SCANNERS

Company	ZF UK Laser	ZF UK Laser	ZF UK Laser	ZF UK Laser	ZF UK Laser
Model	IMAGER 5010C	IMAGER 5010	IMAGER 5006h	IMAGER 5006EX	PROFILER 9012
Type	Phase based	Phase based	Phase based	Phase based	Phase based
Laser Class (IEC 60825-1)	1	1	3R	1	1
Wavelength (Visible /IR)	~1500 nm	~1500 nm	~780 nm	~1500 nm	~1500 nm
Power (mW) / (mJ)	65W max	65W max	65W max	65W max	65W max
Minimum operating range (m)	0.3m	0.3m	0.4m	0.3m	0.3m
Maximum operating range (m)	187.3 m	187.3 m	79m	187.3 m	119 m
Horizontal field of view	360°	360°	360°	360°	N/A
Vertical field of view	320°	320°	310°	320°	360°
Max and min scan rate (pts/sec)	1,016,000	1,016,000	1,016,000	508,000	1,016,000
Maxi resolution (min pt spacing)	0.1mm	0.1mm	0.1mm	0.1mm	0.1mm
Dual axis compension (Y/N)	Y	Y	N	Y	Y
Accuracy @10m 90% reflectivity	0.2mm (80%)	0.2mm (80%)	0.4mm (100%)	0.4mm (80%)	0.2mm (80%)
Accuracy @10m 10% reflectivity	0.4mm (14%)	0.5mm (14%)	1.2mm	1.2mm (14%)	0.5mm (14%)
Accuracy @25m 90% reflectivity	0.3mm (80%)	0.5mm (80%)	0.7mm (100%)	0.7mm (80%)	0.4mm (80%)
Accuracy @25m 10% reflectivity	0.6mm (14%)	1.0mm (14%)	2.6mm (10%)	2.6mm (14%)	1.1mm (14%)
Accuracy @50m 90% reflectivity	0.5mm (80%)	0.8mm (80%)	1.8mm (100%)	1.8mm (80%)	0.9mm (80%)
Accuracy @50m 10% reflectivity	2.2mm (14%)	2.7mm (14%)	6.8mm (10%)	6.8mm (14%)	3.1mm (14%)
Accuracy @100m 90% reflectivity	1.6mm (80%)	2.0mm (80%)			
Accuracy @100m 10% reflectivity	10mm (14%)	10mm (14%)			
Accuracies quoted are r.m.s.e.					
Scanner weight (kg)	9.8	9.8	14	30.6	13.5
Case weight (kg)	1.2	1.2	1.2	included	N/A
Power source	24 V DC 100-240 V AC power unit	24 V DC 100-240 V AC power unit	24 V DC 90-260V AC power unit	18V DC	24 V DC 100-240 V AC power unit
Resolution of integrated camera	ca. 80 Mpx		N/A		N/A
Weatherproofing	IP53	IP53	N/A	IP53	IP54
Data storage	64Gb flash card / 2 x 32Gb USB	64Gb flash card / 2 x 32Gb USB	Internal HDD 60Gb	Internal HDD 80Gb	64Gb flash card / 2 x 64Gb USB

Long range reflectorless

The focus this year includes anti-theft devices and security. But there's also a new player on the block, reports Richard Groom.

THIS YEAR'S total station listings include newcomer Geomax. The company is part of the Hexagon Group – Leica's parent company. When other big boys have bought out smaller players one had the impression that they were just taking out the opposition, but in this case Geomax equipment is sold by GeoSurvey Instruments Ltd , who also supply other makes of equipment, including Leica. The Geomax Zoom range of total stations is characterised by long range reflectorless distance measurement. The Zoom 35 claims to reach 1000m.

Targeting construction

Topcon has launched the PS-AC, a new range of robotic total stations aimed at the construction and engineering surveying market. The new instruments come with Topcon's MAGNET software on board, are designed for stakeout applications and will be a key component of a local positioning system, which is used for 3D machine control. The PS has a strong prism-tracking facility and the fastest re-acquisition time in the industry, according to **Leighton Davies**, survey products manager for Europe. It employs a phase shift EDM

that has a narrower beam width than other reflectorless instruments in its class. The Topcon algorithm reduces the noise associated with reflectorless measurements, providing an accurate result to most surfaces over longer distances up to a 1,000m non-prism range. Topcon's smaller beam width allows measurements in tough situations such as through a chain link fence to a building or other critical surface.

Sokkia's new reflectorless total station – the FX, also includes on-board MAGNET software. It uses Sokkia's long-established RED-Tech EDM technology, which has been improved. With the RED-Tech EDM, the FX provides a tight beam signal and strong returns from the most difficult of surfaces – dark and wet. The FX claims a reflectorless range of 500m and a range of 4km to a single prism. It has a long-range wireless communications system utilising Bluetooth Class 1 technology so the controller can be located at the detail pole. The FX also has a new robotic sister – the SX.

Icons and intuition

During the year, Leica announced a new generation of its mid-range series of total stations – Leica FlexLine plus. There are two models in the '+' range: TS09+, the flagship and TS06+. Each comes with a colour touch-screen and a reflectorless measurement range of at least 500m, with an option of 1000m. The range to a single prism is 3.5km.

Leica has also designed FlexField plus onboard software that uses icons for easy and intuitive operation. The software is especially designed for customers in the mid-range market who will benefit from a low learning curve and high efficiency for their daily work. All keyboards support dynamic graphics in all applications. The new colour and touch keyboard allows direct access to functions and menus.

Reflectorless added

In the autumn, Nikon launched the NPL322 series. These total stations have a reflectorless range of 200m. "The NPL-322 Series adds reflectorless measurement capabilities to the field-proven Nikon DTM-322 product line and further expands our comprehensive range of mechanical total stations," says **Francois Erceau**, general manager of the Nikon and Spectra Precision brands.

FOIF has introduced the OTS680 total station with a reflectorless range of 500m and range of 3km to a single prism and Pentax has introduced the R2500DN, which has a reflectorless range of 600m and an astonishing range of 7km to a single prism – pointing might be a problem though!

Promoting networking

High end total stations are sophisticated pieces of equipment that take time to master. To help with the climb up the learning curve, Trimble has introduced Trimble Survey Team. The initiative is intended to promote networking between customers and the company's hardware and software specialists to help solve field and computing problems and generally to get the most out of the equipment.

Watch out there are still thieves about

It seems that survey equipment is still being stolen at an alarming rate. A recent incident brought to our attention was the theft of a laser scanner near the North Circular Road in north London. The group of thieves waited until one surveyor from the two-person team went out of sight, walked up to the remaining surveyor by the instrument, threatened her with hammers and walked off with a full set of equipment, boxes and all. Earlier in the year a contractor stole a total station from an Environment Agency office and then tried to sell it on ebay. Not a clever idea because it was spotted immediately.

The manufacturers are making efforts to circumvent these casual thefts. All instruments have serial numbers and most manufacturers will check an instrument when it comes in for service that it's not on the 'missing' list. But that has more than an echo of closing stable doors. What is needed are more physical deterrents against the thieves.

Newer instruments have IP addresses and can communicate with remote websites that can quickly alert an unauthorised movement or theft. Topcon's answer is TSshield, a communications module that allows global remote locating and disabling of stolen equipment.

More direct deterrents have appeared in the past year. Several companies have come up with physical devices such as APR Services' Bradlock, a device that locks the tripod and prevents the legs from closing (would still all go into the back of a Transit!). StaySafe is an app for a GPS-enabled phone that encourages the user to log appointment times and durations and prompts a check in. The latter of course is no protection for the instrument but is worthwhile for the more important surveyor.

In these tough times there seem no bar on what people will try to steal. Several ingenious surveyors have come up with chains and bicycle style locking cables. Watch out for other devices in the Products & Services pages of *Geomatics World*.

Earthworks contractor finds speed and accuracy for intricate nature reserve project

A GNSS driven grade control system delivers manpower savings, increased machine productivity, accurate surveying, and increased competitiveness for earthworks contractor the Pryor Group.

THE ISLE OF SHEPPEY is an island off the northern coast of Kent. The land covers an area of approximately 92 square kilometres and is home to the Elmley Marshes Wildlife Reserve, managed by a partnership between private landowners and the Royal Society for the Protection of Birds (RSPB).

After the RSPB adopted the area, the organisation developed a plan to augment it to make it more hospitable to native bird populations. The Great Bells Farm Habitat Creation project is part of a site selected to provide 145 hectares of freshwater habitat. The area was once farmed but is now characterised by intertidal land, saltmarshes, and mudflats.

The design called for transforming and enhancing old drainage features surrounding the area to look more like the native landscape. By creating shallow pools or 'scrapes' and ditches the area can hold water and encourage native birds and invertebrates to reach vital water and food supplies. In addition, the design included tackling past flood defence work done in the area, as well as future proofing flood works that may have to be done over the next hundred years.

To accomplish this, the RSPB contacted its longtime partner the Pryor Group, which specializes in earthworks and civil engineering projects. Fred Lusted, Engineering Manager for the Pryor Group, was selected as the engineering manager on site. He was responsible for creating a 3D model of the project, performing necessary geo surveys, setting up site calibration of equipment, and validating volumes of earth moved.

Seasonal work challenges

The project, which began in 2011, revealed a number of challenges. One of these is the nesting and breeding habits of the birds; another is the extremely wet winter season. As a result, earthworks could not take place from March to September or during the winter, which left Lusted's team only a short window of work time each year.

"Needless to say, maximizing earthworks done in October, November and December was a necessity on this project," explained Lusted. "We regularly use Trimble machine control and site position systems supplied by KOREC so we knew a project like this would be much more lengthy, costly, and virtually impossible, with traditional grading and staking methods."

The team used Trimble's Business Center software for preparing data and tracking progress. For site positioning, a Trimble GNSS based system was used with Trimble's SCS900 Site Controller software. At the busiest time on the project, Pryor had three dozers and one excavator on site, each equipped with a Trimble GCS900 3D machine control system.

Setting out and calibration

After setting up the wildlife reserve site with the Trimble GNSS positioning system Lusted calibrated the system running the SCS900 software. With a semi-permanent pole-mounted receiver in place, he used the software to organize the job site and optimise productivity during earthworks. He believes the intuitive interface makes it easier to perform grade checking, as well as simplifying the process for setting-out, measuring as-builts, and performing consistent quality control checks. In order to create the shallow ditches and scrapes required, the team was tasked with building a number of hydrological earth dams. These gravity-fed dams can be used to control water levels, preserving water in summer and preventing areas from flooding in the winter.

"The Pryor Group is a long standing KOREC customer and we've been involved with machine control right from its earliest days," explains Lusted. "The systems have been useful for all our earthworks jobs, but really came into their own on this particular site. At 145 hectares, it's a vast area and the ditches, ponds,

Pryor used three dozers on the project each equipped with Trimble's grade control system, which displays design and live cut & fill information for the operator in the cab.

hydrological bunds and natural rolling features would have been highly complex for an engineer to set out using traditional methods."

"The RSPB provided us with a drawing and from this we created a 3D design in Terramodel and the machine files were created from this in Trimble Business Center," Lusted continues. "The process has been straightforward from start to finish. The benefits of machine control are well documented; we're more efficient, more cost-effective for clients and achieve our health and safety targets. KOREC has provided all the support we need and Trimble doesn't over complicate its technology – it does exactly what it says on the tin!"

Reviewing and controlling progress

Lusted used Business Center-HCE to calculate volumes and review how much earth was left to be moved. He performed precise volume calculations during continuous work (months at a time) as well as prior to the re-start of work periods. With Business Center-HCE, Lusted was able to view project data in multiple ways, whenever needed during the work cycle. He reviewed progress in plan mode and spreadsheet mode, as well as profile, cross-section and 3D modes.

"This project was all about precision, not bulk," said Lusted. "So setting-out this area with conventional methods would have taken a whole gang of surveyors, with pegs scattered all over the terrain being knocked over repeatedly. Trimble 3D machine control on our dozers and excavator was an ideal choice because it gets us grade and finish grading work, even for complex and intricate designs like this."

For excavation, the Trimble GCS900 grade control system measured the exact position, cross slope and heading of the blade for early grading on the site. On Pryor's excavator, the system uses two GNSS receivers and solid-state angle sensors to measure the precise 3D position of the teeth of the bucket. Operators then have accurate, 3D positioning of the bucket. Following the system guides, operators were able to perform more accurately and to quickly shape ditches and dig precise slopes required in the design.

For excavation, the Trimble GCS900 grade control system measured the exact position, cross slope and heading of the blade for grading. The system uses two GNSS receivers (just visible at the rear of the machine) and solid-state angle sensors to measure the precise 3D position of the teeth of the bucket. Operators then have accurate, 3D positioning of the bucket.

For Pryor's three dozers, the Trimble grade control system displayed design information and live cut/fill indications in the cab. With the system's automatic blade control and configurable earthworks design, progress monitoring is greatly improved operators' productivity. It also collected as-built data as the machine cut to the specified grade height. Lusted believes this accurate, real-time information helped him keep tighter control over safety issues and see precisely where dirt was being moved on site for increased efficiency and productivity.

". . . setting-out this area with conventional methods would have taken a whole gang of surveyors, with pegs scattered all over the terrain being knocked over repeatedly"

Confidence in ROI

After two calendar years, or six months of onsite grading and construction work, Lusted and his team successfully completed the project. He is confident in the ROI (return on investment) of using Trimble 3D machine control and Business Center-HCE. In fact, purely from a manpower standpoint, he estimates that without the Trimble system he would have had to hire at least two or three more workers on the site, one for each machine, to perform surveying and other support work needed for grading. That's a saving of around £600-£700 per week of work. Today, the Trimble 3D machine control systems are being used on other revenue-generating projects, improving the value and returns realized overtime. Looking ahead, Pryor plans to expand its Trimble portfolio by purchasing additional GCS900 grade control kits for its excavator fleet.

"Not only is there a sizeable manpower saving with Trimble machine control, the precision and reliability of our work as well as increased machine productivity, asset tracking and accurate surveying, save us more and make us significantly more competitive," adds Lusted. "From pre-tender meetings, where we can show customers our plan, through to project completion where we finish projects more quickly and with less materials and less rework, customers appreciate working with us in part because of our Trimble expertise."

By using Trimble's grade control system Pryor estimates they saved £600-£700 a week.

Monitoring Banks and other Structures

The Environment Agency is responsible for monitoring many flood defence structures that protect communities from inundation. Here, **Richard Groom** describes how the organisation undertakes this task with particular reference to reservoir safety inspections.

Reference monument located close to the end of the embankment and keyed into underlying rock.

MOST MONITORING surveys carried out for the Environment Agency are required to support statutory reservoir inspections. These have to be made at regular intervals for any reservoir with a capacity of over 25,000 cubic metres but we also monitor smaller reservoirs. The Agency's reservoirs are generally flood storage areas: areas that are used to store water during a flood event at the upper end of watercourses, so as to lower the flood water levels downstream and thereby reduce flooding.

Although some flood storage reservoirs are lakes that have additional capacity for flood water, most are usually empty. Perhaps counter-intuitively, reservoirs that are normally empty can present a potentially greater risk than those that retain water on a regular basis because they have never been fully tested until they have to work 'in anger'. Then, rapid rises and falls in water level can cause bank slips and water reaching levels never previously achieved can uncover weaknesses, such as rodent burrows. Most reservoirs are also located upstream of the built up areas that they protect, so the consequences of failure can be serious. Monitoring, surveillance and maintenance has therefore to be kept at a high level throughout the life of these assets.

. . . to measure annual millimetric rates of movement involves precise (geodetic) levelling.

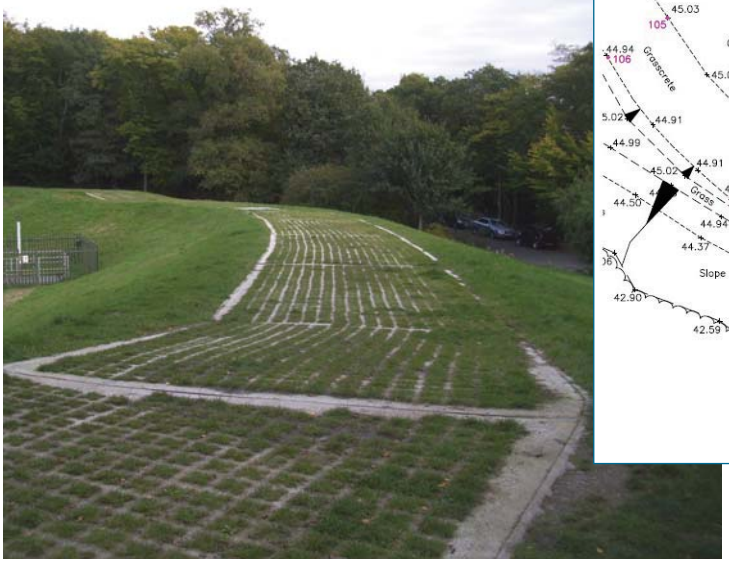
In the months immediately following construction, embankments are subject to settlement, as the material in the structure compacts. This has the effect of lowering the height of the embankment, something that the engineering design will have taken into account. However, embankments are constructed by placing and then compacting thin layers of material and if the contractor has placed thicker layers, uneven layers, or has not compacted the material consistently, the result will be that the effectiveness of compaction during construction will have been reduced, resulting in a weaker embankment that is likely to settle unevenly and by more than was envisaged by the designer.

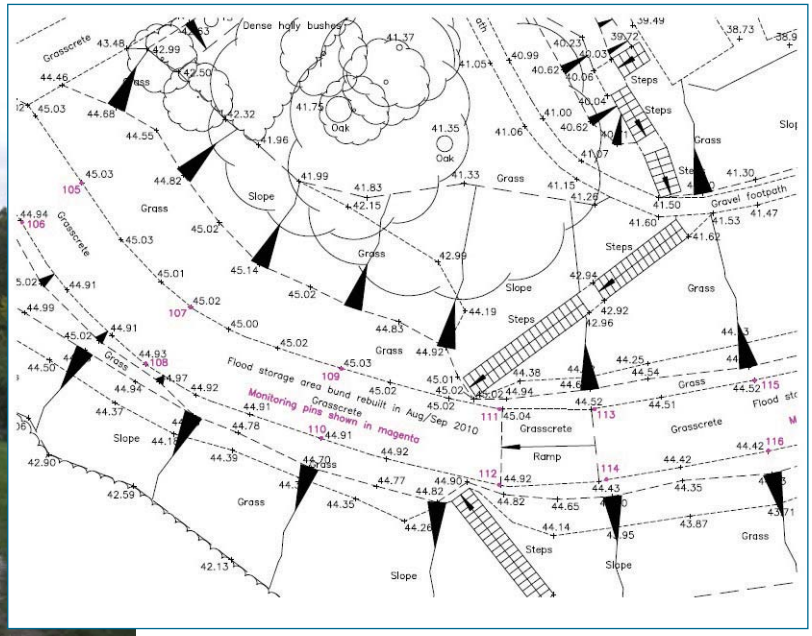
Usually two checks are made. One check ensures that the embankment is maintained at the correct height, and a second to see if the bank is settling or heaving. Both checks are most economically carried out using levelling to a sample of points at intervals along the embankment. To check the level of the bank crest is a third order levelling exercise, but to measure annual millimetric rates of movement involves precise (geodetic) levelling. For both purposes it is necessary to survey from reference monuments on stable ground to monitoring monuments placed within the embankment and designed to move with the embankment.

Stable Reference

The Environment Agency

Below: *the view along an embankment of a flood storage reservoir reinforced with Grasscrete, a cast on site cellular reinforced concrete system with voids created by plastic void formers.*





Above: *Topographic survey also showing, in magenta, the position of monitoring pins set into edges of Grasscrete.*

approach is to site reference monuments away from the structure being monitored and to place them on existing solid, usually concrete, structures. For resilience and redundancy, at least three reference monuments are established. It would of course be possible to establish reference monuments piled to bedrock, but this is expensive and rarely used. Most flood storage areas also incorporate concrete inlet/outlet structures. These are included in the monitoring survey and we frequently find that monitoring pins established on these structures have stability in the long term.

The accuracy of most surveying observation techniques is proportional to distance, so the closer the reference monuments are located to the structure being monitored, the better. Conversely, the further the reference monuments are from the structure the greater the care that is required to eliminate systematic errors from the measurements. This means that the equipment should be calibrated or at least verified carefully before each monitoring survey. It is also advisable to use the same instrument, or an instrument that uses the same technology to measure each monitoring survey. However, this is not a good reason for failing to measure systematic errors in the equipment, because it is always possible that in future a different instrument will have to be used.

Move with the material

Monitoring monuments that are intended to record settlement have to be placed so that they move with the surrounding embankment material. Some Environment Agency embankments have a concrete kerb running along the crest. The normal requirement is to place stainless steel pins in the kerb. Kerbs will usually be at the crest of the embankment and can therefore double as points for checking the crest level. The kerbs are not suitable for measuring settlement unless they are settling with the surrounding embankment. Where there is no kerb, we place monuments within the bank. Monitoring monuments are generally concrete and buried 50 to 100 millimetres below the crest with the intention that the measuring mark will not be disturbed by grass mowing or other surface activity. Whilst, in the GPS age these markers are easy to find, the disadvantage with using buried monuments is that when exposed for survey observations, they may present a trip hazard for passers-by. To overcome this we recently tried another design in which each monitoring monument was placed in a plastic stop valve chamber. We then commissioned a monitoring survey after a period of heavy rain only to find that all the chambers had flooded!

At the same time as carrying out the 'baseline' monitoring survey, we carry out a topographic survey of the reservoir so that we can plot the extent of inundation and calculate the volume of impounded water at 0.25m vertical intervals. The maximum volume and area extent of the reservoir are required to satisfy statutory requirements, a graph of volume against water level is needed by the reservoir operators and inspectors.

Whilst measurement of embankment settlement may be considered the 'basic' requirement, we are also sometimes asked to measure horizontal movement of the crest and bulging of the bank. These are measures generally adopted for banks that are showing signs of instability. It is more difficult and expensive to measure plan movement to the same precision as height and it is even more important that reference monuments are stable.

You don't have to get physical

Reference monuments do not have to be physical. PPP GPS observations are used to monitor the level at tide gauges around Britain's coast. We also use static GPS to monitor the plan position of one particular flood wall which is located in an especially unstable area. In situations where the sky view is clear, network RTK observations may achieve the accuracy required to measure horizontal movement of embankment crests.

Monitoring tends to be a chicken and egg conundrum. Before deciding upon the monitoring regime, it is necessary to know how the structure behaves under normal circumstances. The important factor is the amount of movement that the engineer needs to detect. This has an impact, particularly on the equipment that can be used, but also on the location of reference and monitoring monuments. The engineer has to know what he needs to detect. The surveyor has to translate the requirement into a suitable monitoring system and advise on the technical and cost implications.

Most of the Agency's monitoring surveys are carried out at particular epochs – generally annual or biannual. These will normally take place in the same time every year on the basis that environmental conditions are likely to be similar and seasonal patterns in the data may reveal underlying problems. It is also preferred to measure the environmental factors directly and to co-locate movement, geotechnical and environmental sensors. For monitoring structures that are affected by the tide, we try to carry out each survey at the same state of the tide.

But what happens in between those epochal monitoring surveys? The traditional solution has been to carry out surveys more frequently at the start of the monitoring phase. In the case of reservoir embankments, this coincides with the period of maximum expected subsidence. It is quite common to observe monitoring surveys at monthly intervals for the first few months after construction and then open out the observing interval to three-monthly, six-monthly and then possibly annual measurements, as greater knowledge is gained about the patterns of behaviour of the structure. In all situations, survey monitoring should be made as part of an

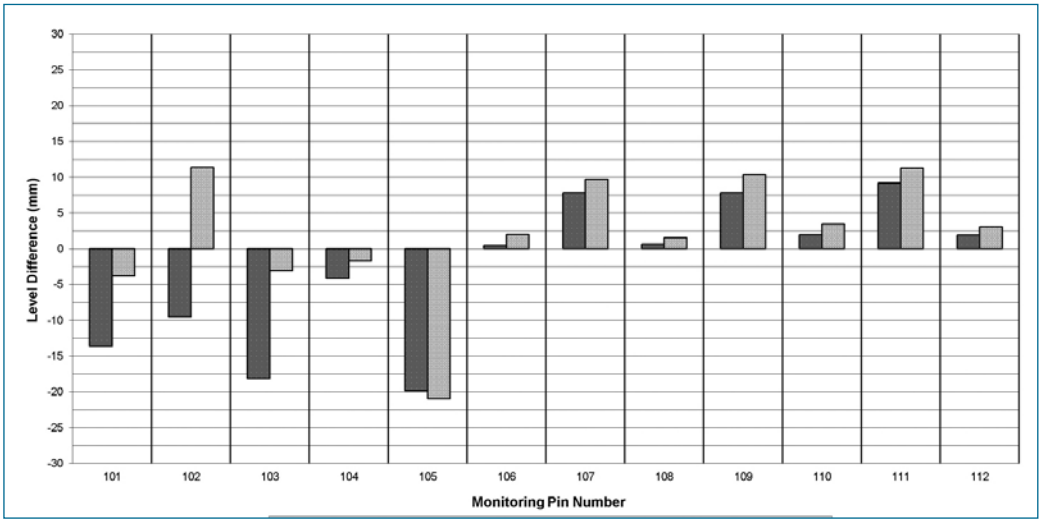
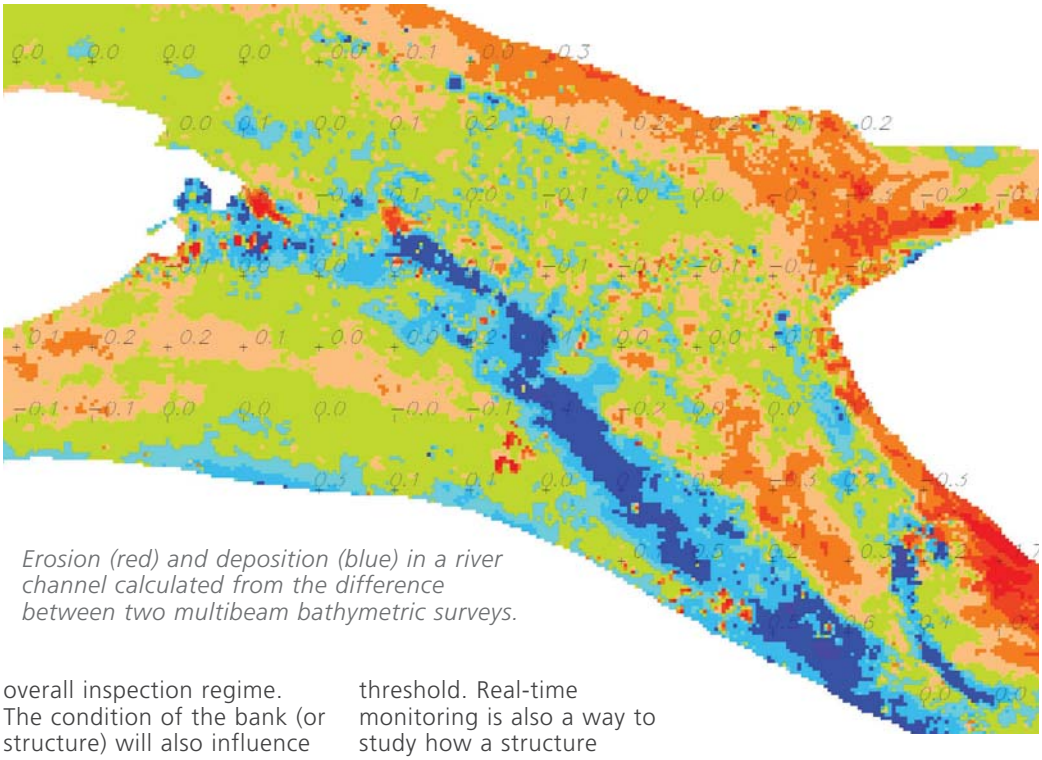


Chart showing the movement of monitoring pins in successive surveys.



Erosion (red) and deposition (blue) in a river channel calculated from the difference between two multibeam bathymetric surveys.

overall inspection regime. The condition of the bank (or structure) will also influence the engineer's decision regarding the interval between monitoring surveys.

Real-time may be the solution

Another solution to fill the temporal gap is real-time monitoring. This is a technique carried out for all major tunnelling projects and most other large construction projects in order to ensure that the structure is being built within the required tolerances and to observe its effect on nearby buildings and infrastructure. Automatic instrumentation, often autonomous total stations, take routine readings, process the data automatically and send alerts to nominated people should movement exceed a pre-set threshold. Real-time monitoring is also a way to study how a structure behaves. As suggested earlier it is quite possible that normal diurnal or seasonal movements may be taking place. Having discovered the normal behaviour of the bank, it is the departure from the norm that becomes of primary interest.

Whilst autonomous monitoring systems can take care of the temporal gaps in monitoring data, point clouds can fill the spatial gaps. The Environment Agency has used point clouds for monitoring vertical walls and for measuring erosion and sedimentation of the bed of the River Thames. Both depend upon measuring movement with respect to a plane surface. For walls, the reference plane is vertical, whilst for river-beds it is horizontal. There is of course a distinction between the two, because every time the scanner returns to survey the wall it will be measuring to the same physical points, so it is measuring deformation of the structure; whereas river bed erosion and deposition involve movement of material. Our survey can show that material has been eroded or deposited but not where the material has gone to or where it has come from. It is also not straightforward to decide at what time interval river-bed monitoring surveys should be observed because the morphology is likely to be heavily influenced by the flow regime in the river. Although flow rates may normally be higher in winter, flood flows can take place at any time of the year. When carrying out bathymetric surveying for monitoring purposes it is important to observe plan position carefully in order relate surveys observed at different epochs: we insist on RTK GPS observations.

. . . point clouds can fill the spatial gaps.

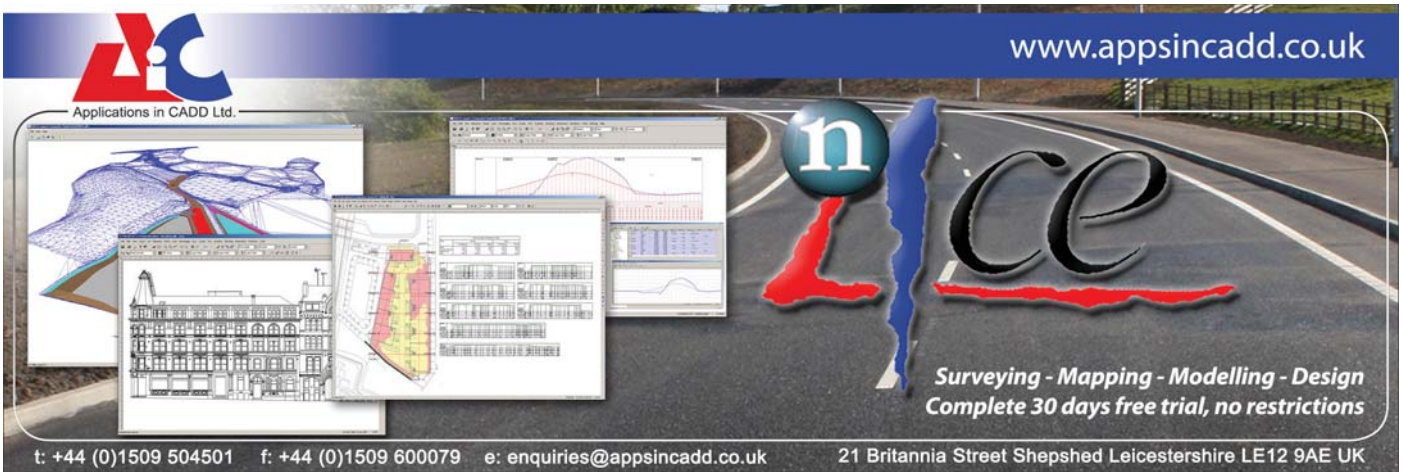
Traditional monitoring of a few discrete points on the structure and epochal measurements has the advantage that the results are easy to present using bar charts, profiles, vectors and so on. Automated monitoring and point clouds involve far more data, so data management, processing and presentation is more of a challenge. When surveying tidal walls, we have also encountered difficulties due to weed and algal growth on the wall.

The Environment Agency therefore applies a range of solutions to ensure that its structures remain safe when they are put under load during flood events. We constantly review our procedures and technologies as they continue to evolve to provide more efficient solutions.

Acknowledgement

Many thanks to Andrew Pepper for his review and comments on this article.

• *Any opinions expressed in this article are those of the author, not the Environment Agency.*



- *a simple guide for*

managers, engineers, architects, surveyors and all who commission or manage survey projects, or needs to discover more about survey techniques and technologies

The concept of risk is well understood in relation to health & safety. But with surveying, people tend to focus on accuracy and precision.

Nevertheless, there *are* technical and commercial hazards in surveying and they come with expensive risks for clients.

The consequences of a survey 'accident' can be significant. Projects can be delayed. Cost implications can be substantial. Sometimes they can be catastrophic and render a project unfit for purpose – like an Olympic-sized swimming pool built too short.

This guide is intended to help those who commission and manage surveys to recognise the hazards and manage the associated risks.

In two parts, Part 1 deals with **Managing Survey Projects** and includes 20 key topics in preparing contracts and specifications as well as managing the work once a survey firm has been appointed. This is essential reading for professionals working in the built environment who appoint or manage survey companies.

Part 2 sets out the **Principles of Surveying** and covers over 30 topics, which may help reveal the hazards that can lurk in surveying processes. Engineers, architects, other professional disciplines as well as older surveyors in need of a reference point or a refresher course, will find this a reliable reference point.

The Guide is therefore intended as an essential reference source. It can also be an ideal source book on surveying for academic courses. Younger readers will find all of the essential techniques presented together with current technology and its applications.

The author is an experienced chartered surveyor with many years experience working in both the private and public sectors as well as in the UK and overseas.

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COYO aims to counter perceptions of industry

Scheme engages school children to dispel construction's negative image as career path.

Alison Watson, left, explains the principles of Design, Engineer, Construct to a team of young Manchester students.

FOR TOO LONG the construction industry has been branded as offering limited scope for academic or vocational progression. An initiative to engage schools is designed to counter this widely perceived but unfair impression. Designed to engage school children aged 11-16 in the opportunities a career in the construction industry can offer, the initiative has attracted strong backing from leading industry players Mott MacDonald, Autodesk and Topcon.

Keith Howells, chairman of Mott MacDonald believes that the industry is desperately in need of a new generation of creative thinkers. "If we are to compete on a global scale in a rapidly urbanising world, we need to develop a new generation of professionals who will uphold our reputation for world-class innovation."

The idea comes from an organisation set up by former land surveyor **Alison Watson** and architect **Dan Gibson**. Frustrated that schools seemed to know so little about the industry and the opportunities it could offer, and what they did know was about manual trade skills, Alison and Dan were determined to do something about it. The result was Class of Your Own (COYO) and a special curriculum initiative - design, engineer, construct. You can read more about how they went about this over the page. Meanwhile, *Showcase* was recently invited to a reception at the House of Lords to see at first hand the fruits of Alison and Dan's labours.

Hosted by **Lord Knight** (formerly Jim Knight MP, and a member of the previous government), this event at the House of Lords was an opportunity to hear how three teams of children from across Britain had responded to a challenge to develop plans for an environmentally friendly and sustainable building project – an Eco Classroom.

The project - Design, Engineer, Construct - is a curriculum approach that challenges young people to create a sustainable building as well as learning about the industry's professions and how they interact and work together. It particularly harnesses young people's capacity to act in collaboration and think outside the box before those little grey cells become too fixed in their pathways.

The teams were given the industry standard design software, Autodesk Revit, access to surveying equipment from Topcon and under the online guidance of a host of built environment professionals, encouraged to get on with it.

All students have a one-day professionally led workshop, four two-hour Expert Workshop sessions and Autodesk's Design Academy/Entertainment Suite software in addition to training for teachers and other support.

'We know what makes a good learning environment!' Students from Burnley at the House of Lords following their 'Weavers Triangle Old Schoolhouse' project presentation.

Uplifting presentation from struggling city

Hull is one of Britain's former industrial cities hit hard by the economic downturn. It has some of the worst social statistics in the country. Much of the city is losing its sense of community with high drug use, 60% are overweight and teenage pregnancies are amongst the highest in the land. Academic achievement is inevitably low. It was uplifting then to hear from a team of five Sentamu Academy students how they'd responded to design a new facility for their school with a net zero energy requirement by using a roof made of ETFE (a polymer with high energy radiation resistance properties), a wood-chip boiler fired by locally-sourced fuel, vertical turbines for cooling in summer and collected rainwater for flushing toilets.

Whilst the children clearly enjoyed using the freely supplied Revit software to create 3D designs and learning about BIM, their research into the facility's needs always seemed thorough and wide ranging. In the land around the facility they had even planned polytunnels for growing vegetables.

Cloth past not forgotten

Burnley is another town that

WHAT THE STUDENTS LEARN

- **Develop a deeper understanding of sustainability and what they must do to encourage their community to take action.**
- **Demonstrate the ways to facilitate community engagement in a construction project.**
- **Appreciate the range of professional responsibilities involved in a construction project and how they contribute to its development and to its sustainability.**
- **Understand the planning requirements of their Eco Classroom.**
- **Understand how careful purchasing is critical to the sustainability of a construction project.**
- **Construct and evaluate their Eco Classroom design in a 3D virtual environment using a range of industry standard Autodesk software.**
- **Compare designs and techniques with other students from different locations around their country and the world.**
- **Understand the need for long term sustainable practice in their construction project and school.**
- **Understand the range of professional careers available in the construction industry and the variety of routes to get there.**

once thrived in Britain's industrial past but today struggles to provide jobs. Built in 1840, the Habergham Eaves Parochial School is situated within the historic Weavers Triangle area – a reflection of the town's former association with cloth. Working in partnership with COYO, the Borough Council and English Heritage, students from five Burnley schools took over the renovation programme of this grade two listed building to create a new facility.

Four students involved with the project gave a fascinating insight beginning with the town's history and grim association with child labour and ending with their enthusiasm for creating a 3D model. One confident student emphasised "We know what makes a good learning environment!" She went on to tell us her generation was not phased by technology and "without my training my Mum couldn't operate the TV remote!"

***Above**: students get their hands on some real surveying equipment, courtesy of Topcon.*
***Right**: a 3D rendered model of the students 'Eco-Socialise Academy' project, produced using Autodesk Revit Architecture software.*

Passion for engineering from capital

Finally, students from St Michael All Angels Academy in London demonstrated their knowledge of surveying, having laser scanned a local primary school, and designed a modern extension, all within a 3D environment. These four young students described their passion for engineering, and their light hearted yet knowledgeable presentation had the audience entranced.

All thirteen students have been invited back to London as keynote speakers at this month's BIM Show Live event - a real accolade for these extraordinary young people.

Showcase spoke to **Alison Watson** about her motivation in setting up the initiative Class of Your Own back in 2009 with partner and architect **Dan Gibson**. We asked her about her background and the obstacles she's had to overcome in getting the "Design, Engineer, Construct" curriculum up and running.

What motivated you to set up Class of Your Own?

A number of reasons. From 2004 I was contracted to provide topo, elevation and building footprint surveys for Building Schools for the Future (BSF). I discovered first hand the lack of knowledge and even apathy towards the construction professional via the kids and teachers I met at the schools I surveyed.
BSF did not seem to offer much scope for kids to learn about the industry - generally, any contact seemed to be least risk, stick kids in a hard hats, give them site tours and offer a few competitions, and tick a big CSR/PR box.

We believed that every school would appreciate a more professionally oriented curriculum in the spirit of aiming high, bridging gaps, introducing the real world of work, having real professionals in the classroom, integrating with industry and higher education.

How many schools to date have adopted the programme?

We have carried out workshops in around 50 schools over the years, and the programme is running in 12 schools across England.

What obstacles have you had to overcome? You must have found many schools with full curriculums reluctant to engage.

The main issue is one of fear of/apathy towards the industry. Traditionally construction has been delivered in FE, however some schools have delivered trade oriented programmes. Teachers don't 'teach' construction - it's seen as non academic generally and often for lower ability children. The high fliers are encouraged towards more traditional professions in law, medicine, finance etc. Even an engineer is seen as a car mechanic. I was told by one grammar school that they don't promote the construction industry as 'our kids are academics'.

Full curriculums can be an issue, but since many schools are now academies, they can effectively teach their own curriculum, and creativity is encouraged.

The style of teaching is different for Design Engineer Construct - it's learner led, rather than teacher led, which demands a teacher to let go a little and shepherd rather than dictate. This is a curriculum that demands both independent learning and peer collaboration - there is no copying from textbooks - there is no textbook!

Teachers have to let go of the strings a little more, and be prepared for their students to overtake them in the technology arena. Some teachers clearly have a morbid fear of the technology - but the problem is, a teacher who doesn't move with the times is effectively denying his/her student the opportunity to learn industry driven skills, and even therefore, a job.

Teaching to the test - schools are measured by exam success and A* - C in subjects quoted on the DfE's performance tables. Because our programme is new, and we are a very small organisation, schools haven't heard of us, nor the awarding body we use (even though it's regulated by Ofqual just like the big boys!). It goes without saying, the huge support we're having from industry is helping.

It's been an absolute slog trying to get in front of the right people in the DfE, and despite countless communications with ministers and education leaders, size dictates and we struggle to make ourselves heard. Again, the intervention of sponsors and key people like the ones who attended our event at the House of Lords (and particularly Mott MacDonald chairman Keith Howells) has played a major part in driving through bureaucracy. I personally take a view of 'carry on regardless' - the Engineering/Construction skills agenda needs to be addressed, and I feel that the work we are doing is very valuable. There's not a lot wrong with children being encouraged to adopt an engineering approach to any career choice. It's about analytics, problem solving, thinking outside the box. . . which profession doesn't need those skills?

Where do you see this going in the future? Is the funding from sponsors secure enough in the long term?

I would like every child age 11-14 to have an introduction

to the industry via the existing Design Engineer Construct curriculum (in the same way they have Design Technology lessons at Key Stage (KS) 3). This would then enable young people to *choose* to continue their studies at KS4 and 5. We are writing the next stages of the curriculum to offer progression.

Industry clearly needs to be more involved at secondary school level, and as such, we are about to roll out an industry wide 'Adopt a School' programme, which will enable us to specifically target the most disadvantaged children from all backgrounds, regardless of gender, race or ethnicity. It includes a Mentoring/ CPD programme for teachers supported by industry and academic links and also provide clear pathways into industry and raise awareness of existing apprenticeship schemes. We are also working with universities, helping schools forge better links, and getting more university students to support younger aspiring professionals in the classroom and via our workshops. We are piloting a scheme with four universities during the summer term.

Funding for me is the new 'f' word. There has been very little financial help for us, and with a strong belief that you only get out what you put in, we have worked on a shoe-string to make this all happen, ploughing any income back into the company. It's probably why it's taken so long to get where we are now - we just don't have the large organisation big bucks, and have turned down the bigger players who simply wanted to pigeonhole the subject into an existing programme of study - we were asked if we could include an element relating to textiles so we could 'fit' Art Design and Technology by a major awarding body! Need-less to say, we walked away.

If our school adoption programme is adopted by industry (and we do have major support for this), then our existence will be secure. Events such as the House of Lords offer a great opportunity to show what kids can do to the decision makers of industry, but it can't just be one of those nice afternoon jollies, tantamount to CSR box ticking á la "We went to the HoL and supported some kids, clapped them on the back and said well done. Job done." Industry needs to put its money where its mouth is, and offer a scheme that is worthwhile and has definite outcomes. I believe Design Engineer Construct is that scheme.

Your sponsors don't include the professional institutions in the industry. Why is that? Do they offer only advice but no cash?

That's a tough one. The response we get from PIs is generally, "oh yes, we do all that what you're doing", and to a certain extend it's probably true, but unfort-unately it's done in silos, concentrating on one particular discipline, rather than have a collaborative approach which I believe, at the age these children are, would be far better. We took the view that kids don't really know what they want to do when they leave school, and therefore need access to programmes which not only demonstrate the wide number of careers available in the industry, but how all those different people work together. There's been a number of occasions when a young person has mistaken the work of an architect with a structural engineer as they never understood the difference. Design is done by architects. Full stop. I would love to see professional bodies working closely together with the age group that we work with. In terms of advice, generally PIs are very helpful, but we'd like to work more closely with them all. The cash issue? No idea - we've never asked!

Alison, thank you for talking to us. Showcase wishes COYO every success.
More at ***www.classofyourown.com***

SURVEY REVIEW

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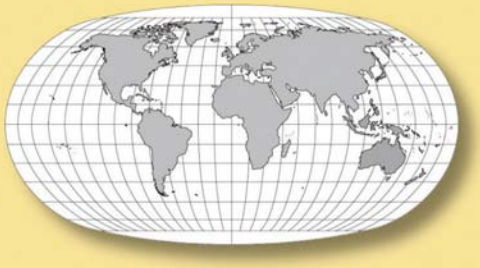

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GNSS equipment: delivering corrections by satellite

GPS has given way to GNSS through incorporating additional satellite constellations to those of the US GPS. There are several different ways in which satellite positional data can be used for survey applications. **Richard Groom** looks at how network RTK receivers operate in the UK and the various techniques they rely on to get accurate positioning data.

FOR GNSS USERS the last few years have seen Bluetooth eliminate the need for cabling, cabling that would inevitably become tangled during the course of a long day in the field. High precision 3D surveying is now possible using corrections from one of the network RTK services in a matter of a few seconds of arriving at site and the equipment for network RTK does not require the tripods, external batteries and so on, that not so long ago were needed for a lengthy static baseline observation. The receiver, the antenna and the data logger or controller can now all be fixed on a detail pole.

With manufacturers claiming the "lightest" it will still depend on what else you want on the pole.

The network RTK receiver on a pole has become a versatile piece of equipment, which can be used to establish control for other instruments or for directly observing detail points. Consequently, the race has been on to produce ever lighter and more compact network RTK receivers. Weighing only 650 grams, Spectra Precision claim that the ProMark 700 dual constellation receiver is the lightest GNSS RTK smart receiver available on the market today and it also boasts a battery life of over ten hours. Meanwhile their competitors Topcon's HiPer SR weighs a tad more at 800 grams but comes with LongLink technology enabling a use to operate within a 300 metre radius. For the not so nimble fingered it can also withstand a 2 metre pole drop.

Comms are the key

Network RTK depends upon communications to deliver the correction to the receiver and this has always been the weak point in the technology. Corrections are generally provided via mobile phone networks, which tend to have relatively poor coverage in rural areas, and it is not unknown to come across poor reception in towns too. There are various ways in which to overcome this problem. A repeater can be located in a place with a phone signal and then used to rebroadcast corrections as a radio signal that can be picked up at the GNSS receiver. Another possibility is to use SIM cards that can automatically switch between mobile phone networks, so that when the main network is not available, it will search for another. Leica's SmartSIM does just that for the company's SmartNet users.

Delivery of corrections via a communications satellite is another possible solution to the problem. The Altus APS-3L is a high precision GNSS satellite receiver with embedded TERRASTAR L-Band capability, designed to provide seamless RTK and Precise Point Positioning* capability. When out of wireless range of terrestrial UHF radios or cellular networks, the APS-3L seamlessly receives TERRASTAR D corrections.

Bubble on the controller

Trimble has improved its range of GNSS equipment and introduced a new flagship receiver – the R10. This receiver incorporates two new features. Their first enhancement to network RTK on the pole is an electronic bubble, which is viewable on the controller. The bubble readings can be recorded, which can be used for QA purposes but perhaps it will not be long before we also see the possibility of applying corrections for pole non-verticality.

The second is a feature called xFill, which appears similar in concept to the Altus TERRASTAR facility. Trimble collect real-time data from a hundred continuously operating GNSS receivers around the world. They model the observations and transmit correction data to users via the internet or via satellite L-Band (provided that the communications satellite is in view).

At first sight, this might seem to be a poor alternative to network RTK, but it is actually implemented in a way that is analogous to the process used by mobile laser scanning systems when they use inertial measurement systems to cover for GNSS outages. The R10 receiver receives both the network RTK (or base and rover) corrections and the xFill corrections simultaneously.

Trimble's white paper on xFill gives the impression that the infill corrections are as good as the RTK corrections but the R10 specification sheet indicates that the accuracy of position fixes drops off at a rate of 10mm per minute in the horizontal and 20mm per minute in the vertical, which for most surveying purposes makes it suitable only for short outages. xFill continues to operate until the precision threshold specified by the user is exceeded or five minutes have elapsed. When the receiver again receives RTK corrections it does not adjust previous observations corrected using xFill, but it is possible to make this adjustment later in the office using Trimble's TBC software.

Whilst these developments are important for enhancing real-time RTK, there is always the alternative of post-processing network RTK if the results are not needed in real time at the pole. For more on the latest receiver developments turn to page 32.

For more on Precise Point Positioning see **Geomatics World 2012, September/October "Precise Point Positioning v. GNSS" by Professor Chris Rizos and colleagues.*

BeiDou operational in SE Asia – position fix for Galileo

Developments in GNSS affect users in several ways. The stronger signals will reduce the risk of jamming. The larger number of satellites will reduce the time taken to initialise receivers and will improve coverage in difficult conditions, for example in so-called urban canyons where there is a severely limited sky view. The more accurate clocks will improve the accuracy of position-fixing.

Left: BeiDou-2 launches

GNSS is the term used to encompass the original global positioning system (GPS), the later Russian Glonass system, both of which are operational, and the much more recent Chinese BeiDou and European Galileo systems, which are currently being established.

GPS: Block III is coming

As of 1st February 2013 there were 12 Block IIA, 11 Block IIR, 7 Block IIR-M and 3 Block IIF operational GPS satellites, 33 satellites in total. Future plans from the US Department of Defense (DoD) include a further eleven Block IIF and thirty Block III satellites.

The Block IIA satellites, SVs (Space Vehicle) 22 through 40, were launched between November 1990 and November 1997. Each contains four atomic clocks: two caesium (Cs) and two rubidium (Rb), and has Selective Availabity (SA) and Anti-Spoof (A-S) capabilities.

The Block IIR satellites, SVNs 41 through 61, were operational replenishment satellites and were launched from January 1997. Each carries three Rb atomic clocks and also has SA and A-S capabilities. The Block IIR-M satellites transmit a second civil signal L2C on the L2 frequency and the military M-code signal on the L1 and L2 frequencies. SVN 49 also transmits on the L5 frequency.

The Block IIF satellites transmit all signals including and the L5 frequency, intended for safety-of-life applications. Launching of the Block IIFs began in May 2010.

Lockheed Martin is currently building the first four of the Block III GPS satellites, the first of which is due for launch in 2014. The satellites will broadcast the L2C signal and the global M-code signals, which were first incorporated into the Block IIR-M satellites; but they will also carry directional antennae to deliver the M-code signal locally at much higher power, to combat jamming. They will broadcast an L1C signal that incorporates the C/A code for backwards compatibility. There will be improved tracking and compatibility and it will offer interoperability with the Galileo L1 signal. The satellites will also broadcast the new L5 (safety of life) signal in the Aeronautical Radio-navigation Services band. The signals will be delivered at higher power than Block II satellites and the L5 signal will be broadcast at twice the power of the other signals. The Block III satellites will be fitted with retro-reflectors so that they can be tracked from earth using laser ranging.

In Japan, GPS will be enhanced by a constellation of three QZSS satellites that broadcast the same signals as GPS. The constellation is designed so that at least one of the satellites is overhead in Japan at any one time, which will improve position-fixing in mountainous areas and urban canyons, but the system will also be usable in neighbouring countries. The Indian space agency is also developing a regional constellation (IRNSS) that will cover the sub-continent. The constellation will consist of three geostationary and four orbiting satellites. Unlike QZSS, the Indian constellation will be able to provide positioning services independently of GPS with a navigation accuracy of 10m on land and 20m within 2000km of the subcontinent. The first satellite is due to be launched in 2013 with the full constellation operational in 2014.

Glonass: K2 set for 2015

There are currently 24 operational Glonass satellites, of which one is a Glonass-K1 satellite and the remainder are Glonass-M satellites. Unlike GPS, each Glonass satellite transmits its L1 and L2 signals on different frequencies within the frequency bands. This is known as frequency division multiple access (FDMA). Glonass-K2 satellites will also broadcast using CDMA (Code Division Multiple Access, as used by GPS) as well as FDMA and transmit a third L3 signal which will be compatible with Galileo and Compass, but the first satellite is not expected to be launched until 2015. The clock error on K2 satellites will be five times lower than the Glonass-M series.

Galileo: 2014 for services

The European answer to GPS and Glonass is gradually taking shape. There are currently four satellites in orbit with a contract in place to launch ten more during 2013 and 2014 and a further eight thereafter. On 12th March this year another milestone was passed when a position fix was calculated from the four satellites using the new ground segment infrastructure and navigation messages sent by the satellites. 'Early services' are expected to start at the end of 2014, with the constellation completed by 2019.

BeiDou: ICD published

The Chinese BeiDou constellation (formerly known as Compass) started to provide a positioning service in China in December 2011 and has recently become operational in south east Asia, including Australasia. There are currently fourteen satellites in orbit – five geostationary, five in inclined geosynchronous orbit and four in medium earth orbit. The full constellation of 35 satellites, providing global coverage, is intended to be operational in the 2020s. The long-awaited Interface Control Document – an essential for equipment manufacturers intending to use BeiDou signals – was eventually published in December 2012.

According to published launch schedules, no further BeiDou-2 launches are planned for the next two years. This means that the next event of note to GNSS users will probably be Galileo's 'Early services' in late 2014.

Once all of these systems are available we can expect much better GNSS coverage, quicker and ever more accurate position fixes and the emergence of new applications involving tracking as well as positioning. Very soon they will almost certainly not only know everything about who you are but where you are and where you've been.

Technical Services

Looking for a company with special experience? Check our chart for details of leading firms & page 34 for more information.

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✓ = service provided.

	Topographical surveys	Pipeline, railway, & other linear routes	Setting out for construction	Building & architectural (incl. measured surveys)	Heritage, historic, ancient monuments, etc.	Underground services tracing & surveys	GIS & mapping system data capture	Control surveys	Deformation monitoring	Proving surveys	Boundary disputes & expert witness	Hydrographic – near shore, river, estuarial, etc	GPS & other satellite positioning systems	Terrestrial laser scanning	Airborne laser scanning	Aerial photography	Ground radar	Infrared	Digital terrain analysis & modelling	3D visualisation & modelling	Remote sensing	Aerial photogrammetry	Terrestrial photogrammetry	Cartographic production	Industrial measurement/ metrology	Geophysical investigation
Anthony Brookes Surveys Ltd	✓	✓	✓	✓	✓	✓	–	✓	✓	✓	✓	✓	✓	–	–	–	–	–	✓	✓	–	–	–	–	–	–
APR Services Ltd	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–	✓	✓	–	–	✓	–	–	✓	–	–	–	–	–	–
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To advertise in the next issue of *Engineering Surveying Showcase* contact Sharon Robson

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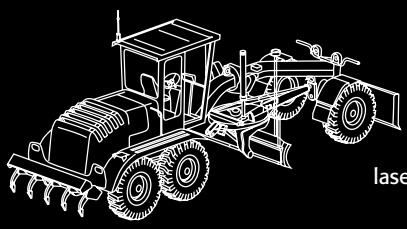

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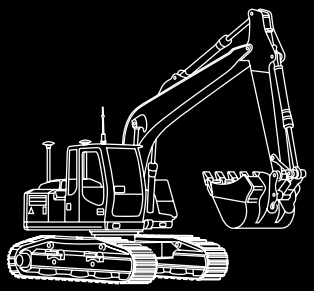

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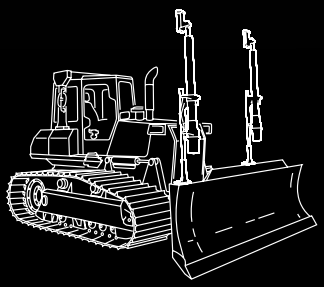

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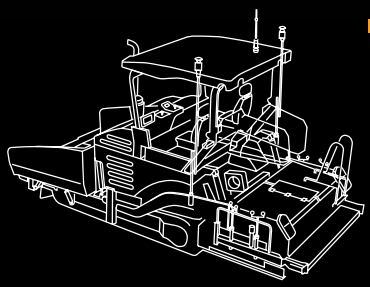

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