

Beyond the Tripod:

Mobile LiDAR SLAM in the Built Environment

by Stuart Hill



Fig. 1 - GX1 hero product shot.

For most of its history, high-accuracy 3D data capture in the built environment has meant one thing: setting up a tripod, taking a scan, moving the tripod, and doing it again. Mobile SLAM LiDAR is changing that — and the implications for survey productivity, project economics, and what clients can afford to document are considerable.

The Limits of Traditional Scanning

Terrestrial laser scanning has been the survey profession's workhorse for 3D data capture in AEC for two decades. Its accuracy is well understood and its outputs integrate cleanly into BIM and CAD workflows. But TLS is slow. Every scan position requires setup, levelling, and registration — a sequence that must be repeated tens or hundreds of times on a complex site. A comprehensive internal survey of a large building can consume several days of field time before post-processing begins. On linear infrastructure — roads, corridors, pipelines — the problem compounds across distance.

The speed constraint has real consequences. When scanning is expensive and time-consuming, it happens infrequently. As-built records lag behind construction progress. Discrepancies between design and reality go undetected until they become costly. Research cited by Emesent estimates that poor construction data costs the global industry US\$1.8 trillion annually — a figure that reflects, in part, documentation that

can't keep pace with the work it's meant to capture.

Drone photogrammetry has provided some relief for large outdoor environments, but it has clear limitations: dense vegetation, underbridges, culverts, and enclosed spaces all defeat aerial capture. What the industry needed was a tool fast enough to scan regularly, accurate enough for survey-grade applications, and flexible enough to reach every corner of a project — indoors and outdoors, in GPS-available and GPS-denied environments alike.

Building the GX1

Emesent was founded in 2018 as a spinout from Australia's CSIRO, initially focused on enabling autonomous drone navigation in GPS-denied underground environments. The core technology was SLAM — Simultaneous Localization and Mapping — which builds a spatial model in real time by correlating successive LiDAR scans without external positioning signals. As Emesent's Hovermap platform found adoption across mi-

ning, infrastructure, and AEC, a consistent theme emerged from clients: they wanted the speed and robustness of Emesent's SLAM in a device built for conventional survey workflows.

The GX1 program was built around that brief. Early feasibility prototypes delivered sub-10-millimetre precision — a result, as senior aerospace engineer Sam Pruden recalls, that came from a prototype that was still essentially a sensor array bolted to an aluminium frame. "That really sealed the deal for us," he says. "We knew we were onto a winner."

Over three design iterations, the team refined an architecture where form follows function directly. Because Emesent SLAM leverages a rotating LiDAR assembly that maximises the field of view for the LiDAR, cameras and RTK antenna simultaneously became a central structural constraint — driving the characteristic stacked, vertical form factor. The chassis is extruded from a single piece of aluminium with no joins or breaks, providing both structural rigidity and thermal stability. All critical sensors are rigidly coupled into a single upper unit, ensuring their spatial relationship remains fixed regardless of environmental conditions. Battery and computer are thermally isolated at the base, preventing heat from influencing sensor performance in hot outdoor environments.

To balance engineering requirements with usability, Emesent worked with industrial design stu-

dio Katapult, embedding one of their engineers in the team throughout the project. The collaboration produced a device with curvature-continuous surfaces and a deliberately minimal external profile — a scanner that is both technically rigorous and straightforward to pick up and use. Hardware team lead Andrew Harrison describes the design goal plainly: "Someone who's never picked up an Emesent product can just start and get really great mapping — from loading it out of the backpack all the way through to putting it on the pole."

What the GX1 Integrates

The GX1 combines a rotating LiDAR assembly, onboard cameras for continuous 360-degree panoramic capture, and an integrated RTK GNSS receiver — all recording within a single unified system under a common clock and coordinate frame. Before the GX1, a mobile scanning setup requiring both LiDAR and georeferenced imagery typically meant managing multiple devices with separate power supplies, separate storage media, and a post-processing pipeline of custom synchronisation scripts to align data streams that recorded at slightly different times and in slightly different reference frames.

The GX1 eliminates that pipeline entirely. All data flows into Emesent's Aura software, where processing, automated georeferencing, point cloud cleaning, and export are handled within



Fig. 2 - Colorized point cloud interior captured with Emesent GX1 — Orion Spatial Solutions project.

one interface. Aura supports direct export to standard BIM and CAD platforms including Autodesk Revit, Bentley OpenRoads Designer, and Trimble Business Centre. Multiple scan sessions can be merged, enabling a continuously updated digital record built incrementally over the course of a project.

In the field, the GX1 is designed for single-operator deployment in whatever configuration the environment demands: handheld, backpack-mounted, on a pole for elevated or confined spaces, or vehicle-mounted for linear assets. Real-time point cloud visualisation via the Commander app allows the operator to confirm complete coverage during capture — reducing the risk of gaps that would require a return visit.

Orion Spatial Solutions:

A Decade of SLAM Adoption

Orion Spatial Solutions, a survey and spatial services firm operating across South-East Queensland, Australia has been using Emesent technology long enough to offer a practitioner's perspective on what SLAM integration actually looks like over time. The company has been in the scanning industry for more than fifteen years, with some team members scanning since the 1990s. Their initial encounter with SLAM was cautious.

"The limitations around SLAM were probably the biggest thing to get used to and get confident with," says Director John Phillip. "It's just come from quite a few years of using them now. You know when to use it, when not to use it,

what sort of accuracies you can expect. Most of the team are fairly comfortable with that. It's an everyday tool for us."

Building that confidence was deliberate: early on, the team ran Hovermap alongside existing terrestrial scanners, checking outputs against known datasets. Two developments accelerated the transition — the integration of RTK GNSS for larger-scale projects requiring stronger positional accuracy, and the introduction of manual control point picking in Aura for constraining SLAM drift in challenging environments. The result is that Emesent's Hovermap STX is now the firm's most-used scanner, accounting for approximately 80% of what had previously been TLS-only work.

The commercial impact goes beyond efficiency. Jobs that previously couldn't proceed — because client budgets couldn't support a full TLS engagement — became viable. "You're putting a job within the client's budget, so a job that might not have progressed before can progress because you gave them an option that wasn't on the table," Phillip explains.

When the GX1 arrived for beta testing, Orion's primary concern was practical: would it solve the operational friction they had learned to work around? Their existing mobile scanning configuration required multiple GoPros, separate GPS receivers, custom cables, and synchronisation scripts for post-processing. The GX1 replaced that entire stack. "I don't even need to go scrounging around for more receivers or GPS gear," Phillip says. "With the GX1 I can turn it on and just log to a base if I want. I don't need to take anything else with me. That's a massive step forward." Orion has committed to adding the GX1 to their fleet.

GeoTwin: A 2.3 km Road in One Day

A topographic and tree survey of a 2.3-kilometre arterial road in New South Wales, Australia — required to support a road upgrade creating pedestrian and cycling infrastructure — illustrates what versatile SLAM deployment looks like in practice. The survey covered 20 hectares without disrupting traffic flow. Using a total station, the equivalent work would have taken approximately three weeks, with surveyors working in close proximity to moving vehicles for an extended period. GeoTwin, a digital engineering services provider, identified Hovermap as the tool for the job — specifically because a single device could handle all the distinct environments the corridor presented. The survey began with Hovermap mounted



Fig. 3 - GX1 on backpack — surveyor in an outdoor AEC environment.

to a drone, flying the route three times using a combination of LiDAR and photogrammetry. For the median strip, where higher point density was required, Hovermap was attached to the Vehicle RTK Kit and driven the corridor. For the bridge underdeck and drainage culverts — environments inaccessible to drone or vehicle — an operator carried Hovermap on a backpack and used a telescopic pole to reach confined spaces. All three datasets were processed and merged in Aura, with colour added from the photogrammetry passes. The combined point cloud was exported to Cyclone 3DR for the topographic survey, tree survey, and CAD model. Total field time: one day. "Emesent and the STX made it significantly easier and quicker to do a topographic survey," says Garry Elali, Operations Manager at GeoTwin. The client received a more complete dataset than traditional methods would have produced, and the safety risk of prolonged roadside work was eliminated.

GeoTwin Hovermap drone deployment over 2.3 km road corridor, NSW (4000 × 4000 px)

Scan-to-BIM and As-Built Documentation

The experiences of Orion and GeoTwin sit within a broader shift in how AEC projects manage spatial documentation. BIM has become the dominant framework for design, construction, and facilities management across most major markets — but its value depends on the accuracy and currency of the as-built data that populates it. When scanning is slow and expensive, BIM

models lag behind site conditions, and the gap creates coordination problems and undetected clashes.

Mobile SLAM scanning changes the economics of frequent capture. With field time reduced by up to 90% compared to TLS — and automated georeferencing removing the manual registration step from post-processing — it becomes feasible to scan complex environments at key construction milestones rather than only at practical completion. Discrepancies between design intent and built reality can be identified while correction is still straightforward and inexpensive.

The Scan-to-BIM workflow with Emesent technology follows a consistent three-step pattern: deploy Hovermap or the GX1 in whatever configuration suits the environment; process and georeference automatically in Aura, merging sessions and cleaning the point cloud; import into BIM or CAD software for modelling and delivery. What this eliminates is the labour-intensive intermediate step — manual registration of individual scan positions — that has historically dominated survey office time on BIM projects. Software integration is broad: Aura exports directly to Revit, Bentley, Trimble Business Centre, Cintoo, Pointerra, and Prevu 3D. The result is an as-built model that reflects real-world conditions rather than lagging behind them — enabling live digital twins, real-time progress tracking, and continuous comparison against design.

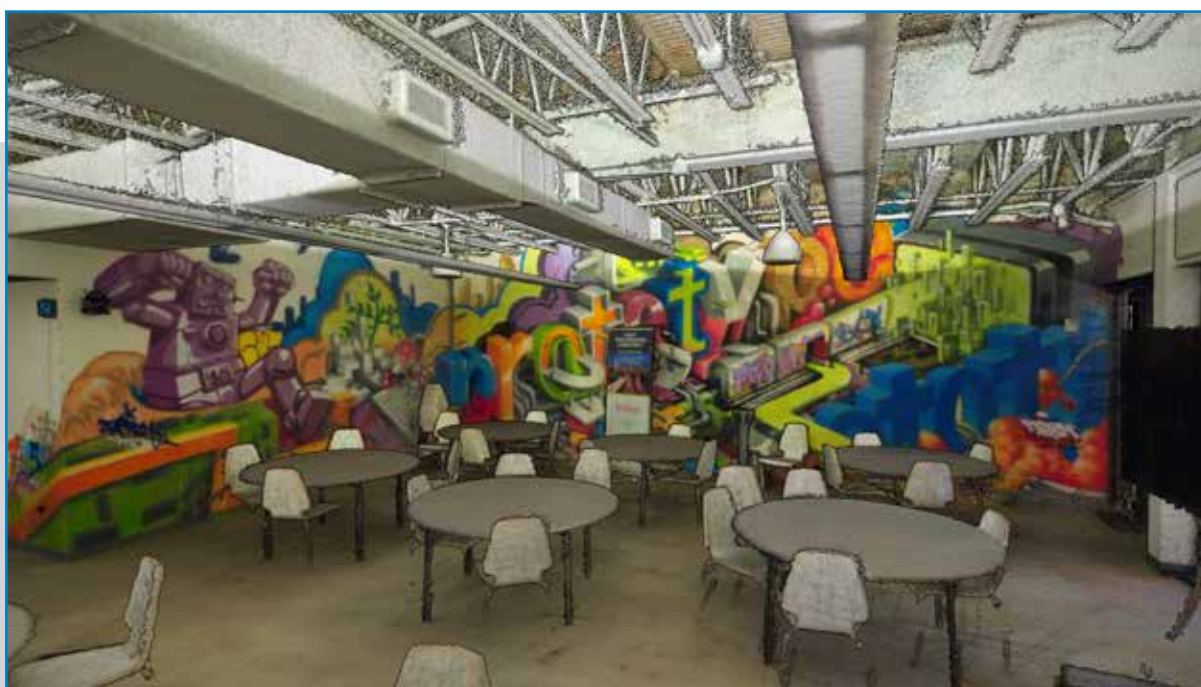


Fig. 4 - Emesent Aura software showing point cloud processing and BIM export workflow.

Conclusion

Mobile SLAM scanning does not replace every application of terrestrial laser scanning — and experienced practitioners like those at Orion are clear-eyed about that. What it does is expand the range of projects where comprehensive 3D documentation is feasible: faster capture, lower cost per scan, and the ability to reach environments that fixed-station instruments cannot. For the AEC industry, where poor spatial data carries a multi-trillion-dollar annual cost, those are not incremental improvements.

The GX1 represents Emesent's most direct statement of intent for the survey market: a device built from the ground up for professional surveyors, with the integration, usability, and accuracy that day-in, day-out field use demands. The field evidence from Orion and GeoTwin suggests the underlying technology is already delivering on that brief.



KEYWORDS

LiDAR · SLAM · SCAN-TO-BIM · MOBILE MAPPING · AEC

ABSTRACT

Mobile SLAM-based LiDAR scanning is reshaping how spatial data is captured in the AEC sector, offering significant reductions in field time compared to traditional terrestrial laser scanning while extending coverage to environments that fixed-station instruments cannot easily reach. This article traces the development of Emesent's GX1 — a purpose-built mobile scanner integrating LiDAR, RTK GNSS, and panoramic imaging — and examines how it performs in the field through two practitioner case studies: a multi-deployment infrastructure survey conducted by GeoTwin across a 2.3 km road corridor and an account by survey firm Orion Spatial Solutions of

how SLAM technology has changed their approach to scanning over more than a decade of adoption. Applications discussed include topographic survey, construction as-built documentation, and Scan-to-BIM.

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EMESENT IS A DRONE AUTONOMY, LiDAR MAPPING, AND DATA ANALYTICS COMPANY FOUNDED IN 2018 AS A CSIRO SPINOUT. ITS HOVERMAP AND GX1 PLATFORMS SERVE MINING, AEC, INFRASTRUCTURE, PUBLIC SAFETY, AND DEFENCE APPLICATIONS GLOBALLY. WWW.EMESENT.COM

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