

CAN PUBLIC MOBILE ROBOTS BENEFIT LOCAL CANADIAN COMMUNITIES?



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WHAT IS THE BRIGHT IDEAS COMPETITION?

The Bright Ideas Competition is an annual idea competition for economic development practitioners of all experience levels. It is designed to give economic developers from across Ontario the opportunity to develop a modern response to proposed topics, have the research work evaluated and receive five professional accreditation points towards a Certified Economic Developer (Ec.D.) designation. www.edco.on.ca

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RECOMMENDATIONS FOR CANADIAN MUNICIPAL OFFICIALS

Based on the pattern of growth of Public Mobile Robots (PMRs) around the world, we expect their greater use in Canadian municipalities in the coming years. Based on the available jurisdictional experience, research interviews and a survey, we present our recommendations for Canadian municipal officials interested in introducing PMRs in their community.

1. Be Open to Collaboration

The introduction of PMRs has the potential to be beneficial to a local community with regards to local prosperity, accessibility of goods and services, and municipal operations such as snow clearing. Robots may also help reduce local CO2 emissions. However, since experience is limited, municipal officials will need to be open to collaborating with PMR manufacturers, community retailers, the local chamber of commerce, accessibility groups, other municipalities, and higher orders of government to develop a nuanced regulatory response.

2. Strike a PMR Staff Working Group

The introduction of PMRs in a community will require internal collaboration within the municipality's staff team. We suggest striking a working committee made up of officials from city departments such as road operations, planning, economic development, technology, bylaw enforcement, public realm, accessibility, community policing and the city manager's office.

3. Beg, Borrow and Steal Good PMR Policy

When crafting a local bylaw to support the introduction of PMRs, we encourage municipal officials to borrow from other Canadian and international jurisdictions. They may also reference the international standard document that is being developed by the Urban Robotics Foundation, based in Canada. Some Canadian municipalities have joined the Urban Robotics Foundation which is helping coordinate the robotic policies for municipalities around the world.

The Ontario Ministry of Transportation pilot may also prove useful. In time, we hope associations such as the Municipal Information Systems Association (MISA), the Association of Municipalities of Ontario (AMO) and the Federation of Canadian Municipalities (FCM) will provide additional guidance on the introduction of PMRs in Canadian communities.

4. Pilot tests are a good first step

The City of Toronto, the City of Calgary and the Town of Innisfil are some of the municipalities that have tested public mobile robots in a controlled setting. These tests allowed city officials to understand the capabilities of different types of robots, serving various uses in real world conditions. It also signaled to the broader business community that their municipality was "open for business."

The testing program also created an opportunity for meaningful dialogue between robot manufacturers, local stakeholders and city officials to take place. We therefore recommend



viewing pilots as a good first step to evaluating PMRs in a given municipality. Pilot testing would likely yield rich quantitative and qualitative data which would be useful to municipal staff, elected officials, local businesses, retailers, as well as PMR suppliers.

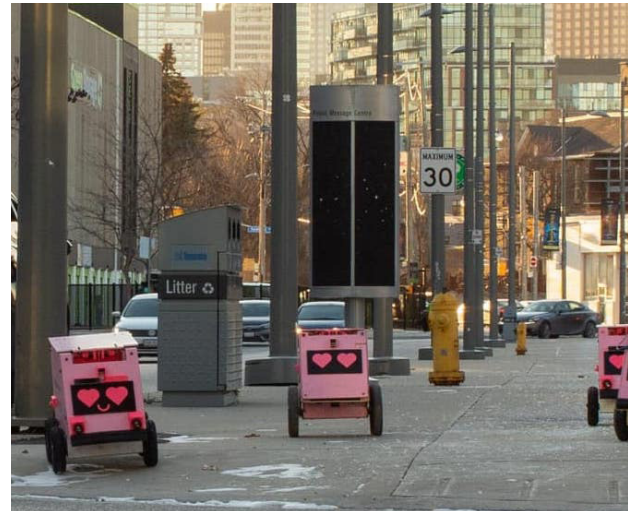
INTRODUCTION:

Technology disruptions happen quickly. In the last few years, governments around the world have had to grapple with how best to manage the introduction of service robots.

Toronto City Council in December 2021 chose to temporarily prohibit the use of “automated micro-utility devices” operated by Canadian robotics company Tiny Mile. Local businesses were using these robots to deliver food orders. However disability advocates, in particular, were opposed to their continued use because of the perceived disruption to sidewalk traffic.

Whether we like it or not, this event signaled the coming introduction of these devices in Canada. Simply put, robots are coming. It is just a matter of time.

In September 2022, Pizza Hut announced a new pilot program where residents in Vancouver can order pizza from their smartphone application and have their meal delivered to their home by a robot. Currently, the pilot project is only operating within two kilometers of the Robson Street store. Pizza Hut customers pre-pay for their pizza, and then the robot will use GPS to guide itself to the customer’s home. The robot is equipped with a box inside that keeps the pizza warm and only opens when the customer confirms using the smartphone Pizza Hut application.



“[Customers] receive a text message that lets them know that their food is there. They will then receive a pin which they can enter into their phone and that’ll actually unlock the drawer where they can then remove their food” - *Daniel Fingerote, Innovation Brand Manager, Pizza Hut*¹

¹ “The future is here; Pizza Hut deliver pies by robot”, City News, Robyn Crawford and Charlie Carey, Sept 23 2022.



“It’s a lot safer than cars for pedestrians, and for bikers and everybody else. Also, you don’t have to tip.” - *Ali Kashani, the CEO of Serve Robotics regarding Pizza Hut Pilot in Vancouver*^(Ibid)



In the same month, local retailer London Drugs partnered with InDro Robotics to test the ROLL-E 2.0 in the City of Surrey. Initial testing began with the robot’s cart loaded up and sent to meet customers for curbside pickup.²

The introduction of these robots have significant policy implications for municipal decision-makers, as they seek to boost local economic activity, by improving the accessibility of goods and services, empowering local business owners, while also balancing the interests of local residents and stakeholders.

“Without the opportunity to field test in a real-world setting, many of the products could not proceed to final development and commercialisation. I am thrilled to see ‘ROLL-E 2.0’ hit Surrey streets for testing, and I am excited to see this initiative launch. The future truly does live here in the City of Surrey.” - *Surrey Mayor Doug McCallum*³

² “This robot just made its first home delivery in B.C.”, CTV News, Lisa Steacy, Sept 17 2022.

³ Ibid.

Who is responsible if a robot is involved in an accident? How many robots should be allowed to operate in a given municipality? Will the introduction of robots be a benefit to local residents and businesses in this sensitive period of post-pandemic recovery? What goods should be delivered by a robot (food, prescription drugs, cannabis)? What happens if a robot breaks down on a sidewalk or roadway? What rules should robots have to follow?

These are some of the questions that will need to be answered. Municipal leaders understand that the coming introduction of robot technology will change local commerce, in much the same way, the recent emergence of Uber ride sharing, Amazon home goods delivery and SkiptheDishes food delivery have created both opportunities and challenges for local communities.

This research report is intended to inform Canadian municipal decision makers by drawing on the available jurisdictional experience, best practices, survey results and interviews with subject matter experts.

TERMINOLOGY, WHY USE “PUBLIC MOBILE ROBOTS”?

In this paper, we are using the term Public Mobile Robots (PMRs) to describe small robotic devices using the municipal sidewalk and right-of-way. These devices may be fully autonomous, meaning they are operated entirely based on their computer software or non-autonomous, which allows a human to operate the robot or intervene in certain circumstances.

This term encompasses common descriptions such as sidewalk delivery robots, autonomous and robotic delivery, and Micro-Utility-Robots. Indeed, PMRs include a range of mobile robots that could operate in public space and serve functions beyond just the delivery of goods. Additional functions of PMRs include infrastructure maintenance and monitoring, public safety, and personal assistance devices for the elderly.

The City of Toronto provides a useful definition for what they call micro utility devices (MUDs), which we find useful and is interchangeable with term PMRs. The City of Toronto states that these robots are “any device that: 1. operates using any kind of power other than solely muscular power; 2. is automated or remotely controlled; 3. transports itself and/or conducts tasks including transporting goods or cargo, but not passengers.” For the purposes of this report, the above definition captures what we consider to be a PMR⁴. It is important to note that PMRs do not include drone or aviation type robotic technology, often thought of as potentially useful for delivery, as this is considered to be another class of robotics.

ORGANIZATION OF REPORT:

This paper is organized into three sections. The first section will provide a brief overview of the different types of Public Mobile Robots (PMRs) and the particular use-cases applicable to a typical Canadian municipality.

⁴ “Agenda Item IE26.12 Automated Micro-Utility Devices - Accessibility Feedback”, Toronto City Council, Dec 15-17 2021.

The second section of our report will examine the opportunities and challenges that PMRs present to Canadian municipalities. This section will review the economic opportunities, as well as the potential environmental benefits of PMRs. We will also discuss the common concerns relating to safety, accessibility and privacy. Other potential economic impacts will also be examined, such as lower operating costs for local businesses, greater competitiveness for some merchants and enhanced productivity.



A Pizza Hut delivery robot is seen on Robson Street in downtown Vancouver on Sept. 23, 2022


The third and final section will examine the regulatory approaches taken in other jurisdictions and what lessons can be drawn for Canadian municipal officials.

“Customers were pleased with both the convenience and experience of having goods delivered to their car by a robot. Delivery robots will one day become commonplace, so London Drugs and the City of Surrey are really ahead of the game.”- *InDro CEO Philip Reece*⁵

SECTION 1 - PUBLIC MOBILE ROBOTS

The list below provides a summary of the PMRs that could be introduced in Canadian municipalities in the coming years, with a summary of the potential benefits and common concerns raised.

Table 1. Main PMR Types⁶

TYPE	SERVICE	ZONE	COMMON CONCERNS	POTENTIAL BENEFITS	IMAGE
Delivery Robots	Food and Small Cargo Delivery	Public Spaces	Traffic and Crowding, Safety, Job Losses, Privacy Concerns	Lower Operational Costs, Lower Pollution, More Competitive Local Businesses	

⁵ Ibid.

⁶ Robotic Cargo Transport: New Technologies, Novel Practices & Policy Readiness in Canada. Shauna Brail and Betsy Donald. June 24 2021. Page 1-41.

“Agenda Item IE26.12 Automated Micro-Utility Devices - Accessibility Feedback”, Toronto City Council, Dec 15-17 2021.







Micro Utility Devices - Observations from Transport Canada’s Winter 2022 Urban Trial. Transport Canada - Innovation Centre. Rielly Young and Mark Robbins. July 2022. Page 4-13.

Robots, Regulation, and the Changing Nature of Public Space. Kristen Thomasen. Page 279-312.

“Preparing for the Future of Autonomous Delivery Robots”, Centre for Integrated Transportation and Mobility, Bern Grush, June 9 2022.

“Meet Geoffrey, the cutest meal delivery robot and downtown Toronto celebrity”, Maclean’s, Marie-Danielle Smith, Dec 1 2021.

“Why sidewalk delivery robots are here to stay”, DriveU.auto, Alon Podhurst, March 9 2022.

TYPE	SERVICE	ZONE	COMMON CONCERNS	POTENTIAL BENEFITS	IMAGE
Snow Removal Robots	Clearing Roads, Sidewalks and Driveways	Public Spaces and Private Spaces	Safety, Traffic, Job Losses	Lower Operational Costs, Less Salt Use, More Accessible Services	
Lawn/Field Care Robots	Mowing Fields, Parks, Yards	Public Spaces	Safety, Job Losses	Lower Costs, More Accessible Services	
Institutional Service Robots	Localized Cargo and Delivery, Other Services	Mixed/Private Public Spaces (Airports, Hospitals, Hotels, Building Cleaning, More Spaces Likely in Future)	Safety, Though Less Concerns Overall, Job Losses	Lower Costs, More Service	
Personal Service Robots	Various	Public Space, Private Space	Traffic and Crowding, Safety, Privacy Concerns	Accessibility Services, Personal Safety	
Infrastructure Maintenance Robots	Street and Sidewalk Cleaning, Road and Infrastructure Inspection	Public Space	Traffic, Safety, Job Losses	Lower Costs, More Frequent Maintenance, Safer Infrastructure	
Security Monitoring Robots	Public Safety and Security, Parking Enforcement	Public Space	Privacy Concerns	Enhanced Public Safety	

As can be seen in the table above, there is a wide variety of PMRs currently being used internationally and this may grow over time. However, it is important to note that PMRs are not at a mature state and their use is therefore not widespread. It is still early days for PMRs and it remains to be seen how popular they become.

PMRs FOR GOODS: DELIVERY

The limited jurisdictional experience thus far suggests that food and cargo delivery robots are the easiest to deploy. These PMRs can assist small and medium sized businesses interested in delivering goods to the local community at potentially a lower cost than traditional transportation methods.

We can infer that if battery operated PMRs gradually replace traditional gasoline powered delivery vehicles, municipal officials can, over time, expect lower levels of carbon dioxide in their community. This reduced carbon footprint may lead to several positive outcomes for the surrounding community in terms of health, livability and tourism attraction. Because of their use of public sidewalks, delivery robots have generated public resistance.

PMRs FOR MUNICIPAL OPERATIONS:

Snow removal, along with lawn and field care robots are in an earlier stage of maturity. Manufacturers are still in the testing and development phase, however the research suggests that we may see these types of PMRs in Canadian municipalities in the coming years. We can also envisage robots used for cleaning sidewalks or garbage pickup in the future.

PMRs IN LARGE INSTITUTIONS:

Institutional service robots are currently being used in some airports and hospitals. These PMRs appear to be far less controversial or concerning to the public. We surmise that this is because of the public communication that compliments their use. For example, hospital or airport visitors often expect to see them and understand the limited role they play in those unique settings. These examples demonstrate that over time and with greater understanding of their value, the public is more accepting of the role of robots.

PERSONAL SERVICE ROBOTS:

Personal service robots, infrastructure maintenance robots, and security robots are in much earlier stages of development and maturity and therefore not widely used anywhere. These robots offer several potential benefits.

We all remember R2D2 in the classic Star Wars movies, always at the side of the hero. In the contemporary Canadian context, a personal robot could assist a senior or an individual with an accessibility challenge. For example, these PMRs could assist in carrying items such as groceries and could be set to follow its owner-operator, even up a flight of stairs. These PMRs could also lead an individual who is blind or deaf through a busy city.






Maintenance robots could patrol pedestrian areas and clear snow, ice or other debris when needed. Similar robots could also be trained to detect maintenance issues such as potholes using computer vision or other sensors.



Security robots could patrol office buildings or other areas at the fraction of the cost of human staff and alert the police if an intruder is detected or if an incident takes place.

We understand that some robots may operate entirely autonomously based on their software and in other cases, there may be a human operator, who may be navigating the robot using a built-in camera, or stepping-in when certain events are detected such as a sidewalk obstacle.

Since delivery robots are the most pervasive segment of PMRs and expected to grow, we summarize the most popular versions in the table below.

Table 2. Table of Delivery Robot Companies:

FIRM	FOUNDING/ LOCATION	SERVICES	PILOTS/USES	IMAGE
Amazon Scout	US-based, Amazon announced in January 2019	Last-mile delivery for Amazon Prime packages Operates on sidewalks	Testing in AT, GA, TN, WA	 A small, blue, three-wheeled delivery robot with the Amazon Prime logo, carrying a package, on a sidewalk.
Dianomix	Canadian firm based in Calgary, founded in 2019	Last-mile delivery of grocery & consumer goods bought at local retail stores Capacity to deliver to multiple addresses in one trip Retailer subscription model Operates on sidewalks at speeds of 4-5 km/h, potential to operate on bike lanes and paths at 16 km/h	Testing in Discovery Ridge, Calgary	 A white, boxy delivery robot with a large bag of groceries attached to its front, on a sidewalk.
Nuro	U.S. based, founded in 2016, HQ in Mountain View, CA	Smaller and lighter than a car, designed to transport goods such as prepared food, groceries and drugstore purchases Partnered with retailers, customer-fee is \$5.95 Operates on streets, max speed is 40 km/h 113 kg max cargo	Tested in Scottsdale, AZ and 2021 pilot in Houston, TX	 A white, car-like delivery robot with a person standing next to it, on a street.

FIRM	FOUNDING/ LOCATION	SERVICES	PILOTS/USES	IMAGE
Starship	Estonian firm founded in 2014 by two Skype co-founders, based in San Francisco as of 2018, with engineering operations in Tallinn, Estonia	Last-mile delivery (mainly food & grocery items) on college and other campuses, and in cities and suburbs Contracts with retailer/campus/ other partners + customer- fee (\$1.99) Operates on sidewalks, 6 km/h max speed 10 kg max cargo	Tested in more than 100 cities globally Autonomous with remote control backup	
Tiny Mile	Canadian firm based in Toronto, founded in 2019	Last-mile delivery of restaurant meals Partnerships with restaurants and delivery platforms (\$6 fee - split between restaurants and customer) Operates on sidewalks, 6 km/hr max speed 2.7 kg max cargo	Tested in Toronto (note that Toronto banned such services in public since this table was created but allows for testing in a select zone that is used to a lesser degree. Tiny Mile later began testing in the City of Charlotte) ⁷	

SECTION TWO - OPPORTUNITIES AND CONCERNS FOR CANADIAN MUNICIPALITIES

In this section we will look at the opportunities and concerns that PMRs present local communities, particularly for municipal staff.

City Council did not make a mistake:

In December 2021, Toronto City Council voted to suspend the operation of PMRs until the Ontario Ministry of Transportation undertook a pilot project regarding this technology.

⁷ “Toronto City Council votes to ban sidewalk robots”, The Robot Report, Brianna Wessling, Dec 17 2021.

“City of Charlotte and Tiny Mile to test Robots for Coffee Delivery to Reduce Traffic and Carbon Emissions”, City of Charlotte, Cory Burkarth, Jan

Prior to that, Tiny Mile was using its robots to deliver food to the public. A few months later the City of Ottawa would also issue a similar temporary ban because of Tiny Mile testing. These robots were “teleoperated”, which means they were remotely controlled by a driver, in some cases by an individual sitting at a desk far away. Tiny Mile’s robot is equipped with five cameras that provide a remote control driver with a wide-angle view (220 degrees), and zooming capabilities to read building addresses and see at night. The electric-powered robot has a 12-hour battery life.⁸

“Unless that municipality has placed on ban on it, its not legal and its not illegal, its sort of the wild west, gray area...” – *Charissa Iogna - Project Manager, Strategic Policy and Innovation, Transportation Services, City of Toronto*

These robots were neither legal nor illegal since existing municipal bylaws and the Provincial Highway Traffic Act did not contemplate their use. They were operating in a “gray zone”.

In the months leading up to the City Council Ban, Tiny Mile’s CEO, Ignacio Tartavull posted a number of images of his robots operating on Toronto’s streets on social media. These posts were shared and picked up by the media who ran a number of stories about the “cute” robots operating on Toronto’s busy streets. If Tartavull’s goal was to raise attention - it worked. Suddenly many people were talking about the positive aspects of these robots and the potential risks.



City Council members soon had to make a high-profile decision, weighing the interests of the businesses and individuals benefiting from Tiny Mile’s delivery service, along with the public’s concern about accidents. Disability advocates were also worried about how these robots may impede members of the public that are challenged by hearing, visual or other physical mobility challenges.

During the City Council meeting, elected officials were relying on staff guidance. However staff had little experience with PMRs and did their best to provide informative unbiased answers. In the end, the City Council voted 25 to 1 in favour of a suspension on the use of Tiny Mile’s robots. Mayor John Tory noted that despite his desire to frame Toronto as an innovative city, he felt compelled to support suspension.⁹

⁸ “Tiny Mile teams with foodora for robotic food delivery in Toronto”, The Robot Report, The Robot Report Staff, March 11 2020.

⁹ “Sidewalk robots: What happened in Toronto? (Dec 17 2021)”, Urban Robotics Foundation, Bern Grush, Sept 2022.

Some may suggest that Toronto City Council made a mistake by temporarily banning Tiny Mile and other robot operations. However, when we reflect on the information available to Council at the time and the absence of any public consultation or regulatory structure, we feel that Council made the appropriate decision.



Investment Ready Municipalities & PMRs:

Ignacio Tartavull claimed to have tried to work with both municipal and provincial officials and noted “I made [it] my priority to have at least one meeting a month with these parties, so I’ve spoken with 10 or so people at the city and another 10 to 15 at the provincial level. And [I received] some advice that governments act reactively so that the only way of getting regulations in place was to put enough robots out there that there is visibility on what we are doing.”¹⁰

We have not been able to substantiate this claim, but if true, it suggests a possible gap in how City of Toronto officials deal with new companies, offering new technological solutions for the public. A better approach may have been for the City’s economic development staff to have worked with Tartavull and his Tiny Mile team to facilitate a pilot in a limited area of the City or in partnership with a local college or university, which could have deployed these robots on its campus.

We understand that it is difficult for municipal staff to anticipate every possible technological disruption and so it is better that they respond after a new tool such as Uber ride sharing or e-scooters have been deployed. In short, a given company introduces a technology tool in the

¹⁰ Ibid.

absence of any regulatory structure, the public starts using it and then city staff and council responds. By responding after the technology has been introduced, staff have real experience to work with and can assess the public and stakeholder interests involved.

“It is a concern when these things just appear on the streets. There was no permission asked at any point.” – *Ottawa City Councillor, Tim Tierney*¹¹

The media attention helped elevate the profile of both Tiny Mile and its CEO, Ignacio Tartavull. Tiny Mile is now operating in several cities in the United States. We feel that Toronto owes Tiny Mile some gratitude for kickstarting PMR policy discussion in Canada’s biggest city and province.

In September 2021, the Ministry of Transportation (MTO) posted a proposal on automated micro utility devices (MUDs) soliciting feedback on a regulatory framework for a provincial pilot project under the Highway Traffic Act (HTA). This pilot would allow remote-controlled MUDs, including automated personal delivery devices, for use primarily off-road in places such as sidewalks in Ontario municipalities. This proposal broadly covers devices that will not be defined as a motor vehicle in Ontario, are task-oriented, and operated to primarily provide services such as the delivery of goods and not passengers, and for operation primarily off-road, on sidewalks. It is expected that the Ministry of Transportation’s pilot project assessing PMRs will begin sometime in 2023.

To better understand the capabilities of PMRs, City of Toronto staff undertook an “Innovation Challenge” with several robot manufacturers in the Spring of 2022. Tiny Mile was one of the companies that participated. In speaking with staff, they found the real world test to be very helpful in assessing how various robots performed in environmental conditions such as rain, wind, snow and ice. The staff report noted that the “the core objective of this challenge is to demonstrate how micro-utility devices can overcome, improve, or address sidewalk challenges and navigate through competing uses in dense urban environments without posing safety risks to sidewalk users.”¹² There were four categories of devices which were the basis for the testing.

Category A	Personal Assistance Devices	Follow a person and provide a service or assistance to that person.
Category B	Delivery Devices	Deliver a product from point A to point B
Category C	Service Devices	Implement an infrastructure maintenance service to the immediate path of travel in which it is operating
Category D	Scanning / Surveillance Devices	Scan and survey the physical area it operates within and collect, transmit, and/or output data

¹¹ “Ottawa battles the pink robots by banning automated delivery vehicles”, Driving.ca, Jon Willing, Feb 3 2022.

¹² Transportation Innovation Challenge: Micro Utility Devices. City of Toronto Staff Report, March 8, 2022.

Several robotic companies participated in the City of Toronto’s Innovation Challenge and the feedback from city staff has been positive. We believe similar day long or multi-day testing events are effective ways for other Canadian municipalities to signal their interest in supporting the emergence of new technological tools, for both municipal operations such as snow clearing, and also robots that service the public, such as delivery robots.

“We also know there is a huge labour shortage, particularly in this delivery sector and I think there is a huge gap that can be filled. These are things we are looking at. What are the use cases of these devices? In what ways are they serving the general public and our economy as well since a lot of these companies are local and that is something we want to encourage.” – *Charissa Iogna - Project Manager, Strategic Policy and Innovation, Transportation Services, City of Toronto*

PMRs for Municipal Operations:

In the Spring of 2021, the Town of Innisfil partnered with Swap Robotics to test real-world applications of autonomous sidewalk robots. Swap Robotics, which is based in Kitchener and Waterloo, makes electric semi-autonomous sidewalk robots for snow plowing, salting, grass cutting and sidewalk inspections.¹³ Town staff have noted that the 24-month test will help them determine if these robots should be used by the municipality in greater use. This test was made possible by an Ontario Centre of Innovation grant.¹⁴ The Town ran a contest to name the robots and the winning monikers were: Optimus Plow and Snowbi Wan Kenobi. These robots are examples of how these devices could be used for municipal operations, potentially improving accessibility of sidewalks because of improved snow clearing.

In its recent research report, ‘Micro Utility Devices - Observations from Transport Canada’s Winter 2022 Urban Trial, the authors argue that the tax savings from utilizing PMRs for infrastructure and maintenance could allow resources to be redirected towards vulnerable groups, and that more frequent maintenance could also increase the accessibility of sidewalks. They also note that PMRs could also make cargo delivery more affordable thereby also benefiting those with accessibility needs.

Enhanced winter maintenance of sidewalks and public spaces could also reduce accidents and injuries for various user groups. In addition, it



¹³ “Robot snowplows? Town of Innisfil enters partnership with two companies to pilot smart technologies”, Simcoe.com, Shane MacDonald, May 3 2021.
¹⁴ Ibid.

has been suggested that PMRs, especially with regards to cargo delivery, might even be safer than the large heavy vehicles that they replace on busy downtown streets, and that at minimum the status quo is not automatically safe or safer - though it is hard to compare at this point due to the lack of widespread PMR adoption and standards.¹⁵ The potential operational cost savings to both the public and municipalities are significant and would allow residents and local governments to redeploy those savings to other priorities. The exact nature of such savings is difficult to estimate, and varies according to the source and context, but it has been proposed that PMR services could be up to 10 times less costly when compared to other service delivery models.¹⁶

In the case of Transport Canada’s winter testing study, the cost savings associated with a snow removal utilizing PMRs was significant. The results can be seen in the table below.¹⁷

Table 4. Comparison of snow removal PMRs from Transport Canada’s 2022 Urban Winter Trial¹⁸

	SWAP MUD (PMP)	SNOWRATOR	HOLDER SIDEWALK PLOW
Noise	70 dBA	95 dBA	120 dBA
Run-Time	4 hours between charges; batteries can be swapped out in under 5 minutes.	Honda GX390 uses 92 gal/hour @ 3600 rpm with an approximate run time of 1 hour 40 minutes	Kubota 4-cylinder 4-stroke turbo diesel uses 1/2 gal/hour @ 2400 rpm with an approximate run time of 30 hours (tank holds 17 gal)
Maintenance	Approx. maintenance ratio 1:30 (1 hour of maintenance per 30 hours of operation)	Approx. maintenance ratio 1:10 (1 hour of maintenance per 10 hours of operation)	Approx. maintenance ratio 3:10 (3 hours of maintenance per 10 hours of operations)

15 “Agenda Item IE26.12 Automated Micro-Utility Devices - Accessibility Feedback”, Toronto City Council, Letter From Frank Naccarato, Dec 15-17 2021. Micro Utility Devices - Observations from Transport Canada’s Winter 2022 Urban Trial. Transport Canada - Innovation Centre. Rielly Young and Mark Robbins. July 2022. Page 24-25.

“These heart-eyed delivery robots are being taken off the streets of Toronto”, Mobile Syrup, Karandeep Oberoi, Dec 10 2021.

Robotic Cargo Transport: New Technologies, Novel Practices & Policy Readiness in Canada. Shauna Brail and Betsy Donald. June 24 2021. Page 35-37

16 “Meet Geoffrey, the cutest meal delivery robot and downtown Toronto celebrity”, Maclean’s, Marie-Danielle Smith, Dec 1 2021.

17 “The potential opportunities and challenges of sidewalk robots: panelists offer diverse perspectives”, University of Toronto Transportation Research Institute, panelist Shauna Brail, May 3 2022.

“Preparing for the Future of Autonomous Delivery Robots”, Centre for Integrated Transportation and Mobility, June 9 2022.

Robotic Cargo Transport: New Technologies, Novel Practices & Policy Readiness in Canada. Shauna Brail and Betsy Donald. June 24 2021. Page 41-46.

Micro Utility Devices - Observations from Transport Canada’s Winter 2022 Urban Trial. Transport Canada - Innovation Centre. Rielly Young and Mark Robbins. July 2022. Page 11-14.

18 Micro Utility Devices - Observations from Transport Canada’s Winter 2022 Urban Trial. Transport Canada - Innovation Centre. Rielly Young and Mark Robbins. July 2022. Page 13-14.

	SWAP MUD (PMP)	SNOWRATOR	HOLDER SIDEWALK PLOW
Environmental Cost	Approx. maintenance ratio 3:10 (3 hours of maintenance per 10 hours of operations)	Honda GX 390 internal combustion engine	Kubota 4-cylinder 4-stroke turbo diesel
Total Cost	Average seasonal cost: \$15,000	Unit price: \$14,000 Total cost: \$28,500 ³	Unit price: \$74,000 Total Cost: \$94,500 ⁴

Data Collection, Privacy and Role of International Standards:

PMRs are collecting large amounts of information on our patterns of movement and interaction. Privacy and security has to be top of mind with policy makers as they seek to balance the benefits of PMRs with the potential risks. Standards and regulations set by international organizations, and higher orders of government, such as Transport Canada, can be helpful in ensuring a harmonized regulatory approach.

Privacy concerns have been raised in regards to PMRs given the amount of sensory and visual data that the devices collect. However, it is not clear that these concerns are not unique in any substantive way beyond the scope of existing regulation for privacy and data protection.¹⁹

The same issues apply to security cameras, smart cars, and many other devices in use in Canadian cities. Consider that through its commercial activities, companies such as Uber and SkiptheDishes are collecting personal information of individuals’ home addresses and credit cards. We expect companies using PMRs to be subject to the same privacy and data protection legislation.

Indeed, as noted in ‘Micro Utility Devices (MUDs) - Observations from Transport Canada’s Winter 2022 Urban Trial’:

“A common, but less widely known concern pertaining to MUDs relates to the collection of data. As noted by Hoffmann & Prause (2018), MUDs require the constant collection of data from a range of sensors and cameras. Though the privacy question is frequently raised in academic discourse, this is in many ways a “solved problem” since there are existing regulations and codes of practice pertaining to data collection and privacy which have a long history of being read-in to new technology areas.

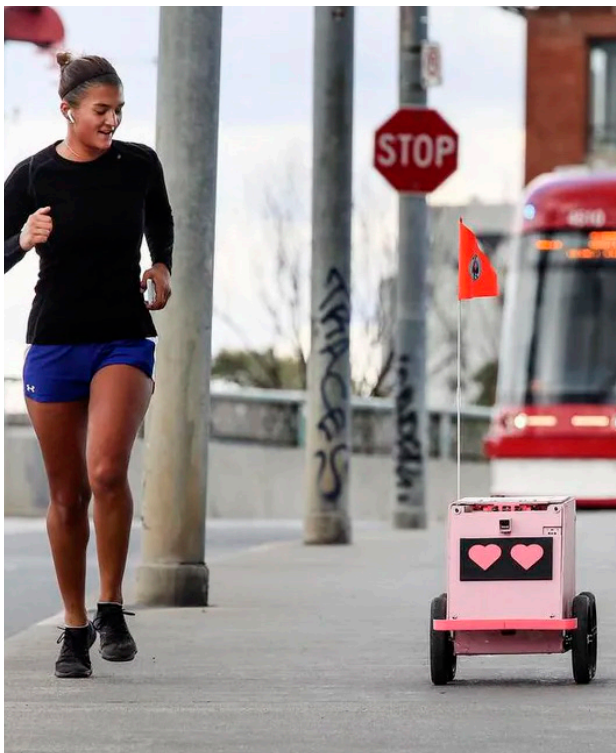
MUDs are subject to existing data privacy laws and should be operated according to the best practices based on “privacy by design”, such as minimum collection of data, differential privacy, federated learning and the right to be forgotten. While more collection may take place as

¹⁹ Micro Utility Devices - Observations from Transport Canada’s Winter 2022 Urban Trial. Transport Canada - Innovation Centre. Rielly Young and Mark Robbins. July 2022. Page 8-9.
 “Delivery robots are coming. The law isn’t ready.”, Tech Monitor, Jan 13 2022.
 Robotic Cargo Transport: New Technologies, Novel Practices & Policy Readiness in Canada. Shauna Brail and Betsy Donald. June 24 2021. Page 41.

MUDs become more pervasive, this is similarly true as streetlights are gradually replaced with smart infrastructure, or as the stock of motor vehicles on the road becomes increasingly “smart”.

Though MUDs may attract more attention, it seems unlikely that their increasing pervasiveness will require a tailor made or entirely novel solution more than diligence in compliance with existing regulatory standards and policy prescriptions for privacy.”²⁰

As PMRs become more pervasive, we believe a registry will need to be created to allow device ownership to be identified, almost like a license plate. We can also imagine having PMRs specifically designed for security patrol and scanning of other PMRs in a given city. Authorized PMRs could also have an ‘off switch’ that can be remotely toggled by a security PMR if need be, and other smart infrastructure.



The Urban Robotics Foundation (URF), based in Toronto Canada was created to help coordinate the robotic policies of member municipalities. URF is the drafter of the ISO 4448 draft series for ground-based automated mobility.²¹ This standard sets up the parameters and procedures for loading and unloading of passengers and goods with automated motor vehicles at the curbside and the movement of PMRs such as delivery robots within pedestrian spaces in cities, towns and suburbs. The completion and adoption of these standards by both PMR manufacturers as well as governments will bring much needed structure to help facilitate the introduction of PMRs in Canada.²² Canadian municipalities will be able to reference the ISO 4448 standard in their locally constructed by-laws.

“Because ROLL-E 2.0 is electric, these deliveries will eliminate carbon emissions that would have otherwise been created by people driving to the store and back. This project involves a single robot, but deploying these at scale in the future will have a measurable impact on CO2.” - InDro CEO Philip Reece²³

20 Micro Utility Devices - Observations from Transport Canada's Winter 2022 Urban Trial. Transport Canada - Innovation Centre. Rielly Young and Mark Robbins. July 2022. Page 8-9.

21 “About URF”, Urban Robotics Foundation.

22 Ibid.

23 “InDro's ROLL-E 2.0 robot delivers to London Drugs customers in Surrey, BC”, InDro Robotics.

Potential Environmental Benefits:

Researchers in Barcelona have suggested that last mile delivery contributes up to 20% of inner-city pollution. When compared to traditional gasoline delivery vehicles, PMRs offer clear environmental benefits by reducing CO2 pollution, since they are not powered by fossil fuels and often rely on a rechargeable electric battery. We therefore believe that the greater use of PMRs will lead to lower levels of vehicular road traffic, thereby reducing the overall carbon footprint of communities. Over time, the greater adoption of PMRs may also lead to fewer traffic accidents as there will be fewer vehicular and bicycle delivery staff using the roads. This is particularly interesting as many experts are expecting the volume of delivery vehicles to rise in urban centres as smartphone based food ordering becomes more popular.²⁴

Research in Tokyo by the World Economic Forum and McKinsey anticipates that “e-commerce volumes will rise by 85% by 2030, leading to a 71% percent increase in the number of delivery vehicles covering 25% more miles. In addition to the added congestion, this will lead to a 20% increase in carbon dioxide emissions.” The European Union has even provided funding to Starship Technologies, which provides PMRs focused on delivery, in part in order to improve sustainable transportation.²⁵

The environmental benefits of PMRs in the context of higher demand for immediate food and goods delivery, appears to be significant. However, some scholars argue that in the long run the pollution related benefits of PMRs may be a mute point as the transition away from fossil fuels will benefit all types of vehicles and transportation modes.²⁶



Accessibility Challenges & Benefits:

Stakeholders and members of the public have expressed concern about the negative impacts that such increased PMR traffic outside of roads may have on general members of the public, as well as those with accessibility needs. A fairness argument has also been made with regards to traffic matters as well, since pedestrians really only have sidewalks designed for their use and have no other walking option to get around in the urban environment, therefore their needs should be prioritized in this crowded space. PMR delivery vehicles which may have access to roads, sidewalks, and even bike paths. Similar concerns have also been raised with regards to

24 “Agenda Item IE26.12 Automated Micro-Utility Devices - Accessibility Feedback”, Toronto City Council, Stakeholder Submissions, Dec 15-17 2021.

“Why sidewalk delivery robots are here to stay”, DriveU.auto, Alon Podhurst, March 9 2022.

“The potential opportunities and challenges of sidewalk robots: panelists offer diverse perspectives”, University of Toronto Transportation Research Institute, panelist Shauna Brail, Matthew Roorda, Ron Buliung, May 3 2022.

“City of Charlotte and Tiny Mile to test Robots for Coffee Delivery to Reduce Traffic and Carbon Emissions”, City of Charlotte, Cory Burkarth, Jan 4 2022.

“Preparing for the Future of Autonomous Delivery Robots”, Centre for Integrated Transportation and Mobility, Bern Grush, June 9 2022.

Micro Utility Devices - Observations from Transport Canada’s Winter 2022 Urban Trial. Transport Canada - Innovation Centre. Rielly Young and Mark Robbins. July 2022. Page 14.

“These heart-eyed delivery robots are being taken off the streets of Toronto”, Mobile Syrup, Karandeep Oberoi, Dec 10 2021.

25 “Why sidewalk delivery robots are here to stay”, DriveU.auto, Alon Podhurst, March 9 2022.

26 Robotic Cargo Transport: New Technologies, Novel Practices & Policy Readiness in Canada. Shauna Brail and Betsy Donald. June 24 2021. Page 38.

winter operations when some sidewalks can become very narrow if snow piles up on the sides. There are safety concerns with regards to PMRs using signalized street intersections since they may be too low to the ground and therefore difficult for other road/vehicle users to notice, especially if visibility is reduced due to inclement weather. Because their use has been limited, but is growing steadily, there have been some reports of accidents with PMRs being clipped, run over, or falling into a canal in one case, as well as some minor accidents. It must also be noted that the reduction of road vehicle traffic in this case would result in an increase in PMR traffic, and possible crowding on sidewalks. This is the most common concern raised by many stakeholders who oppose the greater adoption of PMRs.

In the lead up to the City of Toronto vote discussed earlier, the Toronto Accessibility Advisory Committee (TAAC) was one of the main groups pushing for a ban on the continued use of Tiny Mile robots. This committee has faced criticism that it did not fully take into consideration the accessibility-enhancing technology of PMRs. Dr. Frank Naccarato, President & Founder, Quantum Robotic Systems, has noted that “robots have been safely carrying groceries, clearing snow, expediting sidewalk repair, and delivering food and medicine for years in other cities.”²⁷ Indeed, the recent Covid-19 pandemic revealed how important home delivery of food and prescription drugs can be for the elderly or those that face mobility challenges.

We believe that the benefits of PMRs to those with accessibility challenges must be weighed fairly alongside possible challenges to their use of limited sidewalk space, and that those issues can likely be addressed in ways that are satisfactory to all. The possible solutions to mitigate accidents will be explored in Section 3, including geo-fencing, ISO standards, regulation and fleet orchestration.²⁸

“We urge the Ministry of Transportation and Government of Ontario to exercise their legislative and regulatory powers to ban the usage of MUDs in Ontario, rather than regulate to permit them. As we have learned from the Ontario government’s ill-advised e-scooter pilot, having an opt-in approach for municipalities puts the burden onto the accessibility community to constantly monitor and address issues across the province and creates inconsistent and inaccessible communities throughout Ontario.” – Canadian National Institute for the Blind (CNIB)²⁹

While PMRs may get in the way of pedestrians, they may also provide a significant accessibility and personal service tool for the elder community and individuals with mobility challenges.

27 “Agenda Item IE26.12 Automated Micro-Utility Devices - Accessibility Feedback”, Toronto City Council, Letter From Frank Naccarato, Dec 15-17 2021.

28 “Toronto must ban service robots from its sidewalks”, Toronto.com, David Lepofsky, Dec 9 2021.

“Disability advocates call for stop to delivery robots in public spaces”, CityNews, David Zura, Nov 17 2021.

“Agenda Item IE26.12 Automated Micro-Utility Devices - Accessibility Feedback”, Toronto City Council, Dec 15-17 2021.

“These heart-eyed delivery robots are being taken off the streets of Toronto”, Mobile Syrup, Karandeep Oberoi, Dec 10 2021.

“Podcast: Spacing Radio 063, The War on Robots”, Spacing Toronto, Graham Isador, Dec 30 2021.

“The potential opportunities and challenges of sidewalk robots: panelists offer diverse perspectives”, University of Toronto Transportation Research Institute, panelist Shauna Brail, Matthew Roorda, May 3 2022.

“Delivery robots are coming. The law isn’t ready.”, Tech Monitor, Jan 13 2022.

“Preparing for the Future of Autonomous Delivery Robots”, Centre for Integrated Transportation and Mobility, Bern Grush, June 9 2022.

Robots, Regulation, and the Changing Nature of Public Space. Kristen Thomasen. Page 279-312.

Robotic Cargo Transport: New Technologies, Novel Practices & Policy Readiness in Canada. Shauna Brail and Betsy Donald. June 24 2021. Page 40.

29 “Micro-Mobility Utility Devices” CNIB, Alice Clark.



As a letter from Frank Naccarato from Quantum Robotic Systems Inc., which makes robot devices that help with the use of stairs, to Toronto Council during its debate of the issue, states, “Robots can lift, carry, climb, clean and see for people who can’t.” Of course, points have also been made against the adoption of PMRs from an accessibility lens. For example, there have been reports of PMRs blocking accessibility ramps and curb cuts, and how they represent a significant safety concern for people with disabilities or accessibility needs, such as those with wheelchairs, those with hearing and/or vision impairments, and senior citizens in general.³⁰

Economic Impacts:

With the introduction of any new disruptive technology, we anticipate that it will lead to some job losses as for example delivery workers are no longer needed. However, new opportunities and jobs will be created as PMRs become more widespread and virtual operators and maintenance staff are needed.

PMRs offer potential economic productivity improvements for communities and residents in terms of operational savings and service enhancement. However, these efficiencies come at the cost of short-term job disruptions. A vibrant economy involves the introduction of new technologies and a healthy evolution of how goods and services are delivered.

A Statistics Canada study found that 10.6% of jobs in 2016 were at high risk of automation related ‘job transformation’ or disruption. This job transformation does not always mean that jobs are lost because in many cases they are altered or only partially automated, and hence ‘transformed’. PMRs are part of the overall fourth industrial revolution Canadian society is undergoing as technological tools become more entrenched.



³⁰ “The potential opportunities and challenges of sidewalk robots: panelists offer diverse perspectives”, University of Toronto Transportation Research Institute, panelist Matthew Roorda, May 3 2022.
“Toronto must ban service robots from its sidewalks”, Toronto.com, David Lepofsky, Dec 9 2021.
“The potential opportunities and challenges of sidewalk robots: panelists offer diverse perspectives”, University of Toronto Transportation Research Institute, panelist Ron Buliung, May 3 2022.
“Preparing for the Future of Autonomous Delivery Robots”, Centre for Integrated Transportation and Mobility, Bern Grush, June 9 2022.
Robots, Regulation, and the Changing Nature of Public Space. Kristen Thomasen. Page 279-312.
“Delivery robots are coming. The law isn’t ready.”, Tech Monitor, Jan 13 2022.
“Tiny Mile CEO: If the Ban Goes Through, Then The Company Shuts Down”, OttOmate, Christopher Albrecht, Dec 13 2021.

PMRs offer the potential to allow small businesses and restaurants to deliver goods to local customers at speeds and prices that are competitive with larger retailers, thus helping them compete, stay in business, and grow.

Home delivery could become especially relevant with Canada’s aging population, and with the growth of e-commerce overall, by allowing more consumers to choose local options by making them as accessible and as convenient as the ‘big box store’ retail option. This point has been raised by many proponents of PMR cargo delivery. In the long term, this could help give a competitive edge to local businesses and help revitalize and sustain local economies.³¹

Public Safety Benefits:

Another opportunity that arises from the greater use of PMRs is the potential for enhanced public safety by providing more ‘eyes’ on the street. These devices are capturing video which could help law enforcement agencies solve crimes. The additional visibility that PMRs would bring to local streets may also deter some criminal activity. It is important to note that PMRs could be configured to serve an entirely security focused goal, patrolling local streets or office buildings while alerting a command centre if any suspicious activity is detected.

Table 3. Summary of PMR Opportunities and Challenges Summary

TYPE	OPPORTUNITIES	CONCERNS	MITIGATIONS
Environmental, Traffic, and Crowding	<p>Reduced roadway vehicle traffic</p> <p>Reduced CO2 emissions and pollution from such reduction (until most vehicles are electrified or using green hydrogen - therefore only a short/medium term opportunity)</p>	<p>More PMR traffic, on sidewalks, bike paths, roadway intersections, and other public spaces</p>	<p>Geo-fencing (short term)</p> <p>ISO standards and regulation (medium term)</p> <p>Fleet orchestration (long term)</p>

³¹ “Agenda Item IE26.12 Automated Micro-Utility Devices - Accessibility Feedback”, Toronto City Council, Letter From Brandon Orr, Dec 15-17 2021.
 “Preparing for the Future of Autonomous Delivery Robots”, Centre for Integrated Transportation and Mobility, Bern Grush, June 9 2022.

TYPE	OPPORTUNITIES	CONCERNS	MITIGATIONS
Accessibility	<p>Improved and less expensive delivery for for those with accessibility needs, seniors, and other members of society who benefit from this</p> <p>Enhanced public and private accessibility with stairway assistance, personal service PMRs</p> <p>Enhanced public and private accessibility with better maintained infrastructure and public spaces (i.e. public and private snow removal in winter)</p>	<p>Potential reduced accessibility in public spaces such as side-walks, for everyone as well as those with accessibility needs, due to increased - and non pedestrian - traffic</p>	<p>Accessible design</p> <p>Geo-fencing (short term)</p> <p>ISO standards and regulation (medium term)</p> <p>Fleet orchestration (long term)</p>
Economic	<p>Reduced customer costs</p> <p>More competitive and cost effective deliveries for local businesses</p> <p>Enhanced economic productivity for society</p>	<p>Job disruption for those currently labouring in services that PMRs will disrupt, due to increased economic productivity</p>	<p>Job retraining and support for those who lost jobs specifically due to technology</p>
Public Safety and Security	<p>Enhanced security from personal service PMRs and Security PMRs (as well as more PMRs in general) due to increased surveillance and monitoring in public spaces (including at risk members of society, such as senior citizens and those with accessibility needs)</p>	<p>Privacy concerns due to increased surveillance and monitoring in public spaces, with increased PMR usage</p> <p>Potential risk of use of PMRs for criminal purposes and terrorism</p>	<p>Apply existing privacy regulations and ensure companies follow these or set higher standards</p> <p>Inform public of existing privacy regulations and rights</p> <p>Regulate PMRs with beacons and/or scannable tags, and verify continuously using security PMRs and smart infrastructure, build in remote off switches</p>

In summary, every opportunity and concern comes with tradeoffs and is often another side of the same coin. For example, reduced vehicle traffic on roadways and reduced emissions results in greater PMR traffic on sidewalks. Points can be and have been made that PMRs can enhance accessibility as well as diminish accessibility. On one hand, PMRs can provide delivery services for lower costs to those who need them, which includes many community members with accessibility needs or senior citizens potentially, as well as acting as personal assistance devices and even (eventually) providing assistance with stair climbing tasks.

PMR adoption could also lead to better and more frequently maintained infrastructure, resulting in safer and more accessible public spaces. Snow removal PMRs are an example of this possibility. On the other hand, more PMR traffic on sidewalks could easily reduce accessibility and add risks to the use and enjoyment of public spaces.

The economic benefits include reduced customer costs, enhanced economic competitiveness and new delivery options for local businesses. These benefits may allow small enterprises to more effectively compete with big box retail chains and major online e-commerce companies.

However, the adoption of PMRs may negatively impact many workers, particularly in the service and delivery industry. The greater adoption of PMRs may also lead to the creation of new jobs for maintenance workers, programmers and other individuals needed to facilitate the new PMR economy.

PMRs can provide enhanced surveillance and monitoring of public spaces. We believe this will lead to positive public safety outcomes. While privacy issues have been raised, we do not see these as anything new and our existing regulatory regime is capable of adapting to the potential adoption of PMRs.

Section Three - Enabling Regulation & Recommendations for City Staff

In this third and final section we argue that the role of the municipal staff should be to help foster new economic opportunities while mitigating the potential risks. Let us begin by examining possible regulatory approaches.

“We do not want to rely on a lot of rules and regulation to support business and manufacturers in implementing new technology. At the same time, we also need standardization. How can they be regulated but not to the extent that its going to hinder manufacturing or implementation. It’s a fine line”. – *Lisa Hausz, Manager of Economic Development & Policy , The Town of Aurora*

In an effort to manage PMRs, several jurisdictions have created regulatory frameworks which we have summarized below. These frameworks often include speed and weight limits, physical

distance guidelines, and insurance requirements. The approach of these frameworks has generally meant a soft touch to enable the growth of PMRs or to facilitate a pilot project in a municipality.

Estonia adjusted their national traffic laws in 2018 so as to allow robots to share sidewalk space with people. At the time of writing this report, sidewalk delivery robots are now regulated in twenty US states, plus the District of Columbia. We discuss some of these approaches below to help municipal staff see how parameters such as speed limits, insurance requirements, weight limits, and limits on the number of PMRs which can operate in a given area can be used to regulate their use.³²

The City of San Francisco allows firms to test cargo delivery robots. Companies may apply for a 180-day operating permit with the option for 90-day extensions. The state of Pennsylvania introduced Personal Delivery Devices legislation in 2020. It is notable that Pennsylvania allows robots to travel as fast as 19 kilometers per hour on sidewalks, and up to 40 kilometers per hour on streets. For comparison, the average pedestrian moves at about 5 kilometers per hour. The state legislation requires operators to have, at minimum, liability coverage of \$100,000 and the fines for non-compliance can be as much as \$1,000 USD.³³

To facilitate the testing of Dianomix, Alberta's Ministry of Transportation and the City of Calgary worked to approve their use. Dianomix has been working with local grocery retailers to deliver goods to local residents in the Calgary area.³⁴

In the City of Washington, D.C., City council passed the "Personal Delivery Pilot Act" in 2016. This local legislation was designed to enable the testing of delivery robots. The City of Washington limited companies to using five robots, also specifying that each device could not weigh more than 23 kg without cargo and couldn't surpass a 16 kilometer per hour speed limit. In addition, PMR operators are required to clear broken PMRs from streets and sidewalks within 24 hours of accidents and issues.³⁵



In Madison, Wisconsin, Starship, which is the world's largest manufacturer of PMRs by volume, started operations on the University of Wisconsin Madison campus in 2020. It was interesting to observe that the City of Madison passed regulations prohibiting personal delivery devices on city sidewalks, except for the university campus.³⁶

32 Robotic Cargo Transport: New Technologies, Novel Practices & Policy Readiness in Canada. Shauna Brail and Betsy Donald. June 24 2021. Page 60-67.

33 Ibid.

34 Ibid.

"Calgary-based autonomous robotic delivery company ready for financing", CTV News, Chad Tweten, May 21 2021.

35 Robotic Cargo Transport: New Technologies, Novel Practices & Policy Readiness in Canada. Shauna Brail and Betsy Donald. June 24 2021. Page 60-67.

36 "Delivery robots are coming. The law isn't ready.", Tech Monitor, Jan 13 2022.

Robotic Cargo Transport: New Technologies, Novel Practices & Policy Readiness in Canada. Shauna Brail and Betsy Donald. June 24 2021. Page 60-67.

“We should be the enablers of this and not the operators. We do not want to control the market. If businesses and consumers feel that this is something that they want to support (robots), we just have to provide the infrastructure and guidance to allow this to happen”. – *Lisa Hausz, Manager of Economic Development & Policy, Town of Aurora*

The regulatory approaches noted above should be viewed as a starting point. A more holistic approach is needed, incorporating industry standards for operations. This fulsome framework will be informed by further research, development, and testing of PMRs in public spaces.

We are also confident that the Urban Robotics Foundation’s development of ISO 4448 will assist in coordinating PMR policies in Canadian and international municipalities. These standards will address matters such as right of way, appropriate operating distances and how PMRs should operate when they interact with other devices, dogs and even wheelchairs or police sirens.

“How do we adapt our view of what we do on our streets and sidewalks? We have a very car centric view of streets and a very pedestrian oriented view of sidewalks. So how do we expand our view of both to look at other types of uses and applications?”
– *Chris Rickett, Director, Economic Growth, Culture and Entrepreneurship, City of Markham*

OTHER REGULATORY TOOLS:

Geofencing:

Municipal officials may consider incorporating geo-fencing into their local regulatory regime. Geo-fencing creates a virtual set of boundaries, an invisible fence where desired PMR operations can be limited. Geofencing offers municipal officials the ability to extend or limit the operating zone of PMRs with just a few clicks based on parameters such as time of day, weather and pedestrian traffic. In addition, data may be collected and analyzed.³⁷

Orchestration Management:

When we go to an airport to take a flight, we take for granted all of the industry standards and regulations that underpin safe air travel. These operating standards or orchestration create a structure that all of the actors in the market work with. In much the same way, a similar set of orchestration standards and regulations will need to be developed for PMRs. Greater cooperation, coordination, and information sharing is needed between higher orders of government and industry to develop these standards and the regulatory approach.³⁸

³⁷ Micro Utility Devices - Observations from Transport Canada’s Winter 2022 Urban Trial. Transport Canada - Innovation Centre. Rielly Young and Mark Robbins. July 2022. Page 4-8, 14-24.

³⁸ “Delivery robots are coming. The law isn’t ready.”, Tech Monitor, Jan 13 2022.

“Preparing for the Future of Autonomous Delivery Robots”, Centre for Integrated Transportation and Mobility, Bern Grush, June 9 2022.

Micro Utility Devices - Observations from Transport Canada’s Winter 2022 Urban Trial. Transport Canada - Innovation Centre. Rielly Young and Mark Robbins. July 2022. Page 8-25.

Readiness Levels: Public Mobile Robot Standard

Level 1	Level 2	Level 3	Level 4	Level 5
Wild West	Governance R&D	Initial Deployment	Expanded Deployment	Full Deployment
No stds/regs followed by severe restriction or bans	Best practices identified from other cities/sectors	Limited deployment of international std: ISO 4448	Significant deployment of ISO 4448 subset	Full ISO 4448 rule set, evolution over time
Little or no sharing of development learnings; no risk mitigation	Pilots/trials per contract: objectives, access fees, liability insurance	Pre-orchestration: max 2 fleets in 1 domain; simple rules & regs	Limited orchestration: multiple fleets/missions, ISO 4448 rules, IoT, data	Realtime orchestration: Full ISO 4448 rules IoT, data
No systematic stakeholder input; most unrepresented	Structured stakeholder participation required	Trials of priorities ID'd in stakeholder consultation	Commercial activities: delivery maintenance, etc.	All functions Extensive spatial coverage
Manual operation and oversight	Manual operation and oversight	Manual ops/oversight; Monetization begins	Semi-auto ops/oversight per detailed ISO 4448 rules	Jurisdictional authorities' ops/monetizing fully-auto

Orchestration implies the coordination of robot schedules in time and space to manage traffic flow and safe behavior.

ISO 4448 is a draft technical standard defining orchestration and providing the “rules of the road” to guide robot interactions with non-involved humans on walkways, bikeways and roadways.



The Urban Robotics Foundation provides a summary of the various levels of municipal readiness. This chart helps us understand the various stages municipalities are in with respect to the implementation of PMRs.³⁹ Most Canadian cities are in the Level 1, “Wild West” category with no standards in place yet.

CONCLUSION:

The introduction of Public Mobile Robots (PMRs) is still at a formative stage in Canada. PMRs can support local economic activity and enhance local accessibility to goods and services, if effectively introduced.

More experience and testing is needed to ensure the right mix of regulatory structure is developed. Transport Canada and various provincial Ministries of Transportation will continue to study this issue and their leadership will be beneficial in helping create the conditions for the safe introduction of PMRs in communities across Canada.

“It gets slippery out. It gets cold and wet, but I still do deliveries because I need the money. It’d be a lot safer with the robot.” - *Joseph Wirth, Toronto Bicycle Courier*⁴⁰

³⁹ “Preparing for the Future of Autonomous Delivery Robots”, Centre for Integrated Transportation and Mobility, Bern Grush, June 9 2022.

Micro Utility Devices - Observations from Transport Canada’s Winter 2022 Urban Trial. Transport Canada - Innovation Centre. Rielly Young and Mark Robbins. July 2022. Page 1-25.

⁴⁰ “Meet Geoffrey, the charming pink robot here to revolutionize the future of contactless delivery” Toronto Star, Sean Frankling, Oct 12 2020.

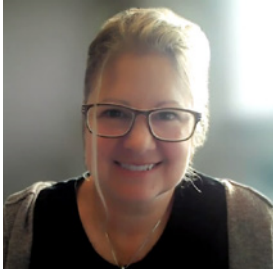
Municipal industry groups such as the Association of Municipalities of Ontario (AMO) and the Federation of Canadian Municipalities (FCM) can also contribute by funding further testing in local communities.

“We need to focus on the problems we are trying to solve and look at how robots could be part of that solution, from a liveability perspective, safety perspective, whatever it might be.” - *Chris Rickett, Director, Economic Growth, Culture and Entrepreneurship, City of Markham*

In the short term, Canadian municipal officials should continue to raise this issue with their colleagues and use innovation challenges to test devices. PMRs can be helpful for municipalities with operations such as snow plowing and lawn maintenance, as well as serving the public by enabling easier access to goods and services. Over time, PMRs can also offer a more environmentally friendly option to traditional transportation delivery modes.

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RESEARCH INTERVIEWS



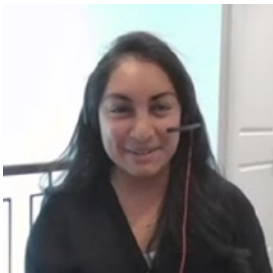
Lisa Hausz, Manager of Economic Development & Policy, The Town of Aurora (EDCO Member), Oct 25th, 2022



Bern Grush, Executive Director, Urban Robotics Foundation, Sept 12th, Oct 16th, Oct 25th, Oct 26th, Oct 27th, 2022



Chris Rickett, Director, Economic Growth, Culture and Entrepreneurship, City of Markham, October 25th, 2022 (EDCO Member)



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