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Solid-State Area-Scan LiDAR for Pavement Profile Measurement

AASHTO R56 Compliant and Automated Distress Readiness

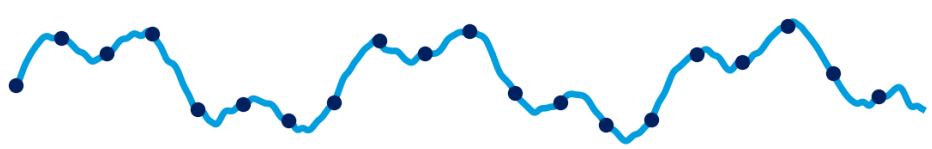
Kevin Mandli
Xenomatix – Americas



How pavement measurement is evolving

For decades, we've measured roads the way we measure a heartbeat…

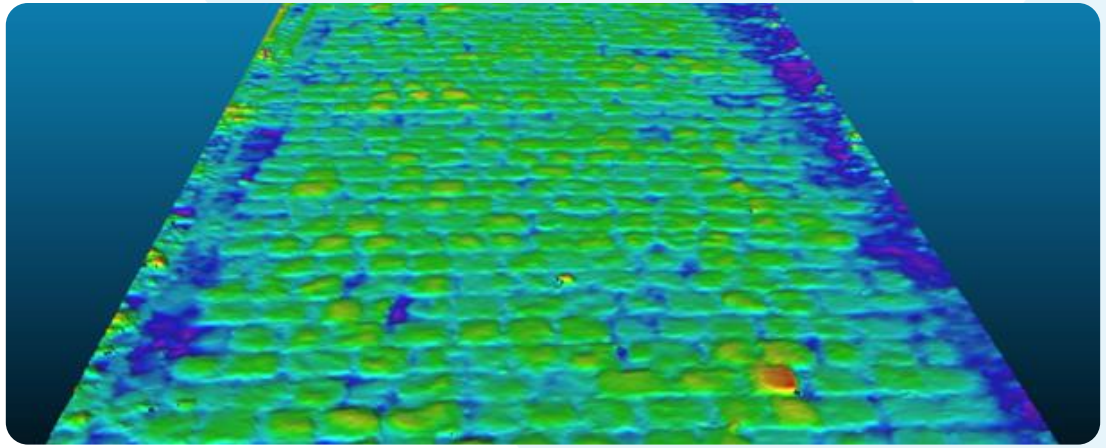
one point and one line at a time.



Yesterday: a single trace along a wheelpath

Today, I want to show you what happens when we finally get the full MRI:

we can measure the entire surface.



Today: a dense 3D height map of the whole lane

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What we'll cover in 15 minutes

1

The sensor

What solid-state area-scan LiDAR is and how it builds a 3D surface

2

Longitudinal

R56-compliant profile and IRI, at any speed

3

Transverse

Full-width rutting and cross slope from the same pass

4

Distress

Cracking and surface defects measured in 3D

5

The case

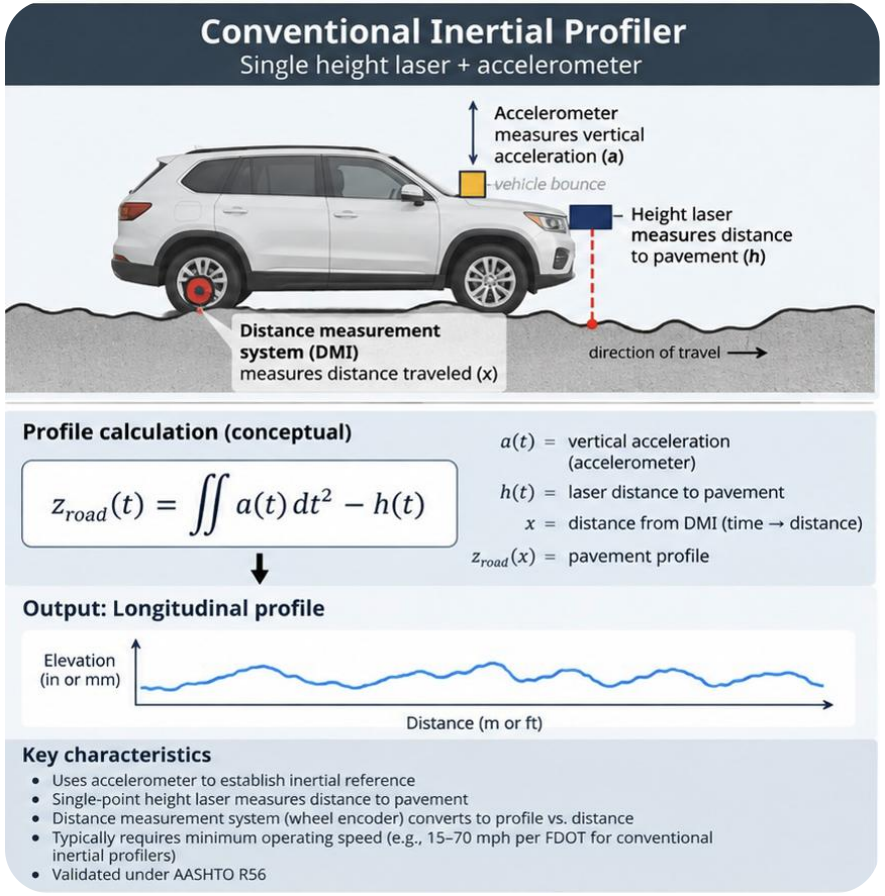
Why one area-scan sensor is the best profiler



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How we profile today: the inertial profiler



What that design means in practice

One narrow trace per wheelpath

Anything beside the laser line is never measured, and results shift with driver wander.

Only works inside a speed window

Below the minimum speed the inertial reference breaks down: urban streets, signals, toll plazas and work zones.

Longitudinal only

No transverse profile: rutting, cross slope and distress need a second set of sensors.

Key takeaway: **Proven and standardized, but it samples lines and depends on motion.**

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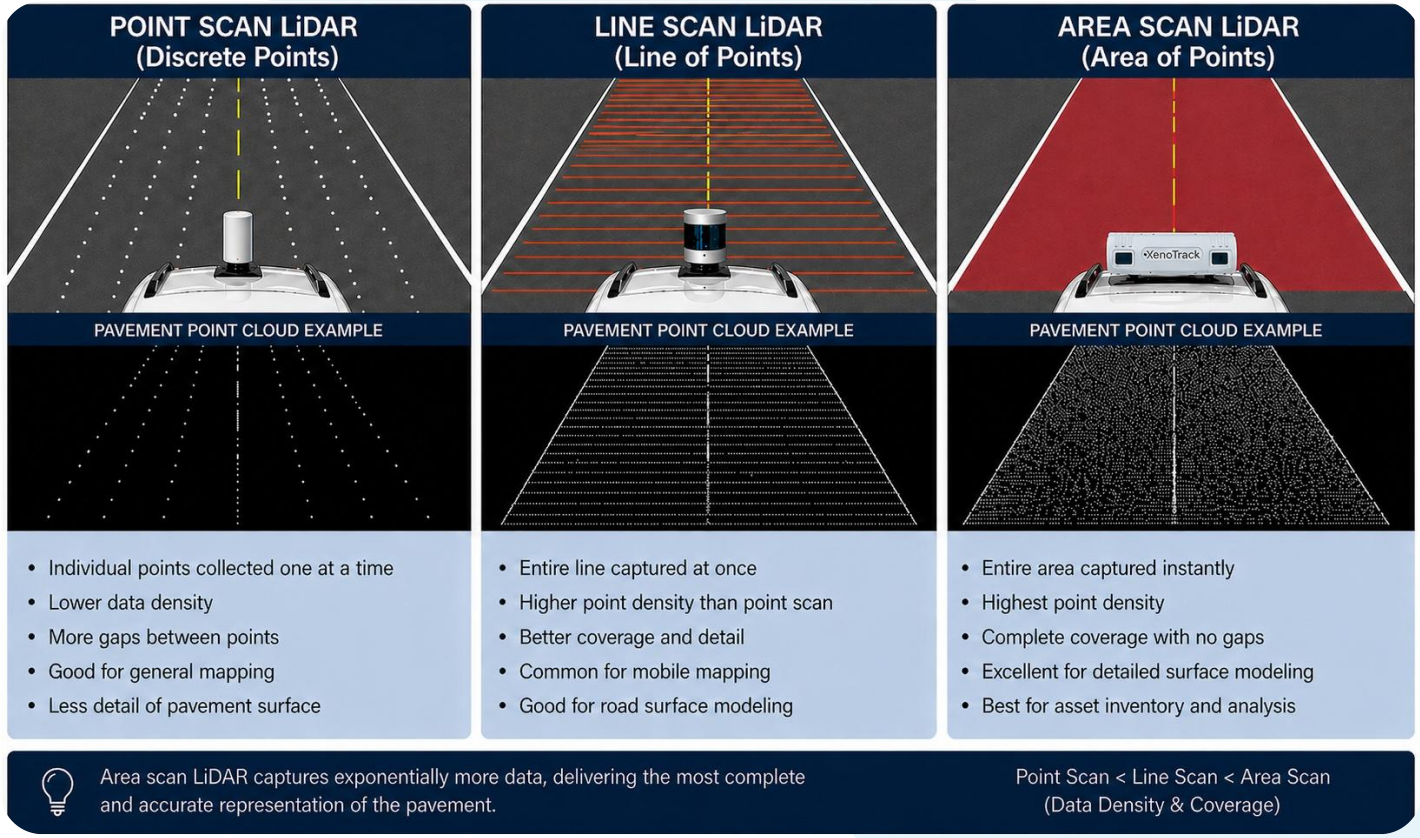
What is solid-state area-scan LiDAR?

Solid-state, area-scan (flash) LiDAR

- No spinning parts
- No mirrors
- No line scanning

Captures the **entire lane surface in one measurement**

Produces a dense 3D elevation map **(X, Y, Z)**

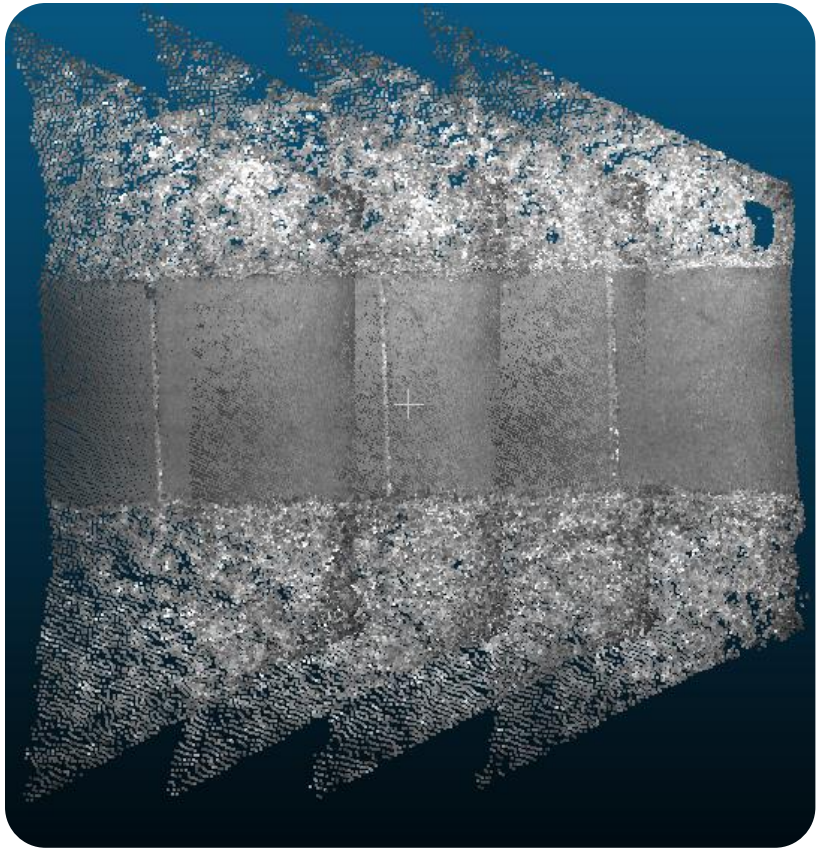


Key takeaway: It measures a surface, not a set of sampled lines.

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From raw data to a 3D surface



1

Pixel → 3D point

Each pixel measures distance, so each pixel becomes an X, Y, Z point.

2

Frames → continuous surface

Overlapping frames are stitched along the vehicle path.

3

Calibrate & filter

Calibration and filtering ensure accuracy and repeatability.

4

Open, analysis-ready output

Dense, gap-free height map exported as LAS / LAZ / CSV.

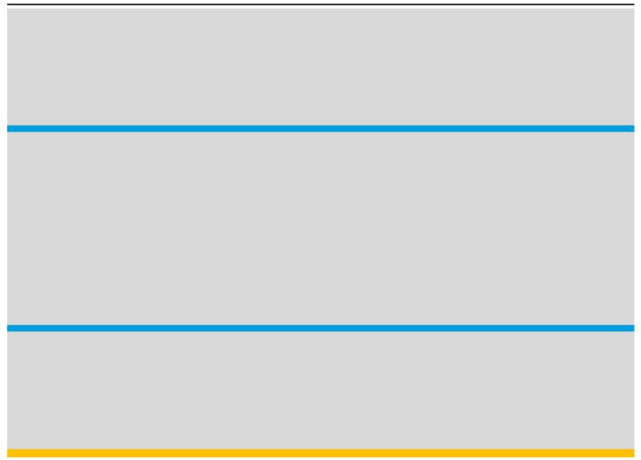
Key takeaway: Every pixel becomes a calibrated 3D point in a gap-free, full-lane surface.

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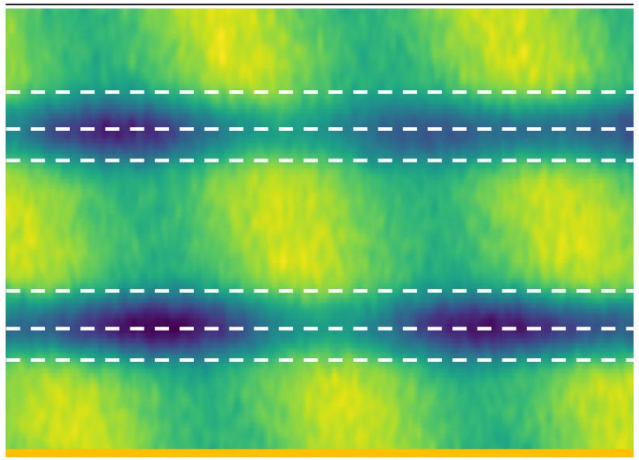
Deriving the longitudinal profile (IRI-ready)

Inertial profiler



Two narrow lines at fixed offsets

Area-scan LiDAR



Full lane · wheelpaths placed anywhere

- **Extract wheelpaths anywhere** — in processing, not fixed by sensor mounting
- **Compute longitudinal profiles** with standard processing aligned to AASHTO R56
- **Report IRI** from those profiles
- **Correct for driver wander** by re-extracting at the right offset
- **No interpolation** between sparse points

Key takeaway: Deriving profile from measured geometry, not reconstructing it.

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Why it works at any speed

Highway speed

Network-level collection

Low speed & stop-and-go

Urban streets, signals, work zones

Zero speed

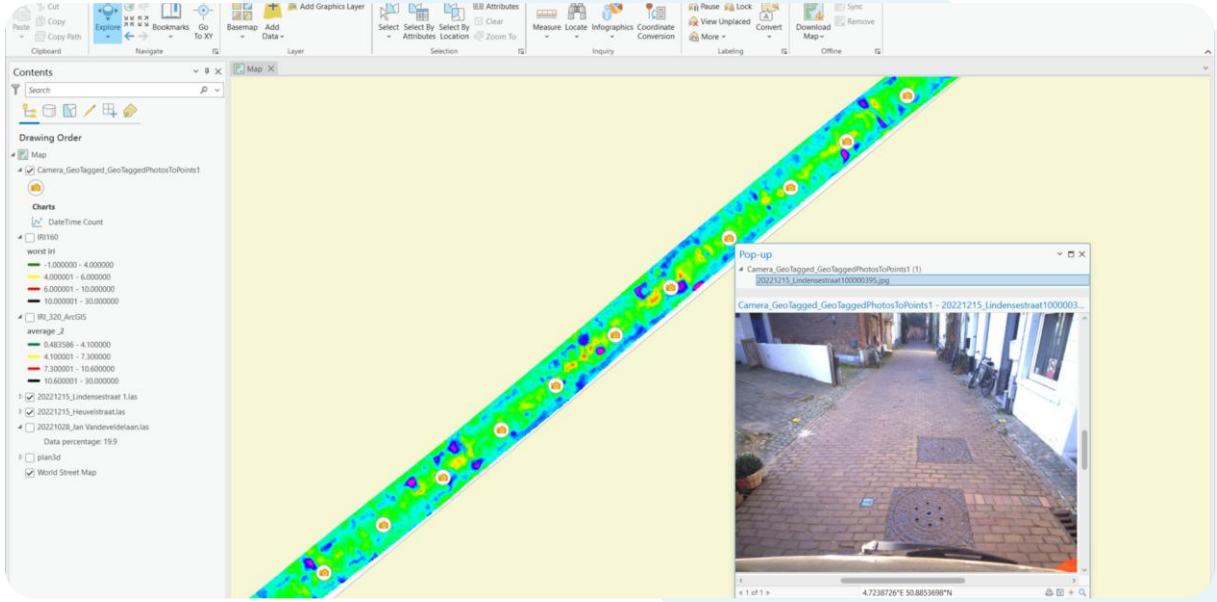
Measure while stopped

Inertial profilers depend on vehicle motion (accelerometers + velocity).

Performance degrades at low speed and at stops.

Area-scan LiDAR measures geometry directly in every frame.

You don't need motion to measure shape when you capture the full surface in 3D.



Key takeaway: Solid-state area-scan LiDAR works at all speeds.

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LONGITUDINAL PROFILE

AASHTO R56: compliant profiles from 3D data

1	**Capture dense 3D lane surface**	Full elevation surface is collected across the lane rather than along sparse traces.
2	**Extract profiles from measured geometry**	Longitudinal profiles are derived from the surface model in the desired wheelpaths.
3	**Process within current certification**	Profile calculations stay aligned with established inertial-profiler criteria (AASHTO R56).
4	**Extend analytically, same sensor**	The full surface remains available for rutting, cross slope, cracking and deformation.

Key takeaway: The hardware does not need to change when the analytics expand.

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Validation: proven on certification tracks

Validated at:

- National Center for Asphalt Technology (NCAT)
- Illinois Certification and Research Track (iCART)

Tested across real-world surfaces

Repeatable and consistent results





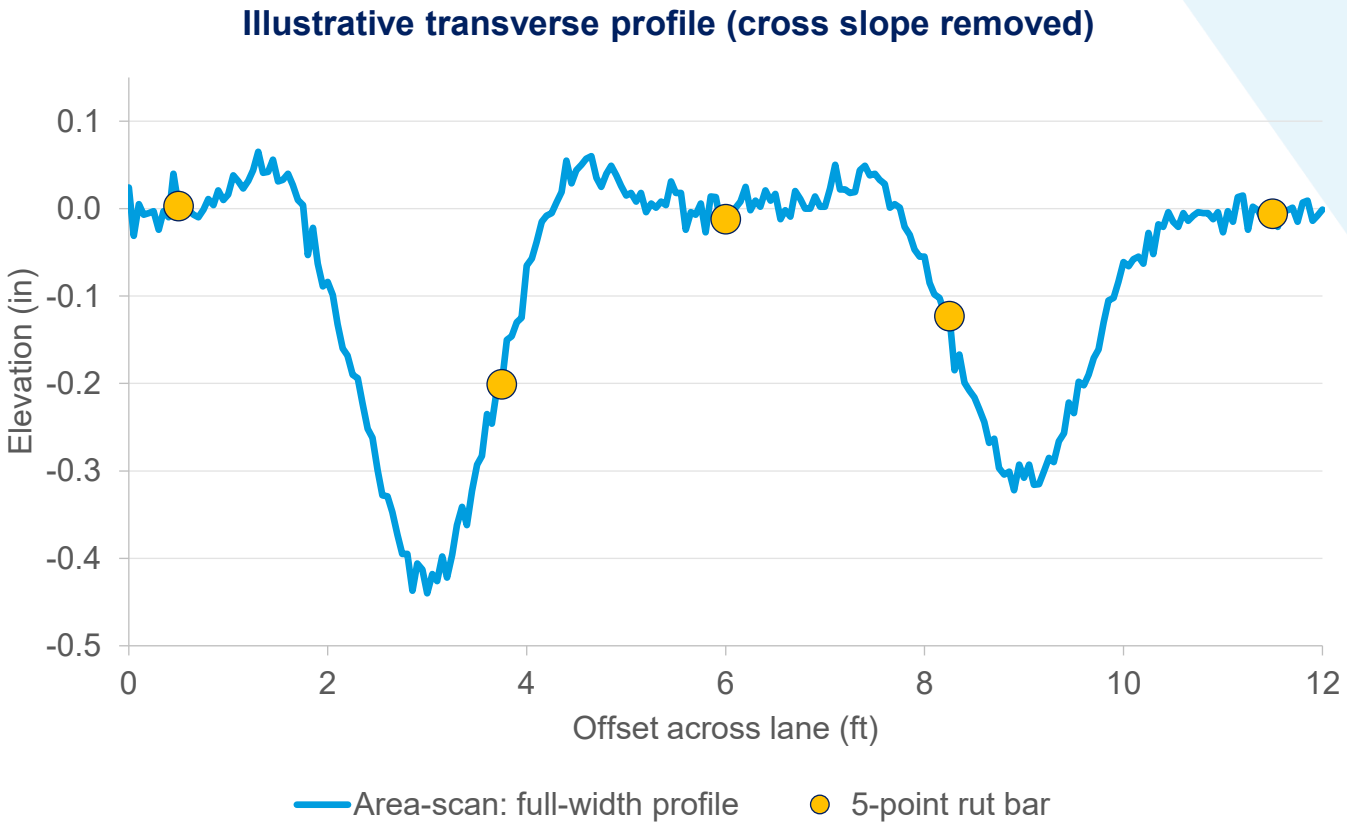


Key takeaway: A certified longitudinal profiler.

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Transverse profile: the full lane width



Rut depth

Straightedge and wire methods computed on the full profile (AASHTO R 87 / R 88).

Cross slope

Drainage and hydroplaning risk from the same cross-section.

Edge drop-off & shape

Shoulder drop-off and deformation shape, not just a single number.

Key takeaway: Rut bottoms aren't missed between sensors, because there are no gaps.

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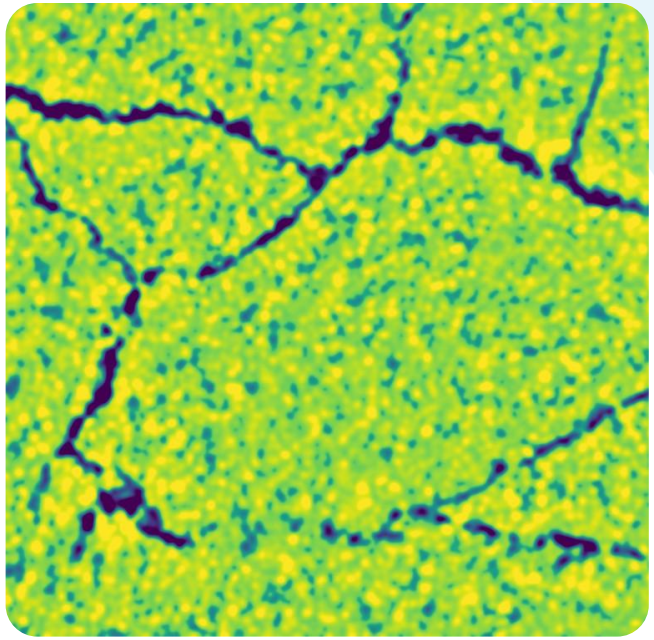
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DISTRESS

Distress: measured in 3D, not from shading



What a camera sees: intensity



What area-scan measures: depth

Illustration only, not survey data.

1. **Cracking**
   Width, length and area
2. **Potholes**
   Area and volume, not just a count
3. **Raveling & macrotexture**
   Surface texture loss from height data
4. **Faulting & joints**
   Step heights on concrete pavements
5. **Patches & deformation**
   Shoves, bumps and patch edges in 3D

Key takeaway: Distress ratings become measurements that feed PCI (ASTM D6433).

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ONE DATASET

Same data → multiple analytics (no new hardware)

Longitudinal profile & IRI

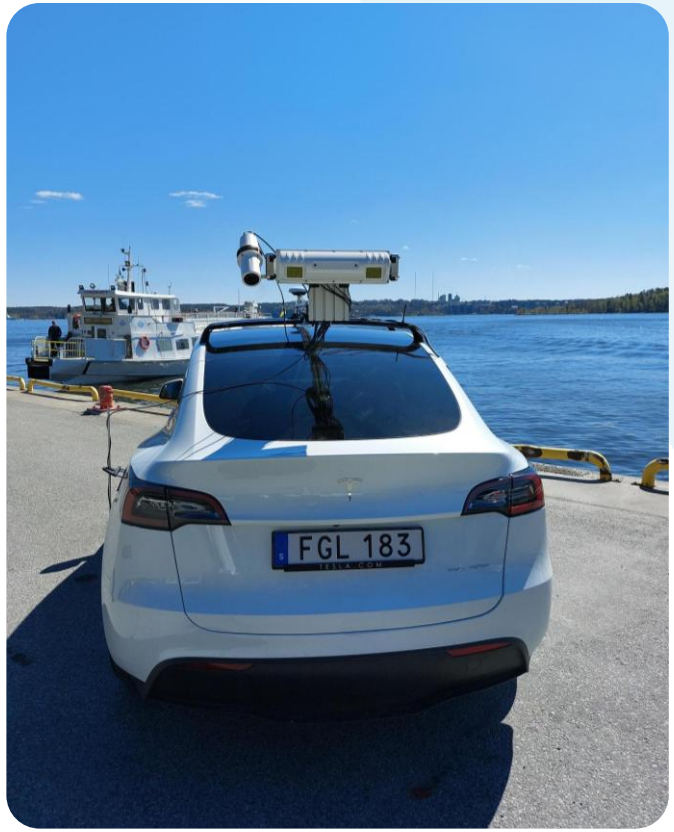
AASHTO R56 processing

Transverse profile & rutting

Direct cross-section from the surface

Cross slope & drainage

Height maps → ponding risk



Distress & PCI

Workflows aligned with ASTM D6433

Construction verification

As-built vs. design

Milling models

True 3D surface

It's not a different system … it's the same dataset.

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THE CASE

Why area-scan is the best profiler option

	Point-laser inertial profiler	Line-scan 3D system	Solid-state area-scan LiDAR
Longitudinal profile / IRI	Yes: the R56 standard	Yes but does not meet all of R56 standard	**Yes: R56-validated at NCAT & iCART**
Coverage	One narrow line per wheelpath	Transverse lines; spacing set by speed	**Continuous, overlapping full-lane area**
Wheelpath location	Fixed by sensor mounting	Selected in processing	**Selected in processing, any offset**
Speed range	Needs a steady minimum speed	Profile relies on vehicle motion	**Highway, low speed and stopped**
Transverse profile & rutting	Needs extra sensors	Yes	**Yes: full width, no gaps**
Distress	No	Yes	**Yes: 3D depth + intensity**

Key takeaway: One sensor, one pass: longitudinal, transverse and distress.

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Next steps & questions



Coming up in Florida

1. Correlation runs on FDOT R56 profiler sites
2. Walking-profiler calibration sections
3. Surveyed cross-slope sections
4. Mount the unit on an FDOT vehicle

Thank you · Questions?

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