RESEARCH WHITE PAPER

Rethinking last-mile delivery

How cargo bikes outperformed trucks across every metric

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The last-mile problem is getting worse

Canadian e-commerce sales have grown 43% since 2017, reaching CAD $27.5 billion annually. Many of those purchases end with a delivery truck navigating dense urban streets, double-parking in loading zones, and idling at the curb. In Toronto alone, parcel couriers accumulated more than CAD $2.5 million in parking fines in a single year. Freight emissions in Canada are projected to surpass passenger transport emissions by 2030.

↑43% $27.5B

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1 YEAR $2.5M

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↑43% 2030

Freight emissions in Canada are projected to surpass passenger transport emissions by 2030.

The conventional response has been incremental: optimize truck routes, expand loading zones, enforce parking rules more strictly. But a research collaboration between the University of Toronto, Purolator, the City of Toronto, and Geotab asked a different question:

What if we replaced the truck entirely?

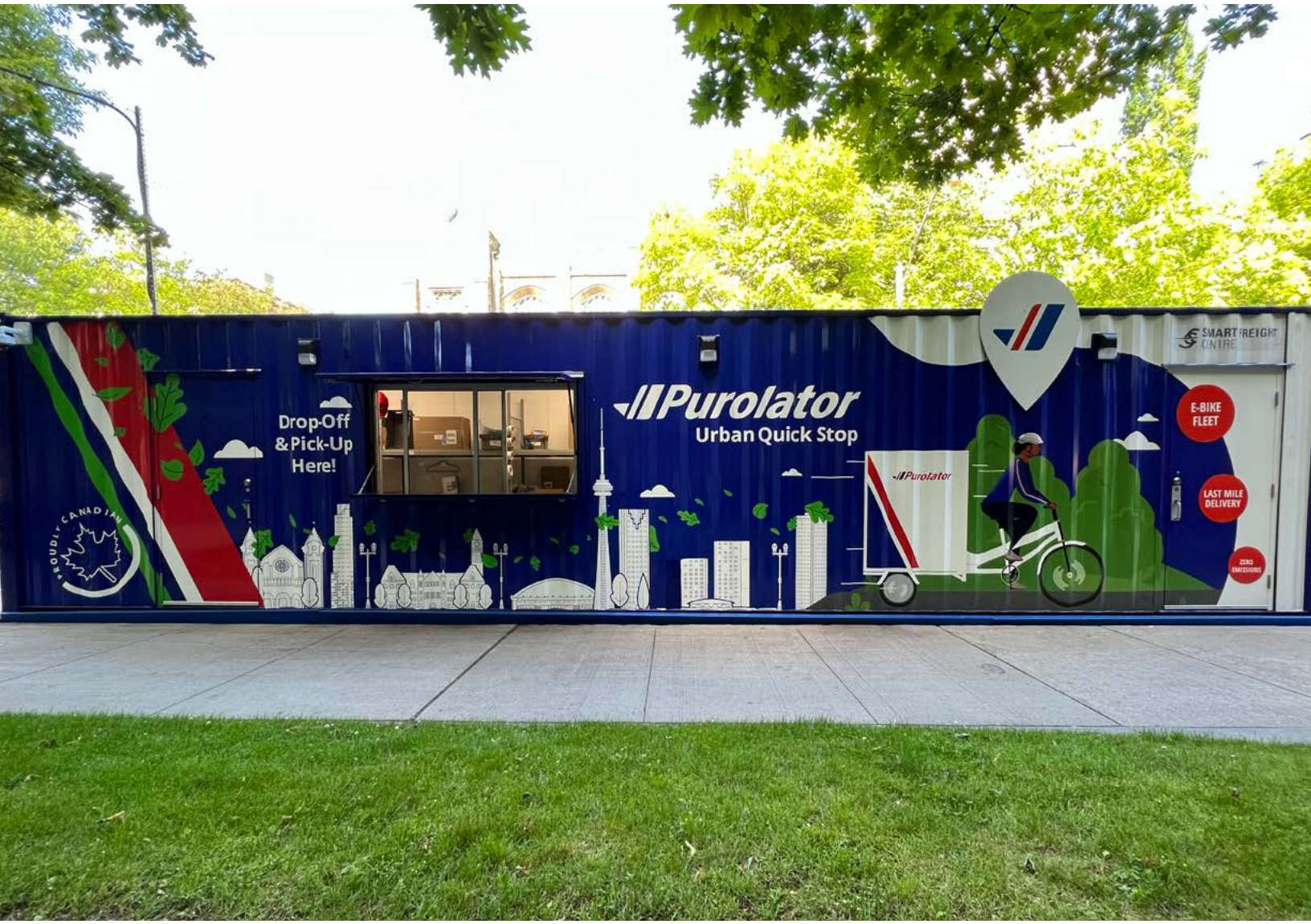
The answer, backed by years of GPS data, air quality sensors, and operational analysis, turned out to be more surprising than anyone expected.

The pilot: 1 shipping container, 3 tricycles, and 1 replaced truck

In August 2022, a repurposed 40-foot shipping container appeared on 5 curbside parking spaces on the University of Toronto campus. Branded as Purolator's "Urban Quick Stop," the container now serves as a permanent micro-hub. Each morning, a truck from Purolator's distribution centre delivers packages to the hub. From there, heavy-load electric cargo tricycles fan out across 3 downtown Toronto neighbourhoods to complete deliveries.

The e-cargo tricycles are electrically assisted and require only a single overnight charge for a full 7-to-10 hour work day. During the pilot, they replaced conventional gasoline-powered box trucks on a one-to-one basis, delivering every package type the trucks previously handled with the sole exception of oversized parcels.

Geotab provided the GPS tracking and air quality sensor infrastructure that made rigorous before-and-after comparison possible.



Finding 1: E-bikes dominate a much larger service area than expected

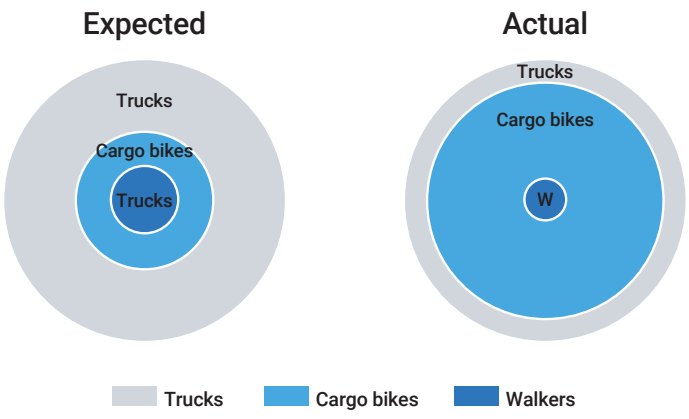
Before the pilot launched, the research team at U of T modelled the optimal distribution of 3 delivery modes (trucks, cargo bikes, and on-foot couriers) across 5,000 demand points in downtown Toronto using a vehicle routing optimization framework.

The intuitive expectation was straightforward: trucks would dominate the outer ring, walkers the inner core, and cargo bikes a narrow band in between.

The model produced an unexpected result. Cargo bikes dominated a vastly larger zone than anticipated, outperforming trucks on cost efficiency across most of the downtown core. Trucks were only cost-effective at the outer fringe, and walking couriers in a small central pocket. This finding held across all sensitivity scenarios tested, including variations in operating costs, service times, and speeds.

The implication is significant: the conventional industry assumption that trucks are the default mode for urban deliveries, with bikes as a niche supplement, may have the relationship backwards.

Optimal delivery mode by service area



Finding 2: more stops, less time, better outcomes

The operational data from the pilot revealed a counterintuitive pattern in parking behaviour.

E-cargo tricycles made about 30% more stops per tour than delivery trucks (25 vs. 19 stops per day), yet they spent dramatically less total time parked, averaging just 7.2 minutes per stop compared to 17.8 minutes for trucks. That is a 2.5x reduction in curbside dwell time per stop.

↑30% MORE STOPS

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7.2 MINUTES

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↓2.5 X REDUCTION

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The mechanism is straightforward. E-cargo tricycles park immediately adjacent to the delivery address. Truck drivers, by contrast, must find a legal (or illegal) parking spot, often much farther from the destination, and walk to and from each delivery point. The farther a driver walks from the parking location, the longer each stop takes.

The net result:

e-cargo tricycles park closer to customers and free up curbside space far more rapidly.

Finding 3: Truck drivers breathe worse air than pedestrians

A parallel study examined air quality exposure for delivery truck drivers in downtown Toronto. Using Geotab sensors mounted both inside and outside truck cabs, researchers measured PM2.5 (fine particulate matter) exposure simultaneously in both locations.

In-cab $PM_{2.5}$ concentrations were on average 25% higher inside the truck than in the ambient outdoor air. On some measurement days, in-cab levels exceeded 40 micrograms per cubic metre, surpassing WHO air quality guidelines. The mean in-vehicle concentration also exceeded the WHO's recommended annual average limit.

One cause is self-pollution. Truck exhaust recirculates into the cabin, and on hot days when windows are open, concentrated roadside pollution enters directly. Truck drivers are, paradoxically, more exposed to traffic-related air pollution than pedestrians or cyclists sharing the same streets.

E-cargo tricycle riders operating in the open air with zero tailpipe emissions reduce this occupational health risk. In a sector already struggling with driver shortages and retention, this finding reframes the shift to cargo bikes as a worker health initiative, not just an environmental one.

Finding 4: Urban parking infrastructure forces trucks into unauthorized zones

A broader study of delivery truck behaviour in downtown Toronto analyzed parking location choices across more than 2,700 truck parking events. The data revealed limited availability of legal commercial loading infrastructure in dense urban cores.

E-cargo tricycles largely sidestep this problem. They have far more options for parking that do not obstruct travelled lanes or use valuable curbside parking spaces. Their shorter dwell times and smaller footprint reduce conflict with both traffic flow and parking enforcement.

This finding has direct implications for municipal curbside management. The shift to e-cargo tricycles reduces not only emissions but also the chronic regulatory friction between delivery operations and urban parking policy.

The environmental case: 3 tonnes of CO_2 per truck, per year

Each delivery truck operating in the pilot's service area generated between 2,700 and 3,400 kg of greenhouse gas emissions annually, along with 7.8 to 9.8 kg of nitrogen oxides (NOx). Replacing one truck with one e-cargo tricycle eliminates these emissions entirely, while also removing approximately 5,000 km of motor vehicle travel from city streets each year.

3,400 KG

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9.8 KG

along with 7.8 to 9.8 kg of nitrogen oxides (NOx).

↓5,000 KM

Removing approximately 5,000 km of motor vehicle travel from city streets each year.

For a courier fleet operating dozens or hundreds of trucks across a metropolitan area, the cumulative impact is substantial. Unlike many decarbonization strategies that require massive capital investment or technological breakthroughs, this one is operationally proven and already scaling.

From illegal to permanent in 3 years

One of the most remarkable aspects of this project is the regulatory journey it catalyzed.

Before March 2021	**E-cargo tricycles over 120 kg were prohibited from Ontario roadways entirely**
March 2021	**Ontario legislated a 5-year pilot allowing power-assist cycles on public roads**
June 2021	**Toronto City Council partially opted in, allowing cargo e-bikes under 120 kg**
December 2021	**Toronto updated bylaws to permit heavier e-cargo bikes (over 120 kg)**
June 2022	**City Council approved the logistics micro-hub pilot on-street**
June 2024	**Toronto City Council approved on-street micro-hubs permanently**

The progression from “not legal” to “permanently approved city infrastructure” in approximately 3 years is a direct result of the university-industry-government collaboration model. Research data from the pilot gave policymakers the evidence they needed to act, and the City of Toronto changed zoning bylaws to facilitate easier hub placement as a result.

This is the pipeline that the CLUE (City Logistics for the Urban Economy) research consortium was designed to create: problem identification, theory and data collection, modelling, pilot testing, and ultimately, change in policy and practice.

What comes next: Scaling across Toronto

The pilot has now been made permanent and is expanding. The research team is advising Purolator on optimal micro-hub sizes and locations across the entire city of Toronto, using shipment demand density mapping to identify the highest-impact deployment zones. Simultaneously, they are advising the City of Toronto on curbside and off-street infrastructure requirements for a broader micro-hub network.

The next phase of research, CLUE 2, will extend over 5 years, involving 12 faculty members, 28 projects, and 50 to 75 graduate students. Research themes span freight decarbonization, community impact, supply chain innovation, and data visualization.

The bottom line

Research across the pilot and related studies produced clear, data-backed conclusions:

Metric	Delivery truck	E-Cargo tricycle
Parking duration per stop	17.8 min	7.2 min
Stops per tour	19	25
Annual CO_2 emissions	2,700–3,400 kg	0 kg
In-cab $PM_{2.5}$ exposure	+25% above ambient	Ambient

1. **E-cargo tricycles can replace delivery trucks one-to-one** in dense urban environments, with the sole exception of oversized parcels.

2. **Cargo bikes are efficient** across a far larger service area than intuition predicts, challenging the assumption that trucks are the default urban delivery mode.

3. **Parking behaviour fundamentally changes:** more stops, shorter stops, closer to customers, and far less reliance on unauthorized parking.

4. **Each truck replaced eliminates approximately 3 tonnes of CO_2 per year** and removes 5,000 km of motor vehicle travel from city streets.

5. **Truck drivers are exposed to 25% higher levels of $PM_{2.5}$** inside the cab than outside. E-cargo tricycles reduce this risk.

6. **University-industry-government collaboration can drive real policy change,** taking a concept from “illegal” to “permanently approved” in three years.

These are not projections or models. They are measured outcomes from a real-world operation, validated with Geotab GPS and sensor data, and already informing the next phase of urban freight transformation in one of North America’s largest cities.

This white paper is based on research conducted through the CLUE (City Logistics for the Urban Economy) consortium at the University of Toronto, presented by Professor Matthew Roorda at Geotab Connect 2026. The research was led by Farah Ghizzawi and Usman Ahmed, with GPS tracking and air quality data provided by Geotab. Funding partners include Purolator, the Natural Sciences and Engineering Research Council of Canada (NSERC), the City of Toronto, and Geotab.

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