Volumet

FIELD GUIDE

Handheld SLAM capture field guide

Walk paths, loop closure, and the capture habits that separate a clean point cloud from a noisy one.

6	1.0 m/s	4–5 h
Walk path rules	Stated walking ceiling (0.5 in HD)	Actual recording in a realistic day

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01 PRINCIPLES

How SLAM capture works

A handheld SLAM LiDAR scanner builds the map and locates itself in it at the same time: Simultaneous Localisation And Mapping. It has no tripod and no fixed stations: your **walk path is the survey plan**. Good geometry in, good point cloud out. Every rule below exists because SLAM accumulates small position errors ("drift") that only well-shaped walk paths let the software correct.

Two practical consequences follow. First, unlike a tripod scanner, you cannot fix a bad SLAM capture by "registering it better" afterwards: the trajectory *is* the data, so capture technique matters more than any processing setting. Second, the algorithm is constantly matching what it sees now against what it has already mapped, which is why revisiting known ground (loop closure) is the single most powerful thing you can do for accuracy.

02 TECHNIQUE

The walk path rules

Each rule below names the failure mode it prevents. If you remember nothing else, remember the failure modes. They are what you will see in the cloud when a rule gets skipped.

1 **Close your loops.** Always return to ground you have already scanned, ideally your exact start point. Loop closure is how the algorithm cancels drift. An out-and-back dead-end corridor is the worst shape; a circuit is the best.

FAILURE MODE PREVENTED Accumulated drift: walls that are subtly bowed or doubled, floors that slope a few centimetres over a long run, and two halves of a building that don't quite meet. Without a closure the software has no reference to correct against, and drift grows roughly with distance walked.

2 **Walk slow, turn slower.** XGRIDS' stated ceiling is 1.0 m/s (0.5 m/s in HD mode); keep at least 0.5 m from the surfaces you are capturing, 0.5–1 m for signage and fine detail. Pause briefly at doorways and corners. Whipping the scanner around corners is the #1 cause of smeared geometry.

FAILURE MODE PREVENTED Motion blur in the map: during a fast turn the scanner's pose changes faster than it can track, so every point collected in that second lands slightly misplaced. It shows up as smeared corners and door frames with fuzzy double edges, and it cannot be processed out.

02 TECHNIQUE · CONTINUED

Rules 3 to 5

3 **Short scenes, generous overlap.** XGRIDS' map-fusion rules are specific: keep each recorded scene under 20 minutes, overlap adjacent scenes by at least 15 m of feature-rich ground (not an empty field or a bare stairwell), and merge at most 10 scenes per fusion job in LixelStudio. Scenes from different device series (K1 vs L2 Pro) cannot be merged at all.

FAILURE MODE PREVENTED The unmergeable pair: two scenes that share only a doorway's worth of common geometry will not align reliably, and drift within an over-long single scene grows past what closures can absorb. Generous overlap gives the merge algorithm something to hold onto.

4 **Feature-rich beats feature-poor.** Long, blank, repetitive spaces (empty carparks, plain corridors) starve SLAM of geometry. Slow down, hug the walls slightly, and include fixed objects in view.

FAILURE MODE PREVENTED Localisation loss: in a corridor where every metre looks like every other metre, the algorithm can mis-match its position, producing a corridor that is the wrong length or a trajectory that jumps. Parked cars, columns, signage and door recesses are your friends; keep them in view.

5 **Transitions need overlap.** Moving indoor→outdoor or between floors: pause, capture the threshold thoroughly, then proceed. Stairwells: keep the scanner high, take every flight in one continuous pass.

FAILURE MODE PREVENTED Split worlds: a rushed threshold gives the two environments almost no shared geometry, and you end up with an indoor cloud and an outdoor cloud joined by a hinge of noise. The threshold is the weld; give it time.

6 **Mind glass and mirrors.** LiDAR sees through or bounces off them. Expect noise near curtain walls; don't aim the scanner at mirrors at close range.

FAILURE MODE PREVENTED Phantom geometry: a mirror at close range reflects the laser and paints a duplicate "room" behind the wall; large glazing produces sparse noise and points floating outside the building line. Angle the scanner away from mirrors and accept (and later clean) noise at curtain walls.

03 STRATEGY

Multi-storey and stairwell strategy

Multi-storey buildings fail at the vertical joints, not on the floors. Treat each floor as its own looped scene: start and finish at the same lift lobby or stair door, then then use the stair cores to stitch the storeys together.

- **Floors first, stairs as bridges.** Capture each floor as a clean circuit. Then capture each stair core as a separate continuous pass from bottom to top (or top to bottom), flowing a few metres out of the stair door onto each landing and into ground you have already scanned. That overlap on every level is what ties the whole stack into one aligned model.
- **In the stairwell itself:** keep the scanner high and level, take the stairs at a slow, even rhythm, and do not stop mid-flight. Half-landings are natural pause points. Never reverse mid-stair. If you missed something, finish the pass and come back.
- **Lifts are not capture paths.** The scanner cannot track through a lift ride (a featureless moving box); the trajectory breaks. Move between floors by stair while recording, or stop the scene, ride the lift, and start a new scene with overlap.
- **Atriums and voids are gifts.** A multi-storey void lets the scanner see other levels directly, cross-bracing the whole model. Walk the balustrade line at each level with the void in view.
- **Plan the vertical order.** A workable pattern for a 4-storey building: floor loops L1–L4 as four scenes, then one continuous stair pass L1→L4 per core. The stair passes are short but they are the highest-value minutes of the capture.

04 STRATEGY

Indoor–outdoor transitions

The doorway between inside and outside is where three problems coincide: lighting changes (cameras re-expose), geometry changes (tight rooms to open sky), and, if you use RTK, GNSS appears or disappears. Technique:

1. Approach the threshold slowly and capture the doorway zone thoroughly from the inside: door frame, adjacent walls, a couple of metres of interior.
2. **Go through sideways.** XGRIDS' own technique for every doorway, indoor or out: stand sideways under the frame and pause so the scanner sees both sides of the opening at once, then move through slowly. Walking face-first through a doorway breaks the shared field of view and is the classic cause of misaligned rooms. (Closed door? Turn early, put your back to it, open it behind you and step through backward.) Then pause just outside; let the scanner accumulate the outside face of the same doorway plus nearby fixed features (planters, columns, kerbs).
3. Continue outdoors on a path that keeps the facade in view, and plan to re-enter through the **same** doorway or a second thoroughly-captured one, closing the indoor–outdoor loop.
4. With RTK: expect the fix to take time after emerging; keep capturing local geometry while it settles rather than standing still in one spot doing nothing. Geometry is your safety net if GNSS stays poor.
5. Strong sun through the doorway will silhouette the interior for the colourisation cameras. Where colour matters, capture transitions in flat light (morning, overcast) and re-do the threshold if the preview looks blown out.

The sideways threshold: walk the opening so the scanner sees both sides at once

05 STRATEGY

Scanning around people

Handheld SLAM tolerates occupied buildings well: moving objects are seen briefly and from changing positions, so they leave thin, ghost-like traces rather than solid geometry, and most are removed or thinned in processing. To keep the cleanup small:

- **Keep moving.** A person who stands next to you for a minute becomes dense, solid noise; a person who walks past barely registers. Your movement, not theirs, dilutes them.
- **Never scan a crowd from a standstill.** In busy zones (lobbies at lunch), keep the scanner's viewpoint changing and re-pass the area once more from a different direction so occluded surfaces behind people get filled.
- **Mind what people block, not just what they add.** A queue against a wall means that wall was never captured. Re-walk key wall lines during a quiet moment.
- **Doors held open by helpful humans** change state mid-capture (open in one pass, closed in the next) and produce doubled door geometry. Prop doors and keep them propped for the whole scene.
- **Vehicles:** a car that leaves mid-scene leaves a half-captured shadow. In carparks, capture each aisle in one pass rather than returning after conditions change, and note in the scene log which zones were live.

06 CONDITIONS

Environmental limits

- **Rain:** do not capture in rain. Drops scatter the laser and streak the camera lenses, and wet floors turn into low-return mirror surfaces. After rain, puddles will scan as holes or noise, so wait for surfaces to dry where the floor matters.
- **Direct sun:** strong tropical sun does not stop the LiDAR but punishes the colourisation: hard shadows, blown highlights and lens flare when facing the sun. For facades, capture in the morning, in overcast light, or with the sun behind you; expect slightly noisier returns off sun-heated dark surfaces.
- **Reflective facades:** glass curtain walls and polished cladding reflect the beam, producing phantom points beyond the facade line and sparse true returns. Capture reflective facades at oblique angles rather than square-on, from several positions, and lean on the colour imagery to reconstruct what the geometry under-delivers.
- **Vegetation:** leaves return well but move in wind. Dense planting scans as fuzzy volume, not surface. For sites where the ground or wall behind vegetation matters, get the scanner in close and low to shoot under or through gaps; accept that a hedge is a hedge, not a wall.
- **Heat shimmer and dust:** over hot open hardstanding or on active construction floors, expect a modest noise floor increase. Keep range shorter (walk closer to what matters) and wipe the cameras between scenes.

07 COORDINATES

RTK vs PPK vs control points

METHOD	WHEN	NOTES
RTK (built into the Lixel K2)	Outdoors with open sky	Live corrections; ≤3 cm RMSE absolute. Check fix status before starting.
PPK	Patchy sky view (CBD canyons)	Log raw GNSS, correct in post.
Control points	Indoors / no sky	Mark 3+ well-spread points with known coordinates (SVY21 for Singapore work); tie the cloud in post.
None (relative only)	Renovation, volumes, clash checks	Cloud is internally accurate (~1 cm relative) but floats in space. Fine for most non-survey work.

The numbers RTK holds you to

From the XGRIDS documentation: miss any of these and the coordinate conversion fails or degrades.

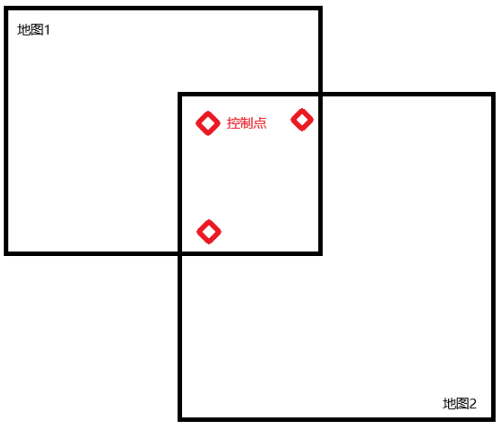
- Keep the fix status "Fixed" as much as possible; every unfixed stretch must stay under 50 m on the K1/K2 (100 m on the L2 Pro).
- The scan must span at least 10 m, and valid RTK data points (checked in LixelStudio) must exceed 100.
- Keep the antenna within 20° of vertical and clear of buildings; the device records latitude/longitude, so confirm your CORS mountpoint (SiReNT in Singapore) streams lat/long.
- Planning an accuracy verification? The route must exceed 100 m and must not be a straight line.

07 CONTINUED

PPK and control-point discipline

PPK adds a base-station ritual: deploy the base first and log for at least 5 minutes before starting the scanner; stop the scanner first and keep the base logging 5 more minutes after; keep the baseline under 5 km (total base deployment ideally over 15 minutes).

Control-point layout rules: at least 3 points, spaced under 50 m apart on the K1/K2 (100 m on the L2 Pro), spread in a triangle or polygon, never a straight line. Lower the scanner gently onto each point, wait for the app's confirmation, then circle the point once or twice for dense coverage; after the last point, wait 15 seconds before stopping the recording.



Control points spread across the overlap between two maps, never in a straight line

Control vs check points: control points *fix* the cloud to coordinates; keep 1–2 extra as *check* points you do NOT use in the adjustment. They are your honest accuracy report. Spread control points across the full extent of the site (corners, not a cluster by the entrance): a cloud pinned only at one end can rotate about that cluster within tolerance and still be wrong at the far end.

08 PLANNING

Capture-day timing model

Plan with rates, not optimism. Treat these as planning figures for a competent operator following the rules above; halve them for a first-ever capture day:

ENVIRONMENT	TYPICAL COVERAGE (WALKING CAPTURE)
Open-plan interior (offices, retail floors)	~1,000–2,000 m² per hour
Cellular interior (partitioned offices, hotels, hospitals)	~500–1,000 m² per hour, doors and turns dominate
Back-of-house / plant / congested M&E	~250–500 m² per hour, slow passes, tight spaces
Stair cores	~5–10 min per core per 4 storeys
Outdoor hardstanding / facades (K2 or L2 Pro)	~1–2 ha per hour depending on detail

Then apply the overheads that the m²/hour figure hides: scene setup and shutdown (~10 minutes per scene), battery swaps, access friction (escorts, passes, locked doors, often the largest single line), and the evening backup + one processed scene (~1–2 hours on a decent laptop). A realistic capture day yields **4–5 hours of actual recording**. If your site divided by these rates needs more than that per day, add days, not walking speed.

09 SCENARIOS

Capture scenarios

The rules in sections 2–6 are universal; the emphasis shifts by site. Seven scenarios that cover most rental weeks, each with the specific adjustments it demands.

Occupied open-plan office

The default Singapore job. Negotiate quiet windows (early morning, lunch) for the busiest zones, but do not wait for an empty building: SLAM tolerates movement if *you* keep moving. Prop and hold door states for the whole scene; hot-desking clutter is fine, but re-walk key wall lines when a queue or meeting breaks up. Watch the glass: full-height partitions mean phantom-point cleanup, so capture glazed meeting rooms from inside *and* outside and accept the noise budget. One floor per looped scene, lift lobby as the anchor.

Active construction site

The environment changes hourly, which breaks the "come back later" habit: capture each zone completely in one visit, because the hoarding line will have moved by tomorrow. Coordinate the route against the day's permit-to-work areas each morning; carry the scene log religiously because a half-finished floor is unrecognisable in the cloud three weeks later. Dust degrades returns and coats lenses: wipe between scenes, scan after (not during) heavy cutting, and treat freshly poured slabs as their own dedicated scenes if flatness QA is in scope. Expect feature-poor open slabs pre-fit-out. Hug the perimeter and include columns.

Heritage shophouse

Narrow frontage, deep plan, airwell in the middle, fragile fabric everywhere. The airwell is your loop-closure gift: route every floor's circuit past it so the levels cross-brace. Steep timber stairs need the full stairwell discipline (scanner high, one continuous pass, no reversing) at a slower pace than a concrete core. Nothing touches the fabric: no propping, no leaning, and plan lighting for dark interior rooms because colourisation is half the record's value here. Where mouldings, carvings or facade detail must be documented at millimetre grade, pair the SLAM coverage with tripod stations (BLK360 G2) on the significant elements, the common heritage pattern.

Industrial plant / congested M&E

The slowest metres of the fleet's life. Pipe racks, cable trays and vessels occlude each other, so plan multiple passes at different heights and angles rather than one walk: under the rack, beside it, above it from the gantry. Shiny stainless and painted pipework scatter returns; get close, move slowly, and let overlapping passes fill what any single angle misses. Confined spaces need permits, a buddy and lighting. Keep scenes small (a bay or a room, not a hall). Dense geometry inflates data fast, and small scenes localise any tracking problem.

Stockpile volumetrics

Walk a complete ring around each pile at a consistent radius, keeping the pile *and* surrounding fixed features (bins, walls, plant) in view for SLAM stability, then add a second pass or a high vantage for the crest if the pile is tall. The summit shadow is the classic volume error. Capture the base/toe area cleanly: the volume is computed against the base surface, so the toe line matters more than the peak. Georeference (RTK on the K2) if the numbers feed inventory or survey reconciliation; and scan when the yard is static, since a loader working the pile mid-scene invalidates the measurement.

Basement carpark / service tunnel

Feature-poor, repetitive, GNSS-free: the environment SLAM finds hardest. Slow right down, hug the walls, and keep fixed distinguishable objects (columns with numbers, parked cars, signage, services penetrations) in view constantly. Break long runs into shorter scenes with generous overlap at recognisable junctions, and close loops wherever the circulation allows rather than relying on one big circuit. If a corridor comes out the wrong length at processing, this is the scenario that did it: re-walk with more passes, not faster.

Venue capture for 3DGS

Here the imagery is the product, so the priorities invert: lighting first, geometry second. Capture with the venue fully lit and dressed, in one consistent lighting state. Splats bake lighting in permanently. Move slower than for pure LiDAR work and orbit key features (bar, stage, feature wall) so the cameras see them from many angles; view-dependent effects like reflections only reconstruct from viewpoint diversity. Empty the space of people if at all possible. Same walk-path discipline for the underlying trajectory, then process the splat scene via LCC CyberColor alongside the standard cloud.

10 ON SITE

Before you press record

- [ ] Battery charged + one hot-swap spare on you
- [ ] Storage clear (512 GB onboard on the K2, but check)
- [ ] RTK fix acquired (outdoor work)
- [ ] Lens caps off, cameras clean (colourisation uses all 3)
- [ ] Test loop: 2 minutes, process same-day, confirm quality
- [ ] Route sketch in your pocket, doors propped, scene log open on your phone
- [ ] LixelGO scan assist on (Guided mode, QUAL rendering): confirm each zone's coverage turns green before you move on; it flags sparse areas live, which beats discovering them at the desk

Starting the scene: XGRIDS initialization procedure

Static start on flat ground or the control-point base, LiDAR facing feature-rich surroundings, never an open field, a glass facade or a moving crowd. Keep the device completely still until LixelGO confirms initialization, then wait another 10 seconds after the point cloud appears before lifting it slowly. A rushed start tilts the whole reconstruction or fails it outright.

Ending the scene

Walk back to your start point, hold the scanner still for 10 seconds, then stop the recording in LixelGO. That final stillness gives the software one last loop-closure constraint; XGRIDS recommends it on every capture, and it costs ten seconds.

11 DESK

After the walk: LixelStudio processing

1 **Back up raw data first**: that evening, every capture day, before any processing. Processing works on copies; the raw scene folder is the master.

2 **Import.** Bring each scene folder into LixelStudio. Check the trajectory preview: it should look like the route you actually walked. A trajectory with jumps, gaps or a shape you don't recognise means a tracking problem. Investigate before optimising.

3 **Optimise.** Run the scene optimisation. This is where loop closures are detected and drift is redistributed along the trajectory. Let it finish; do not compare an unoptimised preview against your expectations.

4 **Inspect residuals.** After optimisation, examine the loop-closure residuals and the cloud itself at the places where your path crossed itself. **Good looks like:** closure residuals at the centimetre level, single crisp wall faces where two passes overlap, door frames with one clean edge. **Bad looks like:** residuals an order of magnitude above the device's accuracy class, doubled or "onion-skinned" walls at overlap zones, a floor that visibly steps where two loops meet. Bad residuals on day 2 mean re-walk on day 3. This is exactly why you process nightly.

5 **Merge scenes.** Align adjacent scenes using their overlap zones, then check every junction the same way: the seams are where multi-scene projects fail.

6 **Georeference** (if required): apply RTK/PPK trajectories or fit to control points, then measure your independent check points and record the deviations. That record is your accuracy statement.

7 **Clean:** remove moving-object ghosts and glazing noise as needed.

8 **Export** to the format your pipeline needs: **.las/.laz** (GIS/survey), **.e57** (exchange), **.rcp** via ReCap (Revit/AutoCAD), mesh, or **3DGS** via LCC CyberColor. Export the master format first, derivatives from it, and state the coordinate system in the filename or a sidecar note.

12 DESK

QA measurement protocol

Do this before you call any dataset done: it takes fifteen minutes and turns "the scan looks fine" into evidence:

1. **Pick 3–5 known dimensions per floor or scene**, spread across it: door widths, floor-to-ceiling heights, a long corridor run, a structural grid bay. Include at least one *long* dimension: drift hides in long runs, not door frames.
2. **Tape-measure them on site** during capture week (not from memory), and record them in the scene log with a photo of where you measured.
3. **Measure the same dimensions in the processed cloud**, point-to-point, at the same locations.
4. **Compare against your tolerance.** For centimetre-class SLAM work, short dimensions should agree within about a centimetre and long runs within the device's stated class; a single outlier means re-measure both sides before panicking, a pattern of outliers means a capture problem.
5. **Record the results in a one-line table** (location, tape, cloud, delta) and keep it with the delivery. If check points were used, include their deviations too. This table is the difference between an argument and an answer when someone questions the data in three months.

Check the geometry, not the render: the same trench as point cloud (left) and 3DGS scene (right)

13 REFERENCE

Troubleshooting in the field

The one page worth printing and keeping in the case.

SYMPTOM	LIKELY CAUSE	FIX
Doubled walls / ghosting	Drift, no loop closure	Re-walk as a circuit; add a closing pass
Smeared corners	Turning too fast	Slow the turn, pause at corners
Sparse noisy patches	Glass, black surfaces, range limit	Move closer; accept noise near glazing
Position jumps outdoors	RTK fix lost	Wait for re-fix; fall back to PPK/control
Failed scene merge	Not enough overlap	Re-capture the junction area as a bridge scene
Corridor wrong length / trajectory jump	Feature-poor repetitive space	Slow down, hug walls, add passes with fixed objects in view
Dark or blotchy colourisation	Low light, dirty lenses, sun flare	Add lighting, clean cameras, re-shoot threshold in flat light
Solid person-shaped noise	Standing still near people	Keep moving; re-pass busy zones from another direction

Rent the scanner behind this guide

XGRIDS Lixel K2 from S$2,300/week (GST-excl.), onboarding from S$250.

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