ARE LASER SCANNERS EVOLVING INTO COBOTS?

DEVELOPMENTS IN AUTOMATION HAVE MOVED HIGH-PRECISION LASER SCANNERS CLOSER TO BECOMING DIGITAL CO-WORKERS. **JODIE HARTNELL** EXPLAINS HOW

While the instruments and equipment of architecture, engineering and construction (AEC) have not reached the levels of autonomy that we might associate with the term "robot", they are evolving towards becoming more like "cobots": advanced robotics that operate with a substantial amount of autonomy, but only with key input and direction from the human operator. The operator is the expert, coaching and guiding the robot through the automated operations and processes, while the cobot does an increasing amount of the work.

For example, a convergence of surveying instrument and scanner technologies has yielded a new class of scanner, bringing increasing benefits of rapid high-precision laser scans to AEC. With legacy scanning there was a premium on the time and the skills of specifically trained practitioners, both for field operations and office processing. Four key developments have completely changed legacy scanning workflows: self-calibration, self-levelling and self-registration of point clouds, as well as the protection of critical components in sealed assemblies.

Scanning interior and exterior sites for engineering design, construction and as-built surveys almost always requires multiple scans – dozens or even hundreds – and the respective point clouds must be precisely registered to each other and merged into a single point cloud or 3D mesh. The workflow with legacy scanners required the time-consuming steps of levelling the instrument and calibrating it. Then there is the labour-intensive process of registering the point clouds in specialised software – after the fact, back in the office. Plus, legacy scanners had cumbersome form factors and were not well protected from the elements.

Scanners have suddenly become a lot smarter. The new systems incorporate surveying best practices in their automated routines and with sufficient reliability that they can serve as highly skilled partners of their human operators.

The updated workflow with this new class of scanner is as simple as choosing each scan location, setting up the instrument (close to level) and starting the scan – the cobot does the rest: precise final levelling, calibrating and registering the scans. You then move to the next location and press the start button.

Self-levelling

Legacy scanner levelling with the standard bubble vials was a common source of user error. Levelling could be time-consuming and was best done by experienced hands. But now most high-end surveying instruments and some scanners have dual-axis compensators in their bases. As long as the instrument is close to level, the compensators can do the fine adjustments. This is much akin to what is in most surveying total stations, such as Trimble's S-series total stations, and SX10 and SX12 scanning total stations.

This feature was particularly attractive for the Danish surveying consultancy LE34, which used one of this new class of scanner, a Trimble X7, for a large asset management project. The company needed to scan thousands of flats so they could be modelled to support the operations of an

With the automation features of its new scanner, LE34 could streamline the scanning of thousands of housing units, with minimal training, to under 45 minutes each. This included up to 20 automatically merged scans per unit. © LE34

A complex scan of a historic windmill presented a challenge to using conventional scanned and targets; the automated scan registration of their new instrument enabled Paul3D to complete and merge the multiple scans rapidly. © Paul3D

affordable housing management company. LE34 engineering surveying director Anders Nygaard Møller says: "It is easy to train someone to operate. For each flat, we do 10 to 25 scans. Each scan only takes a few minutes, then the operator can pick up the whole thing and move it to the next location without having to do any levelling or calibration.

With this simplified workflow, Møller's team could reduce the time needed to scan each unit from several hours to about 45 minutes – including the time to move from one unit to the next. This compressed workflow enabled LE34 to bid the project low enough to win the contract. Møller said that this would not have been possible with legacy scanners.

Self-calibration

A scanner is one of the most complex surveying instruments, with multiple internal components that must be precisely calibrated. Legacy scanners needed to be sent in annually – or even more frequently, depending on the level of usage – to the factory or a qualified lab to perform this operation. The new instruments do this in the field and on a continuous basis.

How these cobot scanners do this is complex, but the idea is simple: miniaturisation of the same types of calibration tools used in factories during assembly and testing. One of the most fundamental steps in calibration is 'collimation' – the alignment of the path that the laser takes through the instrument. Collimation has always been crucial to ensure high precision for any surveying instrument, from legacy optical transits to robotic total stations and modern scanners.

In all, there is auto calibration of the distance measurement, and the vertical and horizontal axes of the scanner. The combination of these processes, which usually take 25 to 45 seconds when you set up for a scan, assures that all axes are perpendicular to one another, the scanner is level, and that corrections will be applied to distances measured. The result is that without any intervention by the user, the system should deliver 3D point accuracies of 2.4mm at 10m, 3.5mm at 20m, and 6.0mm at 40m. The stated range for the system is from 0.6m to 80m.

Avoiding downtime for factory recalibration is crucial for the Survey Group, a West Australian surveying consultancy that performs scanning to support mining operations in mineral-rich, but remote areas of the region. Ben Simpson, who heads operations and business development for the Survey Group, says, "Sending in the scanner for calibration can be costly, but it is the cost of having a scanner out of service that really adds up and makes it difficult to schedule and complete projects."

Self-registering

One of the most time-consuming steps in scanning – and one that has kept it from being used by more people – is the processing and registration of point clouds. Considerable experience was required, software could be expensive, processing times could be lengthy, and operators in the field often needed to set control and targets. There is less manual matching of common features in points clouds now, as nearly all scan processing software does automatic target recognition or recognises common patterns of points between scans. But that still makes the registration an after-the-fact process back in the office. Having registration automated in the field while you are scanning enables you to check for completeness and can avoid time-and-cost busting situations where you need to go back to get something you missed.

New scanners do targetless registration of point clouds with software that runs on a mobile device. You can check the scans for completeness before you leave the site and

SG's new scanner on-site for the Pilbara Australian mining facilities survey. The scanner, with sealed components, weathered a major rainstorm without damage, while a legacy scanner did not. © SG

Paul3D completed 125 scans over two days of the historic village centre of Franeker in the Netherlands. The scans were registered in the field and delivered as a single point cloud. © Paul3D

Paul Van der Linden of Paul3D with his new scanner. The automation features made it practical to provide rapid scans for the wide variety of his clients who produce 3D models for engineering design and renovation projects. © Paul3D

can export the data as a direct deliverable for many applications. In the case of LE34's X7, the companion field software is Trimble Perspective, which runs on the Windows 10 Tablet OS. LE34's Møller says, "Being able to register and check the cloud in the field and eliminate much of the office work made this project approach practical and cost-effective."

Sealed units

New scanning cobots look quite different to most legacy scanners used for AEC applications. You now see, in the case of the X7, a dark-tinted window wrapped vertically around the centre of the instrument. It is visually striking, but it serves a crucial function. In legacy scanners, the crucial spinning distribution mirror is exposed to the elements.

With exposed components, legacy scanners are not particularly resilient in harsh environments. SG found this out the hard way. Ben Simpson recalls an incident during a large scanning job of an iron ore mining facility in the Pilbara region. Although the area is arid, it is subject to acute torrential downpours, particularly in the season of the survey.

"A huge rainstorm rolled in," says Simpson. "We evacuated the crew, but some instruments were left in the storm. The X7 survived fine but an old-style scanner did not, and we had to send the older scanner in for repair."

The dark-tinted window of the X7 is made of hardened polycarbonate optimised for the wavelength of the laser and contributes to the overall IP55 protection rating of the scanner. This provides protection against rain, snow, ice, smoke and dust. You can, for instance, invert it into a sewer maintenance hole and not worry about the environmental conditions.

Paul3D has found that the automation features of its new scanner make it well suited for the surveys of historic, and newer structures the perform for its customers. It can complete multiple scans quickly without having preset targets. The scanner merges the scans on-site, so they can check for completeness and avoid having to come back for more. © Paul3D

The miniaturisation of key components, even with the addition of self-calibration and levelling mechanisms, has contributed to an overall compactness of these new instruments. They are light enough for anyone to carry with one hand, and the form factor is much smaller and more streamlined, with a single handle on top; the whole instrument can fit into a small backpack.

Expanding opportunities

The level of automation of such new systems has spurred new uses and users. Paul van der Linden, founder of Paul3D in the Netherlands, was formerly a construction contractor who started a successful business creating camera-based 3D tours for AEC and other clients. When an engineering firm tasked with a study for proposed lighting for the historic centre of the village of Franeker asked for a full 3D model, van der Linden deployed the X7. "I did 125 scans in Franeker over two days," he says. He could move the tripod and scanner around just as easily as he did for past camera-based projects.

"Without scanning it could have taken months to build a model for the lighting designers, measuring by hand and total station," adds van der Linden. "The scan was delivered as a single cloud, registered in the field in the software on the same tablet I used to control the scanner." Now, with his new cobot, he has evolved his business from 3D photos to 3D point clouds.

It is this kind of automation in workflows that has been responsible for the rise in popularity of scanning for accident forensics, remodelling, theatrical and motion picture set development, BIM, and historic preservation. Achieving high precision and confidence in scanning results used to require a lot more time, skill and experience. While fundamental best practices will always be essential, the advent of such new systems means that operators can be an expert in their field without having to be an expert in scanning. Many more people can now tap into the power of high-precision 3D data – with the help of a new class of scanning cobots.

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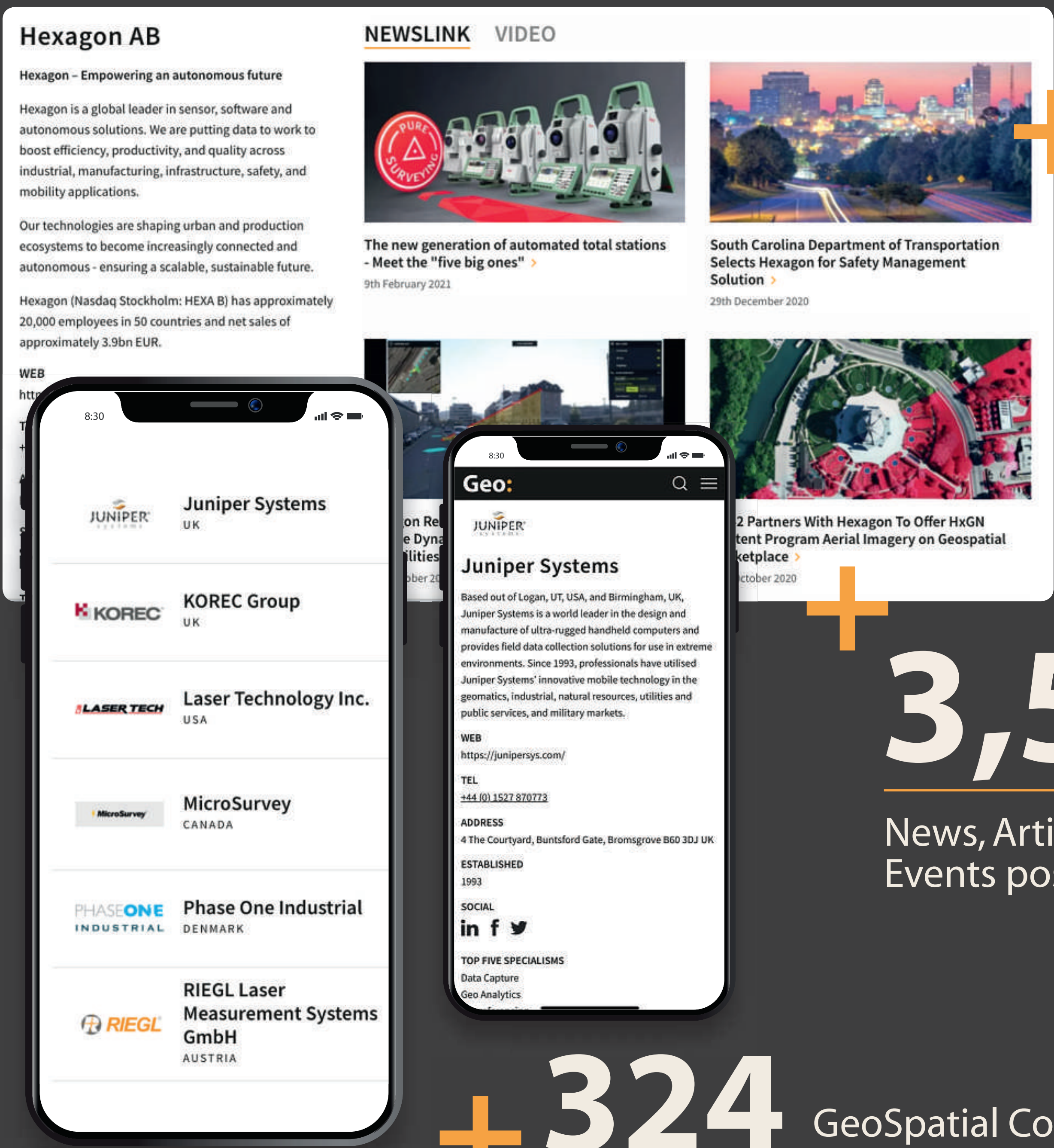

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