White Paper

Infrastructure Monitoring Through Mobile AI Sensing

Accelerating Response Times with Axcelia's Intel-Powered Smart Roads and Safe Curbs Solution

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Executive Summary

Cities nationwide face persistent challenges to maintain safe, clean and accessible streets. Vandalism, illegal camping, trash accumulation, observable altercations and roadway obstructions degrade public safety and mobility particularly along pedestrian pathways, transit corridors and bus stops. Traditional monitoring methods such as fixed cameras, scheduled inspections and community reporting are reactive, costly to scale and inevitably leave gaps in awareness.

Axcelia's Smart Roads and Safe Curbs platform, enabled by Intel® technologies, transforms existing transit fleets into real-time mobile sensing assets. Each bus is equipped with compact Intel-powered industrial compute units (NUC) and multiple wide-angle cameras that continuously scan roadways and curb environments. Using built-in 5G, 4G, LTE and satellite connectivity, video streams are transmitted to an edge AI platform that uses Intel-optimized AI models to detect high-priority issues including illegal camping and dumping, aggressive actions or obstructions. When detection criteria are met, the system automatically generates alerts and routes them to the appropriate agencies such as police, public works and transportation departments.

This approach enables cities to dramatically expand situational awareness and response capabilities without the need for extensive new fixed infrastructure.

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Introduction

Urban streets are dynamic environments where safety, cleanliness and mobility conditions shift rapidly. Traditional monitoring practices rely on either citizen complaints, periodic inspections or observations from field crews or law enforcement to monitor road conditions. These methods are inherently reactive and provide limited, inconsistent visibility. As a result, many issues persist undetected for hours or days.

Transit fleets, however, travel on predictable schedules and cover high-priority routes multiple times a day. Axcelia leverages this mobility by converting buses into continuously moving "street-scanning" sensors. With Intel-powered compute onboard and wide-angled cameras mounted at high vantage points, buses capture video of curbs, sidewalks and roadways, while the edge-AI platform interprets these streams to identify issues such as graffiti, dumping, encampments, altercations, roadway obstructions and curb and sidewalk abnormalities.

This approach allows cities to address these issues proactively, increase their visibility, reduce reliance on fixed infrastructure and provide actionable insights that improve safety, cleanliness and mobility.

System Overview

Axcelia's solution consists of two primary components:

- On-Bus Sensing and Pre-Processing – powered by Intel® Core™ processors and integrated multimodal connectivity.
- Edge AI Processing – powered by Intel® Distribution of OpenVINO™ toolkit, Geti™ and Intel® SceneScape technologies.

Together, these components enable scalable, near real-time monitoring across transit fleets, minimizing frame loss, maintaining low latency and ensuring accuracy across diverse urban environments.

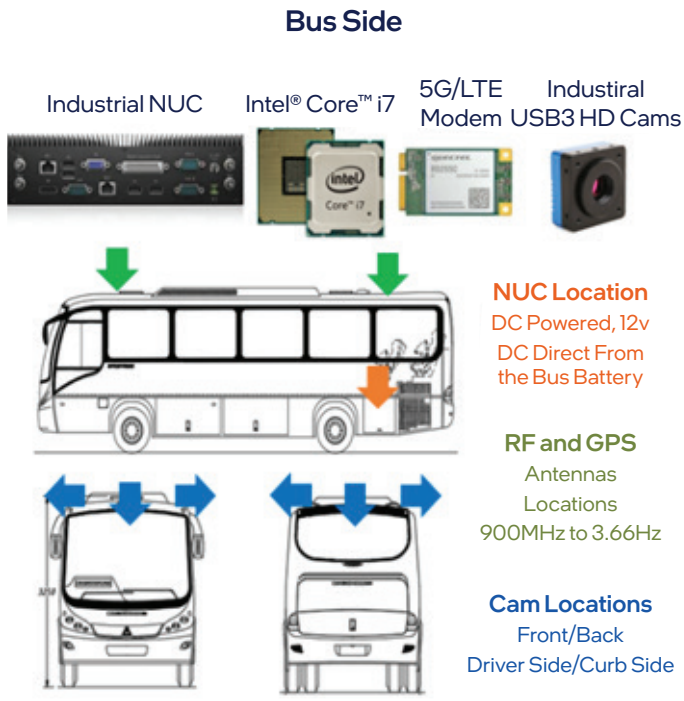

Figure 1. Edge Devices Installed in Buses

On-bus Sensing and Pre-Processing

Each bus is equipped with a ruggedized industrial NUC featuring an Intel Core i7 processor with eight performance cores and 33MB Smart Cache shared across all CPU cores and dynamically allocated to the workload. This onboard compute performs essential pre-processing such as frame sampling, metadata tagging, anonymization and transmission over 5G, 4G, LTE and satellite networks. HDR cameras placed around the bus capture forward, curb and right-lane, left-lane and rear approach views to ensure maximum situational coverage.

Although full AI inference occurs at the edge, the on-bus NUC performs critical pre-processing to optimize data quality and transmission. Frame sampling dynamically adjusts capture rates using GPS speed and location, typically recording one frame every five meters. Each frame is tagged with metadata, including GPS coordinates, timestamp, camera ID and bus ID. Optional on-bus anonymization features blur faces and license plates and apply region-of-interest masking to restrict analysis to curbs and sidewalks. Processed frames are streamed to the edge AI platform via independent camera streams using an acknowledgment-

based method for lossless ingestion. Additionally, the system conducts continuous health monitoring, tracking camera exposure and status, NUC resource utilization and generating diagnostic reports for fleet management. Annex II provides more details on the protocols and methods.

As shown in Figure 2, the Axcelia solution captures, processes, tags and transmits 99% of frames to the edge in under 500 milliseconds. Most measurements cluster between 0.4 and 0.5 seconds, demonstrating consistent low-latency performance.

This reliability directly supports key city use cases:

- **Curb enforcement:** Detecting short-duration double-parking events requires instant frame delivery.
- **Roadway safety:** Sudden obstructions – stalled vehicles, debris or hazards must be captured as they appear.
- **Public safety:** Rapid response of loitering or incursions depends or violent behavior depends on sequential, lossless frame delivery.
- **Trash and dumping:** Illegal dumping often occurs between inspection rounds. Timely detection improves response time and keeps streets clean.

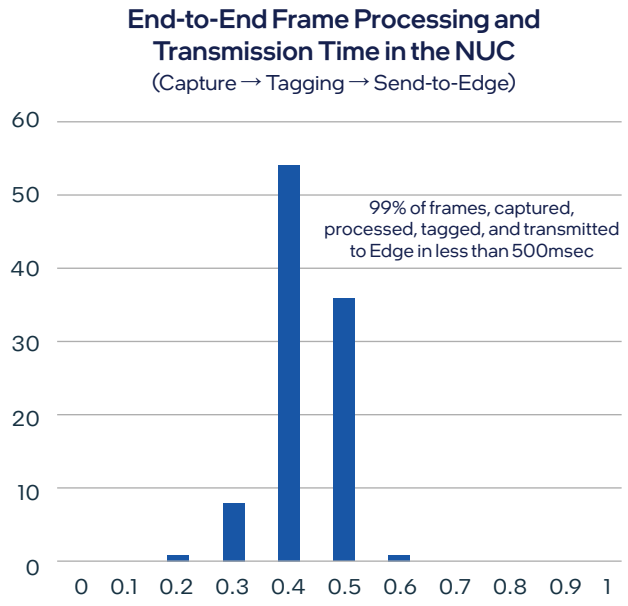

Figure 2. End-to-end performance for video streams analytics

Intel-powered pre-processing ensures frames arrive at the edge fast enough and in sequential order, enabling accurate AI inference and actionable alerts against rapidly changing street conditions. This performance makes high-frequency mobile sensing operationally viable for citywide deployments.

Edge AI Processing

Axcelia's Edge AI platform, powered by Intel technologies, processes video streams from transit fleets to deliver advanced detection and highly precise localization, creating a dynamic digital twin representation of urban roadways. The platform leverages OpenVINO™ and Geti for AI workload optimization, while Intel SceneScape enables accurate 3D localization, ensuring efficient and scalable performance across complex city environments.

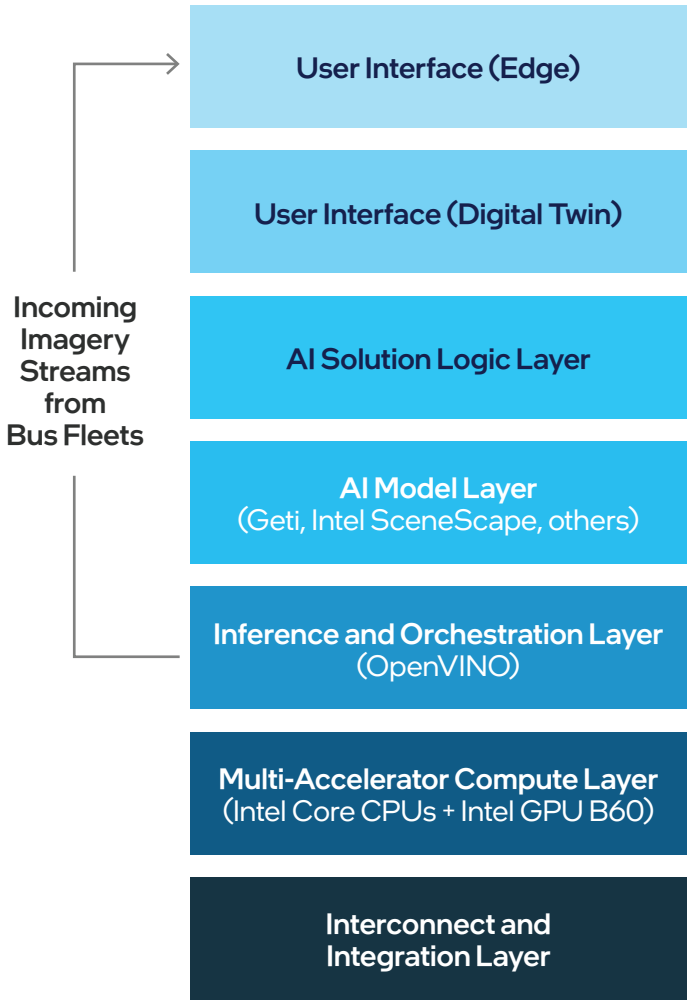

Figure 3. Axcelia's Edge AI Platform

Ingestion and Synchronization

At the edge, incoming imagery is enriched with critical metadata, such as bus ID, camera ID, GPS coordinates, timestamps and route ID obtained through GTFS/AVL integration. A synchronization service aligns these frames by location and time, improving accuracy when multiple buses pass the same area.

AI Models and Detection Tasks

Axcelia deploys multiple computer-vision models optimized using OpenVINO to detect and classify multiple urban conditions including graffiti, trash accumulation, encampments, aggressive behaviors, roadway blockages and curb misuse.

Model outputs, including bounding boxes, labels and confidence scores, are processed through a rule engine to generate structured events for downstream action.

Figure 4. Event categories targeted by computer vision models

Event Fusion and Prioritization

Spatial and temporal fusion techniques ensure accuracy by consolidating detections and increasing confidence through repeated sightings. Additionally, contextual attributes, such as time of day, adjacent land uses and transit corridor significance, are incorporated to refine severity assessments. For example, the system may report: "Large trash pile detected repeatedly over three days on the south side of 5th & Main near bus stop #2043" or "High-confidence road blockage detected: stalled vehicle in the Route 12 bus lane at 10:23 AM."

Intel CPUs and GPUs Deliver Massive Concurrency and Efficiency

Dual 6th generation Intel® Core™ processors processed 50 video streams running six AI models each at less than 20% CPU utilization, showcasing exceptional scalability and resource efficiency. Meanwhile, a single Intel® GPU B60 enabled real-time inference across all streams with 30–70% utilization and stable memory, ensuring low latency and zero frame loss. More details are provided in Annex I.

Alerting, Dashboards and System Integration

Axcelia's platform delivers targeted alerts and operational insights across multiple city agencies:

- **Law Enforcement:** Receives alerts for violent incidents, aggressive behavior, illegal encampments and chronic curb misuse or double-parking misuse.
- **Public Works:** Receives triggers for trash, roadway blockages, flooding, illegal dumping and graffiti, integrated directly into work-order systems.
- **Transit and Curb Management:** Gain actionable insights through email and messaging alerts on traffic conditions, double-parking heatmaps, curb performance trends and metrics impacting service reliability.

Intel-optimized processing ensures alerts are generated quickly and reliably, supporting city workflows that depend on near real-time situational awareness and are integrated into work order and asset management systems, GIS layers for hotspot analysis and planning tools for long-term improvements.

Measured Impact in Cities

To evaluate the effectiveness of Axcelia's Smart Roads and Safe Curbs solution, a mid-sized city of about 300,000 residents conducted a nine-month deployment across 42 buses operating on high-priority transit corridors, commercial districts and high-density residential zones. The deployment produced consistent, measurable improvements across detection coverage, street-condition awareness, operational efficiency and public-safety.

Increased Detection and Faster Response Times

Prior to deploying mobile AI sensing, the city relied primarily on citizen feedback from 311 reporting systems and scheduled inspections, resulting in delays and inconsistent coverage. The Axcelia platform significantly expanded visibility across the city's public spaces and accelerated response workflows.

Key outcomes included:

- Detection coverage increased by 68%, particularly in areas with historically low 311 reporting.
- Average time to detect curb-use violations decreased from 11 hours to 2.3 hours, a 79% improvement.

Roadway blockages were detected 4x faster, enabling quicker removal of hazards affecting buses, cyclists and pedestrians. These improvements demonstrated that high-frequency mobile sensing can meaningfully enhance situational awareness, even in corridors where issues were previously underreported.

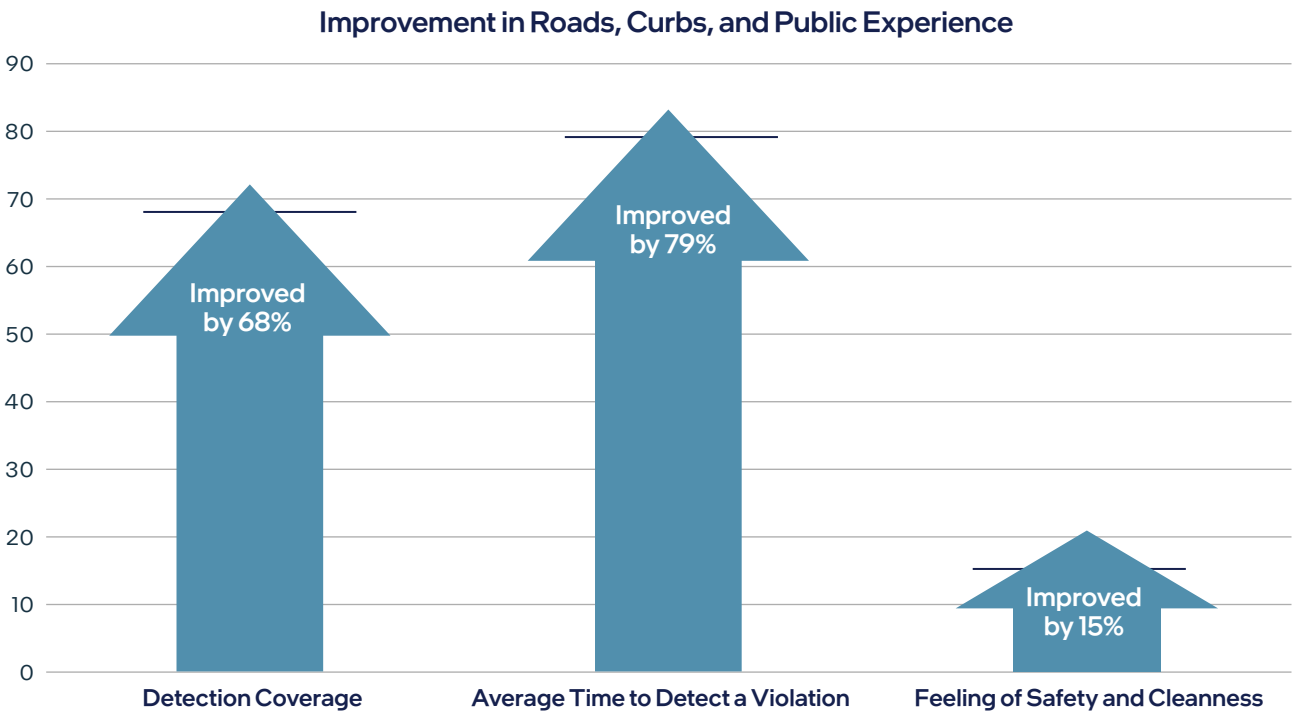

Figure 5. Operational improvements for compliance and efficiency

Reduction in Chronic Curb and Roadway Issues

Continuous Scanning throughout the deployment enabled the city to identify and proactively address recurring problems that had not been visible through traditional or periodic inspections.

Measured improvements included:

- 33% decrease in repeat graffiti sites, with some with transit shelters showing more than a 50% reduction.
- Illegal dumping hotspots declined by 25%, including fewer overflowing bins and new areas identified for targeted cleanup.
- Newly discovered dumping locations were added into route-based maintenance schedules for sustained corrective action.
- 30% reduction in double-parking incidents near bus stops, contributing to more reliable transit operations.
- Earlier detection of encampments led to shorter durations at high-impact transit nodes and targeted coordinated outreach.

Together, these outcomes reflect how mobile sensing turns visible and hidden chronic issues into actionable items that improve public safety, transportation flow and public sentiment.

Enhanced Safety and Public Confidence

- AI-driven detection also supported improvements in public safety and rider experience. Faster identification of safety-related conditions enabled more timely intervention and reduced exposure to risk.

Results included:

- 20% faster identification of violent or aggressive behavior, supporting quicker police and security responses.
- Noticeable declines in pedestrian and cyclist complaints near bus stops due to better curb management and debris removal.
- Rider surveys conducted at 15 transit shelters reported:
  - Improved perception of safety.
  - Cleaner waiting environments.
  - Higher confidence in overall transit conditions.

These improvements aligned with reductions in double parking, graffiti, dumping and manual inspections, reinforcing how the platform contributes to broader public confidence in city services.

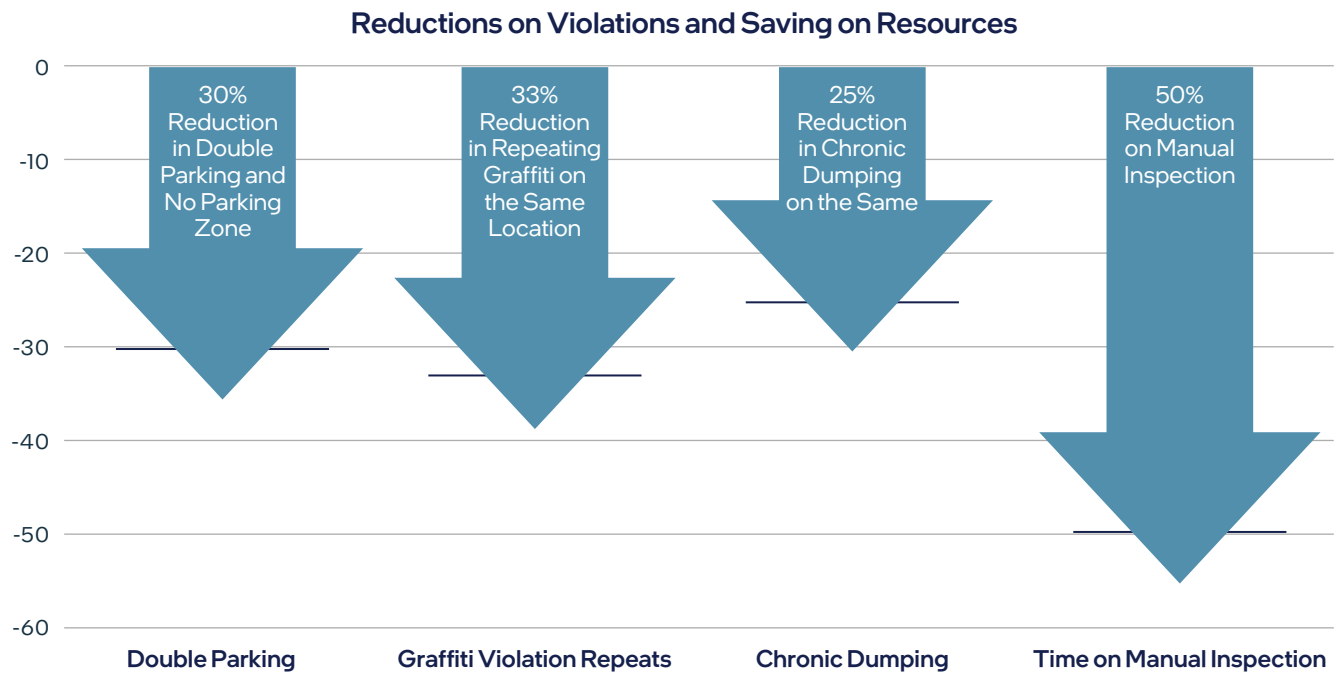

Figure 6. Operational improvements for compliance and resources saving

Operational Efficiency for City Departments

The platform enhanced efficiency for multiple city agencies by providing verified, location-specific alerts and data-rich insights. Each department leveraged these insights in different ways to improve operations, allocate resources more effectively and respond more quickly to emerging conditions.

- **Public Works:**
  - Reduced manual inspection time by 50%.
  - Optimized work routes using AI-generated hotspot maps.
  - Identified 11 locations requiring redesign for improved curb safety and traffic flow.
- **Police Department:**
  - Improved officer deployment to chronic double-parking areas.
  - Enhanced citation accuracy using verified visual evidence.

These operational efficiencies demonstrated that AI-driven sensing is not simply a detection tool, but a cross-departmental resource that improves workflow performance.

Long-Term Insights and Policy Benefits

Beyond short-term operational gains, the continuous dataset generated over nine months provided the city with strategic insights that informed long-term planning decisions.

The data supported:

- Predictive models for future illegal dumping hotspots.
- Priority-setting for capital improvement in high-risk intersections and transit zones.
- Policy updates for commercial curb zones with frequent misuse.
- Development of data-driven proposals for:
  - New priority lanes for emergency vehicles or buses that are often blocked by illegally parked cars.
  - Revised curb regulations.
  - Targeted enforcement strategies.

These insights demonstrated the value of AI-powered sensing as an evidence base for policy making, infrastructure investment and future urban planning.

Conclusion

Axcelia's Smart Roads and Safe Curbs platform transforms everyday transit vehicles into high-frequency, mobile sensing assets. By integrating on-bus vision systems with a scalable edge-AI architecture, cities gain continuous visibility into critical urban conditions that affect public safety, transportation and overall urban vitality. This approach minimizes reliance on fixed infrastructure while enabling proactive, data-driven urban management. The platform enhances citywide visibility using existing fleets, reduces dependence on static cameras and sensors, accelerates detection and response to high-impact events and integrates seamlessly with work-order, CAD and transit systems. While challenges remain around privacy, workflow development and SLA management for alert review, future enhancements will include multimodal data fusion, predictive analytics and deeper integration with connected-vehicle ecosystems. By delivering consistent performance and actionable insights, Axcelia — powered by Intel technology — provides a practical path toward cleaner, safer and more efficient streets, driving the evolution of next-generation intelligent urban mobility.

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Annex: Details on Performance Data

Edge CPUs Utilization and Number of AI Streams Limitation

During testing, dual 6th Gen Intel Core processors, each configured with 50 dedicated cores, processed 50 concurrent video streams processed through six AI models each. Despite this high load, CPU utilization remained under 20%, with memory usage stable between 70% and 85%, demonstrating strong scalability and predictable resource demand.

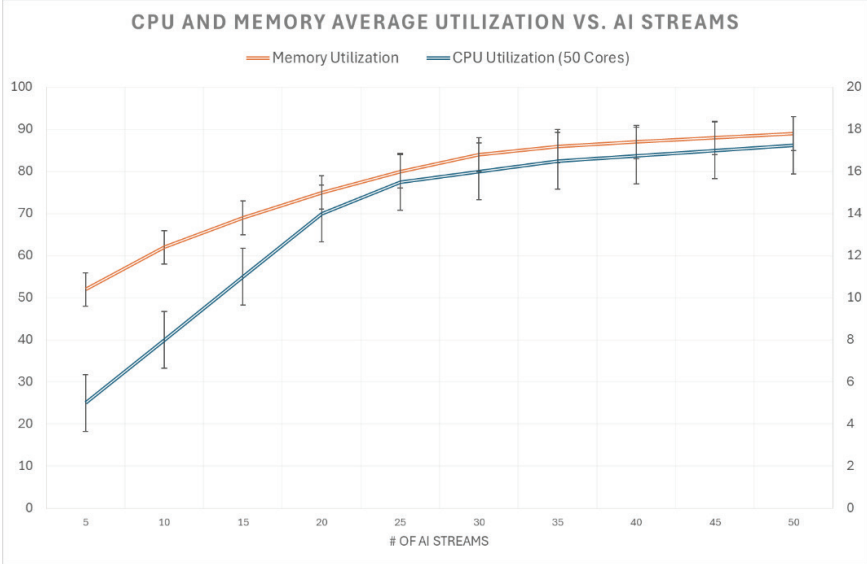

Figure 7. CPU and memory resources utilization

Edge GPUs Utilization and Throughput

On a single Intel GPU B60, utilization remained between 30% and 70% while memory usage held near 80%, enabling real-time inference across 50 concurrent streams. Each stream was processed through six AI models, with dynamic frame rates ranging from 1 to 10 frames per second. Axcelia's stream-flow and buffer management algorithms ensured that frames stayed in sequence without overflow or latency spikes.

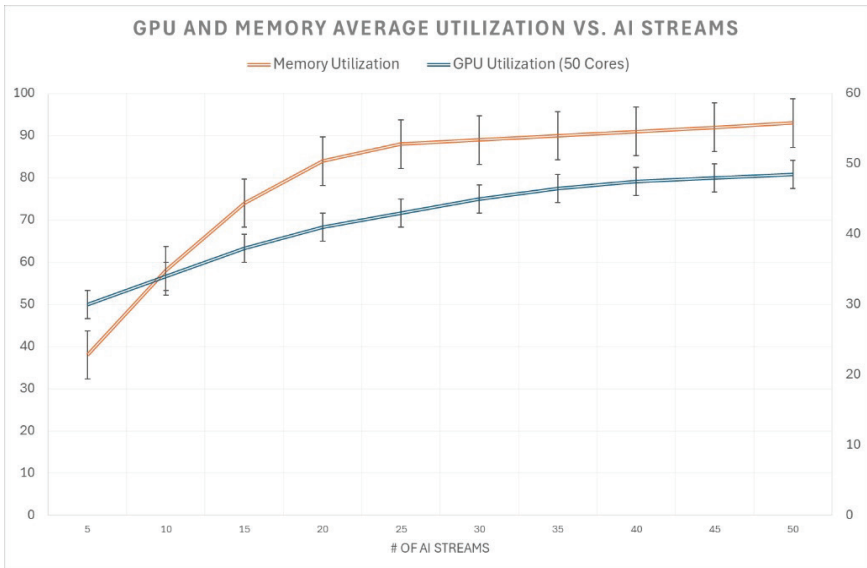

Figure 8. GPU and memory resources utilization

Protocols and Methods Used

Category	Key Functions & Methods
Data Acquisition Protocols	▪ Dynamic frame sampling (GPS-based, speed-based) ▪ HDR camera validation ▪ Metadata tagging (GPS, timestamp, IDs, GTFS route, motion vectors)
On-Bus Pre-Processing	▪ Face and license plate anonymization ▪ Region-of-interest cropping ▪ System health monitoring (camera status, CPU, bandwidth, buffers)
Transmission & Network Protocols	▪ Multi-network transmission (5G, 4G, LTE and satellite) ▪ Acknowledgment-based streaming ▪ Adaptive bitrate control ▪ Compression for low latency ▪ Frame sequencing with re-request on gaps
Edge AI Processing	▪ AI model optimization with OpenVINO™ ▪ Model pruning, quantization, pipeline parallelization ▪ Detection tasks (graffiti, trash, encampments, blockages, aggressive behavior, curb misuse) ▪ Rule-based event generation
Spatial Fusion & Localization	▪ Intel® SceneScape 3D reconstruction ▪ Multi-angle and multi-bus alignment ▪ Temporal smoothing and GPS calibration ▪ False-positive reduction
Event Delivery & Integration	▪ Severity scoring and prioritization ▪ REST, message queue and system connectors ▪ Integration with CAD, 311, GIS and work-order systems
Quality Assurance & Validation	▪ Continuous model evaluation ▪ Ground-truth sampling & consensus checks ▪ False-positive / false-negative audits ▪ SLA monitoring (latency, inference throughput, resource usage, alert timing)