Eyes on the Snow: Automating Road Condition Insights with Edge Vision AI

Delivering Scalable, Real-Time Visibility for Safer Winter Operations

Executive Summary

Snow-covered roads significantly increase the risk of accidents and disrupt essential mobility. According to the Federal Highway Administration (FHWA), more than 1,300 people are killed and over 116,800 are injured each year in crashes on snowy, slushy, or icy pavement. Despite this risk, most transportation agencies still rely on manual driver reports and limited sensors to assess road conditions, leaving critical gaps during fast-changing weather events.

To improve safety and operational awareness, one of the nation's largest Departments of Transportation (DOT) partnered with CompassCom and Nexar to automate snow condition detection using AI-powered dash cams. Nexar's Vision AI runs directly on the camera, detecting snow coverage in real time. This capability is deployed on state-owned snowplows equipped with Nexar dash cams and across Nexar's broader crowdsourced network, with all detections aligned to the DOT's operational categories.

The project began with a 20-vehicle Proof of Concept that captured road imagery under a wide range of snow conditions. Using this data, Nexar's Vision AI demonstrated the ability to automatically assess snow levels on the road in line with the DOT's operational standards. With these results validated, the DOT will now equip its full fleet of 1,800 snowplows with Nexar dash cams, enabling automated snow condition detection at scale for faster response and safer winter roads ahead of the 2025–26 snow season.

[1]United States Department of Transportation, Federal Highway Administration: https://ops.fhwa.dot.gov/weather/weather_events/snow_ice.htm

Challenge

A DOT responsible for roadway maintenance and safety needed a more reliable and scalable approach to monitor snow coverage during winter operations. Accurate road condition assessment is critical to prioritizing response efforts, allocating resources efficiently and ensuring public safety. However, the agency's traditional methods relied on periodic driver reports and scattered fixed sensors, which provided limited coverage, inconsistent reporting, and lacked the real-time visibility necessary for data-driven decision-making.

To overcome these limitations, the DOT sought a solution that could deliver automated, consistent, and visual assessment of road conditions directly from the field. The objective was to enable real-time monitoring, historical documentation, and standardized classification of snow coverage across the network.

Solution Overview

To address this challenge, Nexar partnered with CompassCom, a leader in geospatial fleet management, on a Proof of Concept integrating AI-powered dashcams with live fleet data in CompassCom's Esri-based AVL platform. To ensure operational relevance, Nexar's Vision AI was trained to align with the DOT's classification framework.


The initial deployment involved installing 20 Nexar Beam2 dash cams on snowplows operated by the agency. This setup enabled the collection of thousands of roadway images under varying snow conditions, providing a diverse and representative dataset. Experts then annotated these images to create high-quality training data, which served as the foundation for training Nexar's Vision AI system to classify road surface conditions according to the DOT's grading standards.

To ensure alignment with operational needs, Nexar tailored its AI model to detect a custom range of snow condition categories based on the DOT's specific classification scheme. Following training, the model was deployed over the air to the dashcams to validate system performance during the most recent snowfall events, allowing the agency to assess detection accuracy in real-world conditions.

Finally, the system was seamlessly integrated into CompassCom's operational platform via Nexar's APIs. This integration provided real-time visibility into roadway conditions. It supported automated workflows without requiring additional infrastructure, ensuring that the solution could scale efficiently within the DOT's existing fleet management environment.

While this PoC focused specifically on snow condition detection, Nexar's broader CityStream platform enables additional road intelligence capabilities for future integration.
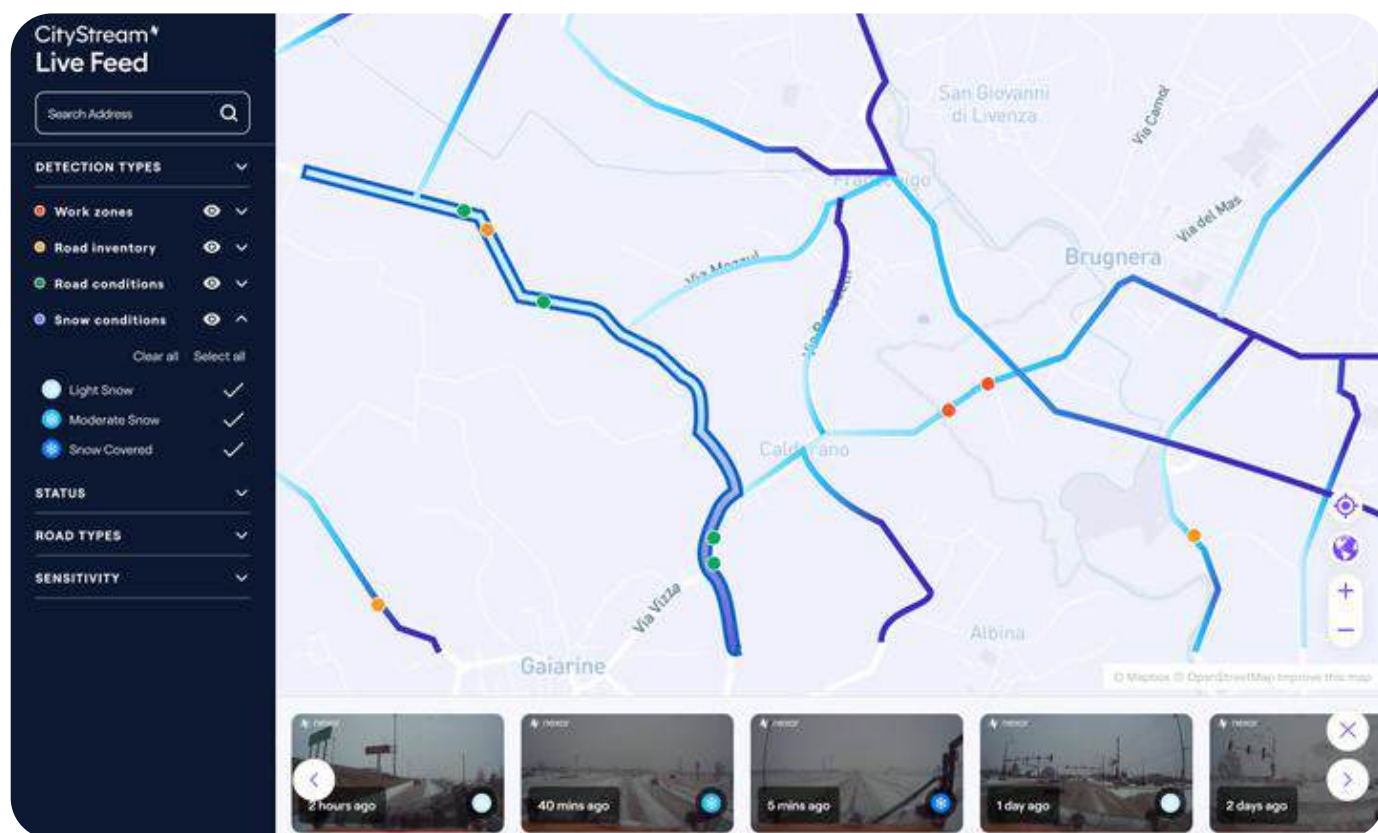
Outcomes & Impact

The Proof of Concept demonstrated that Nexar's AI-powered dash cams can accurately detect and classify road snow conditions in real time, delivering consistent and actionable insights across the fleet.

Trained on real-world imagery captured during snowplow operations and annotated by CompassCom, the model provided visual data aligned with operational needs. Detection results, including condition, timestamp, location, confidence, and supporting imagery, were integrated into CompassCom's platform to enhance situational awareness and support automated workflows.

"The process using AI at the edge with Nexar technology has automated the determination of current road conditions for snowfighting activities," said Brant Howard, Founder and CEO of CompassCom Software. "The Nexar AI integrated into our CompassVision real-time platform replaces the unsafe and inconsistent manual process of pushing a button on a tablet to map conditions. From the machine learning process applied to the cameras through deployment of the AI, DOTs are now receiving more accurate and consistent data while improving driver safety."

Architecture Overview

| Nexar dash cam | → | Edge AI | → | CityStream API | → | CompassCom dashboard (Esri-based) |

Snow Condition Categories (customized for the DOT)

- **Snow Covered** – Road fully covered in snow
- **25% Bare** – Mostly snow with small clear areas
- **50% Bare** – Half the road surface is clear
- **75% Bare** – Most of the road is clear with minor snow patches
- **Scattered** – Patchy snow coverage
- **All Clear** – Road completely clear of snow

Visual Evidence

Snow covered
The road is fully covered in snow.

25% bare
Mostly snow, but a small portion of the road is clear.

50% bare
About half the road surface is clear.

75% bare
Most of the road is clear, but some snow remains.

Scattered
Patchy snow coverage.

All clear
No snow on the road.

Conclusion

This Proof of Concept highlights the transformative potential of integrating vision-based AI into fleet operations. By automating the detection of road snow conditions, which were previously reliant on manual reports, the DOT gained access to consistent, scalable, and verifiable insights that supported faster, safer, and more informed decision-making.

The success of this initiative demonstrates how real-time visual perception, delivered through connected dashcams and edge AI, can unlock new operational capabilities. These extend beyond winter response to include infrastructure monitoring, asset management, and roadway safety analysis.

By aligning with existing workflows and integrating seamlessly with CompassCom's Esri-based AVL fleet platform, the solution proved both effective and immediately actionable. For the DOT, moving from a 20-vehicle pilot to a statewide deployment reflects the growing recognition of the value that visual intelligence brings to public operations.

As public agencies continue to modernize, the ability to capture and act on road-level insights in real time will become essential. This capability will support not only snow operations but the development of smarter, safer, and more resilient road networks.