RIEGL LiDAR – SUPPORTING PUBLIC SAFETY AND FORENSIC INVESTIGATIONS FOR OVER 15 YEARS

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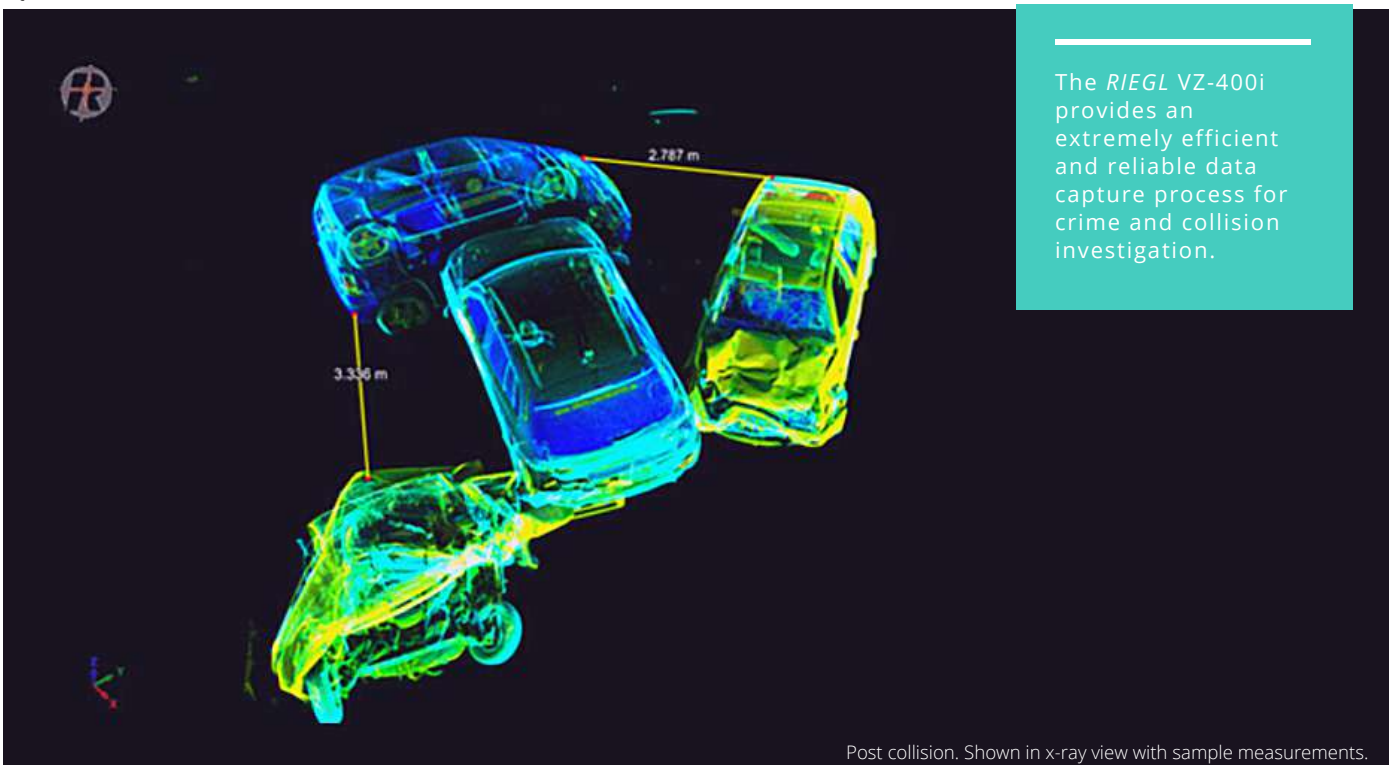
by David Foster



Post collision. Shown in x-ray view with sample measurements.

The *RIEGL* VZ-400i provides an extremely efficient and reliable data capture process for crime and collision investigation.

The value of LiDAR or 3D Laser Scanning for accurate documentation of crash and crime scenes has been discussed through numerous forums over the years. *RIEGL* has supported Public Safety and Forensic Investigations for many years and continues to supply class leading technology (both hardware and software) for efficient recording of such scenes. It may be useful to consider a little of the history before bringing the subject up to date with current practice with the latest scanners (VZ-400i and VZ-2000i), showing their leading operation and best performing fit for purpose testing.

Background

Documentation of crime and crash scenes over the years has traditionally been done with photography and sketches.

Some departments may have developed plan drawing teams, and these were certainly prevalent with

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Collision Investigation. Measurements taken with tape were time consuming, requiring many man hours to complete; clearly the more complex the scene the longer such measurements took. Setting out tapes in a datum line methodology (chain and offset) relied on keeping the tapes straight, and measurements offset at right angles, often in far from ideal conditions.

For crash investigators and reconstructionist, the need for such measurements, which were later drawn to produce scale plans, are crucial in determining key evidential matters such as point of impact and lengths of skid marks for example. Similarly, with crime scenes, locating key items of evidence assist in the investigation process and bringing offenders to justice.

Figure 1: *RIEGL* LMS-Z420i. Contingency Planning (Courtesy: Metropolitan Police, London).

Other areas which benefited from detailed plans related to pre-event security, contingency planning, and asset management, all of which required time consuming recording and processing to produce plans.

The move to recording scenes with total stations, then supplemented with GPS survey technology was a major boon. However, they were still time consuming, albeit faster than laying measuring tapes; even in Public Safety, time is money. Many resources are required in keeping a scene safe to work in, to preserve evidence and to redirect traffic around the road closure. This is also detracting from other duties which still need to be performed.

Laser scanning started to appear on the scene within Public Safety in the early 2000's. Initially costs were prohibitive, with operation slow and cumbersome requiring planning of associated resources (batteries!!).

However, the seed was sown; the benefit for producing an accurate 3D facsimile of a crash or crime scene was starting to be acknowledged. The ability to freeze the scene in time allowed investigators to return to the scene time and time again.

Deployment of 3D laser scanners also greatly assisted contingency planning and event security planners.

RIEGL's development of the VZ-400 series scanner provided a major breakthrough in adaptation of laser scanning for Public Safety – this scanner was much faster, smaller, portable, with self-contained power source and operated from the scanner itself with easy touch control panel on the body of the scanner. A large rollout program in the UK was based on the costs associated with sudden unexpected road closures, and these costs are significant. Reducing the length of time roads were closed saved money both to the general economy and to law enforcement agencies. Studies in a number of different jurisdictions indicate such costs, but also that deployment of the *RIEGL* VZ-400 was likely to and did provide for faster road re-opening times, whilst preserving the necessity to accurately document the crash scene.

Importantly, the software was developed alongside to ease back office processes; this had the advantage of leading to greater uptake and deployment of the VZ-400 to more crash scenes with the benefit to both the investigator and the motoring public/economy becoming increasingly apparent. Thus, the adoption of *RIEGL* VZ-400 scanners can be offset against the gains made; the high costs of road closures means monies saved with further reductions in road closure times pays for the initial capital outlay of the scanners many times over.

Additionally, the quality of engineering of the *RIEGL* VZ-400 and long-term reliability has proved that the scanner is not only long lived (original VZ-400s from the 2011/12 roll out are still widely use today), but that they offer an excellent return against any Best Value analysis.

The development of the current VZ-400i advanced on the success of the VZ-400 and added a variety of features from inception; during its life time the software and how the workflow from data capture through process to end deliverable has progressed, means the VZ-400i has

cemented itself as the class leading LiDAR unit for Public Safety and Forensic Investigations.

RIEGL VZ-400i

The VZ-400i is one of the most productive laser scanners available: very fast laser pulse speeds (1.2MHz) and measurements rates coupled with the ability to obtain imagery at the same time as scanning means scans obtained at the panorama_40 setting (40mdegs) are completed in 45 seconds. One-touch workflows make operation of the scanner incredibly easy. Automatic detection of position moves means that at each new position, the operator needs only press the START key to begin a new scan. The touch screen operation was developed in response to feedback from a broad customer base. These also informed the basis of the workflows with which the operator selects the scanning mode. It should be borne in mind, that the VZ-400i can also be customised - a workflow could be set for crash scene in daylight, rural crime scene at night as examples. Additionally, the ability to utilise user configurable scan patterns (variable scan densities, range modes etc) means that the scene can be captured in particularly good detail generally, but key items can be focused in high-detail scan windows.

The operator needs to understand what it is that is being captured, what the evidence in front of the scanner is, and why that data would need to be recorded. Using the *RIEGL* VZ-400i is an objective data capture process. The operator and any person involved in subsequent analysis of the data need also to be confident in the accuracy and reliability of the instrument, so that any data drawn down can be done with high confidence, and minimal measurement uncertainty.

Of course, in all this the capacity for *RIEGL*'s VZ-400i fast-scanning, easy workflows, simultaneous image capture (and ease of use in software) continues the ability to document such scenes very quickly, allowing closures to be opened sooner. Survey times can now be measured in minutes.

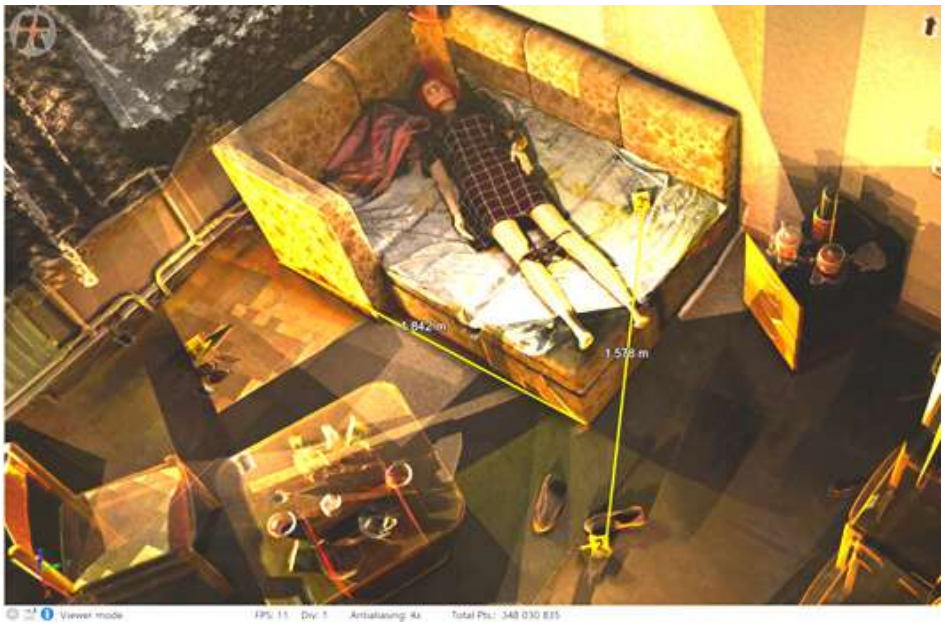


Figure 2: Crime scene documentation - exercise.

Figure 3: Wet weather testing.

But what of the accuracy? In the UK a series of tests have been conducted to determine just how 'fit for purpose' the *RIEGL* VZ-400i is, including testing in wet conditions (Figure 3).

Working with the NPCC Specialist Capabilities Programme (SpecCap) a sequence of demanding test situations was created, with only the final extreme weather tests to be completed (CoVID-19 permitting) at the time of writing. In deployment the VZ-400i has been happily(?) used across wide temperature variations such as at -11oC / 12F in Latvia up to +45oC / 113F in Arizona. On-board sensors allow for variations in atmospheric conditions: this is an important consideration to allow for field conditions compared to laboratory results, in order to maintain accurate measurements.

Fit for Purpose

Figure 4: Collision Teams respond to incidents day/night, rain/shine.

The SpecCap tests were designed to be a process to determine a device's suitability for use – in these specific circumstance – for evidence capture at crash scenes. Levels of accuracy of the scanners and of registration were set, controlled scans performed at ground truth sites, and levels of performance determined in adverse weather conditions. For Law Enforcement Collision Investigators there is no planning to go out to survey when a crash occurs; each incident has to be responded to on demand. It was also a mandate that the device had to be capable of automatic registration without the use of targets. In such circumstances there is no requirement to tie to survey control.

The exercises detailed single station accuracy, which included targets as a mean of checking accuracy. Targets could not be used as part of the registration process. *RIEGL* uses reflector type targets which are fine scanned after the main scan has taken place. For the VZ-i series this process has been hugely streamlined and automated. However, it still adds time, both in setting out the targets and then conducting the fine scanning element. Where time is critical, steps taken to minimise time consumption are key. Again, the method validation process was to determine the parameters the VZ-400i could work at without targets. Standard deviation for a single scan in comparison to survey control was reported at better than 1mm. For multi-positions after registration, this was around 1mm – these figures married with initial tests which were processed and checked against numerous control measurements[1] by an independent body with the average error being better than 1mm (0.00088m).

Now for the real-world testing: the accuracy tests described above were conducted in a controlled environment with relatively short distances. How was the VZ-400i to perform in a variety of environments, without targets, and still register robustly to give accurate geo-referenced measurements, data that could be relied upon? Indications at this stage suggested we could extend scan position centres to as far as 40m and achieve the required accuracies.

The ground truth location was a police training facility in the UK. It involved urban street scenes, semi-urban areas and a rural featureless site. Each of the open areas had to extend for 300m minimum to replicate typical scenarios encountered by Collision Investigators across a wide variety of policing areas. The first scan project was completed with scan positions at 20m intervals at the semi-rural scene. Here, there are some buildings to one side of the road, but these were masked at intervals by trees. Opposite was a ditch and flat grass land. On-board registration was enabled.

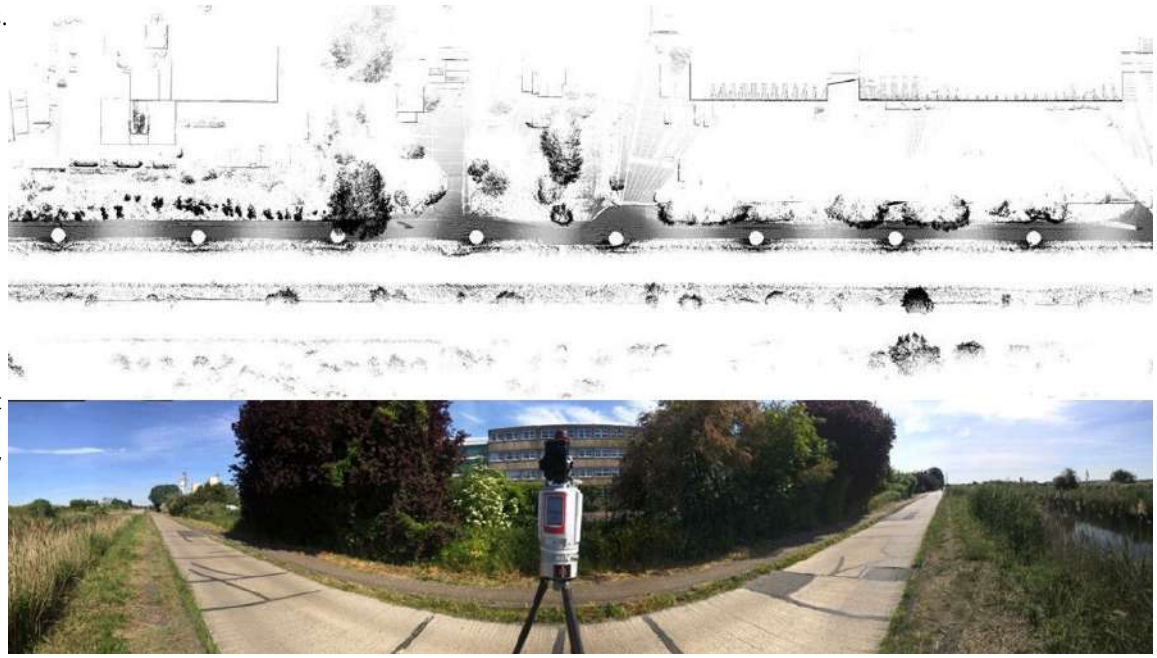
The scan pattern was set to a prescribed resolution that the SpecCap defined (6mm @ 10m). This translates to 34mdegs (0.0034 degs) on the *RIEGL* VZ-400i. The workflow parameters were set up on the scanner ahead of time, so that this operation was selected as a defined process. The operator need only confirm that he/she will be using the correct workflow.

On board registration is completed, as implied, on board the scanner, without the need of a tablet or other device. This enabled real-time assessment of the registration process as the scans were being completed. The VZ-i Project Map app displays scan locations together with a streamlined version of the scanned data so that the operator can check each scan location relative to the previous as the registration is built up. Any gaps in data can easily be determined in the field at the time, reducing the need for return visits.

Figure 5 displays the results of this second scan project at the first – semi-urban – scene. Each scan position centre is at 40m, with each scan being completed in 61 seconds (including imagery). Registration was recorded with a standard deviation (3mm) that far exceeded the requirements of the test. The scene length was 320m between start and finish positions. Actual survey data extended for much further and control targets bracketed the 320m scene length. Similarly, on-board registration allowed the operator to analyse the registration in real time as scanning progressed.

Finally, a third examination was completed utilising the scanners capability to adjust the resolution of the scan; in this format the scan pattern was changed to read 50mdegs

frames and 25mdegs lines. This has the effect of increasing the number of points on the horizontal surfaces, particularly useful for documenting relevant marks, gouges and debris on the road surface. For this scan pattern each scan is completed in 59 seconds.



The next location was that of the rural featureless scene. Here the "roadway" was bordered on both sides by grass land with the grass being approximately 1m tall. There were occasional small trees and shrubs interspersed across the scene layout but the distances between each was large.

Figure 5: Ground truth location: semi-urban scene.

Figure 6 shows the results as we moved to the rural location. The same process was carried out: a 20m separation initial test then scans performed at 40m intervals over the 300m+ scene length, both at the 34mdegs and the 25/50mdegs settings (roadway).

Figure 6: Rural featureless scene, registered automatically without targets, 40m intervals.

Similar results were reported with regards to accuracy across the whole project. It was clear, and wholly as expected, that scanning at 20m makes for a better data set, however, what was revealed was the robust nature of the registration process both on-board the scanner and within the partner software RiSOLVE.[2] The combination of the *RIEGL* VZ-400i (with its numerous sensors as well as the scan data) and the algorithms relating to registration on board the scanner and mirrored in the software, makes for a compelling argument and a reliable data capture process.

Finally, similar tests were then carried out in an urban location with the added complication of one additional test: at one corner location (street junction), the scan positions had to be sited so that they could not see the targets for the adjacent / previous scan. Targets were carefully placed to control this sub-test to examine the registration in a real-world environment. For this scene, the scans were recorded at appropriate scan separations with the caveat of the sub-test. Not surprisingly, at both the 34mdegs and 25/50mdegs scan patterns, registration was completed successfully, again far exceeding the requirements of the overall test.

Incidentally, the same scenes were also scanned with the *RIEGL* VZ-400 which are still in widespread use across many Public Safety bodies. The results revealed that the scan separations in the rural and semi-rural areas should be reduced from the maximum 40m, but that the registration obtained was robust. This is reassuring to existing users as *RIEGL* continues to support those bodies with the VZ-400 instrument, allowing them to work with their current instrumentation.

Conclusion

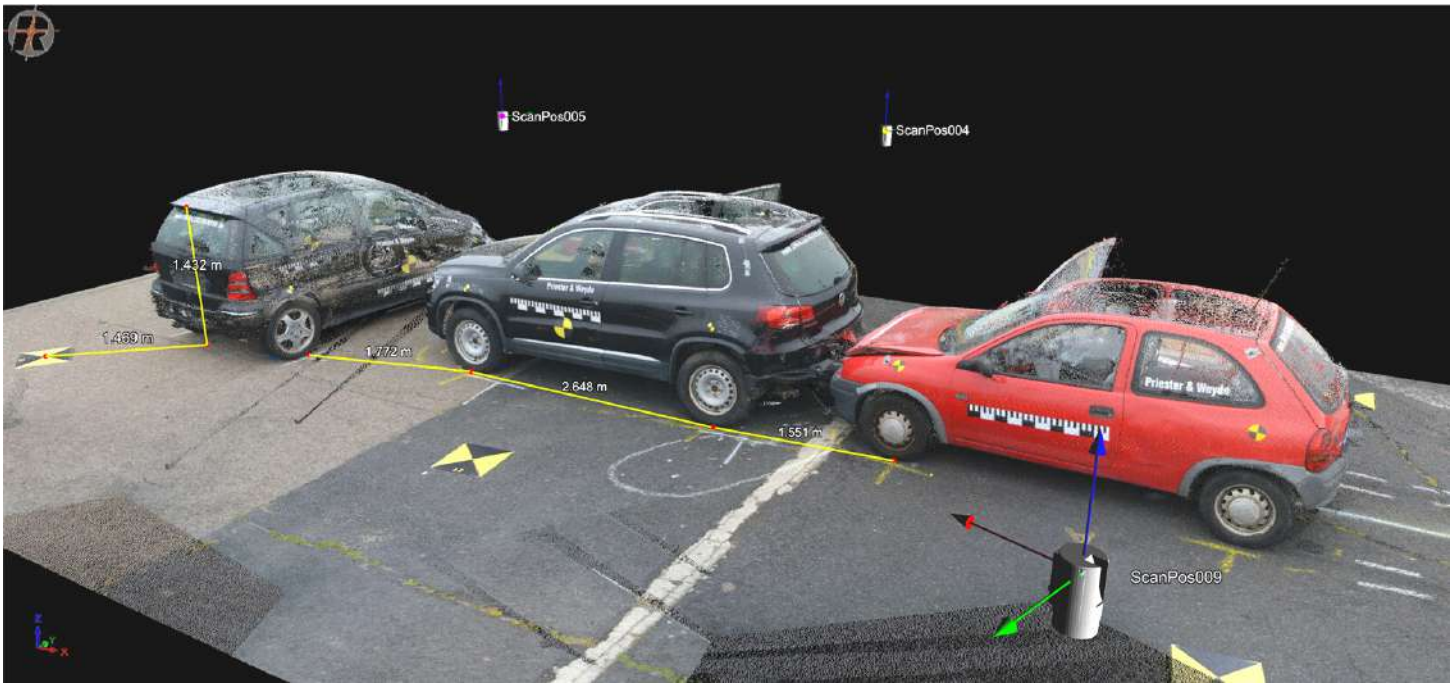


Figure 7: Post collision. Shown in colorized point cloud view with sample measurements.

The test provided for here mirrored, as far as is possible, real world environments to examine the capabilities of the *RIEGL* VZ-400i. The series of tests throughout are repeatable. *RIEGL* is very pleased with the performance of the VZ-400i and RiSOLVE software in meeting and indeed exceeding the requirements set by the SpecCap testing team to determine the "fit for purpose" nature of the scanner and methodology when being deployed.

We have demonstrated under challenging conditions, the ability to perform accurate scans which are registered automatically without targets in all 3 typical scenarios. It is important to observe that the scans were also registered on-board the scanner in real time, and that colour imagery to colourise the point clouds in the software, is obtained synchronous to the scanning operation.

Thus, the *RIEGL* VZ-400i provides an extremely efficient and reliable data capture process for crime and collision investigation. In achieving this, each scan is taking no more than 61s at the 6mm@10m resolution (panorama_34, 34mdegs) so providing for very rapid objective data capture. Fast scanning of this nature is a boost to road re-opening times, providing LiDAR data for professionals in subsequent investigations and reconstructions.

"*RIEGL* has been delighted to work with the NPCC SpecCap team through the series of examinations to date.", says Dave Foster, *RIEGL* Forensic Consultant, and continues, "We are proud to support the work of Forensic teams across the Public Safety arena, proving high quality data for investigators to conduct their analyses, reconstructions and conclusions."

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For further information on how *RIEGL* laser scanning systems are deployed with Public Safety teams across the world and how they can be applied to your situation email: *info@riegl.co.uk*

Refernce

[1] Survey control to targets with Leica TS15i, both faces.

[2] RiSOLVE is a processing and registration only version of RiSCAN_Pro.

Author Bio

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After over 30 years with UK police, David retired to take up a position as a consultant. He had practiced in the field of Collision Investigation and Reconstruction for over 16 years, leading a small team of dedicated investigators. He was an early adopter of LiDAR to complete objective scene data capture. Having gained many years of user experience, Dave now leads for *RIEGL* for Public Safety and Forensic Investigations, working with *RIEGL* with their development of hardware, software and workflows to share; As a result, Dave and *RIEGL* have worked with a wide variety of clients to achieve the best solutions for their needs with a number of ongoing projects to develop client solutions and enhance *RIEGL*'s position as Innovators in 3D, providing LiDAR for Professionals.