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Microtransit: An assessment of potential to drive greenhouse gas reductions

The Atmospheric Fund & Coop Carbone

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Executive Summary

This scoping study provides a high level estimate of the greenhouse gas ("GHG") emissions reduction potential of microtransit in the Greater Toronto and Hamilton Area ("GTHA") and Greater Montréal Area. The study also identifies key factors that will influence the adoption of microtransit and the approach needed to test and scale any implementation. The time scale under consideration for this study is from one to five years.

For the purpose of this study, microtransit is defined as: "shared public/private sector transportation offerings that offer fixed or dynamically allocated routes and schedules in response to individual or aggregate consumer demand". This definition includes:

a) Commuter shuttles, currently operating in certain areas based on demand; and,

b) Ride-sharing, including services that allow a passenger to share a ride with others nearby who have a similar destination.

Under this definition, these services can be offered by both private companies and/or public sector transportation agencies.

Based on learnings from secondary market research, literature review, primary research with microtransit practitioners and GHG modeling, microtransit has the potential to transform the transportation sector and affect GHG emissions in both the study areas as follows:

1) In the Greater Montréal Area, microtransit could deliver GHG reductions of up to 174.2kt carbon dioxide equivalent ("CO2e") over five years (or 3.8% of emissions from personal transportation) by capturing just 5% of personal car travel with a mixed microtransit fleet.

2) In the GTHA, the identification of specific use cases (i.e., well-defined, commonly used travel patterns) provides an opportunity to introduce microtransit at scale to address key travel needs. In this region, microtransit could offer potential GHG reductions of up to 588.42 kt CO2e over five years (or 5.7% of emissions from personal transportation) by replacing personal car travel with a mixed microtransit fleet.

The primary factors influencing estimated GHG savings are: i) the size of the travel patterns being addressed (i.e. travel distances); ii) the willingness of consumers to share their journeys (where proxies were based on carpooling and carshare deployments to date) and; iii) the occupancy rate in microtransit vehicles. Emissions based on vehicle type used in microtransit and routing inefficiencies were found to be secondary contributors to potential savings.

Consumer conversion rates significantly impact savings, however are difficult to predict given the lack of empirical or preference survey data for conversion from private cars and from transit or active transport. Understanding price and convenience trade-offs by consumers for different use cases would further clarify potential adoption and travel patterns that could be served (i.e. as would be provided through an activity-based simulation of consumer response to the availability of new microtransit models). Alongside consumer preference, there are many other factors that will impact deployment and adoption such as cultural preferences, the level of engagement by transit agencies, the regulatory context for new private delivery modes and the integration of services and payment models.

Many stakeholders will need to be involved to create a ripe environment for successful microtransit deployment. As such, a test-and-learn approach is needed to enable stakeholders to participate and to validate the combinations of factors that will enable the most effective deployment. A proactive test-and-learn approach can enable cities to shape the development of microtransit to meet their GHG goals and support other social outcomes such as reduced congestion, better air quality, transportation, access equity and greater consumer satisfaction.

This report was prepared by the MaRS Data Catalyst team, with support from Richmond Sustainability Initiatives, the University of Toronto and Polytechnique Montréal. MaRS Discovery District ("MaRS") is dedicated to driving economic and social prosperity by harnessing the full potential of innovation. MaRS is a not-for-profit innovation hub that works with an extensive network of partners to help innovators achieve these goals. MaRS works with entrepreneurs and investors to launch and grow companies having broad economic and societal impact, convening both governments and stakeholders to enable widespread adoption in complex market places and systems, including transportation and energy.

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Sommaire Exécutif

Cette étude de cadrage fournit une estimation globale du potentiel de réduction des émissions de gaz à effet de serre (« GES ») du transport collectif flexible (« microtransit ») dans la région du grand Toronto et de Hamilton (« GTHA ») et la région métropolitaine de Montréal. De plus, l'étude détermine les principaux facteurs qui influenceront l'adoption et la démarche nécessaire à la mise à l'essai et la mise à l'échelle. L'échelle de temps considérée pour cette étude est d'un à cinq ans.

Aux fins de cette étude, on définit ainsi le microtransit : « Offres de transport partagé offertes par le secteur privé ou public et qui fournissent des trajets et horaires définis ou répartis de manière dynamique en réaction à la demande des consommateurs ou groupes de consommateurs. » Cette définition comprend :

a) Les navettes, déjà en activité dans certaines zones selon la demande;

b) Le covoiturage, y compris les services qui permettent à un passager de faire du covoiturage avec d'autres personnes à proximité vers une destination semblable.

En fonction de cette définition, des organismes de transport des secteurs public ou privé peuvent également offrir ces services.

Selon les apprentissages découlant des études de marché secondaires, des études primaires auprès des spécialistes du microtransit et de la modélisation relative aux GES, le microtransit est en mesure de transformer le secteur des transports et d'avoir une incidence sur les émissions de GES au sein des deux zones à l'étude de la façon suivante :

1) Dans la région métropolitaine de Montréal, le microtransit pourrait se traduire par des réductions de GES pouvant atteindre 174,2 kt d'équivalent CO2 sur cinq ans (ou 3,8 % des émissions provenant du transport personnel) en ne remplaçant que 5 % des déplacements de véhicules personnels avec une flotte mixte de microtransit.

2) Dans la GTHA, le fait de désigner des cas d'utilisation particuliers (c.-à-d., des schémas de déplacement bien définis et couramment utilisés) donne l'occasion d'introduire le microtransit à grande échelle dans le but d'aborder les principaux besoins sur le plan des déplacements. Dans cette région, le microtransit pourrait donner des réductions de GES jusqu'à 588,42 kt sur cinq ans (ou 5,7 % des émissions provenant du transport personnel) en remplaçant les déplacements des véhicules personnels par une flotte mixte de microtransit.

Voici les principaux facteurs qui influencent les économies estimées de GES : i) la taille des schémas de déplacement abordés (c.-à-d., distances de déplacement), ii) la volonté des clients de partager leurs trajets (pour lesquels les approximations ont été fondées sur le covoiturage et le partage de véhicules jusqu'à maintenant) et iii) le taux d'occupation dans les véhicules de microtransit. Les émissions du type de véhicule utilisé lors du microtransit et l'inefficacité des trajets se sont avérées des facteurs contributifs secondaires aux économies potentielles.

Les taux de conversion des consommateurs ont de grandes répercussions sur les économies, bien qu'ils soient difficiles à prédire en raison du manque de données d'enquêtes empiriques ou de préférences sur la conversion à partir des véhicules privés ou du transport collectif ou actif. La compréhension des choix en matière de prix et de commodité par les consommateurs pour différents cas d'utilisation permettrait d'éclaircir davantage les schémas d'adoption et de déplacement potentiels (c.-à-d., ce qui sera fourni lors d'une simulation fondée sur les activités de la réaction des consommateurs à l'accessibilité des nouveaux modèles de microtransit). En plus des préférences des consommateurs, il existe de nombreux autres facteurs qui auront une incidence sur le déploiement et l'adoption tels que les préférences culturelles, le degré de participation des organismes de transport, le contexte réglementaire pour les nouveaux modes de prestation privés, ainsi que l'intégration de services et de modèles de paiement.

De nombreux intervenants devront participer à la création d'un milieu propice au déploiement réussi du microtransit. À ce titre, une démarche de mise à l'essai et d'apprentissage (« test-and-learn ») est nécessaire pour permettre aux intervenants de participer et de valider les combinaisons de facteurs, et ce, afin de réaliser le déploiement le plus efficace. Une démarche « test-and-learn » proactive permet aux villes de façonner le développement du microtransit de manière à atteindre leurs objectifs en matière de GES et soutenir d'autres résultats sociaux tels que la réduction de la congestion, une meilleure qualité de l'air, l'égalité en matière de transport et d'accès, ainsi qu'une grande satisfaction des consommateurs.

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1. Introduction

Both Toronto and Montréal have committed to achieving a 30% greenhouse gas ("GHG") reduction target by 2020 compared with 1990 emissions rates, and both Ontario and Québec have enacted Cap-and-Trade frameworks to address emissions in each province. Transportation-related GHG emissions constitute one of the largest and fastest growing emission sources in Ontario and Québec. Toronto and Montréal have the highest total GHG emissions from private vehicles of Canada's Census Metropolitan Areas, although GHGs per capita in both cities are relatively low due to the fuel efficiency of the fleet, high urban density, and availability of public transit.[1] These latter attributes suggest that opportunity exists to further optimize existing infrastructure, and concurrently diminish low efficiency private vehicle usage and related emissions in Toronto and Montréal.

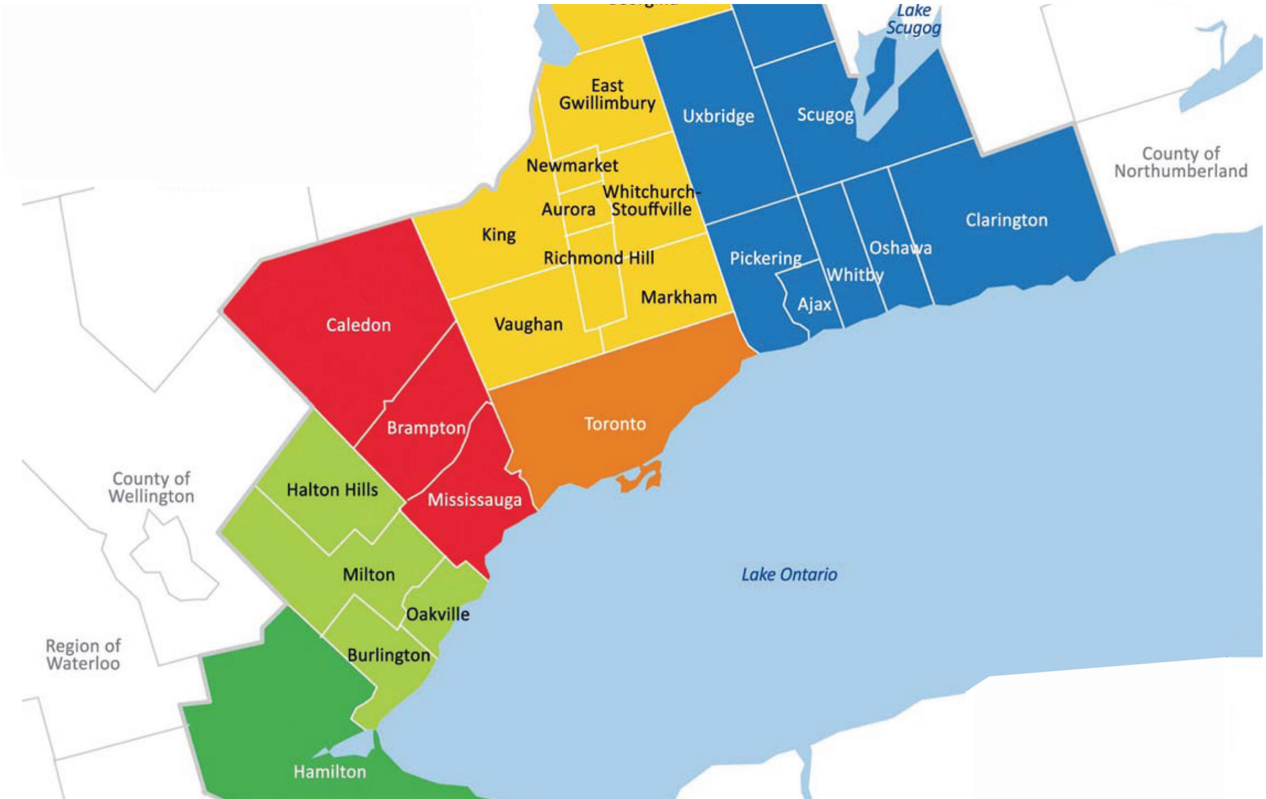
In recent years, microtransit has generated renewed interest as a potential mechanism for addressing transportation-related GHG emissions, particularly in dense urban areas. While microtransit has been around for many years in select global pockets, it is the concurrent rise in 'sharing economy' based services like Uber and Lyft that has unlocked new opportunities for scaling adoption and potential impact. The growing acceptance of IT-enabled shared services from consumer to consumer presents an unprecedented opportunity to leverage microtransit as an effective transportation option. If deployed strategically to reduce personal vehicle usage, microtransit can positively impact GHG emissions and other urban issues such as traffic congestion, public transit ridership, parking and air quality. Conversely, microtransit could also negatively impact such factors by increasing the number of vehicles on the road and/or kilometres travelled by vehicles. This wide disparity in outcomes underlines the importance of exploring and identifying how microtransit could be best deployed in light of regional contexts and planning priorities.

The purpose of this Scoping Study is to explore microtransit deployment in the GTHA and the Greater Montréal Areas. A working definition of microtransit is proposed in Section 2, along with a brief discussion of recent developments and projected trends in this area. Section 3 provides a succinct treatment of select microtransit initiatives existing in other jurisdictions. Section 4 puts forward a high level methodology and analysis of the potential impact microtransit could have on GHG emissions in the GTHA and Greater Montréal Area. Section 5 includes follow-on research questions that must be addressed to refine microtransit deployment strategies.

Finally, Section 6 provides an outline of key conclusions and recommendations for how these two regions might undertake the design, development and effective rollout of microtransit options within their jurisdictions.

1 http://www.statcan.gc.ca/pub/16-001-m/2010012/part-partie1-eng.htm

2. Definition And Scope



source: http://www.metrolinx.com/thebigmove/Docs/big_move/TheBigMove_020109.pdf

Over the past decade, public sector interest in the shared mobility opportunity has increased due to growing environmental, energy and economic concerns, as well as urban congestion and sprawl. Simultaneously, technological advances have made consumer access to dynamically shared assets - including cars and buses - easier and more efficient, which has led to rapid growth and demand for services that are tailored to a consumer's individual needs.

Shared mobility encompasses a range of transportation options, including the new generation of microtransit services that capitalize on widespread mobile GPS and internet connectivity. In general, such services combine smaller vehicles, flexible routes and schedules, a marketplace for trips, and access to vehicles and rides without the burden of ownership.[1] In North America, microtransit innovation has grown apace with consumer smart phone applications, particularly in dense urban centres throughout the U.S.

2.1 RECENT DEVELOPMENTS IN MICROTRANSIT

Although different forms of microtransit have been around for some time (i.e. dollar vans, mini buses, sheruts), in North America a novel configuration was arguably demonstrated in 2004 by the Google Shuttle operation.[2, 3] To expedite employee commutes and productivity, Google - and subsequently, other tech companies – availed themselves of IT and GPS technologies and began their own shuttle operations to and from Silicon Valley. These operations now accommodate on order of 17,000 daily boardings in San Francisco alone.[4,5,6,7]

1 Institute for Transportation and Development Policy (2015)
2 Modified/excerpted from Sampson, R. (2015), "Microtransit: A Bigger Impact than its Name Suggests" ctaa.org
3 Although other specialized shuttles had routinely been run by the private sector for some time, Google was arguably one of the earliest to begin capitalizing on the IT opportunity. In 2007 Google already had a small team of transportation specialists monitoring regional traffic patterns, mapping out the residences of new hires and plotting new routes.
4 https://www.wired.com/2015/11/google-buses-battle-isnt-over-as-san-francisco-regulators-vote/ Approximately 47% of commuters have indicated they would drive to work if a shuttle wasn't available
5 For an excellent discussion on this area, see: http://humantransit.org/2012/10/the-silicon-valley-shuttles-revealed.html
6 This commuting service has become an additional perk to entice and retain top talent. http://www.nytimes.com/2007/03/10/technology/10google.html
7 Modified/excerpted from Sampson, R. (2015). Ibid.

Ten years after Google, private-sector firms such as Leap Transit (2013) and Chariot (2014) saw opportunities for evolving such services to further leverage consumer smartphones and applications like Google Maps. These companies began offering premium commuting shuttle services that could ostensibly augment existing mobility options: Chariot for example, uses crowdsourcing to identify which routes to run in San Francisco. The company also tailors its routes in real time based on this demand.

Several other companies also debuted shuttle and/or rideshare systems around the same time, including Boston's Bridj, which launched in 2014 and is now operating in Washington, Kansas City, and Chicago; and Via, which started in New York in 2012 and has since expanded to Chicago. Transportation Network Companies,[1] or "TNCs", have also entered the shared on-demand transit market: Uber and Lyft have introduced their shared options, UberPOOL and Lyft Line. These latter offerings group rides based on demand and provide incentives for users to congregate in select locations (i.e. Uber's 'Suggested Pick Up Points', Lyft Line 'Hotspots').[2,3] Google has been exploring developing its own ride-hailing service, and in the longer term, the use of autonomous vehicles to meet this demand.[4]

Still other variants are emerging, including aggregator-style or "Combined Mobility Service" models. Now defunct, the company SideCar operated through bundling ridesharing, instant carpooling and on-demand routes in Austin, Philadelphia, Charlotte and Long Beach.[5] TransLoc, a company which currently serves over 130 public transit authorities with its real-time transit tracking app, has recently embarked on a partnership with Uber to address the first mile-last mile issue by integrating public transit, Uber, and walking.[6,7] Various European countries (Finland, Netherlands, Sweden) have all explored models that bundle commuting options. Significantly, several of the European systems have also explored incentivizing commuters to select more sustainable travel modes by offering bonuses for taking this option (see Appendix C).

1 TNCs are companies that provide prearranged transportation services for compensation using an online-enabled application (app) or platform to connect passengers with drivers using their personal vehicles – See Appendices 2.2 and 2.3 for more discussion of TNCs.
2 Lyft Line has experimented with "hot spots" in the San Francisco Bay Area that encourage passengers to congregate at select intersections in exchange for discounted fares. Similarly UberPOOL has been testing "Smart Routes" where users can get a discounted fare off the normal UberPOOL price in return for walking to a major arterial street, allowing drivers to make fewer turns and complete ride requests faster (UCLA TSRC & Caltrans, 2015).
3 Ince, J. (2015) "Is Microtransit Coming of Age?" http://therideshareguy.com/is-microtransit-coming-of-age/#sthash.qroBAseF.dpuf /
4 http://www.bloomberg.com/news/articles/2015-02-02/exclusive-google-and-uber-are-going-to-war-over-taxis
5 CTAA (2015), "Microtransit: A Bigger Impact than its Name Suggests" ctaa.org
6 Triangle Business Journal (2014) http://www.bizjournals.com/triangle/news/2014/11/11/transloc-durham-nc-new-tool-for-transit-agencies.html
7 Somerville, S. (2016) "Uber pushes into public transit with new app partnership" http://www.reuters.com/article/us-uber-partnership-idUSKCN0UP18L20160111

These new technologies and innovative service models will likely be instrumental to the next generation of transportation infrastructure and transit services, given that they are enabling more flexible options for commuters of all kinds. When executed in keeping with regional transportation priorities such as GHG reduction or accessibility, these opportunities arguably offer the means to positively impact traditional commuting[8] or transit models with little to modest investment in capital (compared to the cost of building new public transit infrastructure, for example).[9]

2.2 DEFINING MICROTRANSIT

The microtransit space to date has a dearth of clear rules or definitions when it comes to municipal policy or regulation. At this point the literature, with a few exceptions, seems to point to policymakers taking a wait-and-see approach prior to establishing set definitions and associated rules around this space.

One exception identified is the City of Minneapolis, which within its submission to the U.S. Department of Transportation defined microtransit as "merging the 'Mobility on Demand' trip planning with innovative vehicle technologies and advanced safety features. The right vehicle providing the right service at the right time." It is of note that the City sees microtransit development also leading to many desirable outcomes for its constituents.

> ...policymakers [are] taking a **wait-and-see** approach prior to establishing **set definitions** and **associated rules** around this space.

In California, the Sacramento Area Council of Governments ("SACOG") defines microtransit systems as:

"...fleets of privately-owned vans and shuttle buses with flexible routes based on user demand. Most microtransit systems are focused on commuter routes. At this time, microtransit services are not a significant part of the Sacramento region's transportation landscape. For long-term planning in the region's more suburban communities, microtransit services could act as feeder routes that help connect people to destinations or major transit hubs".

Interestingly, SACOG has defined Lyft Line and UberPOOL as services that fall outside of this definition, terming these instead as "real-time ride-sharing by TNCs/Ride Sourcing Companies". The City does however include privately owned dollar vans as well as Chariot, Bridj, Via, Ford's Dynamic Shuttles, and Microsoft Connector as microtransit.[10]

City definitions identified to date are largely sourced

8 i.e. By making more efficient use of existing road capacity
9 Excerpted from Transportation Research Board (2016) "Between Public and Private Mobility: Examining the Rise of Technology-Enabled Transportation Services"
10 Sacramento Area Council of Governments (2016), Draft TDM Strategic Plan, 4/11/16

from draft plans and proposals as opposed to established policy.[1,2] The research thus far has illustrated the paucity of regulatory definitions in this area, and in addition, how widely microtransit is interpreted in popular as well as academic literature. We submit that this open field provides the opportunity for stakeholders to both resolve and justify how microtransit is best categorized for their jurisdictions, in light of the longer term objectives accompanying any related deployment strategy (i.e. microtransit as the first-mile/last-mile scenario, microtransit as paratransit, microtransit as a GHG displacement strategy, other).

It is suggested here that the relative nascency, rapidly changing and experimental nature of the microtransit systems and space means the bulk of policy or regulatory documentation relating to microtransit may yet be in its infancy. In the absence of clear (or consistent) regulatory definitions on what, exactly, is microtransit, a literature scan was conducted to define microtransit for this report (Appendix A provides a listing of microtransit definitions promulgated by research associations; as well as definitions salient to TNCs).

For the purpose of this study microtransit is defined as "shared public/private sector transportation offerings that offer fixed or dynamically allocated routes and schedules in response to individual or aggregate consumer demand". This definition takes into consideration definitions put forward by research associations and other groups including *The Shared Mobility Reference Guide* (2015)[3], *Institute for Transportation and Development Policy* (2015)[4], and the *Transportation Research Board* (2016)[5], in addition to a number of blogs and white papers.[6] Flexibility is a key aspect of this definition.

This definition includes:

- Commuter shuttles, including services like Chariot and Bridj that are operating in certain areas based on demand;
- Ride-sharing, including services like UberPOOL, UberHOP and Lyft Line which allow a passenger to share a ride with others nearby who have a similar destination; and,
- Services as listed above that could be offered by both private and/or public sector transportation agencies
- Other forms of shared mobility (i.e. carsharing, bikesharing, parksharing) are considered out of scope.

2.3 TRENDS & PROJECTIONS: SHARED MOBILITY - THE SHARING ECONOMY AND TRANSPORTATION

In its 2016 report, the Transportation Research Board ("TRB") identified two major potential effects resulting from aggregating disparate travel routes into a single vehicle, the first being to: "lower travel costs for users and increased car-pooling and ridesharing, which may in turn lead to increased average vehicle occupancies". This will ultimately reduce vehicle travel as well as the associated negative externalities (i.e. emissions, congestion).[7]

The second effect of increasing access to convenient travel alternatives may be to lower household vehicle ownership levels. The TRB indicates that this outcome could in turn "spur travel by public transit, walking, and biking and potentially favor urban over suburban residential location choices". The TRB goes on to caveat that the proliferation of less expensive and more convenient travel may however, result in the opposite scenario, where convenience lends itself to induced transportation demand, greater dispersion, and thus, urban sprawl.[8, 9, 10]

The main takeaway to date is that it is yet too early to tell what will happen, as scenarios will play out in different ways depending on the market, regulatory context, and other factors. Given this uncertainty, governments have the early opportunity to ensure that local circumstances favour the best possible outcome for their constituents.

2.3.1 TRANSPORTATION TRENDS AND PROJECTIONS

The TRB report also includes an overview of transportation trends and projections salient to the development of shared mobility and microtransit. Excerpts have been highlighted in the subsequent text and references relevant to the Canadian context have been added.

- At 87% of daily trips, TRB concludes that the private automobile remains the dominant mode of travel in North America. Canadians in particular have become more

1 Toronto Transit Commission Committee Minutes from January 29, 2016 stated that TTC staff will begin to study microtransit. The report is expected to be out during Q2. This discussion was under the purview of the Advisory Committee on Accessible Transit

2 From this initial review it seems that jurisdictions have been more active in defining Transportation Network Companies (TNC). In 2013 the California Public Utilities Commission defined TNCs as "companies that provide prearranged transportation services for compensation using an online-enabled application or platform to connect passengers with drivers using their personal vehicles." Shared mobility services including UberX and Lyft are considered as TNCs. However, it is yet unclear how the latter's pooled services (UberPOOL, UberHop, and Lyft Line) will be categorized. It is of note that TNCs as defined to date do not seem to exclude shared mobility, but do include personal vehicle ownership as a definitional component. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M077/K132/77132276.PDF

3 "The Shared Mobility Reference Guide" (2015) Shared-Use Mobility Centre http://sharedusemobilitycenter.org/research/shared-use-mobility-reference-guide/

4 "Harnessing Shared Mobility for Compact, Sustainable Cities" (2015) Institute for Transportation and Development Policy https://www.itdp.org/wp-content/uploads/2015/08/Harnessing-Shared-Mobility-1.pdf

5 "Between Public and Private Mobility - Examining the Rise of Technology-Enabled Transportation Services" Transportation Research Board (2016) http://onlinepubs.trb.org/onlinepubs/sr/sr319.pdf

6 See Appendix A

7 However, it is also possible that lowering the cost of vehicle travel may also "poach" would-be mass transit riders, thus having the opposite impact and in fact increasing the overall number of vehicles on the road. The outcome that materializes will highly depend on the region in question, in terms of the efficiency and cost of its existing transit infrastructure, population profile, urban and transit planning priorities, and other factors.

8 Still other consideration is the extent to which TNC drivers travel without passengers between customers. This factor could increase total vehicle travel and contribute to increased congestion, energy consumption, and emissions. TRB, 2016

9 http://www.conferenceboard.ca/conf/16-0133/reception.aspx

10 This was a key point made by Director Antoine Belaieff of Toronto Metrolinx at a 2016 event on the future of urban mobility in response to the potential for added congestion resulting from autonomous vehicle development.

dependent on their automobiles, with the proportion of daily trips by car rising from 68% in 1992 to 74% in 2005.[1]

- Less obvious is the finding that carpooling has declined to only 10% of work trips today compared to 20% in 1980.[2] In the U.S. this is the only travel mode that has seen an absolute overall decline (-2.2 million from 2000 to 2014).[3] This trend raises questions about how willing people may be to share new modes of travel (although microtransit is arguably different than traditional carpooling in a number of ways, including driver and passenger anonymity and in terms of passenger convenience).[4]
- Other forms of shared transit, namely taxi and transit, have increased.[5] In Canada, the proportion of workers who commuted via transit remained at about 12% between 1992 and 2005, but this proportion was higher in large urban areas, at 20%.[6] In the Cities of Toronto and Montréal specifically, commuters were the most likely to take public transit to work (23.3% and 22.2%, respectively).[7]

The TRB concludes that the "current scale and growth of TNCs, bikesharing, carsharing, and microtransit can only be approximated based on a variety of different sources" – namely through conjecturing how the demand for personal vehicles and public transit will be impacted by the advent of services that offer commuters' greater convenience. Although the impact of relatively new companies like Via, Bridj, Chariot, and others is difficult to quantify with certainty, it seems likely that these services (or some variant thereof) will continue to contribute to the rise of on-demand options, and ultimately shape transportation networks that are multi-modal and yet seamless, flexible and yet practical.

2.3.2 IMPACT OF NEW TRANSPORTATION SERVICES

The most rapidly growing forms of shared mobility to date fall under exclusive use, in that vehicles are shared sequentially as each user has exclusive access on a consecutive basis (i.e. TNCs as in the Uber and Lyft models). Several sources have indicated that, and as articulated by the TRB, the concurrent sharing of vehicles (i.e. UberPOOL) may have "more far-reaching impacts on personal mobility, vehicle use, energy consumption, congestion, and environmental impacts" than many of the mobility options in play or under development today.[8]

Data on the specific impacts of TNC services and microtransit is not yet available, although at least one academic study by the University of California Transportation Department has shown that TNCs in particular may be substituting for both transit and driving trips. The study indicates that ridesourcing appears to substitute for longer public transit trips but otherwise complements transit. Impacts on overall vehicle travel remain ambiguous in terms of whether or not TNCs reduce personal car ownership and/or vehicle trips. In the U.S., TNC use today has been suggested to be roughly comparable to the use of taxis (3%of respondents reporting "almost daily" use of both modes).

The study also concludes that: "although still exploratory, these findings nevertheless indicate ridesourcing enriches mobility options for city dwellers, particularly in large, dense cities [like San Francisco] where parking is constrained and public transit incomplete".[9] Similarly, the City of Minneapolis/St. Paul sees microtransit development leading to many desirable outcomes for its constituents, outcomes that include flexibility, environmental benefit, first mile-last mile connectivity, reduced travel costs, and other attributes (see Figure B.2; Appendix B). New forms of microtransit can also help reinvent specialized transit, such as Toronto's Wheel-Trans, potentially reducing the cost of running such services and possibly optimizing the efficiency of these services.[10]

When it comes to environmental impacts such as GHG emissions, the depth of reductions that are achieved will depend primarily on how microtransit is applied in terms of which (if any) incumbent transportation technology it replaces, as well as other factors such as occupancy, kilometres travelled, fuel used, and fuel efficiency, for example.

Overall, the eventual role of shared mobility services and microtransit in particular remain to be determined as these new business models are deployed more fully and mature in the marketplace. Their role may be to supplement or even partially replace traditional taxi, limousine, and transit services, or – more ideally – they may represent a movement towards a profound and systemic transformation of urban mobility, for example through toppling the supremacy of the single-occupant vehicle trip. Case Studies in other jurisdictions are listed in Appendix C.

2.4 STUDY SCOPE

This study is limited to the movement of people, although we recognize the associated opportunities resulting from applying microtransit principles to goods movement. It is

1 http://www.statcan.gc.ca/pub/16-201-x/2006000/9515-eng.htm
2 Transportation Research Board, 2016.
3 http://www.cutr.usf.edu/wp-content/uploads/2015/07/CUTR-Webcast-Handout-10.1.15.pdf
4 Another potential trend to watch is the convergence towards 'Suggested Pick Up Locations' for ridesharing options – both Uber and Lyft have developed applications that identify popular locations that users walk to in exchange for a cheaper ride. This may circumvent the initial reluctance to 'share a ride', as has been posited by some analysts. In the longer term, it is conceivable that this application may even lead to the dynamic interpretation of a fixed route!
5 Possibly attributable to a larger increase in transit users in large cities as opposed to a general increase over time
6 http://www.statcan.gc.ca/pub/16-201-x/2006000/9515-eng.htm
7 "Commuting to Work" National Household Survey (2011) Statistics Canada – Catalogue no. 99-012-X2011003
8 Excerpted and modified from the Transportation Research Board, 2016.
9 Rayle et al., (2015) "App-Based, On-Demand Ride Services: Comparing Taxi and Ridesourcing Trips and User Characteristics in San Francisco" University of California Transportation Centre, Working Paper
10 In Ontario, the Accessibility for Ontarians with Disabilities Act requires transportation services to be accessible, a requirement that can be sidestepped by private transportation services but not by public agencies.

also worth noting that progress in autonomous or self-driving vehicles may have a significant impact in the development of microtransit initiatives, offering more opportunities to find rides and reducing labour costs.[1] As this study focuses on the mid-term (five year) potential of microtransit, and as autonomous vehicles are not anticipated to penetrate North-American markets on a significant scale during this term, their impact is out of scope for this study.

The study will focus primarily on GHG direct emissions i.e. emissions from microtransit vehicles. Indirect GHG emissions, such as those resulting from the life cycle impact of vehicle turnover, and secondary impacts of improved transit like urban sprawl, are out of scope.[2]

The study captures quantifiable changes in GHG emissions that result in movement from personal vehicles to microtransit.

The study covers the following geographic areas:

1. The Greater Toronto-Hamilton Area, which encompasses the City of Toronto and the regions of Durham, Halton, Peel and York, as well as the City of Hamilton. This area includes 30 municipalities and 6.5 million people as of 2011. [3,4]
2. The Greater Montréal Area, which has a population of 4.288 million and includes 190 municipalities as of 2013.

The time scale under consideration for developing the findings from this study is from one to five years.

Further characteristics of each jurisdiction are noted in Table 2.1.

Table 2.1: Characteristics of the Study Areas

	Greater Toronto and Hamilton Area	Greater Montréal Area
Transit Governance	The area is served by a regional transit service (GO Transit) and by nine local transit agencies. Regional transit and local transit authorities (TTC, YRT, Brampton).	The area is served by one principal transit agency (Agence Metropolitaine de Transport, «AMT»), three transit companies, and twelve municipal transit organizations[5]
Transit Patterns & Characteristics	Approximately 23.3% of the Toronto population commutes via public transit, and in Hamilton, 9.3%.[6,7]	480 million transit trips were made in 2011; approximately 22.2% of the population commutes to work via public transit.[8]
GHG Emissions & Targets	Sample targets for municipalities in GTHA: Reduction target (Toronto): 80% below 1990 levels by 2050. Reduction target (Hamilton): 80% below 2005 levels by 2050 Ontario: 15% below 1990 levels by 2020 and 80% by 2050. Mid-term target of 37% by 2030.	Reduction target: 30% below 1990 levels by 2020. Quebec: GHG reduction of 37.5% below 1990 levels by 2030 - this is currently the most ambitious target in Canada.
Microtransit and/or related enterprise	UberHOP (ridesharing) since late 2015, Toronto. Line Six Transit (privately-run shuttle bus) from 2014 to late 2015 in Liberty Village, Toronto. RideCo, Milton (2015, one-year pilot)	No microtransit initiatives as per the study definition however taxibus (on-demand public transit operated by private taxi companies) has been in place since 2009
Cultural Acceptance	Anecdotally, the two geographical regions have reacted differently to the emergence of new initiatives having some relevance to microtransit. Reaction to the development of Uber may provide a proxy or bellwether for acceptance, given Uber's on demand service, flexibility, and use of IT/GPS technologies (and in addition the UberPOOL and UberHOP services, which we classify as microtransit). This reaction however may be associated more with the business model rather than the technology itself. Greater Montréal has witnessed more systemic opposition to Uber with petitions and demonstrations, as well as a proposed bill which might shut down operations. The GTHA has witnessed some protest from the taxi industry. Both Montréal and Toronto also have petitions in favor of Uber services,[9] however some municipalities within the GTHA have outright banned Uber services (Mississauga, Brampton). Cultural variations and sensitivities should be considered when designing and communicating microtransit plans and how they are communicated in Montréal and Toronto.	

1 Labour costs have been identified as the principal challenge to microtransit, based on interviews with stakeholders and secondary research.
2 This report does however account for the GHG emissions arising from electricity associated with existing public transit (Section 4.0).
3 The Big Move, 2008 http://www.metrolinx.com/thebigmove/Docs/big_move/TheBigMove_020109.pdf
4 https://en.wikipedia.org/wiki/Greater_Toronto_and_Hamilton_Area
5 Greater Montréal's transit governance could evolve in the next little while as a proposed law is currently being examined by the Montréal Metropolitan Community which aims at simplifying existing governance and split AMT's roles (planning and operations). See proposed model here: https://www.transports.gouv.qc.ca/fr/salle-de-presse/nouvelles/Documents/2015-11-12/modele-actuel.pdf
6 https://www12.statcan.gc.ca/nhs-enm/2011/as-sa/99-012-x/2011003/c-g/c-g01-eng.cfm
7 There is far greater reliance on public transit in Toronto than in other parts of the GTHA, roughly divided between buses and subways. York Region is roughly in the middle compared to other Central Region areas in its reliance on private vehicles; and second to Peel in reliance on public transit (12%). See: http://www.workforceinnovation.ca/sites/default/files/On%20the%20Move%20Report%202014.pdf
8 https://www12.statcan.gc.ca/nhs-enm/2011/as-sa/99-012-x/2011003/c-g/c-g01-eng.cfm
9 https://action.uber.org/toronto/

2.4.1 MICROTRANSIT DEVELOPMENTS: GTHA

Under the City of Toronto Act, the Toronto Transit Commission ("TTC") has a legal monopoly on public transit. Corporations are not allowed to charge a direct fee for transportation, but exceptions are made for tours or charter buses, as well as certain private sector shuttle services.

Uber, UberX, and UberHOP

In 2012 Uber launched in Toronto, initially offering limousine and taxi services (without being licensed as a broker with the City) and then expanding its services to include ride-hailing (UberX) in 2014 and a rush-hour shuttle service (UberHOP) in 2015. Uber has been quickly adopted by Torontonians, creating frictions with the established taxi industry.

In April 2016, the City issued draft rules to loosen regulation for the taxi industry while imposing new requirements for ride-hailing services such as Uber, including driver checks and the creation of "vehicle-for-hire" licenses.[1] City council legalized UberX on May 5 2016 and approved the following measures:

- Allow Private Transportation Companies ("PTCs") like Uber to operate in Toronto, booked only through a smartphone app, with a $3.25 minimum fare, no maximum fares, and "surge" peak-time pricing.
- Allow taxis to adopt "surge" peak-time pricing for rides booked via smartphone apps.
- Maintain requirements for taxis to have cameras, and flashing emergency lights, but not for PTCs. Have city staff report back next year on whether PTCs need cameras.
- Ensure PTCs and taxis have insurance of at least $2 million on all drivers for bodily injury, death and damages to people or property.

Conversely, on May 11 2016, the City of Mississauga suspended all operation of ride-sharing services including UberX.[2] Only ride-sharing companies that effectively follow the same regulations governing traditional taxi companies are legally allowed to offer services to Mississauga residents. The ban in Mississauga was lifted on May 25,2016 and the City set up a committee to create a framework for UberX and similar services. Earlier in the year, the City of Brampton had also suspended UberX operations until the completion of a public consultation.[3]

The disparities in the reception to Uber within the GTHA highlight the some of the work that should be considered when developing a microtransit strategy.

Line Six Transit

In the fall of 2014, a crowdfunded bus platform, "Line Six Transit", was launched to offer people an alternate bus option starting from the Liberty Village neighbourhood and serving multiple stops in downtown Toronto at peak hours. This route is typically one of the busiest in the city; the 504 streetcar carries more than 60,000 passengers a day. The Line Six service ran for less than two years before shutting down, mainly due to high upfront costs.

Microtransit

On January 21, 2016 a *Notice of Motion for a Staff Report on Microtransit* was passed in Toronto. With TTC ridership increasing and repeated calls for service improvements, it was suggested that microtransit could:

- Provide a transit option during off-peak periods in underserved areas.
- Reduce pressure on the capital budget by allowing the private sector to pay for any needed capital expenditures for microtransit deployment.

The TTC Board has requested a staff report on microtransit to be received by the second quarter of 2016 to allow TRB to make informed decisions on the impact of such services.

> ...STM is working to integrate bus, bicycle, metro, taxi, shared taxibus, carpooling, and carsharing to promote a **"smart combination of individual means of transportation"**.

2.4.2 MICROTRANSIT DEVELOPMENTS: GREATER MONTRÉAL

The Société de Transport de Montréal ("STM"), the authority responsible for managing Montréal's network of bus, metro, and paratransit services, is undertaking an experiment in integrated mobility. Within the Montréal region, STM is working to integrate bus, bicycle, metro, taxi, shared taxibus, carpooling, and carsharing to promote a "smart combination of individual means of transportation". Via this new model STM has reached agreements with various transportation providers to offer customers bundled and discounted services (i.e. discounts on Bixi bike rentals, Communauto, and others).[4] Fares are integrated across all modes of STM transit.

A central part of expanding this program involved transforming STM's relationship with the taxi industry into that of a key partner. This was accomplished by leveraging the taxi industry's role in the paratransit services market to address geographic gaps in the fixed-route transit network. STM now offers a shared taxibus service in areas where low

1 http://app.toronto.ca/tmmis/viewPublishedReport.do?function=getAgendaReport&meetingId=10981
2 https://www.thestar.com/news/gta/2016/05/11/mississauga-bans-uberx-and-other-ride-sharing-services.html
3 https://www.thestar.com/news/city_hall/2016/02/24/brampton-calls-on-uber-to-suspend-ride-sharing-service.html
4 http://www.stm.info/en/offers-and-outings/benefits/exclusive-offers

population density makes bus service impractical, meaning that 99.5% of the Montréal area is now covered by the STM network.

However new services from companies like Uber that can also provide microtransit services like UberPOOL and UberHOP have been facing a different set of challenges to establish themselves in Montréal area. In 2014, Uber launched its UberX operation in the Montréal area. This service now is said to offer roughly 300,000 trips every month and is used by nearly a half million people in the province.[1] A new bill, proposed by Quebec's Transportation Minister in May 2016, is aiming to introduce new requirements for taxi companies.[2,3] If passed, the Act would require remunerated passenger transportation services to use a taxi permit or face fines (for both the driver and the company). This means that all UberX drivers would have to buy or rent taxi licenses (which cost upwards of $200K on the secondary market), as well as meet other requirements (i.e. Class 4C drivers license, pay GST/PST, etc.).[4]

Since the launch of UberX, more than 1,000 cars have been seized and impounded by the Montréal Taxi Bureau, which charges drivers $1,000 to get them back. Some of the factors that may have contributed to this backlash have to do with the cost of expensive permits and commercial insurance that taxi drivers have to incur and Uber drivers currently do not. However, an in-depth examination of the reasons why this is a flashpoint in some regions and not in others is beyond the scope of this exercise.

Nonetheless, this troubled relationship between public authorities, the taxi industry and Uber will have to be factored in and carefully considered when designing any related microtransit strategies in the Greater Montréal area.

1 http://www.theglobeandmail.com/news/national/quebec-cabbies-to-file-court-injunction-in-hopes-of-getting-uber-off-the-roads/article28475293/
2 http://www.cbc.ca/news/canada/Montréal/quebec-uber-bill-jacques-daoust-1.3578819
3 In Quebec Uber falls under provincial, not municipal jurisdiction.
4 Uber has since proposed the creation of special ridesharing permits for its UberX drivers (May 31, 2016).

3. Profile of Microtransit Delivery Models and Use Cases

A scan of the existing literature was conducted to identify jurisdictions leading in microtransit deployment and the characteristics of these systems (Appendix B). Case studies are detailed in Appendix C and were chosen in order to illustrate the varying configurations microtransit can take (depending on involved stakeholders and objectives), categorized as follows:[1]

1. Public-Private Partnership (e.g. RideKC in Kansas City, U.S.A.)
2. Combined Mobility Service (e.g. UbiGo in Gothenburg, Sweden)
3. Private Enterprise (e.g. Bridj in Boston, Chariot in San Francisco, and Via in New York, U.S.A.)[2]

These selections reflect developments in public-private partnerships, for example between local transit authorities and on-demand transportation companies, and in combined mobility service models, which seek to aggregate various modes of travel for commuters (and in some cases prioritize sustainable options). Also profiled is private enterprise, arguably the most rapidly evolving new generation of microtransit offerings, particularly in the U.S.

Specific use cases for microtransit applications in the GTHA and Greater Montréal Area markets are presented. These use cases form the basis for the GHG savings estimates developed in subsequent chapters.

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1 Note that these case studies reflect the particular architecture of various microtransit models as opposed to the various applications/specific use cases that microtransit can address (i.e. particular routes). This latter area is the subject of Section 4.0. The models discussed in Section 3.0 are considered salient in that they offer a high level view of how microtransit can be deployed depending on who is involved and what the objectives are.

2 These categories are not mutually exclusive; partnerships between transit agencies and Uber or Lyft can be included under Category 1 for example, or even as a hybrid between Category 1 and 3.

3.1 DELIVERY MODELS

Public-Private Partnership: Public-private partnerships offer a means for local governments, transit authorities and private enterprise to collaborate on initiatives that otherwise may be construed as competing with incumbent transportation options and/or working at cross-purposes to regional priorities, such as GHG reduction. Partnership-based approaches may help smooth the development of systems that ideally benefit the public, accommodate the priorities of all parties involved, and leverage the various capacities each partner brings to the table. On the other hand, such projects may take more time to execute compared to private sector initiatives and can be costly. There is also the possibility that an overly prescriptive approach may erode the key attribute of microtransit: flexibility.

Combined Mobility Service: The concept of combined mobility service has found traction in the E.U. and other jurisdictions. These types of offerings are of interest in that they can act as a useful aggregator of local transportation options, provide granular data on daily travel patterns which can be of use when planning routes and serving demand, and offer a potential means to encourage more sustainable travel choices. This said, such projects may also require significant development time and financing depending on scope, objectives, available data, and proponents. One might also reasonably ask if the level of uptake by the public will meet expectations, as to date the most advanced applications have been deployed largely on a pilot or development level.

Private Enterprise: Overall, one of the key recurring questions with private sector microtransit enterprise is its relationship to public transit: will it complement and augment existing infrastructure or will it compete, thus drawing away ridership? These businesses have the advantage of being nimble and quick to fill real or perceived gaps in public transit, which can provide transit agencies with a practical and low cost way to backfill existing operations. However, these initiatives also run the risk of competing with or even replacing transit, potentially increasing GHG emissions, thus depressing fare revenues and potentially marginalizing low income and lower mobility population segments.

Table 3.1: Benefits and Drawbacks of Various Microtransit Configurations

Architecture	Benefits	Drawbacks
Public-Private Partnership	• Allows local governments, transit authorities and private enterprise to collaborate and leverage their strengths • May help expedite systems that benefit the public good (i.e. accessibility, GHG reduction)	• May take more time to execute • Can be costly • May erode the flexibility of services offered
Combined Mobility Service	• Can serve to aggregate existing options, making it easier for consumers to plan efficient trips • Can result in data that is useful to transportation planning • Can be designed to incentivize more sustainable choices • Helps households manage without vehicle ownership	• Can require significant system development time and financing (if developed from scratch) • Most uptake to date has been by early adopters; application to broader public remains to be tested
Private Enterprise	• Potential to augment transit networks by backfilling low density and underserved areas • Can be rapidly implemented to meet areas of high demand; costs are borne by private sector • Allows market to innovate freely	• Potential to draw away transit ridership and increase vehicle trips, congestion and environmental impacts • Could further marginalize low income and lower mobility population segments • Potential resistance from public and private transportation sector incumbents

Appendix C provides a more detailed treatment of each case study in support of the findings presented in this section.

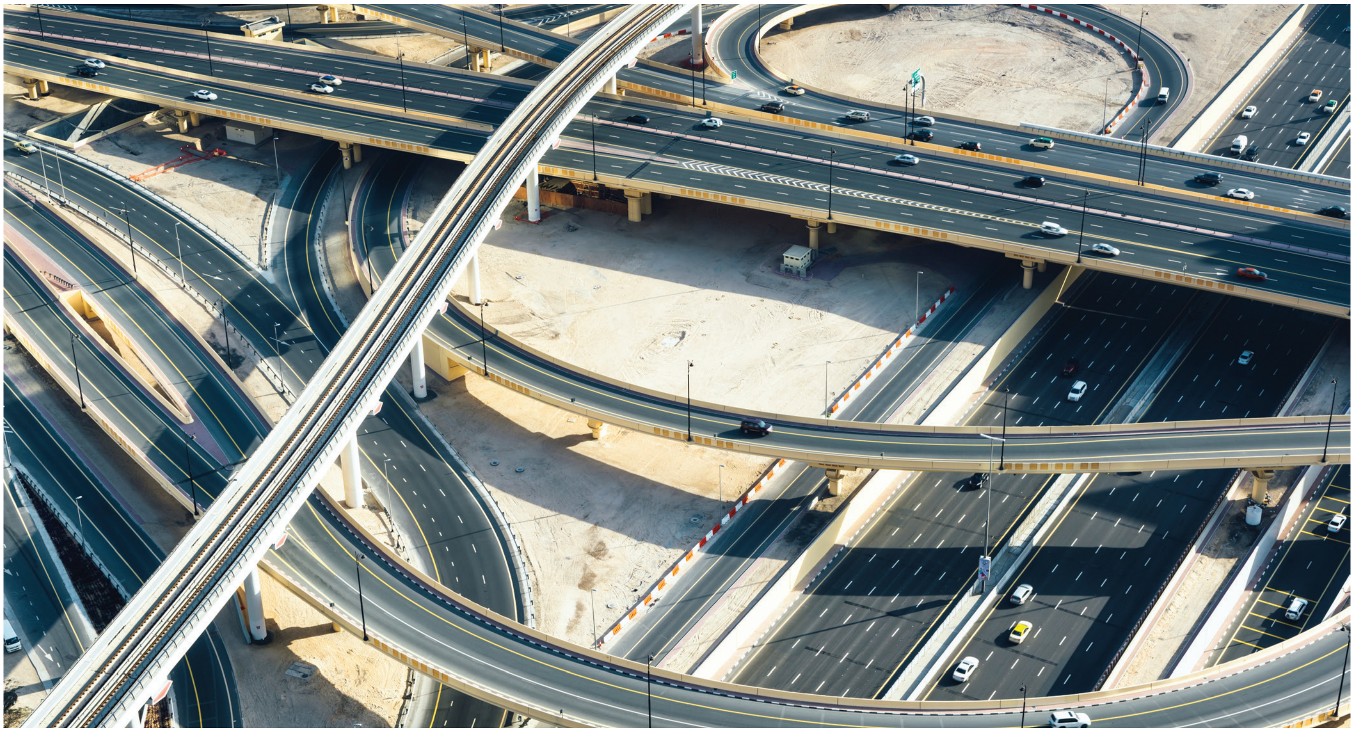
3.2 CONSUMER USE OF MICROTRANSIT

The secondary research and interviews uncovered a large variety of situations where microtransit can provide attractive alternatives to existing modes of transportation. These situations include typical commute trips such as suburb to downtown/suburb, to and from suburban public transit stops, and home to school or work. Conversations with experts and local stakeholders also surfaced additional "niche" uses for microtransit including underserved low-density areas, occasional trips (airport, sport and cultural events) or people with specific transit needs (accessibility, shift workers).

Table 3.2: Microtransit Use Cases Identified for GTHA and Greater Montréal Area

#	Title	Description
1	Suburban Rail: Shared dynamic shuttle services to suburban rail stations	Use of dynamic microtransit to substitute private car use to go to suburban rail and metro stations
2	Lower Density Neighbourhoods Underserved by Transit (trips originating in suburbs)	Use of dynamically allocated services to aggregate demand, especially at peak times, from passengers in underserved areas
3	Off-peak services to mid-density suburbs	Use of dynamically allocated services to aggregate demand from passengers at off-peak times to increase cost-effectiveness
4	Busy corridor commutes	Publicly or privately operated shuttle services based on fixed or dynamic scheduling to provide an alternative to fixed public transportation and to create additional capacity
5	Paratransit: Accessible and special transport services	Use of on-demand services to aggregate demand from passengers wishing to use accessible and special transportation services to improve cost-effectiveness, increase frequency and areas served
6	Downtown circulation	Substitute use of personal cars in downtown Toronto and Montréal with microtransit services. This could also include substitution of transit, walking, cycling with microtransit (though the data needed was unavailable to quantify the reverse effect) .
7	School drop off	Use of microtransit services to substitute for use of personal cars to drop off and pick up children at schools.
8	Airport drop off	Use of microtransit services to substitute for use of personal cars or taxis to drop off and pick up passengers from airports. This could also include substitution of transit with microtransit (though more data is needed to quantify the reverse effect)
9	Retail: Suburban malls	Use of microtransit services to substitute for use of personal cars or taxis to go to large retail malls, usually located in suburban areas
10	Shift workers	Use of microtransit services to provide shift workers with more options to go to and leave work at off-peak hours, where traditional public transit options are scarce.
11	Trip chaining – home-school-work	Substitute for use of personal cars to drop off children at school and then commute to work
12	Entertainment: Events	Use of microtransit services to transport a large number of people to sport and cultural events, reducing the number of personal cars on the road.

4. Methodology and Results



The following activities were undertaken to identify the best local opportunities for microtransit as well the potential GHG impacts resulting from deployment:

1. **Key stakeholder interviews having applicability to both the GTHA and Greater Montréal Area;**
2. **Identification of potential microtransit use cases and related assumptions, based on analysis of interview and research data; and**
3. **Development of a GHG model to estimate savings for each microtransit use case identified.**

4.1 STAKEHOLDER INTERVIEWS

As part of this exercise, a number of key stakeholders in the transportation sector were interviewed. These interviews were conducted to identify and understand the key variables affecting:

1. The adoption of microtransit in the GTHA and Greater Montréal Area; and
2. GHG emissions resulting from microtransit deployment compared to business-as-usual scenarios.

Stakeholders canvassed included private sector companies (10), regional transportation agencies (5), local municipalities (2), and academics and subject matter experts (3) from North America and Europe. Stakeholders are listed in Section 7: Resources.

Table 4.1: Sectors and Companies Interviewed			
Private Sector Transportation Companies	Transportation Agencies	Select Municipalities from the Region	Transportation Experts
Uber Kutsu+ RideCo Line Six Transit Netlift Line 6	Metrolinx Toronto Transit Commission Agence Métropolitaine de Transport Société de Transport de Montréal	City of Toronto City of Montréal	University of Toronto Montréal Polytechnique École de technologie supérieure (ETS) de Montréal Columbia University UC Berkeley Canadian Urban Transit Research and Innovation Consortium FleetCarma

The stakeholder interview template is included in Appendix D.

4.2 USE CASE IDENTIFICATION

The interviews were synthesized to identify the common patterns of people movement associated with successful microtransit initiatives in other jurisdictions and/or having relevance to well-known patterns of movement in the GTHA and Greater Montréal Area.

Two key factors were used to underpin this synthesis:

1. High volume movements of people that occur in a similar time and space; and that could potentially be aggregated; and
2. A likelihood of consumer willingness to share the journey under a microtransit service model (likelihood of mode conversion).

The suggested patterns to consider were then validated against available sources (primarily the *Transportation for Tomorrow Survey*) to verify their significance and identifiable patterns in the GTHA and Greater Montréal.[1] These patterns were distilled into "use cases" most applicable to each region.

The use cases developed for this study would likely have some overlap and therefore it is possible that there would be some double counting in baseline emissions considered across all the use cases and also the subsequent microtransit enabled emission reductions developed for each use case. Since this double counting was applied to both the baseline scenario and the emission reduction scenario it is anticipated that they cancelled each other out and had minimal impact on the results obtained.

The use cases are summarized in Table 3.2 presented in Section 3. More detail on each use case is provided in Appendix F.

4.3 GHG MODEL

To determine the potential GHG impact of consumers switching from the incumbent mode of travel to microtransit, a model based on existing baseline and projected GHG emissions was developed and applied to each use case. Baseline and projected emissions were based on the following factors:

Baseline GHG levels: For each use case, data was obtained on the i) number of relevant annual vehicle journeys (personal car and taxi) and total distance traveled.[2] Research was also conducted into: i) the vehicle occupancy rate, ii) emissions for the vehicle and fuel type, and iii) any use case specific factors (i.e. inefficiency, such as the reported 20% inefficiency for paratransit modes).

Projected GHG levels: Assumptions on the total number of journeys and distance travelled were kept the same as the

1 The Transportation Tomorrow Survey collects information on the demographics (age, gender, etc.) and travel choices and preferences of people who live in the Greater Golden Horseshoe Area. The survey aims to find out how, where and where trips were made on weekdays. See: http://www.transportationtomorrow.on.ca/

2 Personal vehicle travel was used as the incumbent GHG baseline level for the use cases as other modes (i.e. transit) were not available within the study timeframe. It should be noted that this will result in the most optimal GHG scenarios exhibited by use case. Further work will be needed to refine the baseline GHG levels for the use cases, particularly those that currently make use of public transit and lower impact transportation modes.

baseline. Research (based on interviews and expert input) informed assumptions on the following factors: i) the likely switching rate by consumers to microtransit to calculate the associated journey miles covered, ii) the inefficiency to account for when empty between pick ups, iii) the GHG emissions resulting from the type and size of microtransit vehicle employed (car/van/small bus), and the fuel type used (gas/hybrid/electric).

The detailed GHG model and methodology is outlined in Appendix E. The use case specific values assumed for each factor are in section 4.3.2 below.

4.3.1 DATA SOURCES FOR BASELINE TRAVEL PATTERNS

Several relevant sources of data have been employed in estimating baseline travel patterns and transportation-related GHG data for both study areas. Detailed distribution of the travel patterns observed can be found in Appendix E.

For the GTHA, we had access to the Transportation Tomorrow Survey (2011) data exploration tool, which is the most comprehensive source of data existing for this area. Conducted by a consortium of regional and provincial transportation agencies, this telephone-based survey provides a detailed profile of household travel behaviours in South Central Ontario.[1]

A similar "Origin to Destination" study has been conducted by Montréal's Agence Metropolitaine de Transport ("AMT") in the same timeframe. However, for this analysis only aggregate data was made available from the study. As a result, reduction estimates for Montréal were developed only for the potential of microtransit to offset aggregate, and non-use case specific, vehicle household travel in this region (as opposed to on a per use case basis as was done for GTHA). The total emission reduction exhibited in aggregate for GTHA was extrapolated to the Greater Montréal data to arrive at this estimate.

GHG emissions for the transportation sector were sourced from Natural Resource Canada's GHGenius model, Plug n' Drive, TAF Reports and the Low Emissions Van Guide.

4.3.2 ASSUMPTIONS

Specific assumptions made for the identified factors in the GHG models for both baseline and projected GHG levels for all use cases are listed in Table 4.2 and for specific use cases in Table 4.3.

Table 4.2: Table of factor level assumptions for all use cases

	Assumptions for all use cases

Baseline GHG levels	i) number and distance of relevant vehicle journeys:
	• Where the Transportation Toronto Survey is used,
	  • the GTHA scope includes planning districts 1-46 only based on an overlay of Metrolinx map
	  • only weekdays are accounted for, with 261 weekdays in one year (this figure includes work days and public holidays) as only weekdays are included in TTS
	• Population and location of population remains constant over time
	• Table E2 in Appendix E outlines the exact data source and parameters for each use case.

	ii) vehicle occupancy rates: • Occupancy rates are use case specific (see below) • Occupancy for all vehicles are averaged over the duration of the trip
	iii) Emission rates for vehicle and fuel types • Emissions Rates (kg CO2eq/km): Avg personal vehicle: 0.23; Sprinter Van: 0.23; Bus: 1.49.[2] • Average emissions intensity factors are used for the vehicle mixes found in both study areas • Emission levels of vehicles do not account for full lifecycle of vehicle (tailpipe only)

1 See more at: http://dmg.utoronto.ca/

2 Source GHGenius, 2013 http://www.ghgenius.ca/downloads.php

Projected GHG levels	i) total number and distance of journeys • Total number and distance of journeys taken from baseline GHG levels factor
	ii) switching rate by consumers to microtransit: • Assumptions made on a use case specific basis
	iii) vehicle occupancy rate: • 6-person occupancy on an 8-person sprinter van for all use cases except where stated in specific use case
	iv) inefficiency factor: • Routing inefficiency set to 1.1 (i.e. a 10% inefficiency in routing) based on key informant interviews for all use cases except paratransit
	v) Emission rates for vehicle and fuel types[1] • Electric vehicles (kg CO2eq/km): Car: 0.01; Sprinter Van: 0.01; Bus: 0.01 • Hybrid vehicles (kg CO2eq/km): Car: 0.07; Sprinter Van: 0.07; Bus: 0.102[2] • Conventional vehicles[3] ((kg CO2eq/km): Car: 0.23; Sprinter Van: 0.23; Bus: 1.49 • Mixed fleet (kg CO2eq/km based on average of electric, hybrid, and conventional vehicles): Car: 0.101; Sprinter Van: 0.101; Bus: 1.49 • Average emissions intensity factors are used for the vehicle mixes found in both study areas • Emission levels of vehicles do not account for full lifecycle of vehicle (tailpipe only)

Table 4.3:	**Table of factor level assumptions for specific use cases**
Use Case Specific Assumptions	
Suburban Rails	
Baseline GHG levels	i) vehicle occupancy rate: 1.2 people per vehicle (Single Occupancy)
Projected GHG levels	ii) switching rate by consumers from personal vehicles to microtransit: reaching 20% over 5 years.
Lower Density Neighbourhoods Underserved by Transit (trips originating in low density suburbs)	
Baseline GHG levels	i) vehicle occupancy rate: 1.2 people per vehicle (Single Occupancy)
Projected GHG levels	ii) switching rate by consumers to microtransit: reaching 5% over 5 years
Paratransit	
Baseline GHG levels	i) vehicle occupancy rate: 2.5 people per vehicle
	ii) a use case specific assumption of a currently inefficiency of routing was set at 1.2 based on TTC estimate[1].
Projected GHG levels	iii) switching rate by consumers to microtransit: 0 – i.e. same user base as baseline
	iv) vehicle occupancy rate: remains at 2.5 people per vehicle
	v) inefficiency factor: set to 1.2 to represent the 20% efficiency gain estimated by TTC from application of microtransit technology.
Downtown Circulation	
Baseline GHG levels	i) vehicle occupancy rate: 1.2 people per vehicle (Single Occupancy)
Projected GHG levels	ii) switching rate by consumers to microtransit: reaching 15% uptake over 5 years.
Movement away from transit & active transport. E.g. biking, walking	iii) Due to a lack of data on when and under what conditions, a customer would move from walking, cycling and transit to microtransit, the impacts of these shifts, while potentially significant were not quantified for this exercise. It is strongly recommended that further work be undertaken to understand the drivers, scope and scale of this shift.
School Drop-offs	

1 GHGenius, 2013 http://www.ghgenius.ca/downloads.php

2 https://www1.toronto.ca/city_of_toronto/waterfront_secretariat/files/pdf/ch_6-transportation.pdf

3 https://plugndrive.ca/sites/default/files/Electric%20Vehicles%20-%20Reducing%20Ontario's%20Greenhouse%20Gas%20Emissions%20-%20A%20Plug'n%20Drive%20Report.pdf

4 interview with TTC staff

Baseline GHG levels	i) vehicle occupancy rate: 2.0 people per vehicle
Projected GHG levels	ii) switching rate by consumers to microtransit: reaching 20% uptake over 5 years.
Airport Drop-offs	
Baseline GHG levels	i) number and distance of relevant vehicle journeys Assumes all travel in traffic zones of airports was for the purpose of airport drop offs or work.
	ii) vehicle occupancy rate: 2.0 people per vehicle
Projected GHG levels	iii) switching rate by consumers to microtransit: reaching 10% uptake over 5 years.
Retail	
Baseline GHG levels	i) vehicle occupancy rate: 1.0 people per vehicle (Single Occupancy)
Projected GHG levels	ii) switching rate by consumers to microtransit: reaching 10% uptake over 5 years.
Shift Workers	
Baseline GHG levels	i) vehicle occupancy rate: 1.2 people per vehicle (Single Occupancy)
Projected GHG levels	ii) switching rate by consumers to microtransit: reaching 20% uptake over 5 years.
Entertainment	
Baseline GHG levels	i) number and distance of relevant vehicle journeys 42% of "Other" travel is for entertainment (based on TTS 2006 proportion of leisure travel).
	ii) vehicle occupancy rate: 1.0 people per vehicle
Projected GHG levels	iii) switching rate by consumers to microtransit: reaching 20% uptake over 5 years.

Information on travel patterns in Montréal was provided in aggregate form parsed by 10-kilometre bins (1-10; 10-20; 20-30; 30-40; 40-50; 50+), with data on the corresponding number of trips in each bin. No information was provided about the distribution of travel distances within each bin. For the purposes of the Montréal model, trips under 0.99 kilometres were not included. As no maximum distance was provided, 100 kilometres was selected as the maximum for the 50+ kilometre bin. This information resulted in the development of emissions reduction scenarios based on bin maximums, minimums, and mid-ranges. In the absence of detailed information, emissions scenarios based on mid-range distances are presented for consideration.

The assumptions used for the GTHA use cases (i.e., kilogram CO2 equivalent per kilometre emissions for each car type, occupancy changes, as well as a 10% routing inefficiency) were also applied to the aggregated Montréal travel data. Due to the absence of detailed information on specific travel patterns, the development of use cases for Montréal was not possible within the study timeframe.

4.4 RESULTS

Results from the analysis are listed in Tables 4.4 and 4.5 and, where available information exists, show the potential GHG impacts associated with each use case.

For the GTHA, potential GHG emissions reductions associated with deployment range from ~515 to 654 kilotons, depending on the fuel source used in the microtransit fleet scenarios.

Table 4.4: GTHA GHG Emissions Impact Scenarios representing cumulative reductions over five years (in kilotons CO2eq)

Use Cases*	Current Emissions (per year)	Hybrid Shuttle Fleet (5 yrs)	Electric Shuttle Fleet (5 yrs)	Conventional Shuttle Fleet (5 yrs)	Mixed Shuttle Fleet [1] (5 yrs)
Suburban Rail	208.72	-39.16	-41.28	-32.56	-38.38
Lower Density Neighbourhoods Underserved by Transit (trips originating in suburbs)	9,131.52	-428.32	-451.49	-356.13	-412.43
Paratransit	8.23	-1.18	-1.58	-0.27	-1.04
Downtown Circulation	9.54	-1.34	-1.42	-1.12	-1.32
School Drop-offs	41.74	-7.49	-8.19	-5.29	-7.00
Airport Drop-offs	30.16	-2.71	-2.96	-1.91	-2.53
Retail	110.09	-10.44	-10.91	-8.99	-10.12
Shift-workers	511.19	-95.91	-101.10	-79.75	-85.76
Entertainment	237.13	-33.74	-35.24	-29.05	-29.84
Total Emissions Impact	10,288.35	-620.29	-654.16	-515.06	-588.42

* Does not include the following use cases due to lack of data: 3) Off-peak services to mid-density suburbs; 4) Busy corridor commutes; and 11) Trip chaining – home-school-work.

Aggregate emissions reductions estimates for the Greater Montréal Area were based on high-level data provided by AMT, which provided the total number of all vehicle trips for all purposes grouped into 10 km distances. A 5% conversion of all household vehicular travel in this region to shared transit (based on aggregate trends developed for the GTHA) would result in reductions ranging from 154 to 191 kilotons, depending on the fuel source used in the microtransit scenarios.

Table 4.5: Greater Montréal Area GHG Emissions Impact Scenarios representing cumulative reductions over five years (in kilotons CO2eq). Analysis conducted in aggregate as more granular scenario level data was not available.

Montréal Travel	Current Emissions (per yr)	Hybrid Shuttle Fleet (5 yrs)	Electric Shuttle Fleet (5 yrs)	Conventional Shuttle Fleet (5 yrs)	Mixed Shuttle Fleet [2] (5 yrs)
Emissions Impact		-182.76 (at 5% uptake)	-191.93 (at 5% uptake)	-154.19 (at 5% uptake)	-174.2 (at 5% uptake)
Total Emissions	3,879.59	3,696.20	3,687.03	3,724.77	3,704.23

These estimates, when matched with future research to assess public appetite for various microtransit services and other factors critical to the success of micrtoransit, will form an important starting point for developing a microtransit strategy that prioritizes GHG reductions. The methodology used for deriving these savings numbers is detailed in Appendix E.

1 Assuming an equal breakdown between gas, electric, and hybrid configurations.

2 33% h

4.5 DISCUSSION

Figure 4.1 shows the potential GHG emissions reductions for each use case and also gives a sense of the scale and proportion of these impacts relative to other use cases. While the Low Density suburb use case is responsible for the largest emission impact, the biggest variable that influences the actual GHG reductions is the rate of consumer adoption for each use case. This variable is one of the primary drivers of potential reductions and is also one of the hardest variables to predict without further research.

Figure 4.1: Total GHG emissions reducing by use case over time

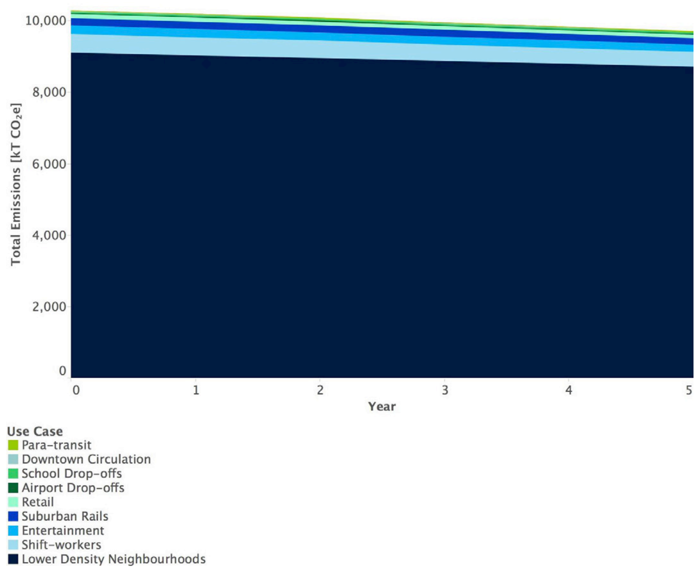
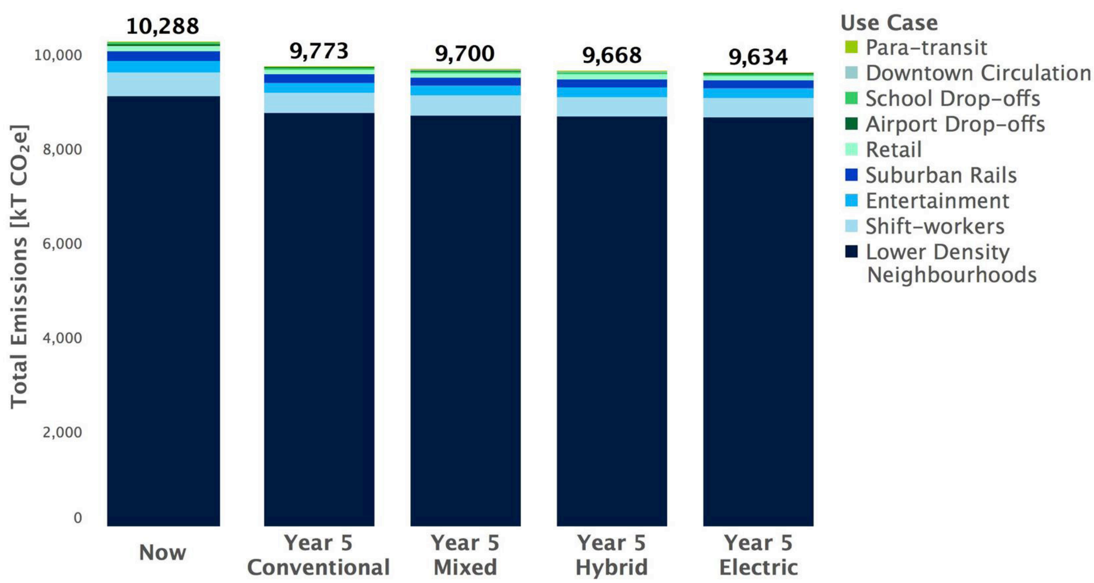


Figure 4.2 shows how the technology or technology mix used to replace existing modes of transportation impacts emissions. While the vehicle technology employed (conventional, hybrid or electric) does have an impact on emissions, the savings generated by different technology adoption pales relative to the potential savings that can be driven through consumer adoption of microtransit alternatives when applied to the overall baseline.

Using electric vehicles to deliver microtransit services would result in the greatest GHG emission reductions. However, factors such as vehicle range, current availability of charging infrastructure, gas prices, and policy context (as in the committed support for EV charging infrastructure under Ontario's recently announced Climate Action Plan) will all play into the mix of solutions that should be considered. Within a five-year time frame, hybrid vehicles could provide a more readily available alternative as they have good range, provide payback for vehicles that cover large distances and are based on a technology that is tested and can be supplied at scale.

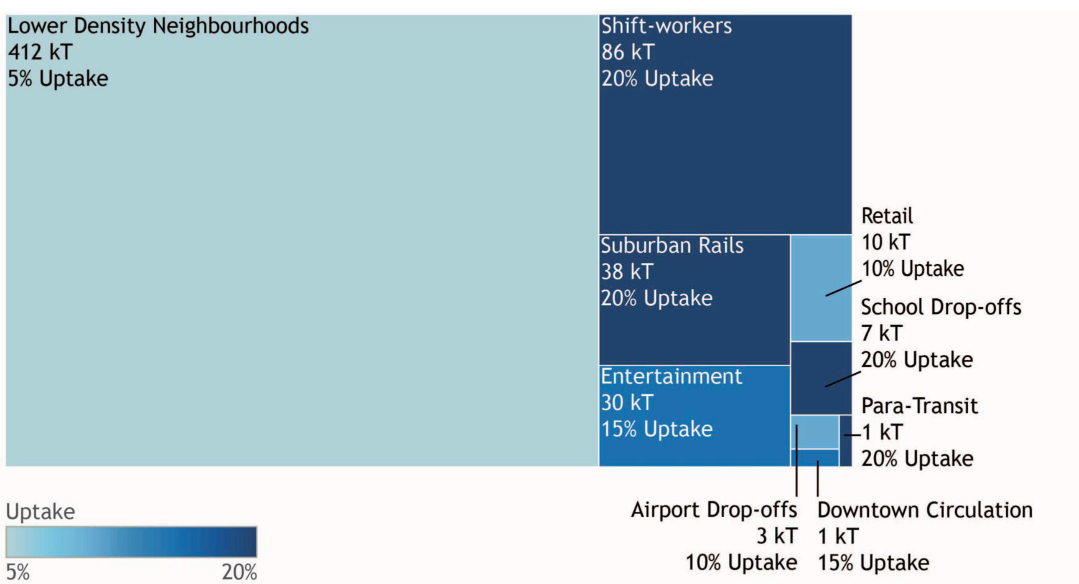
Figure 4.2: GHG reductions based on replacement vehicle technology used for microtransit



*mixed scenario assumes an equal one-third split between conventional, hybrid and electric vehicles

Figure 4.3 demonstrates key variables that could enable microtransit initiatives to achieve GHG reductions. One key variable to consider would be the use case size (i.e. size of the rectangles below) and another would be the predicted rate of customer adoption of microtransit for that use case (with darker squares representing higher likelihood of adoption). In reality, a mixed approach could be considered, with both those use cases that have a higher predicted rate of adoption but smaller volume and savings potential (e.g. school drop offs) and also a focus on large volume use cases that may initially exhibit a lower level of adoption (e.g. low density suburban commute). As mentioned previously, the hardest variable to define/assume in this exercise is estimating customer adoption for each use case. These estimates were developed based on discussions with key stakeholders and subject area experts. Further work must be undertaken to refine these assumptions (see Section 5).

Figure 4.3: GHG reductions per use case based on estimated customer uptake of microtransit



5. Research Questions for Future Microtransit Deployment

The previous Section 4.3 stated a number of generic and use case-specific assumptions that were made in order to estimate the potential GHG emissions reductions resulting from microtransit deployment in the GTHA and Greater Montréal Area. The following outlines key areas that should be further explored in order to validate these assumptions, refine our results, and build on our initial recommendations on how to approach this work.

5.1 REFINING CONSUMER PREFERENCE

As was exhibited in Figure 4.3, consumer preference/uptake is one of the largest variables impacting microtransit utilization and the subsequent savings that can be realized. Opportunities to further refine consumer preference/ microtransit adoption estimates include:

1. Conducting stated preference surveys to better understand consumer willingness to adopt microtransit solutions;
2. Conducting ethnographic research to better understand the context under which customers would use microtransit services and what impact that this would have on their lives; and
3. Leveraging (1) and (2) to fully understand elasticity of consumer preference and their thresholds for both price and convenience (e.g. door-step pick-up, on-demand service, ability to use time productively).

Consumer preference/ uptake is one of the largest variables impacting microtransit utilization

While consumer preference findings would be useful to estimate GHG savings potential of microtransit adoption in specific use cases, it is equally critical to understand how microtransit could potentially increase GHG emissions in use cases where microtransit replaces transportation modes with lower emissions intensity such as walking, biking, carsharing and even transit.

Due to the limited origin, destination, frequency of data available for these other modes of transportation and – equally importantly – the current lack of understanding of consumer preference for mode-switching, these areas need further exploration.

5.2 REFINING GHG ESTIMATES

As mentioned above, personal vehicle travel was used as the incumbent GHG baseline level for the use cases as detailed data on other modes (i.e. transit, cycling, walking) was not available within the study timeframe. This approach has resulted in the most optimal GHG scenarios associated with each microtransit use case.

Further work will be needed to refine the baseline GHG levels for the use cases, and particularly so for those that currently make use of public transit and lower impact transportation modes (for example: the downtown circulation use case).

5.3 AUTONOMOUS VEHICLES ("AV")

Transportation experts have predicted that the first commercially available AVs will be available by 2020.[1] As these vehicles begin to increase in market share, their potential application to microtransit may significantly alter the cost structure of microtransit services due to impact on labour costs. These reductions could in turn substantially change the economics of microtransit services and therefore have a significant positive impact on adoption, however these projections are a number of years away from playing out. Nonetheless, the introduction of AVs and related technology needs to be considered in any longer-term microtransit strategy.

5.4 LIFECYCLE ANALYSIS OF MICROTRANSIT DEPLOYMENT

Microtransit services can result in a movement away from existing modes of transportation (personal vehicles, buses, transit) to modes of transportation (sprinter vans, mini-buses, shuttles, etc) used for microtransit. At the same time, the retirement/decommissioning of existing vehicles and the development, manufacturing and procurement of new vehicles can create substantial GHG emissions.

Future assessments of the net GHG impact of microtransit should include a lifecycle analysis of the impact of adding a new fleet of vehicles to deliver microtransit services – as well as the corresponding reduction in purchases of personal vehicles.

5.5 ADDITIONAL IMPACTS OF MICROTRANSIT DEPLOYMENT

As microtransit services can have a wide array of impacts beyond GHG emissions, the development of a microtransit strategy should consider its likely influence on other important social and economic objectives. Other impacts, such as those listed below, can further strengthen or weaken the case for microtransit deployment.

1. **Impact on congestion within urban centres.** To the extent that microtransit reduces congestion, it would also result in less idling, improved air quality, greater productivity and lower emissions. If the converse proves true, it could result in a rebound effect with greater personal vehicle use in urban centres, lower productivity, and subsequently higher emissions;
2. **Impact on urban sprawl.** Mictrotransit could lead people to live further and further away from urban city centres due to improved travel times and productivity. This urban sprawl could increase the carbon footprint per household, among other impacts;
3. **Investments and improvements in technology as microtransit scale.** These factors could dramatically increase the demand for and potential to deliver more on-demand products and services. While this would leverage shared transportation services, reduced cost and efficiencies could dramatically increase the volume of services offered, which may pose another kind of rebound effect; and
4. **Impact on the need for parking lots and spaces** in urban centres (or the converse).

Further enquiry into some of these impacts is warranted.

1 As per Barrie Kirk, Co-Founder and Executive Director, Canadian Automated Vehicles Centre of Excellence ("CAVCOE") and other key transportation experts speaking at a recent 2016 event: https://storify.com/cbocevents/automated-vehicles-planning-the-next-disruptive-te

5.6 USE CASE-SPECIFIC RESEARCH

Table 5.1 highlights a number of research questions that should be considered in order to refine the various use cases employed in this scoping study.

1

Table 5.1: Potential for Future Research	
Use Cases	Future Research
Refinement across all use cases	• Dynamic, agent-based modeling to better reflect the choices of individuals and to reflect varying conversion rates to microtransit by different socio-economic groups, household composition and reasons for travel as well as to factor in population growth projections, facilitators, and barriers for uptake of microtransit • Data on types and distribution of current vehicles in order better estimate current GHG emission rates. • Data on weekend travel patterns • The use cases reviewed in this case study may not have all been mutually exclusive and so it is possible that there may be some double counting in some use cases. This should be addressed to obtain more refined GHG reductions estimate. For example, the airport drop off use case may overlap with the lower density neighbourhood use case.
Suburban Rails	• GO ridership and parking survey data, including on-peak and off-peak use. • Similar data from AMT's annual on-board surveys • Geographic information on home location (as origin and destination) to help determine potential conversion to microtransit for the "last mile"
Lower Density Neighbourhoods Underserved by Transit (trips originating in suburbs)	• Environmental Systems Research Institute ("ESRI") mapping of transit services for both on-peak and off-peak of all Planning Districts[1] ("PDs") to determine degree of service, and proxy potential car dependency.
Paratransit	• Transit data beyond TTC paratransit catchment to include full study area. Paratransit data for Montréal
Downtown Circulation	• More detailed data on occupancy rates and purpose of travel (e.g. from taxis) to better estimate conversion potential • Revealed preference survey to estimate under what conditions people might be willing to convert from transit, walking or cycling to microtransit
School Drop-offs	• Data or estimates on travel for individuals under age 11 (currently unavailable in Transportation Tomorrow Survey). Acquire similar data for Montréal area from AMT.
Airport Drop-offs	• Data on mode of arrival to, and departure from, airports
Retail	• Data on types of retail (e.g., major retailers, corner stores, big-box stores, shopping centres). Potential footfall and mode of arrival and departure data from major retailers or firms that track retail location footfall.
Shift-workers	• Information on type of shift work (e.g. factory, retail, etc) and refined geographic location of home (as origin and destination) to help determine density of shift workers to determine potential conversion and efficiency of microtransit and shared transit.
Entertainment	• Up-to-date travel data for entertainment events, including type of entertainment, from major venues or from firms that track ticket sales and entertainment venue footfall.

1 A "planning district" is a spatial area used, among other purposes, to provide a land use planning system in the Province of Ontario. (cite: xhttp://www.mah.gov.on.ca/Page1760.aspx) There were 46 planning areas in the GTHA, as determined using maps made publicly available by Metrolinx.

5.7 STAKEHOLDERS ESSENTIAL TO DEPLOYMENT

Throughout the process of conducting research for this study, both within the study area and in international markets, it became evident that designing and executing an effective microtransit pilot or scaled roll-out will require a diverse set of stakeholders. Based on the research to date, key stakeholders from the GTHA and Montréal areas should include but not be limited to:

- Existing public transportation companies (i.e., TTC, GO Transit, AMT, STM, Mississauga Transit, York Region Transit, etc.);
- Regional transportation authorities (i.e., Metrolinx and AMT);
- Existing private sector microtransit service providers (i.e., Uber Hop, Uber Pool, RideCo, Netlift, etc);
- Municipalities in the GTHA and Montréal Areas (i.e., Transportation, Finance & Environment departments);
- Provincial Ministries of Transportation (Ontario and Quebec);
- GHG and Social Innovation partners and potential funders;
- Existing shared mobility service providers (taxi, carsharing, bikesharing etc);
- Insurance companies; and
- Labour unions at transit companies.

Given the multiple interests and varying priorities of the stakeholders identified to date, successful stakeholder engagement will likely necessitate the use of a neutral third party facilitator with subject area expertise. It will be important to start the discussion by effectively communicating the benefits that each party could realize from microtransit within that region, and then leverage these interests to develop a strategy for follow-on work.

Scoping studies such as this report and any subsequent research can form the basis for initial discussions and engagement with some of the key stakeholders identified above.

6. Conclusions and Recommendations

6.1 POTENTIAL GHG SAVINGS

Microtransit has the potential to transform the number and types of vehicles used in the transportation sector and positively affect the sector's environmental impact. Based on the findings to date, microtransit as defined in this paper is still in its early stages of implementation. Multiple models of deployment are being market tested and there are not yet any verifiable results regarding their GHG impact.

This study provides an important contribution that initiates exploring the link between microtransit and potential GHG savings. The expert insight gained from market research and data on current travel patterns indicate there are some clear use cases associated with common travel patterns where microtransit could yield significant GHG reductions for both the GTHA and the Greater Montréal Area.

In the Greater Montréal Area, microtransit could potentially deliver GHG reductions of up to 174.2 kt or 3.8% of emissions from personal transportation by capturing 5% of personal car travel with a mixed microtransit fleet scenario.

The use cases for the GTHA identify discrete opportunities for introducing microtransit at scale to address key travel needs. The GHG emissions associated with use cases considered across the GTHA are 10,288 kt, with the potential to save 588 kt (or 5.7%) based on assumptions outlined for consumer adoption over five years and using a mixed fleet scenario.

Among the use cases examined, overall emissions are dominated by commutes that originate in lower density neighborhoods underserved by transit. While this use case represents 89% of emissions among all the use cases examined, it may be the hardest to convert to microtransit due to its diffuse travel patterns and a high consumer dependency on vehicles. Although smaller in GHG reduction potential, other use cases (such as school travel and downtown car and taxi trips) are more concentrated in time and space and thus may exhibit higher likelihood for adoption.

The primary factors that determine GHG savings by displacing private car travel include:

1. The size/scale of the travel patterns being addressed (i.e. distance and volume of vehicular traffic);
2. The willingness of consumers to share those journeys (based on proxies from carpooling, carshare schemes and microtransit deployments to date); and

3. The estimated occupancy for microtransit vehicles.

Vehicle type used in microtransit (i.e., electric cars) and routing inefficiencies were identified as secondary contributors to potential savings.

The substitution of other modes of travel such as transit, cycling and walking, could result in GHG increases for those use cases that currently exhibit these modes for the majority of travel. There exist few proxies in the market today for estimating the potential for this substitution, however this area needs to be better understood.

The baselines employed and projected estimates for each use case will need to be refined in subsequent studies to further refine the GHG emission reduction impact of microtransit.

6.2 KEY FACTORS FOR ADOPTION

Adoption of microtransit is dependent on providing a service that is highly convenient – both in terms of being very timely and reliable. The service must also be reasonably priced relative to the apparent cost of alternatives, such as private cars (where the per-trip cost is less apparent) or transit (where the cost per-trip is typically more apparent). The specific factors identified from the deployment models reviewed and evidence gathered from other jurisdictions are shown in Figure 6.1.

Figure 6.1: Key factors for consumer adoption and GHG savings from microtransit

Consumer adoption ⟷ **Potential GHG savings**

Consumer adoption

1. High frequency or timeliness of service
2. Wide coverage and connection to other modes of transportation
3. Lower price relative to personal car or taxi
4. Willingness to travel with others

Potential GHG savings

1. Ubiquity of service high enough to substitute for personal cars in key use cases
2. Integration of microtransit deployment pattern with existing transit services to increase transit use in overall trip
3. Higher price relative to transit

Although the research to date has helped to identify the potential for GHG savings resulting from the substitution of private car journeys, the potential for substituting transit and active transportation has also been identified as a consideration. The key factors that will influence this consumer choice is how convenient microtransit is and its ability to integrate with transit for the whole trip, in addition to the price point relative to transit as the perceived alternative. Publicly licensed or managed microtransit services could also assist with greater consumer confidence as well as lead to integrated services and pricing with traditional transit modes.

Consumer uptake can also be encouraged by focusing on distinct and largely substitutable travel patterns (i.e., travel to outermost suburban rail stations or within the downtown core may more easily achieve an optimal price and convenience point). More diffuse patterns are harder to deliver on price/convenience benefits as well as pose difficulties for effectively sharing this mode.

Amongst microtransit developers and participants interviewed, there was a general thesis that there is a minimum scale needed for microtransit to be viable. Any such initiative will need to leverage optimal routing algorithms to maintain high occupancy (low emissions/capita/km), high quality of service (frequent pick-up) and to also reach cost efficiencies (i.e., through leveraging economies of scale through wider deployment).

6.3 FURTHER RESEARCH

Consumer uptake is the most significant variable which will influence the GHG impact of microtransit. While the current data on consumer uptake is insufficient, it will be most influenced by convenience and price.

Developing and testing pricing relative to existing transportation options is critical to determining the longer-term viability of a microtransit service model and its ability to scale to move larger volumes of passengers. As referenced in Section 4, stated preference surveys can play a significant role in narrowing down 'willingness to pay' values for different use cases. This can also reveal the extent to which certain travel patterns are inelastic and consumers have a dependency on certain forms of transportation, where the need for having necessary transportation will overcome lower levels of convenience or higher price.

Consumer response for microtransit services will likely vary by use case, however key data could provide better estimates of travel patterns. This data and areas of refinement are listed in Table 6.1.

While the identification of major travel patterns and use cases is sufficient to scope the potential for and magnitude of microtransit adoption, the approach taken in this study relies on a static model with general assumptions about how modes interact, the routes taken, potential to share routes in time and space and consumer willingness to share for all consumers in each pattern. In reality these choices are very fluid and impacted by the choices of others, including those in the same household. In a fuller planning study a more complete understanding could be better achieved by a more activity-based and dynamic model (Miller et al 2015[1]). This is a more complex model but allows more realistic simulation of how different people will respond to the different variables that determine their choice of transportation mode.

While this study has mainly focused on microtransit and its impact on GHG emissions, microtransit can affect many other areas of public benefit. For example, microtransit has the potential to impact traffic flow and volumes, air pollutants, requirement for parking, car ownership and access to other transportation services. If a microtransit strategy is developed for the GTHA and Greater Montréal Area, it is important to consider the impact on these other variables (and associated stakeholders). Such a comprehensive analysis could significantly strengthen or weaken the business case for deploying microtransit.

6.4 CONSIDERATIONS FOR DEPLOYMENT

6.4.1 MARKET FACTORS AND EVOLUTION

Given the rapid development of microtransit, urban centers like the GTHA and the Greater Montréal Area have an opportunity to take some very deliberate steps to define and test new microtransit options that could enable the transportation sector to evolve. This can include offering improved microtransit enabled public transportation services, which achieve GHG reduction objectives and realize other related benefits related to social equality and access. To some extent, small-scale implementations of these partnerships can already be seen in the Milton Metrolinx and RideCO pilot and through the taxibus services model being employed by STM in Montréal. Both jurisdictions should undertake a process to prioritize identified "opportunity areas" based on (a) the level of existing transportation services to identify opportunities; and (b) the level of intervention required to achieve optimal outcomes to target the low hanging fruit first.

> **…urban centers** …have **an opportunity** to take some **very deliberate steps** to define and test **new microtransit options…**

As these models scale, there will be a trade-off between a widely available and cost effective service that is attractive enough to capture potential consumer demand and one that does not unduly substitute for low carbon transit and active transport. There are varying opinions as to the role of policy in facilitating market adoption of microtransit services – or conversely, in limiting the growth of these services where they do not support broader policy goals. Even if there were consensus regarding the role of policy, predicting its influence on the market with any certainty would be challenging. Different policy approach options require further testing and validation in the real world.

The capacity of the market to supply services at a scale also needs to be encouraged, for example by removing restricted monopolies on inter-suburb bus services, integrating fare card and payment systems with transit, providing personal tax incentives for regular use of microtransit rather than a car, and/or providing funding and tax structures to operators to ease the high initial capital costs for development.

6.4.2 REGIONAL AND CULTURAL CONTEXT

Public expectations, cultural acceptance and values are still evolving, as are emergent technologies. Each region will also have different contextual and cultural needs and wants. Within the GTHA, some municipalities like Toronto have exhibited proactive engagement with and incorporation of new ridesharing and TNCs into an acceptable regulatory model, whereas other municipalities such as Brampton and Hamilton have taken a radically different approach to such services. There is also some interest from regional transportation agencies in exploring alternative and complementary models to address service capacity constraints and in examining ridership patterns for noticeable shifts in ridership.

Within Greater Montréal Area there have been fewer at-scale market deployments or collaborations with transit agencies to explore potential uses of microtransit. This said, agencies have been proactive in exploring combined mobility service models that leverage existing assets (i.e., public transit, taxibus, bikesharing).

Both the GTHA and the Greater Montréal Area are comprised of multiple municipalities. To attract and develop optimal microtransit products and services for these regions, it will be important to eventually get to a coordinated regional microtransit strategy and/or alignment across municipalities on how microtransit services are treated.

6.4.3 TRANSPORTATION AND EQUITY

Equal Access for Consumers: With no public sector engagement, there is a risk that private microtransit

1 Miller E et al 2015, Implementation of a "Next Generation" Activity-Based Travel Demand Model: The Toronto Case http://conf.tac-atc.ca/english/annualconference/tac2015/s9/miller.pdf

services could evolve into an elite and vehicle (carbon) intensive transportation medium, where reduced revenue to public transit services could further marginalize low income and low mobility population segments. This resultant 'transportation poverty' resulting from the potential erosion of public transit systems would likely require more policy intervention in the future, as opposed to a balanced approach to deployment that prioritizes early engagement.

Equity across Transportation Sector Service Providers: Labour costs will continue to play a key role in the delivery of transportation services. Public and private sector providers and new market entrants operate under varying cost structures and standards with respect to factors such as training, experience and insurance.

In order to minimize conflict and even promote greater collaboration amongst different service providers (public and private), it is important that policymakers consider developing consistent standards to be met by all transportation providers.

This could include both developing new regulations for new market participants and/or easing existing regulations for highly regulated incumbent service providers. Toronto's recent approach to licensing TNCs provides a prime example of this direction.

6.4.4 MANAGING TRANSPORTATION SYSTEM COMPLEXITY

Urban transportation systems and their underlying stakeholders and operations are highly complex, with many interdependent processes and inter-related issues that are now exposed to rapidly changing technology and corresponding market expectations. Traditional approaches to introducing new forms of transit often involve years of research, studies and planning while the proposed can become outdated. Any microtransit implementation strategy will need to encompass policy, business viability, technology feasibility and consumer desirability. Given the complexity, market evolution, and the multiple stakeholders associated, the traditional approach of policy development also needs to evolve in terms of prioritizing agility, collaboration and timeliness.

6.5 IMPLEMENTATION APPROACH WITH KEY STAKEHOLDERS

There is a real risk that the full benefits of microtransit will not be realized if its development is left to market forces alone. It would be far preferable to prioritize the creation of a coordinated regional microtransit strategy for both the GTHA and the Greater Montréal Area. Key public and private sector partners need to be engaged from the outset to help co-create, test and scale up microtransit solutions that create verifiable GHG reductions, generate value for individual partners and fulfill broader public goals.

The microtransit strategy should encompass an action-oriented approach that blends systems/policy design, user-centred design and the transportation sectors capacity to adapt to the upcoming change. The suggested approach would ideally balance in-depth research and studies with low-cost, iterative experiments to quickly expand working knowledge and identify consumer preferences. The results of such tests will help tease out the dependencies, particularly around consumer preferences and will help inform modeling assumptions and inform how and where to deploy microtransit more broadly.

In order to most effectively convene the diverse key stakeholders needed for such a strategy, it would be useful to develop a more refined forecast of the GHG emission reduction potential from the high potential use cases and, equally importantly identify their respective interests in realizing effective microtransit solutions. Common benefits across multiple microtransit use cases for various stakeholders are identified in Table 6.1 below.

Table 6.1: Common Microtransit Use Case Benefits[1]			
Consumers	Municipality / Provincial Governments	Public Transit Company and/or regional transit authority	Private Sector Service Providers
• Greater convenience (front door pickup) • Reduced travel time • Increased productivity • Lower cost (fewer cars per capita)	• Lower GHG emissions • Lower road congestion/ delayed infrastructure investments • Greater productivity / higher tax revenue • Recognition of leadership • Reduced subsidies • Job growth	• Increased ridership • Improved service • Reduced need for parking infrastructure • Right sizing modes of transportation based on real-time customer demand	• Increased ridership / subsidies if needed • Clearer path to market • Clear rules of engagement and operations • Competitive marketplace

6.6 PROPOSED NEXT STEPS

1. Communicate with and convene selected and willing municipalities, private sector vendors and other innovators from the GTHA and the Greater Montréal Area. Get buy-in to test and validate interest and next steps for executing a microtransit transportation strategy that reduces GHG emissions and realizes wider social benefits.
2. Explore opportunities to form partnerships with interested and willing public and private sector partners and potential funders.
3. Identify and engage researchers to develop a strong framework to monitor, track and modify microtransit prototypes and their follow-on iterations.
4. Work with stakeholders (e.g. community associations, labour, various transit and road safety agencies) to engage them as co-designers, informants or testers to:
    - Conduct user research (with local transit operators, residents, businesses), design and prototype three to five solutions in rapid succession; and
    - Field test solutions, develop and prototype sustainable scaling strategies and business models.
5. Validate potential business models and identify the minimum scale for viable deployment.
6. Expand stakeholders to include new municipalities, expand field tests, and launch scaled solutions. These scaled implementations should consider:
    - Developing and communicating clear rules for microtransit service providers that encourage GHG reductions;
    - Providing clear models for public and private sector service providers to accommodate changes in customer demand and transportation sector technologies (labour requirements, subsidies, service levels, autonomous vehicles);
    - Enabling access to capital (both financial and political) for designing, implementing, scaling and enforcing microtransit strategies.

1 Some use cases will have very specific benefits that are not highlighted in the table above. For example, Use Case (5) "Accessible and Special Transportation Services" if implemented at a significant scale could lead to improved and more equitable service. Similar benefits could also be attributed to Use Case (2) "Underserved, Low-Density Suburbs" and (10) "Shift Worker".

APPENDICES

Appendix A: Microtransit and Transportation Network Company Definitions

The relative nascency and the rapidly changing and experimental nature of the microtransit space means the bulk of relevant policy or regulatory documentation is still in its infancy. In the absence of clear or consistent regulatory definitions of microtransit, the literature scan was expanded to definitions put forward by research associations and other groups.

RESEARCH PAPERS & REPORTS

Shared Mobility Reference Guide (2015): "...Most recently, IT-enabled private shuttle services such as Bridj, Via and Chariot have emerged that serve passengers using dynamically generated routes. Because they provide transit-like service but on a smaller, more flexible scale, these new services have been referred to as "microtransit." In general, they draw customers who are willing to pay somewhat more for greater comfort and service".

Institute for Transportation and Development Policy (2015): "The term 'shared mobility' encompasses a range of transport options. Shared mobility systems combine smaller vehicles, flexible routes and schedules, a marketplace for trips, and access to vehicles and rides without the burdens of ownership. These services have also been referred to as microtransit, reflecting both their scale, in terms of ridership capacity, and their increasing role in urban transport networks".[1]

Transportation Research Board (2016): "Microtransit encompasses flexible private transit services that use small buses (relative to traditional transit vehicles) and develop routes based on customer input and demand. Companies in this category include Bridj, Loup, and Chariot. Data on these services, including number of vehicles, routes, or riders, are not yet available. Microtransit services are aimed at those who could otherwise use the traditional public transit system but are willing to trade off a higher fare for a more convenient trip. Microtransit companies are private and un-subsidized. The degree to which they are integrated with existing transit services appears to be fairly minimal".

It is of note that the Transportation Research Board defines shared concurrent services such as Lyft Line and UberPOOL as Transportation Network Companies as opposed to as microtransit. The agency also makes an important distinction between sequential and concurrent services.

UCLA TSRC and Caltrans White Paper (2015): "A more technology-enabled type of alternative transit service that can incorporate flexible routing, flexible scheduling, or both. These services operate much like jitneys of the past but are enhanced with information technology. Existing microtransit operators target commuters, primarily connecting residential areas with downtown job centers... Microtransit services can include variations of the following two models: (1) fixed route, fixed schedule (similar to public transit, and (2) flexible route with on-demand scheduling (more closely mirroring ridesplitting and paratransit services)."

BLOG POSTS/OTHER

Smart Circle Blog (2015): This blog post states that two main streams are in evidence when it comes to microtransit: "(a) a 'downsizing' in public collective transport; and (b) an 'upscaling' in private individual transport. "The first refers to on demand public transportation initiatives, such as Bridj, a startup that facilitates bus rides for commuters based on reservations. An example of the second stream is Uber, which is using private transportation as a basis for on demand transportation. These two streams together are referred as 'Microtransit' and could be seen as a new form of modality, in between private individual and collective public transportation. The most important characteristic is the use of ICT in order to connect supply and demand".

Strong Towns (2015): This blog post (credited in some posts as originator of the microtransit moniker) labeled microtransit as: "bridging the gap between single user transportation (car, Uber, taxi) and fixed-route public transit".

City Lab (2015): "Commuter buses like Leap Transit or Chariot in San Francisco or Bridj in Boston (and now Washington). Dynamic vanpools like Via in New York. Carpool start-ups like Carma. True cabshare options like UberPOOL (now claiming millions of trips) or LyftLine (now with fixed-point pick-ups). Company and housing shuttles like the Google bus belong in the mix, too".

Brown Political Review (2015): "With the stratospheric rise of Uber and its competitors has come a new form of urban transportation known as "microtransit," which falls somewhere between private car or taxi use and fixed forms of public transportation.

TVO (2015): "Generically called "microtransit," smartphone-enabled apps – everything from basic carpooling to digitally-generated on-demand bus routes – aim to provide something more tailored than transit. Uber itself offers a carpool option that it opened in Toronto during the Pan Am Games, allowing UberPOOL users and competitors to take

1 IDTP (2015), "Harnessing Shared Mobility for Compact, Sustainable Cities"

advantage of the temporary high occupancy vehicle (HOV) lanes around the GTA".

Fehr & Peers: "A new entrant in the field of public transportation is microtransit, defined as a privately operated transit system, which in many cases mirrors the operations of public transit agencies along select routes. Current microtransit providers include, Leap Transit, Loup, Chariot, Bridj, Shuddle and others".

The RideShare Guy (2015): "There are two broad categories of microtransit: One is services like Chariot and Bridj, which operate commuting shuttles in certain areas based on user demand. Then there are several services that let you split a ride with people nearby who need to get to a similar destination — including CabCorner, Via, UberPOOL, and Lyft Line. So far, these microtransit companies only operate in a handful of cities. But their backers hope they could one day do for public transit what Uber has done for cab rides".

A1. DEFINING TRANSPORTATION NETWORK COMPANIES ("TNCS")

In 2013, California legislators created a category and rules for TNCs to cover companies like Uber, Lyft, Sidecar and other apps offering pre-booked transportation in return for a fare.

> "The California Public Utilities Commission (CPUC) today took action to ensure that public safety is not compromised by the operation of transportation services that use an online-enabled platform to connect passengers with drivers who use their personal, non-commercial vehicles. The CPUC determined that companies such as Lyft, Sidecar, and UberX are charter party passenger carriers subject to CPUC jurisdiction. The CPUC created the category of Transportation Network Company (TNC) to apply to companies that provide prearranged transportation services for compensation using an online-enabled application (app) or platform to connect passengers with drivers using their personal vehicles."

Pennsylvania also has encoded a TNC definition within its policy, as follows:

> "... TNCs are altering the space traditionally occupied by taxicabs and the difference is much more than reinventing dispatch methods. The most fundamental change between TNCs and traditional taxicab services is the contractual use of private personal vehicles and drivers to carry passengers, rather than ownership of vehicle fleets by the certificate holder. This innovative use of the public space should be encouraged in a way that is consistent with the Pennsylvania Public Utility Commission's (Commission) mission to both protect the public interest and foster new technologies. Thus, we consider the experimental application of this series and move to grant [such applications as] Experimental Service..."

As per the Pennsylvania example, some jurisdictions have classified these companies as "experimental" service providers, in recognition of the fact that both their long-term impact and viability is unknown. It is of interest that jurisdictions like Pennsylvania as well as Detroit have given such companies temporary, two-year approvals (or temporary regulatory waivers) to operate while they decide on a more permanent response.

In its 2015 paper, the Mowat Centre concludes that this experimental (waiver/exemption) approach allows sharing economy enterprises to keep operating while regulators gather information on real-world experience. Ideally, such information can eventually be used to craft regulation that makes sense given market dynamics.

The Mowat Centre makes this conclusion in acknowledgement that there are two key challenges of the sharing economy to policymakers: (1) the speed and scale of change; and (2) the difficulty of categorizing these enterprises.

Appendix B: Market Review

B1. THE GROWTH OF TRANSPORTATION NETWORK COMPANIES

The use of TNCs is growing rapidly (Figure B.1). Since 2009, Uber has expanded to over 36 countries and 97 cities, and Lyft, launched only in 2012, is now active in 20 cities with over 1M rides. In 2013 and 2014, enrolled drivers at Uber doubled every six months; 40,000 new drivers enrolled in December 2014 alone. To date Lyft has raised $1B in financing including a $500M investment from General Motors. As of 2016, Uber is valued at $62.5B – this is more than the majority of companies in the S&P 500.

By 2020, Frost & Sullivan have predicted that carsharing will grow to 26 million users worldwide, up 1,030% from today's ~2.3 million.

Figure B.1: Snapshot of Peer-To-Peer, Rideshare, and Carshare Growth

Survey data on business travelers' use of TNCs indicate that such travelers are selecting TNCs more frequently than taxis, perhaps because of lower average fares. "As fragmentary as these indicators of scale and growth may be", TRB concludes that they "exceed what is publicly known about the use of other TNCs". Part of the complexity may have to do with the fact that private companies (i.e. those largely at the helm of shared mobility) have been loath to reveal exact industry figures.

B2. LOCAL BENEFITS OF MICROTRANSIT

Figure B.2: Broad Outcomes and Technology Solutions, Beyond Traffic

Broad Outcomes	Technology Solutions: Mobility Alliance • Data Clearinghouse • Shared Use Mobility Service	Advanced Vehicles & Mobility • Autonomous Vehicles • Connected Vehicles – Transit • Connected Vehicles – Snow Plows / Maintenance Fleets • Connected Bikes • Electric Vehicles	Micro Transit	Advanced Traveler Information and Smart Parking • Enhanced NexTrip Mobile App • Snow Routes Status Mobile App • Smart Parking and Dynamic Parking Prices	Advanced Sensors and Integrated Corridor Management
A. First/last mile travel connectivity	●	●	●	●	
B. Access to options for best travel choices and flexibility	●	●	●	●	
C. Availability, access and management of open integrated data	●	●		●	●
D. Shared usage / shared trips	●	●	●	●	
E. Comprehensive incentive programs for smarter travel	●		●	●	
F. Mobility options for diverse populations and visitors	●	●	●	●	
G. Reduce travel costs – mobility, safety, energy	●	●	●	●	●
H. Integrated payment services combining travel modes and parking	●		●	●	
I. Safety for all travelers and modes		●	●	●	●
J. Reduce modal delays	●	●	●	●	●
K. Event parking information and availability	●			●	
L. Inter-jurisdictional corridor management					●
M. Ability to address policies and adapt to rapidly changing technology	●	●	●		
N. Rules for public/private partnerships	●				
O. Citizen engagement programs	●				
P. Greener energy	●	●	●	●	

B3. JURISDICTIONAL SCAN OF MICROTRANSIT SYSTEMS

A scan of the existing literature was performed to identify jurisdictions leading in microtransit deployment. Where available, research relating to key elements of infrastructure, design parameters, and overall benefits and drawbacks to the systems was conducted. The following areas were reviewed:

- Kansas City, U.S.A.
- Greater Boston, U.S.A.
- Washington, U.S.A.
- Chicago, U.S.A.
- New York, U.S.A.
- San Francisco, U.S.A.
- Silicon Valley, U.S.A.
- Helsinki, Finland
- Gothenburg, Sweden
- Netherlands
- Montréal, Canada
- Toronto, Canada

An overview of microtransit characteristics identified is presented in the following sections.

Case studies for select cities (Kansas City, Boston, San Francisco, Gothenberg, and New York) have been briefly expanded upon in Section 3.0 within this report. These cities were selected due to the depth of information available as well as to illustrate specific applications of microtransit design.

B3.1 KEY ELEMENTS OF MICROTRANSIT INFRASTRUCTURE (I.E. SCOPE, SCALE, TARGET MARKETS, SYSTEMS, KEY TRAVEL ROUTES, OTHER)

Scope

Microtransit has been described as generally embracing route deviation with no fixed stops. Although the definition of microtransit varies in the literature and in its use, vehicles typically depend on individual rider inputs, within specified geographic parameters and "stations" that move around each day. For the purposes of this review, microtransit services are considered to fall into two broad categories: (1) services like Chariot and Bridj, which operate commuter shuttles in certain areas based on demand, and (2) services like UberPOOL and Lyft Line, which allow a passenger to share a ride with others nearby who have a similar destination.

The following examples illustrate the range of microtransit systems currently in play:

- **Private Microtransit Enterprise:** Several private microtransit companies have emerged in the last five years. In the U.S., current players include Bridj, Chariot, UberPOOL, LyftLine, and Via, with expected entry to be made by Google in the near future. All make use of smartphone location applications, in particular Google Maps, to triangulate passenger requests and optimize routing.

  As a specific example, Via is a shuttle-based system servicing upper and midtown Manhattan in New York. The system is designed to reduce traffic associated with solo taxi trips and to fill the gap in the New York City transit grid by consolidating cross-town service into a single seat.

- **Combined Mobility Service:** In Gothenburg, the Swedish Transit Authority's (STA) goal for UbiGo is "to procure everyday travel in volume, repackage and deliver it in a simple way, offering an easy everyday life without having to own a car". The service, termed Combined Mobility Service, combines Public Transport, carsharing, rental car service, taxi and a bicycle system, in one app and in one invoice, with 24/7 support and bonus for sustainable choices. UbiGo positions itself against car ownership, and, as per the STA: "We know that if we can offer such a reliable and easy-to-use service that households feel confident enough to let go of their own car, they will drive much less."

  A similar model to UbiGo is Mobility Mixx in the Netherlands. This Dutch company provides a full range of mobility services including rental cars, public transit, carpooling, bikesharing, autos and taxis as well as trip scheduling and payment in one package. The system is primarily designed for business travel. Employers can also set up the system to provide each employee with a set mobility budget for the month that they can use as they see fit. If employees choose to travel by less expensive modes such as transit instead of by auto, they gain money. Companies can also use Mobility Mixx to help meet Corporate Social Responsibility goals by encouraging employees to use sustainable travel options.

- **Public Private Partnership:** Another business model is demonstrated by Kansas City, which is exploring a private-public partnership with Bridj, government and transit authority, and Ford to enhance existing mass transit. The one-year pilot model is seeking complementary with existing bus routes. Amalgamation of transit and Bridj fare structures is being explored.

> **Kansas City claims to be the first U.S. public-private collaboration brings together a major U.S. transit system, an automaker and an urban technology company to enhance existing mass transit by providing greater mobility options to residents of Kansas City.**
>
> http://www.kcata.org/news/bridj_kcata_launch_pilot_program

Scale

The majority of microtransit initiatives are stand-alone services that operate independently and often are run by private companies. Most systems reviewed have focused on either the displacement of single vehicle traffic (preferable) and/or supplementation of existing transit in select city pockets.

However, in Helsinki, the vision of now-defunct pilot project Kutsuplus was that all kinds of transportation services would be used together by a singular portal. In addition to 'normal' open transportation, it embodied taxis, carsharing, and other services. This model has also been followed and expanded upon by the Netherlands and in Sweden, as well as through companies like Transloc which are exploring integrating modes like transit, Uber, and walking.

In North America, most of the models reviewed are characterized by private sector enterprise providing alternative – and in some cases, premium – transit models in dense urban neighbourhoods traditionally underserved by public transit and/or specialized commuter routes (i.e. Google, Bridj, Via). This opportunistic approach is evolving as companies are recognizing the need for and value of collaborating with municipal governments and transit agencies. The emergence of public-private partnerships may mark a trend to watch.

Target Markets

In general, microtransit projects, particularly those run by private enterprises, have targeted urban business commuters during rush-hour periods, namely those constituents who prefer a car free lifestyle and who can afford to pay a little more for premium commuting options. In North America this approach has been criticized as pandering to the elite classes. The fear is that – taken to its extreme – this could lead to a two-tiered transportation system, where wealth allows a select few to travel expediently and luxuriously and everyone else relegated to public transit systems eroded by declining ridership and support.

Examples of target markets served by microtransit to date include:

- Mobility Maxx, Netherlands: Mobility Maxx is currently focused on serving business travelers; people also want to use one such service to manage their personal travel as well.
- Via, New York: Via serves primarily residents and visitors to mid and upper Manhattan that are seeking to traverse an otherwise inconvenient stretch of the city. Almost a third of Via passengers are over 55, which is a slightly different demographic than the usual commuter that are of a younger demographic.
- Chariot, San Francisco: Chariot has developed a shuttle route servicing Fisherman's Wharf to meet the specific demand for "first-mile/last-mile" service, a gap not currently adequately addressed by San Francisco's surface transit. This target market largely reflects employees of the tourism businesses active in the area.
- UberPOOL, Toronto: UberPOOL offers several options to commuters in Toronto. One of the most active routes is between downtown from Liberty Village. The latter is a rapidly growing and highly dense urban area.

Systems

Systems reviewed include Bridj, Chariot and Via (on demand shuttles), as well as UberPOOL, UberHOP (Toronto), and Lyft Line (shared ridesourcing). European systems include Mobility Maxx, UbiGo, and Kutsuplus – the latter being form of shared shuttle combined with trip efficiency and routing strategies. All systems make extensive use of GPS, IT, and algorithm theory to determine the most optimal configurations of passenger pickup, routing, and travel strategies, as well as cellphone apps so as to engage with their customer base and in some cases process fare transactions.

Key Travel Routes

Microtransit routes differ based on rider requests for pickup but typically travel along key travel (commuter) routes between residential and downtown business areas, for example:

- In Toronto, rush-hour rides are available to Toronto's financial district from four spots – CityPlace, the Distillery District, Liberty Village and Fort York. These areas have seen an influx of condo development and associated population density.
- In Kansas City, on Bridj one can travel between the KU Med residential areas in the west to the downtown area.
- In Boston, one can travel between several western Boston neighborhoods connected zones, inbound in the morning and outbound in the evening.
- In Chicago, Via microtransit travels anywhere in the Loop, West Loop, River North, or Lincoln Park and Lakeview (east of Sheffield).
- In New York, Via travels anywhere in Manhattan south of 110th St., between 32nd and 110th streets from 6:45 a.m. to 9 p.m.

B3.2 DESIGN PARAMETERS (I.E. TYPES OF VEHICLES, TYPES OF MOTIVE POWER AND FUEL TYPES, CARRYING CAPACITIES, SAFETY CONSIDERATIONS, ROUTING STRATEGIES, FEE/FARE COLLECTION PROCESSES, OTHER)

Vehicles

The microtransit shuttle fleet is usually typified by slimmer, European-style mini-buses that have better fuel mileage and lower operating and maintenance costs. Some systems also utilize smaller vans or sedans, while Google has found its demand grow to the point where 50-seat motor coaches are needed for some routes.

Fuel Types

In general the majority of microtransit fleets reviewed are either gasoline or diesel powered.

- In Kansas City, Bridj uses domestically produced Ford Transit vans with 3.5-litre V6 EcoBoost® engines which are gasoline powered.
- Other Microtransit operators employ diesel powered Mercedes Benz Sprinter vans with a 2.1 L, 4-cylinder,

2-stage turbocharged BlueTEC engine. For increased horsepower and torque of a V6, the 3.0 L BlueTEC diesel engine is also available.

Carrying Capacities

The carrying capacities for minivans range from 8 to 15 seats and up to 26 for mini-buses. Also in the microtransit mix are large SUVs with seating for 7, 8 or 9 people (including the driver). System carrying capacity also varies according to trip frequency, with some services providing rides every 10 minutes during peak times. In general, microtransit providers are able to offer rides "on demand", meaning that capacity ebbs and flows according to need. This is in part expedited through innovative pricing structures (i.e. such as Uber's "surge" pricing, which serves to (1) incentivize more drivers to get on the road; and (2) displace non-urgent demand to less busy times).

Safety Considerations

In Canada, all vehicles used in microtransit must conform to Canadian Motor Vehicle Safety Standards (CMVSS). Aside from mandatory safety gear, in the U.S., one microtransit operator (KCATA) installed large running boards for passenger convenience and safety as well as bright decaling for visibility. Typical to most commercial fleet vehicles, locally installed options would include such items as extra mirrors to reduce blind spots, a convex interior mirror that would allow the driver to observe passengers, safety reflective markings, paint highlights to draw attention to hazardous areas of the vehicles, (such as steps etc.), and safety lighting such as oversized flashers and more.

Routing strategies

App-based routing systems vary somewhat but common to most is that when requesting a trip, riders receive walking directions to their dynamic pickup and drop-off spots. In general, passengers use their smartphones to request a pickup and specify their destinations. Kutsuplus, for example, used an algorithm to determine the most efficient bus to send, and specified a fare for each passenger (which ran, on average, about a quarter of the price of a taxi). Once in motion, a microtransit bus might make occasional detours to pick up other passengers, but stops much less often than a regular bus would.

In Kansas City, users drop two pins/select two locations via the Bridj app, select the trip that meets their needs, purchase in-app, then walk to their tailored pick-up location. The system optimizes pick-ups, drop-offs, and routing based on demand, meaning a 40 to 60% more efficient trip (on average) than traditional transit at a $2 to $6 price point. The Bridj algorithm sorts pickup requests and sets a central meeting spot. Passengers go to the spot, get on the bus and travel with others heading for a similar destination.

In San Francisco, Chariot launched a beta version to run a series of private shuttle routes between neighborhoods that are poorly served by current public transportation options in the city. Calling itself "the world's first crowdfunded network of commuter routes," Chariot asks commuters where they live and where they want to go and uses the data to design and launch new routes. Once enough people sign up for passes, the vans start running. It purportedly took all of three hours build enough support for one popular route, the Richmond Racer.

Fares

Fares vary according to regional economics, incumbent public transit and taxi fares, and other local factors. The following provides a sense of the variation of and justification behind existing microtransit fare structures:

- For Kutsuplus (Helsinki), the price was between a taxi and a bus fare: a €3.50 flat fee, plus 45 cents per kilometre. That worked out to about $5 for a 3.2- km journey. The average fare in 2014 was around €5 — about US$5.50. By comparison, a single ride by bus or metro in Helsinki is €3. Taxi fares start at €6 and can go much higher depending on the distance traveled.
- In New York, all rides on Via from 6am until 9pm are paid for with pre-purchased Ride Credits which are a flat fee of US $5 plus tax per ride. Members who elect not to purchase Ride Credits, or who are out of Ride Credits and instead choose to pay-per-ride, will incur a US $2 surcharge, bringing their total to US $7 plus tax per ride. Each additional passenger traveling within a party will be charged at half the price of the full fare.
- In San Francisco, Chariot passengers can buy pay-as-you-go or multi-ride packs of rides, or opt for a monthly pass for access to its service. Chariot's most popular option is a 12-ride pack for US $47, and it also offers a US $93 monthly option. For those who commute twice a day, 20 days a month, the monthly pass ends up costing only slightly more than paying for the municipal bus each day. The company also accepts all the same regular commuter benefits as other public options.
- In San Francisco, Leap launched with US $6 rides on luxurious buses with Wi-Fi and selling coffee and US $7 juice. Such amenities prompted cries of elitism and Leap soon ran into regulatory problems: the California Public Utilities Commission issued a cease-and-desist order in May 2015 because it said the company was operating without a permit. Leap reportedly began selling off buses in June and is no longer operating.
- In Silicon Valley, fares for a VTA FLEX trip are US $3 per ride during peak commute times and US $2 during off-peak times.
- In Kansas City, each Bridj ride costs US $1.50, paid through a credit card connected to the Bridj app.
- In Boston, Bridj rides cost anywhere from US $5 to US $8, more than double the average MBTA fare (US $2.00 to US $2.40). It is expected that as more people use the system the price will decrease to somewhere between $3 and $4 per trip, and, with increasing ridership, the "smarter" the

system will become. This will allow the company to better analyze commuter patterns and offer pop-up routes accordingly.

- In Toronto, uberHOP charges a flat fare ranging from CDN $3.50 to CDN $4.50 along Toronto's most popular routes during peak hours.

Fee/Fare Collections Processes

As with other ride hailing services, microtransit travelers typically book and pay through a smartphone app. Passengers can also register online and pre-load their fare payments. Fares can modulate in response to time, demand and other factors and can respond to the users' desires for more options while also potentially generating greater revenue returns for providers than a fixed-fare structure.

(In the case of Kutsuplus, the user experience was rudimentary. There was a separate user account and wallet that customers had to transfer funds to. There was no mobile app, and there was no possibility of booking a ride more than an hour in advance.)

B.3.3 BENEFITS AND DRAWBACKS TO THE SYSTEMS (I.E. ENVIRONMENTAL IMPACTS, LEVEL OF FLEXIBILITY, ROLE OF TRANSIT AUTHORITIES, RELATIVE COSTS COMPARED TO ALTERNATIVE OPTIONS, ETC.)

Environmental Impacts

To date there is limited information published on the impact of microtransit on emissions. Some opine that, through potentially displacing transit ridership and encouraging more vehicle trips, microtransit has the potential to increase emissions, although this is not a conclusive finding. In general, most carsharing systems have been found to reduce the environmental impact of driving, as they typically offer newer, low emission vehicles, and members report driving less, using public transportation more, and opting out of private car ownership. After joining a carshare service, "the vehicle holding population exhibited a dramatic shift toward a carless lifestyle" (ITDP, 2015)

In Boston, while the majority of initially carless households increase their emissions, carshare members who owned at least one car when they joined decreased their emissions significantly by driving much less and selling a car or two. When members pay for carshare use by the hour or km / mile, they are motivated to drive less, or to take another mode or trip chain (do many stops on one trip, take longer trips as compared with taking lots of separate, little car trips).1

In the Netherlands, proponents of Mobility Mixx claim that this system would lead to an estimated 4.2-9.6 billion fewer car-kilometres being driven, a 0.6-1.4 Mt decline in CO_2 emissions and a reduction in the total cost of mobility for employers of €0.6-1.4 billion. In addition, annual productivity is projected to rise by around 15 billion hours and the number of employees parked daily to decline by around 300,000.2

In Helsinki, it's hard to say whether Kutsuplus actually convinced anyone to give up their cars. It is noted that private car usage grew in Helsinki until 2008 and then went flat — but the reasons for that may have more to do with the slow economy.3

To date, the reporting of environmental impacts associated with the systems reviewed is scarce. Overall, well-planned shared mobility appears to have a moderate effect of reducing a city's vehicle kilometres traveled (VKT) and greenhouse gas (GHG) emissions, but more research to evaluate the impact of these systems over time is needed.

Level of Flexibility

The promise of microtransit lies to a large extent in its routing flexibility, which enables it to fill in service key gaps in lower occupancy areas. Software applications allow riders not only to determine availability of service and book a trip, but also to react to ever-changing price points to determine their willingness to pay. On the back end, service providers can also match user inputs with available vehicles and drivers to provide the most efficient trip.

> "A number of environmental, social, and transportation-related benefits have been reported due to the use of various shared mobility modes. Several studies have documented the reduction of vehicle usage, ownership, and vehicle miles or kilometres traveled (VMT/VKT). More research is needed, nevertheless, to further understand impacts on a city and regional level and across the wide range of shared mobility modes."
>
> http://innovativemobility.org/wp-content/uploads/2015/11/SharedMobility_WhitePaper_FINAL.pdf

1 http://www.oneearthweb.org/uploads/2/1/3/3/21333498/localgovsharingecon_report_full_oct2015.pdf

2 http://www.cedelft.eu/publicatie/impacts_of_mobility_mixx_products_for_the_netherlands_plc/1125

3 - See more at: http://citiscope.org/story/2016/why-helsinkis-innovative-demand-bus-service-failed#sthash.SgxmMrmb.dpuf

Social Impacts and the Role of Transit Authorities

The coordination of microtransit with conventional big-vehicle transit can result in (a) lower overall Vehicle Miles Traveled, emissions, and congestion, and (b) stronger cases for transit-oriented land use and thus (c) better, more humane and inclusive cities. Conversely, if microtransit competes with transit, customers are drawn away from big vehicles into smaller ones, and the opposite impacts ensue.

Some microtransit projects are actively partnering with the local transit authorities. Some, like Bridj, are explicitly trying to work with transit agencies and have gained regulatory approval from cities before entering the market. Examples include Bridj/Ford Motor Company/Kansas City Area Transit Authority (KCATA), Massachusetts Bay Transportation Authority (MBTA) / Bridj, and Helsinki Regional Transportation Authority / Kutsuplus. These kinds of public/private partnerships can mitigate regulatory hurdles and ease tensions, particularly in unionized environments.

There is another way to look at UberHOP and similar services – not as a threat but as an opportunity. Combined with other new services such as app-accessed ride hailing, carsharing, bikesharing and car pooling, microtransit can help evolve how people move around cities, using private services that mine rich veins of data to get them where they need to go. Some of the European examples reviewed offer interesting applications in this area as they provide customers with the best combination of travel options in light of all available modes of travel, as well as incentives for choosing the most sustainable modes.

Governments should guide and work with shared-use mobility companies to ensure their services complement rather than compete with public transportation. For example, incentives can be provided for shared mobility services to connect under-served areas, extend the reach of public transit, and increase transportation access. It is important that governments work with shared mobility companies to gain access to the data needed to plan a better overall transportation system. For example, data access can be shared in exchange for operating rights and use of public space (e.g. roads and parking spaces).

Relative Costs (System)

Information on microtransit system costs has been to date limited. This may in part be due to the fact that most microtransit deployment has been at the hands of the private sector. Uber for example has been criticized in the media for its intransigency when it comes to the sharing of information accumulated on passenger travel and routing, although this may in part be due to the competitive nature of the industry.

More research is required to pinpoint overall system costs associated with microtransit, however Kansas City offers a starting point in terms of specific project costs. The agency KCATA spent $1.3 million in funds left over from sales tax on its on-demand ride-hailing system, which was also supplemented by Ford's vehicle financing program.1 And, although exact figures are unknown, Helsinki authorities shut down Kutsuplus on the grounds that the cost to taxpayers was too high.2

On the private sector side, the scale of funds raised ranges significantly. Bridj began with $4M in seed funding and recently closed another financing round (undisclosed). As of May 2016 Via has raised another $70M in financing, in addition to $27M raised in 2015. The more established TNCs are well-financed, Lyft for example, has raised $1B including a $500M investment from General Motors. As of late 2015, Uber was reportedly valued at $62.5B – this is a higher value than over 400 of the 500 companies in the S&P 500.3

Ultimately, the business case for microtransit is based on the convergence of a few simple principles that mobility providers are already accustomed to incorporating: vehicles, fares and technology4. Both private and public sector providers need to hit that sweet spot where technology matches the right vehicle with the optimal number of riders at an acceptable price point to deliver an efficient and responsive service.

1 http://theworldbulletin.com/2016/02/18/kansas-city-is-embarking-on-a-great-microtransit-experiment/

2 The economics of the system relied on scale. It had one big problem: its operation costs were too high," said Teemu Sihvola, the founder of Ajelo. "It was very hard to make profitable. You had the expensive vehicle models. You also had three year fixed contracts for the drivers." To be profitable, HSL needed to grow its fleet of vehicles: a minibus becomes more cost-effective with more paying passengers.

3 http://www.investopedia.com/articles/markets/082015/startup-analysis-how-much-uber-worth.asp

4 http://web1.ctaa.org/webmodules/webarticles/articlefiles/Ridesharing15Micro-transit.pdf

Appendix C: Case Studies in Microtransit

C1. PUBLIC-PRIVATE PARTNERSHIP: RIDEKC (KANSAS CITY, U.S.A.)[1]

RideKC is a one-year pilot involving the Kansas City Area Transit Authority ("KCATA"), Ford Motor Company, and the company Bridj. Launched in March 2016, it is the first public-private collaboration between a major U.S. transit system, an automaker and a transportation technology company. The pilot seeks to enhance existing mass transit by providing "greater mobility options to Kansas City residents".

Using the Bridj mobile app, riders can request on-demand shuttle service in real time and up to 24 hours in advance. Each ride currently costs $1.50 USD, payable through a credit card connected to the Bridj app. The system uses individual rider inputs to command vehicles and triangulate pop-up shuttle stations to identify the best service routes. The pilot currently includes downtown Kansas City as well as portions of midtown, the hospital area, and other areas of interest (i.e., Vine Jazz district). As boundaries are based on rider demand, these are expected to shift or possibly expand over the pilot period.

The system is delivered through 10 locally built Ford Transit vans, which are high-roofed, long-wheelbased vans with V6 engines. The vans have been modified to accommodate up to 14 passengers and include a large running board for passenger convenience and bright decaling for visibility. Drivers, who are KCATA-employed and union-represented, will be paid by the hour. Paratransit is available to those who meet certain qualifications.[2] KCATA has allocated $1.3 million for Ride KC, which is further supported through Ford's municipal lease finance program.

It is hoped that this pilot will enhance Kansas City's existing mass transit system by facilitating other forms of transit. Bridj and KCATA are planning to share data with the intention of connecting microtransit with existing bus routes and ideally, integrating fare structures. As only 18% of jobs in the region are currently accessible by mass transit, it is hoped that RideKC will catalyze "social and economic opportunity, and [provide] an example of what is possible when cities adopt technological innovation and work in collaboration with private entities to create a truly modern city."

Public-private partnerships such as that underway in Kansas City offer a means for local governments, transit authorities and private enterprise to collaborate on initiatives that otherwise may be construed as competing with incumbent transportation options and/or working at cross-purposes to regional priorities, such as GHG reduction. Partnership-based approaches may help smooth the development of systems that ideally benefit the public, accommodate the priorities of all parties involved, and leverage the various capacities each partner brings to the table. On the other hand, such projects may take more time to execute compared to private sector initiatives and can be costly. There is also the possibility that an overly prescriptive approach may erode microtransit's key attribute: flexibility.

C2. COMBINED MOBILITY SERVICE: UBIGO (GOTHENBERG, SWEDEN)[3]

UbiGo, a combined mobility service model, was launched in 2014 as a one-year pilot. The system was designed to repackage everyday travel (i.e. public transport, carsharing, rental car, taxi, cycling) into one system and on one invoice. The UbiGo model was developed under the Go:smart project, headed by Lindholmen Science Park in partnership with industry, academia and the public sector, co-funded by Vinnova at a budget of ~20 million EUR over two years.

The project was designed for families that have more than one car in the household and complicated transportation needs, as well as the B2B-market, where businesses could include employers, events, shops and restaurants. Via UbiGo, participants subscribed and prepaid for their monthly transportation needs (i.e. 'x' number of transit tickets, carsharing credits, and/or bikesharing credits). Unused days or hours are saved for later use. These 'digital punch cards' are stored in the cloud and managed by the participating household through an app. In addition to bonus points for taking more sustainable options, the system offers 24/7 support and a quality guarantee in that any delay in public transportation was backstopped by taxi service, paid for by UbiGo.

In essence UbiGo is a transportation broker service that aggregates services into a single web portal for use, and unique in that it provides incentives for sustainable travel

1 http://www.citylab.com/cityfixer/2016/02/kansas-city-bridj-microtransit/462615/
http://theworldbulletin.com/2016/02/18/kansas-city-is-embarking-on-a-great-microtransit-experiment/
http://web1.ctaa.org/webmodules/webarticles/articlefiles/Ridesharing15Microtransit.pdf
http://www.kcata.org/news/bridj_kcata_launch_pilot_program

2 http://morides.org/search-counties/2075/ride-kc-kansas-city-regional-transit/

3 https://publications.lib.chalmers.se/publication/204386
http://sharedusemobilitycenter.org/news/three-european-cities-making-on-demand-mobility-a-reality/
https://www.viktoria.se/publications/mobility-as-a-service-maas-describing-the-framework
http://www.ubigo.se/published-papers/

choices.[1] After six months, all 195 participants were still using the service and over 90% indicated they would be interested in a regular service.[2] Participants ranked simplicity and security as the most important benefits in this model. Moreover, many indicated that "that they had become less reliant on private cars and were more likely to use other forms of transportation such as public transit, walking and cycling".[3]

The pilot has shown that an aggregator model that still includes access to a car may have environmentally positive impacts. These benefits can be improved yet further if the carshare or rental is non-fossil-fuelled. Critically, the pilot also showed that if environmental gains are to be made, these will largely ensue through making the desired behaviour simpler as opposed to making it an ideal and/or reward-based choice.

In partnership with Ericsson, UbiGo is currently planned for re-launch in 2016 and discussions for expanding the service are also underway. For example the regional public transportation operator is aiming to create a "concession procurement" that will allow UbiGo to serve as a model for other cities, and a franchising concept is being developed based on the knowledge, brand, and platform that was deployed in Gothenberg. Interestingly, the E.U. overall seems to be moving toward mixing mobility and travel needs under a singular use agreement.[4]

The concept of combined mobility service has also found traction outside of the E.U. For example, the TransLoc mobile app mentioned previously integrates various modes of transportation. STM in Montréal is also considering an integrated mobility system. These types of offerings are of interest in that they can act as a useful aggregator of local transportation options, provide granular data on daily travel patterns to help plan routes and serve demand, and potentially encourage more sustainable travel choices. This said, such projects may also require significant development time and financing depending on scope, objectives, available data, and involved proponents. One might also reasonably ask if the level of uptake by the public will meet expectations, as to date the most advanced applications have been deployed largely on a pilot or development level.

1 For every kilo CO_2 saved (compared to if the trip would have been made by private car), users get bonus points that can be used to buy services or products from UbiGo partner organizations (bike service, home delivery, health clubs, concerts etc).
2 http://trrjournalonline.trb.org/doi/abs/10.3141/2536-01
3 The UbiGo website claims that "half of the users changed their modes of travel, four out of ten have changed the way they plan their trips and one out of four have changed their 'travel-chains'".
4 See: http://www.lvm.fi/en/-/mobility-to-be-turned-into-an-overall-service-795359

C3. PRIVATE ENTERPRISE: BRIDJ (BOSTON), CHARIOT (SAN FRANCISCO), AND VIA (NEW YORK)

Bridj (Boston):[5] Bridj, the commuter shuttle company involved in the Kansas City project, originally launched in Boston in 2014 with $4M in seed funding. The company offers four direct commuter routes selected to address the city's perceived public transit gap (Brookline, Cambridge and downtown), although one of Bridj's main routes transports commuters between Brookline and downtown Boston, a route already served by the City's Green Line subway.

Customers request rides through the Bridj app and meet at a central spot identified based on similar requests and system algorithms. This "pop-up urban infrastructure" model prioritizes flexibility and convenience by optimizing pick-up, drop-off, and routing. The cost per ride runs from $3 to $6 USD (compared to $2.10 for a one way ride on public transit). Customers can access 14- to 18-person shuttles such as Ford Transit and Mercedes-Benz Sprinters as frequently as every 10 minutes during peak hours.[6] Bridj also uses other companies' licensed buses and is in the process of obtaining the requisite approvals. Bridj asks customers with disabilities to contact customer support in advance. Service animals accompanying a customer are allowed on Bridj at any time.

Boston's Massachusetts Bay Transportation Authority ("MBTA") has identified ridesharing as a means for the transit agency to supplement or even possibly eliminate its late night service. The MBTA has already explored means to backstop its expensive paratransit service, The Ride, for seniors and the disabled, and has piloted a taxi subsidy program that could expand to Uber and Lyft. Services like Bridj may play similar roles in expanding the multimodality of transit, and the appetite seems to exist to explore private-public partnerships in this regard.

5 http://www.brownpoliticalreview.org/2015/11/magic-pool-bus-the-rise-of-microtransit-puts-public-transit-access-at-a-crossroads/

http://www.bostonmagazine.com/news/blog/2014/06/11/bridj-service-coolidge-corner/

http://commonwealthmagazine.org/transportation/bridj-revs-up/

http://www.icic.org/connection/blog-entry/blog-microtransit-movement-looks-to-improve-transportation-access-for-all

http://www.metro.us/boston/boston-s-bridj-eyeing-place-in-public-transit-s-future/zsJolo---hfxbAygnhz21Y/

http://innovativemobility.org/wp-content/uploads/2015/11/SharedMobility_WhitePaper_FINAL.pdf
6 The company claims to be moving 22 passengers per vehicle per hour.

Chariot (San Francisco):[1] Also in 2014, the private shuttle company Chariot launched in San Francisco with four buses. Two years later, Chariot now operates more than 50 small buses on seven busy routes, weekday mornings and evenings, and closed $3M in seed funding in 2015. Its most recent routes were crowdsourced and crowdfunded in that riders proposed the new routes and voted for them via the company's website. Routes are considered viable after at least 60 people have purchased their first passes (when the route "Tilts") and can be running in a matter of days.[2] This is in direct contrast to the decade and a half process to plan Bus Rapid Transit routes in the Bay Area.

The system runs 15-passenger rented Ford vans on its 'regular routes'. Users can sign up for these through Chariot's website or a mobile app, and buy pay-as-you-go, multi-ride packs, or monthly passes. The company provides wheelchair-accessible service with one day's notice. For those with regular commuting patterns the monthly pass costs only slightly more than the public bus. The company also attempts to provide the same regular employee benefits as other public options.[3] With 80 hired drivers and 13 office workers, Chariot currently serves about 700 to 1,000 people per day (in comparison, the significantly higher capacity and more established 38-Geary city bus lines serve over 33,000 riders a day).

Although Chariot offers a more expedient alternative to surface transit in San Francisco, its very versatility in adapting route service also runs the risk of leaving lower-income or more vulnerable residents hanging, unlike public transit which prioritizes equity and accessibility. Both approaches have merit however, and may yet find they complement each other in the future through leveraging each other's attributes. This is the outcome that Kansas City and Boston are also hoping for, although each city has taken a varying level of direct involvement in this outcome.

1 http://www.theglobeandmail.com/news/Toronto/microtransit-cities-should-explore-innovation-that-will-help-move-people/article27931173/

http://techcrunch.com/2015/11/29/the-last-bus-startup-standing-chariot/

http://www.bbc.com/autos/story/20150903-microtransit-aims-to-civilise-the-worst-part-of-your-workday

http://innovativemobility.org/wp-content/uploads/2015/11/SharedMobility_WhitePaper_FINAL.pdf

http://techcrunch.com/2015/01/26/chariot-new-route/

2 For example, the Fisherman's Flyer route was created to address the need for businesses around Fisherman's Wharf to retain employees challenged by transportation problems. Many workers reside in the East Bay and ride BART trains into San Francisco, but once off the train, the commuters had trouble travelling the last two miles to work.

3 The company pays a 20 to 25% premium in payroll and workers' compensation and gives its captains (salaried employees with equity) some benefits. See: https://www.linkedin.com/pulse/ride-sharing-founder-who-says-employing-drivers-good-fairchild

Via (New York):[4] Modeled on Israel's Sherut van service, New York's Via shuttle/vanpool service currently provides tens of thousands of rides a week in midtown and uptown Manhattan. The service is fully dynamic as it does not have any static routes; instead, vehicles are requested and rerouted based on traffic and demand. Routes are determined by the company's algorithms and drivers follow a plotted line on a tablet organized around multiple pickups and destinations. A common concern with mictrotransit is that it will either create new congestion and/or compete with existing public transportation. However, based on experience documented so far, Via's shared approach in its chosen service area - i.e. crosstown Manhattan, which is notoriously difficult to traverse using the transit grid - is likely to reduce vehicular traffic due to offsetting taxi trips. This suggests a key niche for microtransit initiatives seeking to offset private vehicle use.

The Via fleet consists of premium SUVs and Sprinter vans. The service accommodates folding wheelchairs and is actively looking at integrating wheelchair accessible vehicles, including purpose-built vehicles.[5] As with Bridj and Chariot, travelers book and pay through a smartphone app. The cost is a flat USD $5 a trip if prepaid, compared to the cost of taking a taxi or a USD $2.75 NYC subway ride. Customers must be flexible regarding the exact origin and destination points (by a block are so) and also are subject to sharing their journey. Interestingly, 27% of Via riders are over 55. This illustrates that older constituents are also open to using this type of service, even though companies like Bridj and Chariot have primarily focused on tapping the commuter segment.

Via drivers draw an hourly wage of USD $30 (USD $40 during rush hour), which have led some to conjecture on the sustainability of the current business cost model.[6] This said, Via just closed a round of USD $70 million in venture capital funding to expand into new markets, including Chicago, on top of USD $27 million raised in 2015. The company is also looking to partner with transit agencies in smaller cities, where a dynamic-route vanpool option may be found to be complementary and cost-effective.

4 http://www.citylab.com/tech/2015/04/the-new-york-car-service-that-charges-almost-transit-prices/389985/

http://innovativemobility.org/wp-content/uploads/2015/11/SharedMobility_WhitePaper_FINAL.pdf

http://www.brownpoliticalreview.org/2015/11/magic-pool-bus-the-rise-of-microtransit-puts-public-transit-access-at-a-crossroads/

http://www.crainsnewyork.com/article/20150524/TRANSPORTATION/150529933/yet-another-ride-service-only-this-one-is-different

http://nymag.com/daily/intelligencer/2015/12/via-ride-sharing-app-seniors.html

http://www.nytimes.com/2015/12/31/fashion/with-via-sharing-more-than-just-a-ride.html

5 Pers. Comm. Via Support (June 6, 2016) "We are also actively exploring options for integrating wheelchair accessible vehicles into Via's shared ride model. We're in contact with the team at MV-1 (the manufacturers of a purpose-build vehicle for wheelchair accessibility) and are considering a proposal from them to introduce wheelchair accessible vehicles into our fleet. We are also actively engaged in a dialogue with the Taxi and Limousine Commission as to how we can work together to increase access to wheelchair accessible vehicles in NYC.

6 In comparison, the median NY bus driver salary is less than $25K USD annually http://www1.salary.com/NY/New-York/Bus-Driver-salary.html

Appendix D: Stakeholder Interviews

D1 INTERVIEW LIST

Company	Contact	Interview date
Metrolinx	Josh Tzventarny, Senior Advisor, Sustainability (Innovation) Antoine Belaieff, Director of Innovation	Feb 12th , 2016
Toronto Transit Commission (TTC)	Laurence Lui, Transportation Planner Yuval Grinspun, Senior Business Process Analyst	April 19th 2016
Agence Metropolitaine de Transport (AMT)	Nicolas Tanguay, Directeur Développement des Réseaux, Plannification et Innovations Ludwig Desjardins, Directeur Planification Stratégique	May 6th, 2016
Société de Transport de Montréal (STM)	Michel Tremblay, chef de division, Développement des réseaux	May 17th, 2016
City of Toronto	Jesse Coleman, Big Data Innovation Team Lead	May 6th, 2016
City of Montréal	Isabelle Morin, Chef de Division, Département des Transports	May, 2016
University of Toronto	Eric Miller, Director, University of Toronto Transportation Research Institute	April 20th, 2016
Montréal Polytechnique	Catherine Morency, Professeure agrégée, Titulaire de la Chaire Mobilité	April 19th, 2016
UC Berkeley – Transportation Sustainability Research Center	Adam Cohen, Research Associate, Innovative Mobility Research Group	April 21st, 2016
Columbia University	David King, Assistant Professor of Urban Planning	April 22nd, 2016
Canadian Urban Transit Research and Innovation Consortium (CUTRIC)	Josipa Petrunic, Executive Director & CEO	May 12th, 2016
Company	Contact	Interview date
Uber	Andrew Salzberg, Global Mobility Policy Lead	May 13th, 2016
Kutsu+ / Helsinki Region Transport	Kari Rissanen, Program Director	May 3rd, 2016
RideCo	Prem Gururajan, Co-Founder	May 5th, 2016
Line Six Transit	Brett Chang, CEO	May 4th, 2016
Netlift	Marc-Antoine Ducas, CEO	May 10th, 2016
FleetCarma	Matt Stevens, CEO	May 16th, 2016

D2 INTERVIEW REFERENCE GUIDE

Note: Sample interview guide template: interview questions and context provided was modified based on stakeholder type and background

INTRODUCTION:

Hi this is ________ and with me is ________ taking notes. I have that we're scheduled for a __ minutes interview – does that still fit with your availability?

Context – describe your research: we are conducting a scoping study on the opportunity to reduce greenhouse gas emissions via microtransit in large cities in Canada including Toronto and Montréal, in partnership with The Atmospheric Fund and Coop Carbone.

Context – describe why you are interviewing them: The intent of the study is better understand the potential of microtransit in reducing GHG emissions and identify the key success factors for a successful implementation in cities. The study will include a profile of existing microtransit and initiatives, an analysis of the key success factors and some recommendations for pilots.

We've heard about your company ____ and we'd love to hear about your experience and feedback with microtransit.

Can we record the interview for our own note-taking purposes?

We won't attribute any ideas specifically to you without your prior consent.

1) OVERVIEW OF MARS & WHY WE ARE INVOLVED IN TRANSPORTATION:

- About MaRS and Data Catalyst
- Our involvement in transportation
- How we are going to use the information gathered today

2) YOUR EXPERIENCE WITH MICROTRANSIT

- Definition of microtransit
- Can you tell me about your company? How did you get involved with ____?
- What has been the experience of setting up a microtransit service?
- Trends
- What are the barriers to expanding your reach?
- What has been your experience with the regulatory environment in running _____?
- What has your interaction with the government (city, province) been like?
- Do you think there are opportunities for startups in transit planning?

3) MODELS AND DATA SETS

- Are you aware of any research on the impact of GHG?
- What opportunities do you think microtransit presents in how we get around the city?
- Do you track the social and environmental impact of your service?
- What is the occupancy rate?
- What types of vehicles are in your network?
- Our thinking is that microtransit can impact positively or negatively GHG emissions, based on the way it's being implemented (rebound effect – replacing cycling or walking VS serving underserved areas or improving paratransit for example). According to you, what would be the key variables to take into account?

4) ADOPTION

- What is your take on the development of microtransit? Do you see a real market potential?
- What would you say are the key critical success factors?
- Barriers to adoption

5) FURTHER RESEARCH

- Part of our role is to advise on a potential pilot or more detailed research project. According to you, what should we be exploring?

6) CONTACTS AND RESOURCES

Appendix E: The GHG model

E1. MODELING STEPS

1. IDENTIFY THE SIZE OF USE CASE

From the available transportation pattern data sources, queries were submitted to determine the number of trips by mode, and Manhattan distance travelled for each use case. Where relevant, each sample was extrapolated to the total population based on the published population expansion factors for those data sources (see table E2 below).

2. CALCULATE PRESENT TOTAL GHG EMISSIONS

To calculate the present total GHG emissions, the total distance traveled for each use case was multiplied by the emission factor for the vehicle (avg fleet composition) and fuel type .

$$\textit{Present GHG Emission} = \sum(\textit{Distance} * \textit{Trips} * \textit{kg Emissions per kilometer})$$

3. CALCULATE FUTURE EMISSIONS FOR CONVERTED POPULATION

Future emissions were determined by accounting for the change in occupancy (from largely single journeys to shared journeys, and a conversion ratio (i.e., the percentage of the total number of people in each use case that would change their mode of travel to microtransit). Conversion ratios were based on best-available evidence and expert consultation. Together these provide the new distance to be travelled by shared transit vehicles.

An inefficiency factor is then applied to take account of any extra distance travelled by vans in picking up as part of a shared route for example

Emission rates of different vehicles (e.g., electric motor vehicle, hybrid, and conventional) are then applied to derive the resulting GHG emissions.

$$\textit{Converted Population Emissions} = \left[\frac{\textit{Old Distance}}{\frac{\textit{New Occupancy}}{\textit{Old Occupancy}}} * \textit{Conversion Ratio} \right] \textit{Inefficiency Coefficient} * \textit{New Average Emissions Rate}$$

As the total future emissions accounts for that total population (both those who have converted and those who have not yet converted), the two populations must be considered together as the new emissions total.

$$\textit{Non-converted population GHG Emissions} = ([\textit{Old Distance} * (1 - \textit{Conversion Ratio})] * \textit{Old Average Emissions Rate})$$

$$\textit{Future GHG emissions} = \textit{Converted population emissions} + \textit{non-converted population emissions}$$

4. DETERMINE THE DIFFERENCE BETWEEN PRESENT AND FUTURE EMISSIONS

The difference between present and future emissions for each use case was determined by subtracting future scenarios from present GHG emission levels.

$$\textit{GHG Reduction} = \textit{New Emissions} - \textit{Present GHG Emissions}$$

This process was repeated for appropriate GHG efficiencies for differing vehicle types (electric, hybrid, and conventional). All use cases were then summed.

Worked Example: Travel to Suburban Rail

One area that provides high potential opportunity for conversion to micro transit is travel to and from suburban transit. In the GTHA use case, suburban transit was defined as travel to TTC subway or GoTrain stations.

1. Identify the size of use case

Using the TTS, a cross tabulation query in 2011 transit surveys was submitted for Manhattan distance (in metres) of trips using cars and taxis, originating in planning districts of 1 – 46 (representing the area of GTHA) for the purposes of access to

GO Rail and TTC.

2. Calculate present total GHG Emissions

To calculate the present total GHG emissions, the total distance traveled for each use case was multiplied by the emission factor for the vehicle and fuel type.

$$\text{Present GHG Emission} = \sum(\text{Distance} * \text{Trips} * \text{kg Emissions per kilometer})$$

The resulting TTS cross tab provided 3780 rows of distances with corresponding number of trips for each distance. Each distance was multiplied by the number of trips in that distance. The resulting distances were summed to determine the total distance for the use case.

The TTS query resulted in 3,476,994,114 metres per day, which was multiplied by 261 work days per year to result in 907,495,463.8 km per year. Assuming a 1.2-person occupancy per vehicle, and conventional car emissions of 0.23 kg CO2eq/km, this resulted in 208,723,957 kg of CO2 emitted (20.87kT CO2).

3. Calculate Future Emissions

Future emissions were determined by accounting for the change in occupancy from 1.2 occupancy to 6.0 occupancy using sprinter vans, and a conversion ratio of 20% (meaning 20% of people currently travelling in single occupancy vehicles would change to microtransit). Together these provide the new distance to be travelled by shared transit vehicles.

An inefficiency factor is then applied to take account of any extra distance travelled by vans in picking up as part of a shared route for example. In this use case, 10% routing inefficiency was applied.

Emission rates of different vehicles (e.g., electric motor vehicle, hybrid, and conventional) are then applied to derive the resulting GHG emissions.

$$\text{Emissions from Converted Population} = \left[\frac{\text{Old Distance}}{\frac{\text{New Occupancy}}{\text{Old Occupancy}}} * \text{Conversion Ratio} \right] \text{Inefficiency Coefficient} * \text{New Average Emissions Rate}$$

$$\text{Emissions from Converted Population}_{Hybrid} = \left[\frac{907{,}495{,}463.8\text{km}}{\frac{6.0}{1.2}} * 0.2 \right] 1.1 * 0.06\text{km } CO^2\text{eq/km}$$

$$\text{Emissions from Converted Population}_{Hybrid} = 2{,}583{,}458 \text{ kg } CO^2\text{eq}$$

As the total future emissions accounts for that total population (both those who have converted and those who have not yet converted), the two populations must be considered together as the new emissions total.

$$\text{Emission from Non-converted population}_{Hybrid} \text{ GHG Emissions} = \left[907{,}495{,}463.8\text{km} * (1-0.2) \right] * 0.23\text{km } CO^2\text{eq/km}$$

$$\text{Emission from Non-converted population}_{Hybrid} \text{ GHG Emissions} = 166{,}979{,}165 \text{ kg } CO^2 \text{ eq}$$

New GHG emissions=Converted population emissions+non-converted population emissions

Future GHG emissions=2,583,458+166,979,165

Future GHG emissions=169,562,623 kg CO2eq

4. Determine the Difference between Present and Future Emissions

The difference between present and future emissions for each use case was determined by subtracting future scenarios from present GHG emission levels.

GHG Reduction=New Emissions-Present GHG Emissions

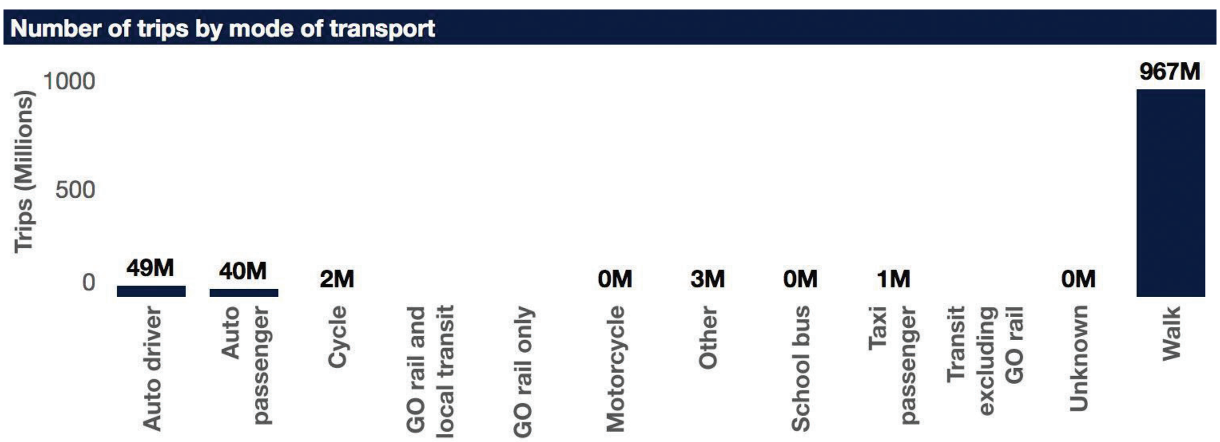
GHG Reduction=169,562,623 kg CO2eq-208,723,957 kg CO2eq

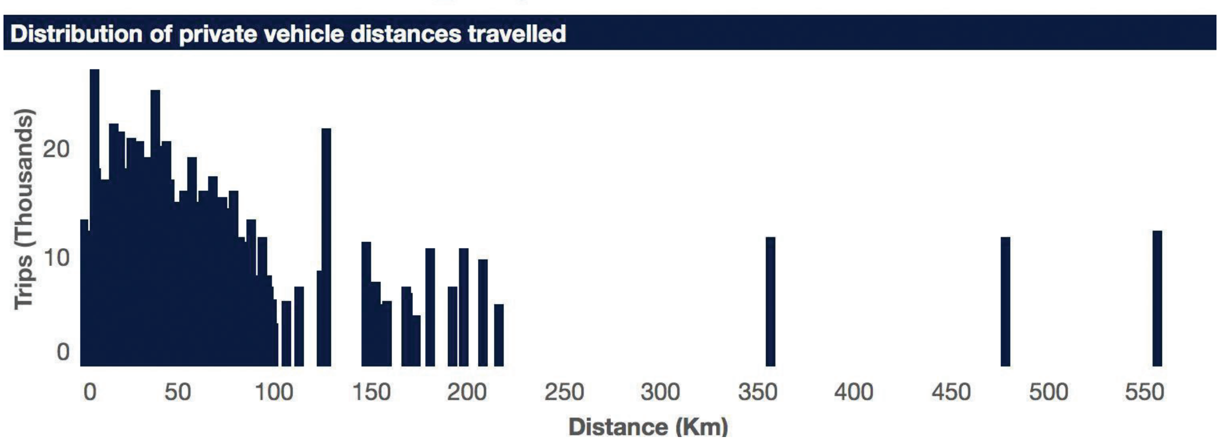
GHG Reduction=-39,161,333 kg CO2eq

The table below outlines the data sources used for each use case and the estimation of the baseline number of journeys and distance.

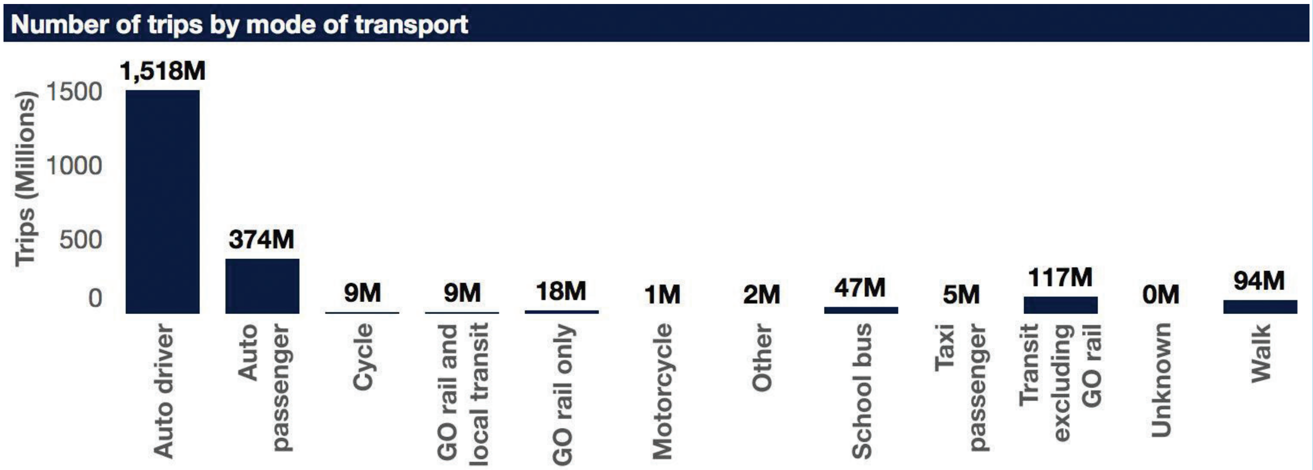
Table E2: Data Source and Methodology for Each Use Case

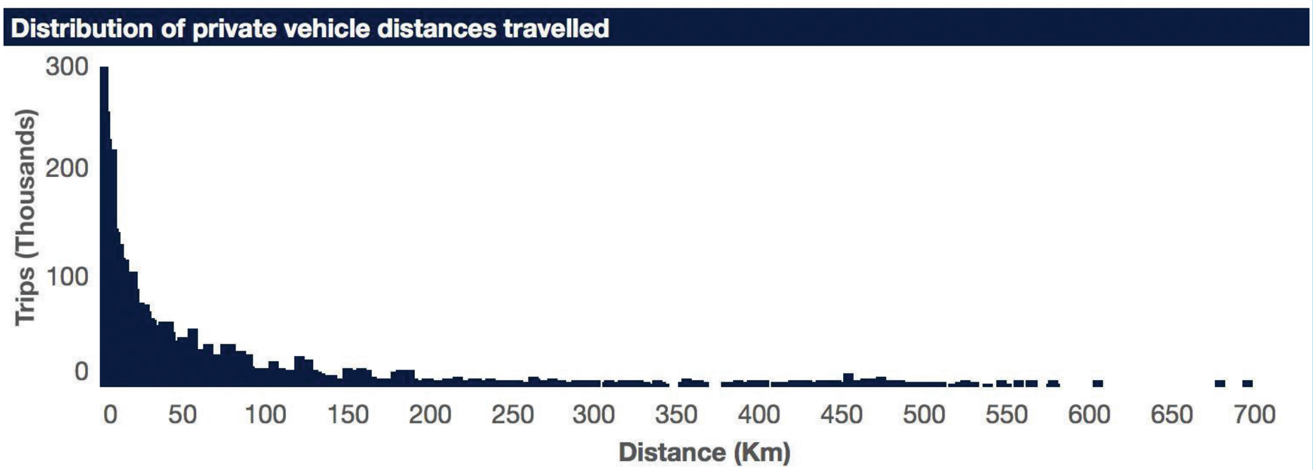
	Scenario	
Use Cases	Data Source	Method and Limitations
General for all use cases	n.a.	Data sources: Estimate of current emissions was based on best available data source as listed for each use case. Number of days: Where TTS is used this includes one, 24-hour week-day reporting of travel. As such, where TTS was used, the resulting travel was multiplied by 261 (number of work days in a year). Data on weekends was not attainable. Filtering data to the GTHA: Data from TTS was filtered to Planning Districts (PDs) 1 – 46 to represent GTHA. Population sample: Though TTS is the best available data for GTHA travel patterns, TTS methodology and sampling and its expansion to the total population may result in biased sampling as a result of landline, nested clusters in Ontario population. Expansion to the total population: The extrapolation of travel patterns to the total population was based on the expansion factor applied by the TTS which extrapolates from the nested stratified random sample to the population based on the 2006 census.
Use Cases	Data Source	Method and Limitations
Suburban Rails	Transportation Tomorrow Survey (TTS) 2011	Number of trips by Manhattan journey distance and by car and taxi obtained from TTS for individual trips from home originating from GTHA PDs and ending at GO Train stations or TTC subway stations.





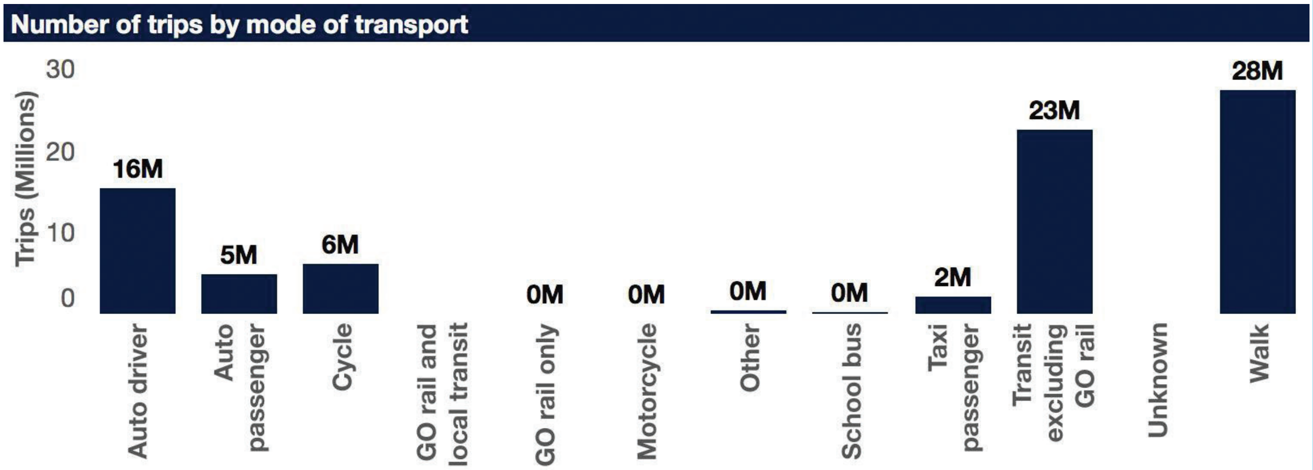
Use Cases	Data Source	Method and Limitations
2) Lower Density Neighbourhoods Underserved by Transit	Transportation Tomorrow Survey (TTS) 2011	The total number of journeys taken by all modes of transportation was identified from TTS for all GTHA PDs. To estimate those suburbs most dependent on cars, we took the top quartile (top 25%) of PDs that used private cars as transportation. For those PDs this equated to approximately 60% or more of all journeys being undertaken by private cars. As such, these PDs were considered car dependent The distance traveled for all trips by private car starting and/or ending in these high car dependency PDs were queried from TTS and used in the calculations.

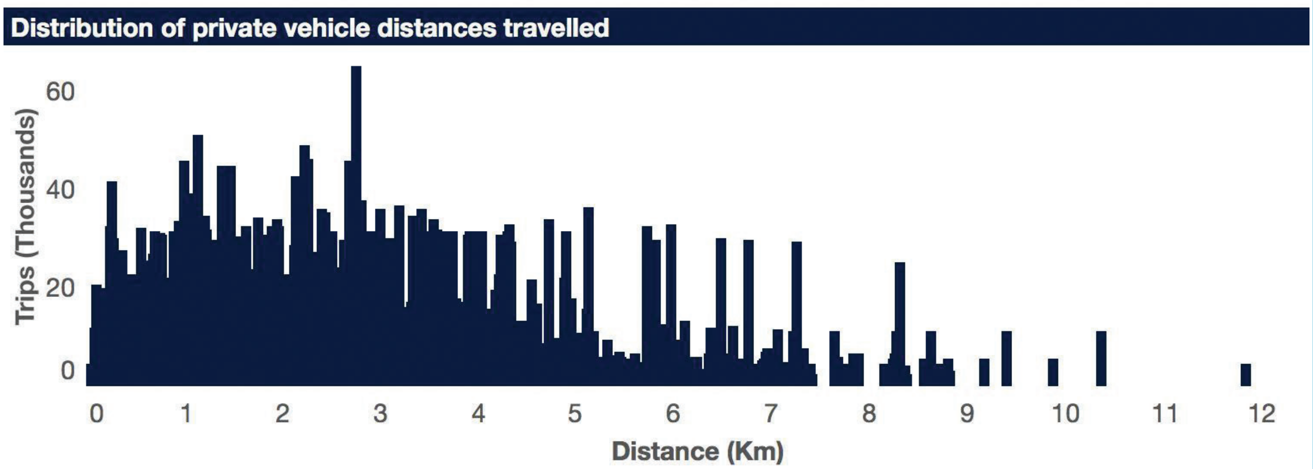




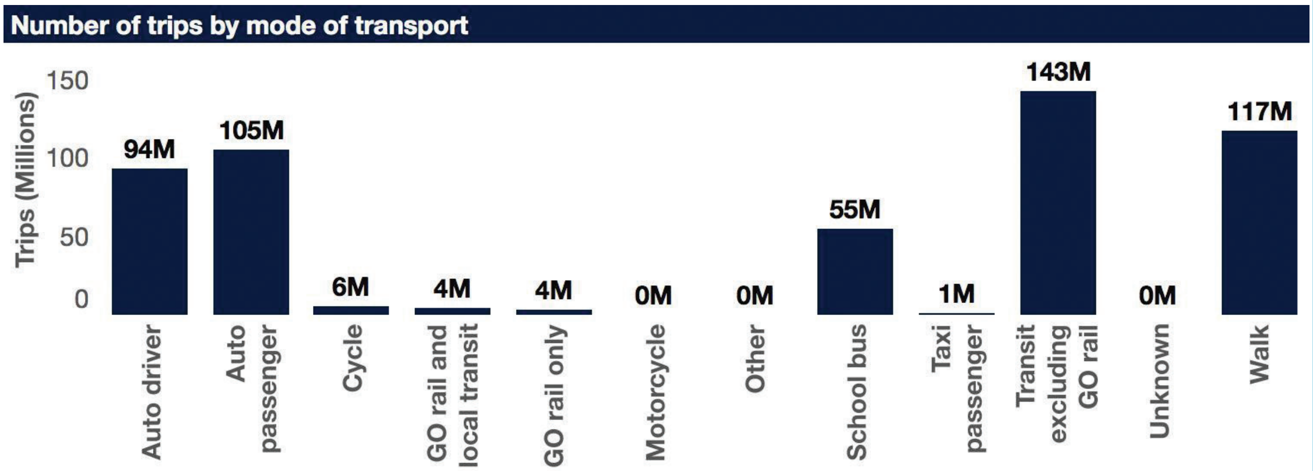
Use Cases	Data Source	Method and Limitations
3) Para-transit	Data sources and key informants from TTC	Information, including total passengers, occupancy, total kilometres, distance between pickups, total demand, and total demand met by para-transit services were provided by TTC. Para-transit data included TTC service areas only; due to variable nature in GTHA, no expansion to other areas was assumed.

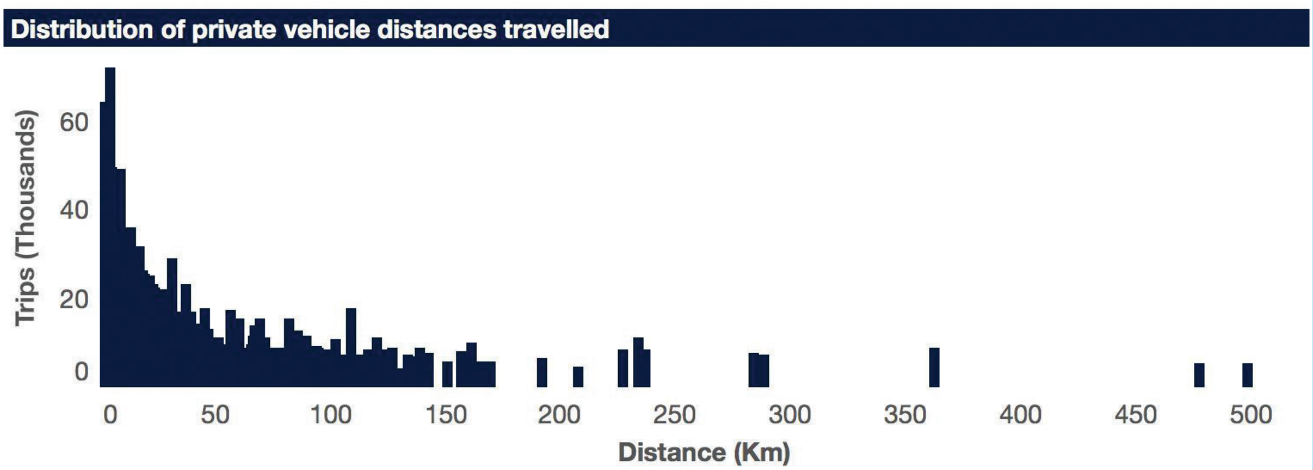
Use Cases	Data Source	Method and Limitations
4) Downtown Circulation	Transportation Tomorrow Survey (TTS) 2011	The number of trips by Manhattan distance by car and taxi per trip that start and stop in downtown Toronto (PD1 in TTS) were included in calculations.



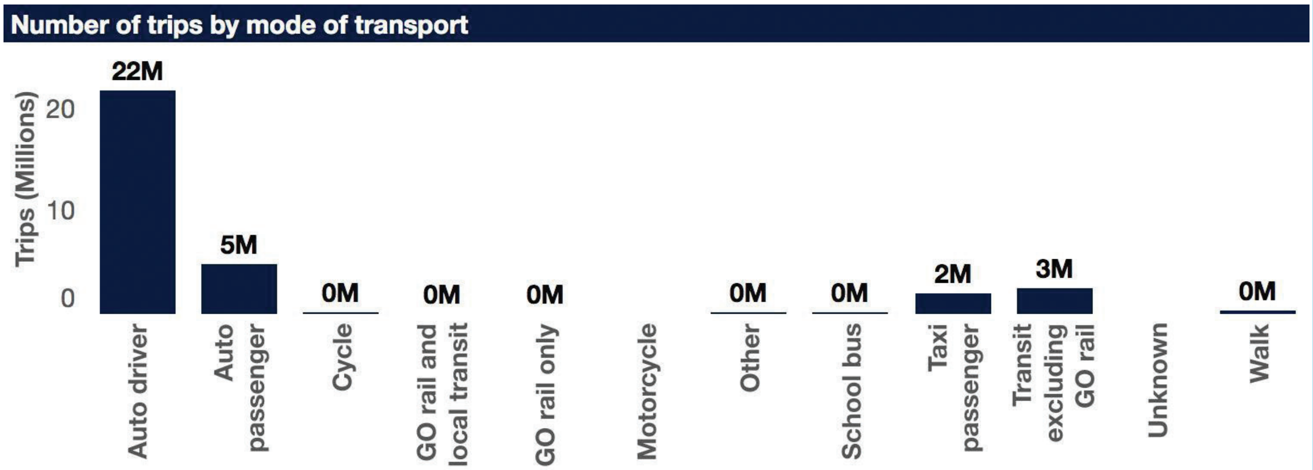


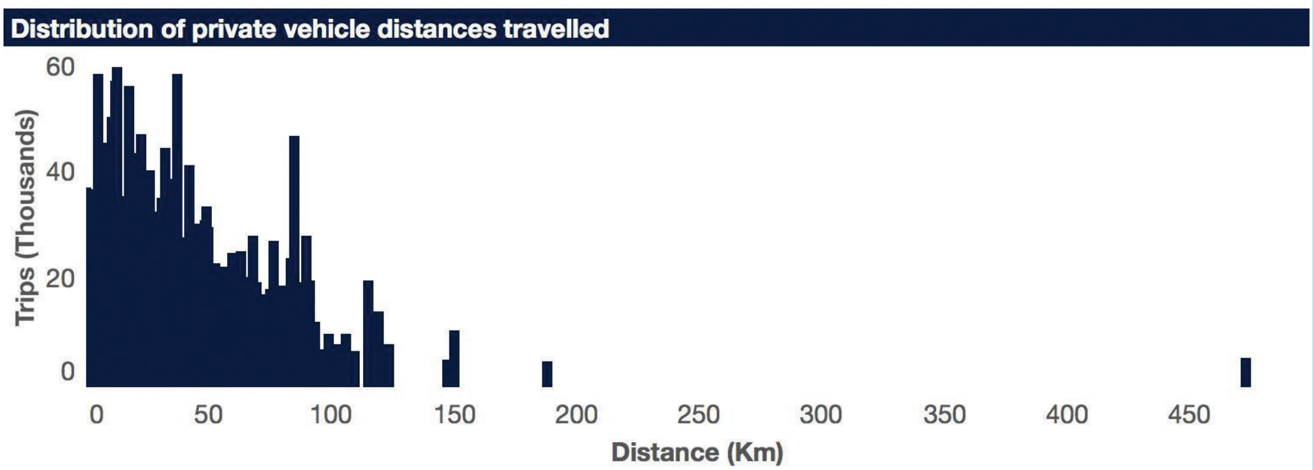
Use Cases	Data Source	Method and Limitations
5) School Drop-offs	Transportation Tomorrow Survey (TTS) 2011	The number of trips by Manhattan distance made by car, taxi, and as a passenger with origin or destination at schools were included in the calculations. Note TTS data is not collected for individuals under the age of 11 so schools drop offs for this younger cohort is not captured and reflected in the calculations, but school drop-offs for the purpose of school and post-secondary school travel is included for individuals above 11.



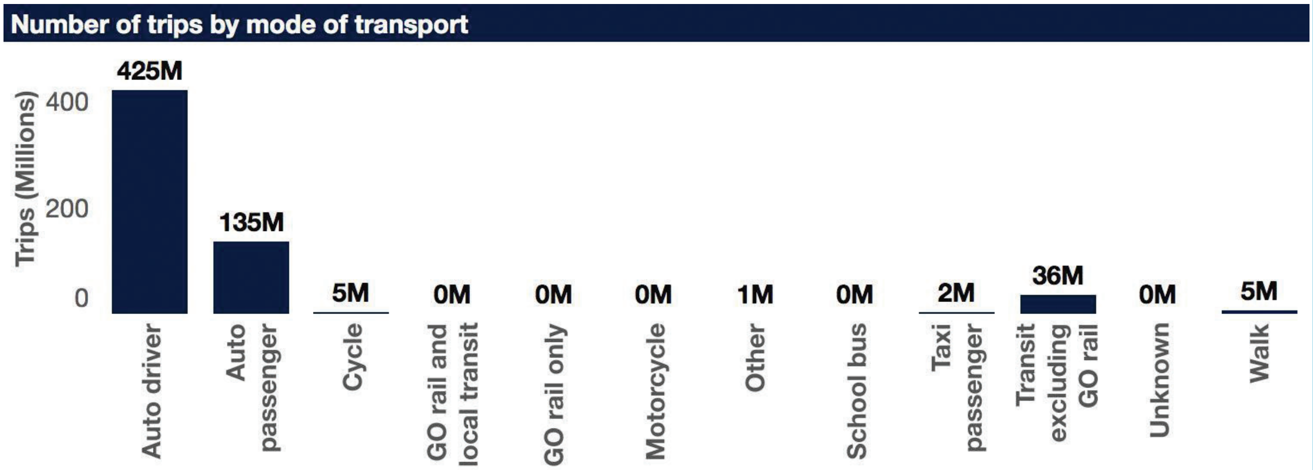


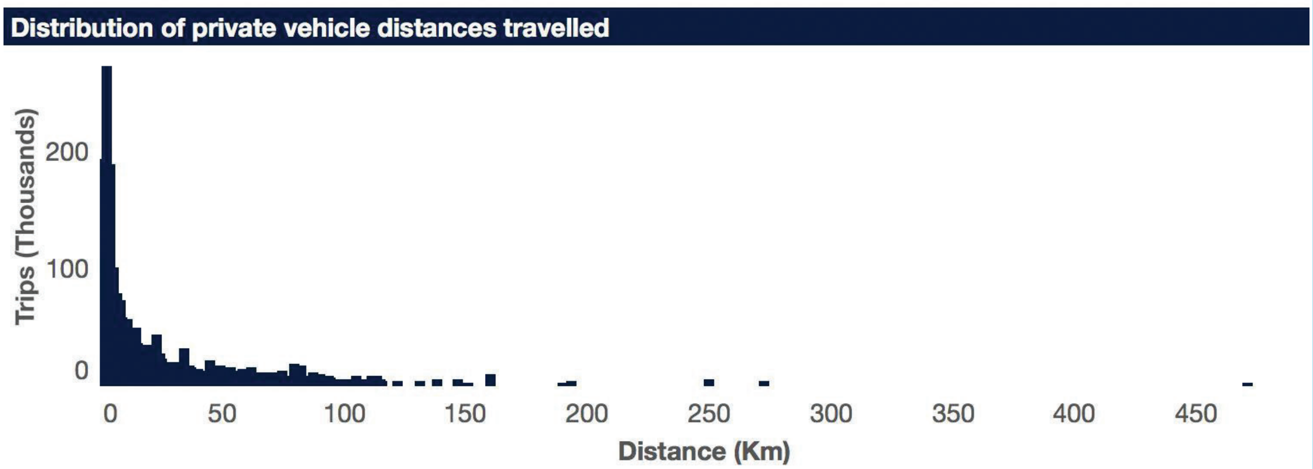
Use Cases	Data Source	Method and Limitations
6) Airport Drop-offs	Transportation Tomorrow Survey (TTS) 2011	To estimate airport drop-offs the smaller scale traffic zones in TTS for Pearson International Airport (Toronto), Billy Bishop Airport (Toronto), and John C Munro (Hamilton) were identified. These traffic zones correspond directly to the airports. The number of trips by Manhattan distance by personal car and taxi originating and ending in these traffic zones to or from the relevant GHTA PDs were included in the calculations.



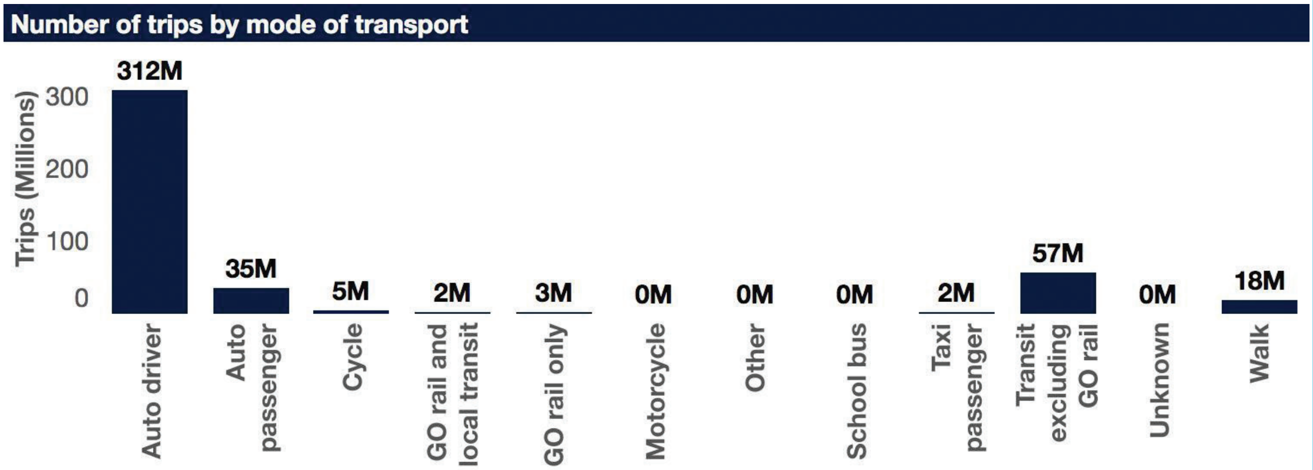


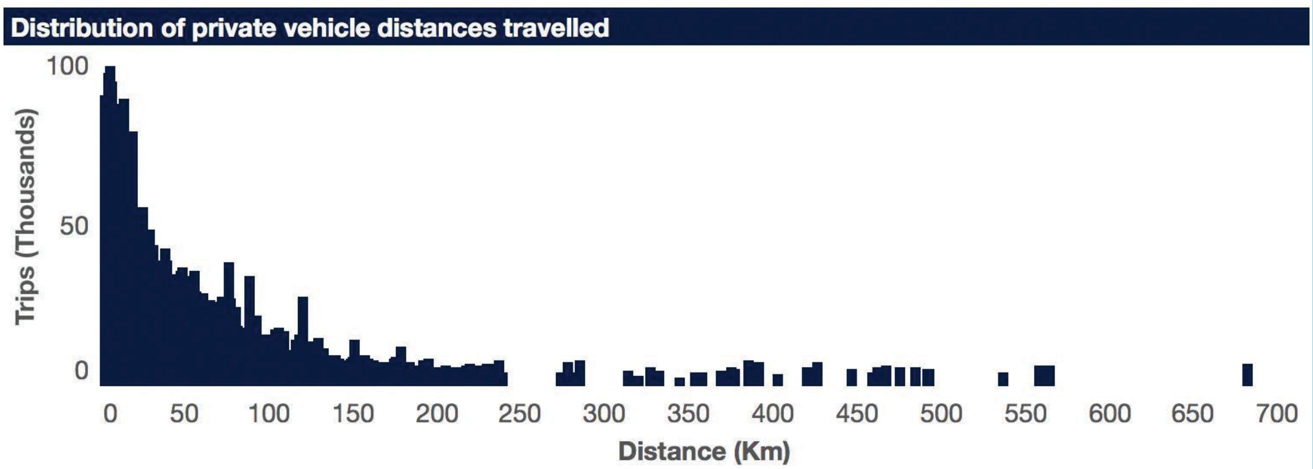
Use Cases	Data Source	Method and Limitations
7) Retail	Transportation Tomorrow Survey (TTS) 2011	The number of trips by Manhattan distance made by car, taxi, and passenger trips with origin or destination for going to retail locations in all relevant GTHA PDs were included in calculations.





Use Cases	Data Source	Method and Limitations
8) Shift-workers	Transportation Tomorrow Survey (TTS) 2011	The number of trips by Manhattan distance made by car or taxi for the purpose of work (includes travel to and from work), outside rush hours (6am to 9am and 4pm to 7pm) with origin and destination in the GTHA PDs were included.





9) Entertainment	Transportation Tomorrow Survey (TTS) 2011	TTS 2011 does not provide the detailed information on trips for entertainment, rather it consolidates entertainment with travel for other and personal purposes into the overall category of "Other". However, the TTS 2006 survey did have proportions of travel for "Other" (1%). These were entertainment (47%) and personal purposes (52%). This proportional breakdown was applied to the 2011 "Other" category to determine travel for entertainment purposes.

Appendix F: Detailed Description of Potential Microtransit Use Cases

1) **Shared dynamic shuttle services to suburban rail/metro stations**

Use of dynamic microtransit to substitute for private car use to suburban rail and metro stations given the high concentration of users in time and space. This use case offers the additional potential to relieve capacity constraints and costs of providing parking at suburban stations. Examples: Substituting single car commutes to the GO stations or outer end of TTC lines for the GTHA or outer SMT stations in Greater Montréal.

2) **Reaching underserved, low-density suburbs**

Many low-density areas cannot support the cost of a fixed schedule service with a high enough frequency to be an attractive alternative. This results in many suburbs being underserved by fixed schedule transit. Dynamically allocated services could aggregate enough demand, especially at peak times, to offer a convenient and cost-effective alternative to the private car, or relieve long walking and high transit times for those unable to afford a private car alternative.

3) **Off peak services to mid-density suburbs**

Providing a high-frequency, all-day fixed schedule service attractive enough to attract commuters is costly, yet in the off-peak demand drops significantly. Use of dynamic services on those routes could provide an attractive service at a lower cost in the off-peak period. This use case combines fixed and dynamic service for the same route area based on time of day.

4) **Busy corridor commutes**

Significantly, dense accommodation close to urban cores is generating a demand for travel that far exceeds the capacity of public transit systems. Publicly or privately operated shuttle services offering either fixed or dynamic schedules provide an alternative to fixed public transit and create additional capacity.

5) **Accessible and special transportation services**

Use of on-demand services to aggregate demand from passengers wishing to use accessible and special transportation services to improve the cost-effectiveness and frequency of services as well as expand the areas served.

6) **Downtown circulation**

Substitute use of personal cars in downtown Toronto and Montréal with microtransit services.

7) **School drop-off**

Use of microtransit services to substitute for use of individual cars to drop off and pick up students at schools.

8) **Airport drop-off**

Use of microtransit services to substitute for use of individual cars or taxis to drop off and pick up passengers from airports.

9) **Suburban mall/big retail**

Use of microtransit services to substitute for use of individual cars or taxis to travel to large retail malls, usually located in suburban areas.

10) **Shift workers**

Use of microtransit services to provide shift workers with more options to travel to and from work at off peak hours, where traditional public transit options are scarce.

11) **Trip chaining – home-school-work**

Use of microtransit services to substitute for use of personal cars to drop off children at school and then commute to work.

12) **Events and entertainment destinations**

Use of microtransit services to transport a large number of people to sporting and cultural events, reducing the number of personal cars on the road.

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The MaRS Discovery District would like to acknowledge our partners at The Atmospheric Fund and Coop Carbone for their generous support and dedication to developing this report. This publication is developed in line with our mission to foster the adoption of innovative market solutions in Ontario and Canada and to leverage those successes and experiences into international markets.

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