A Unified Modular System for Multimodal Roadway Data Acquisition

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The Modern Roadway Data Challenge

Agencies and roadway owners increasingly require **multimodal, spatially coherent datasets** — yet face persistent operational constraints that limit data collection scope and frequency.

Competing demands:

- Multimodal data needs across pavement condition, assets, and geometry
- Limited mobilization budgets and restricted roadway access windows
- Dependence on dedicated, purpose-built survey platforms
- Difficulty scaling collection programs to network level

With 39% of major U.S. roads in poor or mediocre condition and a $684 billion funding gap over the next decade (ASCE, 2025), scalable and cost-effective data acquisition is no longer optional.

ASCE. 2025. 2025 Report Card for America's Infrastructure: Roads. American Society of Civil Engineers.

ARAN® Elite: Vehicle-Agnostic Sensor Pod Design

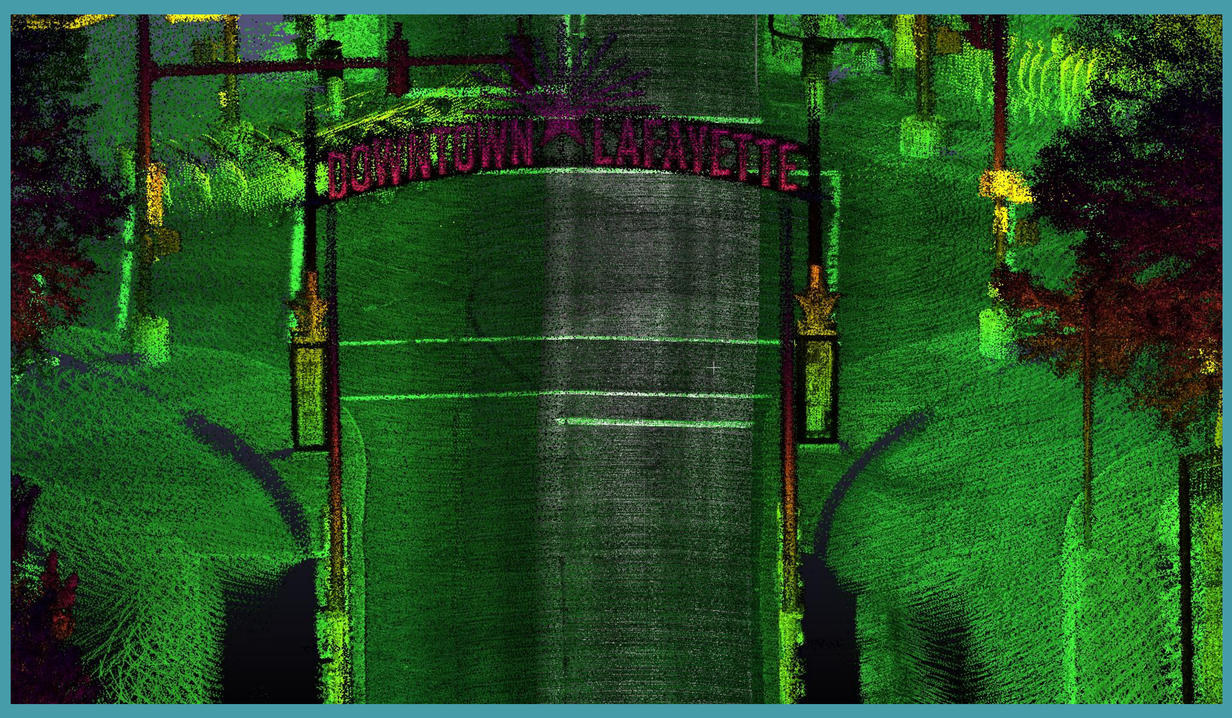
The core innovation is a **modular sensor pod architecture** deployable on standard fleet vehicles with integrated timing and synchronization across all sensors that produces spatially coherent datasets at traffic speed.

Single-Pass Deliverables

Deliverable	Source
IRI, rutting, texture, distress, surface characterization	Pavement profiling
Asset inventory & roadside features	LiDAR + imagery
Cross-slope, grade, curvature, lane geometry	LiDAR + profiling
3D corridor model	All streams, fused

Modular, Fleet-Ready Approach

Traditional Approach	Modular Pod Architecture
Dedicated survey vehicle required	Deploys on existing fleet vehicles
Lengthy mobilization cycles	Rapid deployment and redeployment
Single platform, limited scaling	Multi-vehicle, fleet-level coordination
High operational overhead	Standard vehicle maintenance and logistics



Navigation & Positioning Architecture

Challenge: Variable GNSS Environments

Reliable positioning is critical for spatial coherence — yet survey corridors routinely pass through GNSS degraded environments.

Environment	Challenge
Urban canyons	Signal multipath and blockage from tall structures
Tree canopy	Seasonal and persistent satellite occlusion
Tunnels & underpasses	Complete GNSS signal loss
Bridge structures	Overhead obstruction and reflection

Solution: Survey-Grade INS with Multiple Aiding Sources

- Inertial navigation foundation — Continuous position and orientation through GNSS outages
- Multi sensor aiding — DMI and additional correction sources maintain accuracy
- Continuous profile derivation — Pavement condition metrics remain reliable regardless of GNSS availability
- Spatial consistency — Condition data continuity across heterogeneous environments

Cloud-Based Processing & Scalability

The collection architecture is paired with a **cloud-based processing pipeline** designed around a core principle that raw sensor data should be archived and available for reprocessing as analytical methods improve.

- Retrospective analysis — Reprocess archived datasets with updated algorithms
- Scalable compute — Cloud infrastructure grows with processing demand
- Centralized QA — Standardized processing ensures uniform, quality-controlled outputs across all units
- Standard format deliverables — Compatible with existing pavement management systems and workflows