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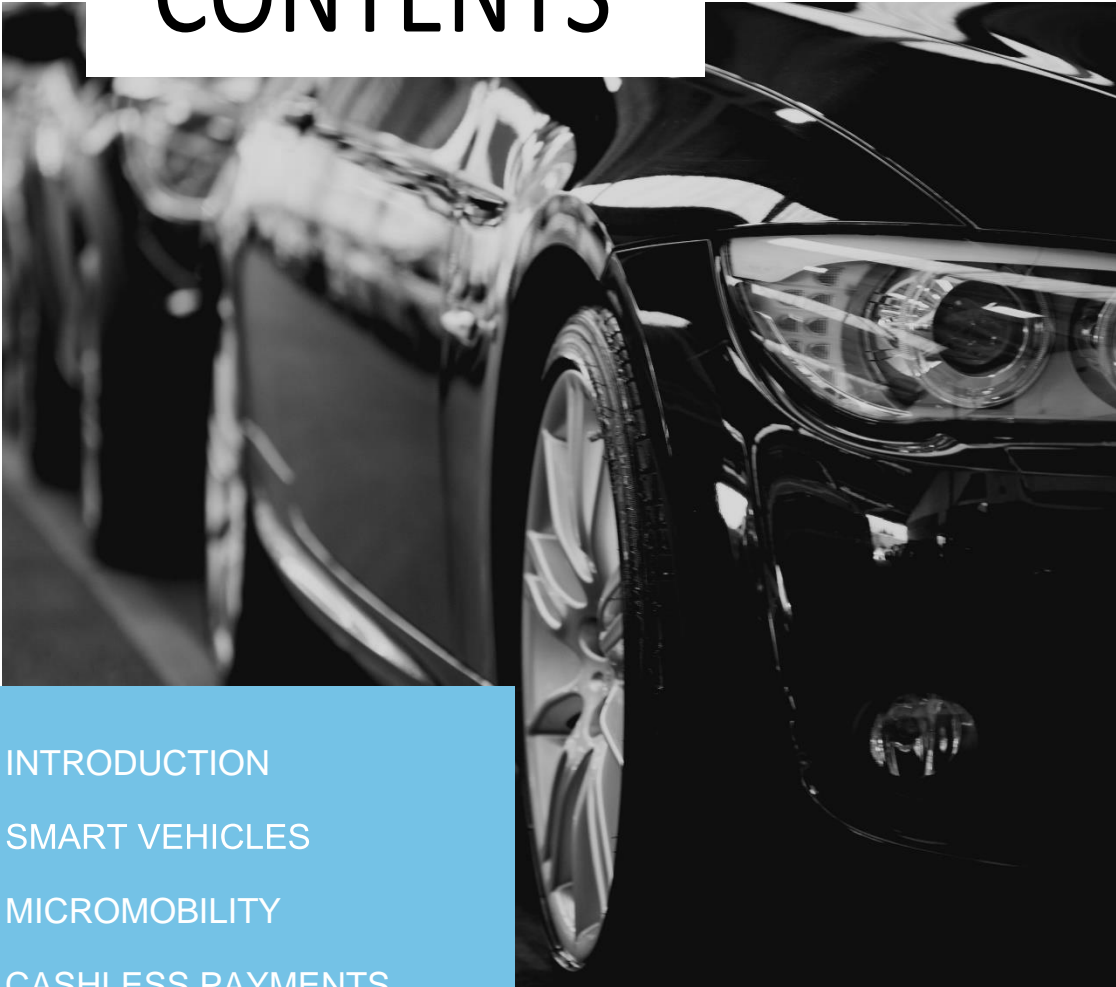
THE FUTURE OF TRANSIT

Disruptive Trends Reshaping Transit Services

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INTRODUCTION

The mobility landscape continues to evolve as a result of disruptive innovations that have emerged in the last decade thanks to the rapid advances in information and communication technologies. High-speed connectivity, high-performance computing, applied artificial intelligence, and advanced micro-electro-mechanical systems have all facilitated the introduction of emerging technologies and concepts such as the Internet of Things[1] (IoT), connected and autonomous vehicles (CAVs), and ubiquitous computing[2]. These technologies have started to revamp how people and goods are moving. As integral parts of the transportation network, public and private transit services are, consequently, experiencing substantial transformations, and are anticipated to further revolutionize as technologies evolve. In this report, we discuss these major transformations that have started to reshape the present and future of public and private transit.

A part of these transformations is the adoption of **connected vehicles** that, when ubiquitously deployed, are anticipated to add efficiency and comfort to the way riders plan and access their transit trips. **Autonomous vehicles** are

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[1] The Internet of Things (IoT) is a large- scale networking paradigm connecting smart objects to the Internet with a capability for controlling, identifying, and harvesting data through them remotely.

[2] Ubiquitous computing, also called pervasive computing, is a concept in computer science referring to the availability of computing facilities anytime and everywhere, using any device and in any format.

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also anticipated to reshape the whole mobility landscape, boosting safety levels on roads and bringing new forms of mobility such as autonomous transit shuttles and air taxis.

The technological advances have also been promoting modes of transport that have not been widespread before. Bikes, scooters, and mopeds have been widely offered in the last few years as shared services, known as **micromobility**.

Mobility payments have also been taking new forms, providing transit riders with convenient and seamless fare payment experiences. **Cashless payments** have been waiving the need of riders to line up and buy paper tickets. Using contactless cards, smartphones, and wearable technologies, paying for the different modes of transport has been an ultimate convenience.

Services like ride hailing and car sharing have also been transforming the mobility and vehicle ownership experiences. With these services, people can go around enjoying the convenience of a private vehicle without owning a vehicle themselves. These services are offered as a part of a bigger umbrella named **Mobility as a Service (MaaS)**. MaaS aims at providing user-centric mobility experience, offering access to different modes of transport simply from a mobile/web application. MaaS integrates these different modes to provide optimized, door-to-door, multi-modal trips to MaaS users, with the ability to pay for all parts of the trip through the same application.

In this report, we walk through the disruptive transit trends highlighted above, delineating the array of services and innovative solutions that transit riders can experience and benefit from now and in the near future. Technology companies, mobility providers, and city authorities should also look at these trends as major opportunities for economic growth, improved consumer experience, and reduced environmental pollutions. The key is to harness the ever-growing technological advances and work all hand in hand to facilitate and capitalize on the potential opportunities.

SMART VEHICLES

The mobility industry has been experiencing one of its most significant transformations with the development and initial deployment of smart vehicles. These vehicles have added capabilities that allow them to have external connectivity and perception of the surrounding environment. In previous AVIN specialized reports, we discussed the enabling technologies, opportunities, and wide impacts of these smart vehicles; namely the connected and autonomous vehicles (CAVs)[3].

Connected Vehicles

The connected vehicles (CVs) were the earliest forms of smart vehicles to hit the market. Automakers have been mainly focusing on bringing Internet connectivity to these vehicles to enable access to infotainment services on the go. Yet, the external connectivity capabilities of CVs are more realized and capitalized on when these vehicles are able to directly communicate with their neighboring vehicles, infrastructure, cyclists, and pedestrians[4]. When such vehicular connectivity is available on a large scale, vehicles will not be isolated entities anymore. They will be seen as part of a massive transportation network where all

[3]The Autonomous Vehicle Innovation Network. AVIN Specialized Reports. Retrieved from
https://www.avinhub.ca/reports/

[4] The Autonomous Vehicle Innovation Network. (2019). Opportunities for Connected Vehicles Beyond Transportation. Retrieved from
https://tinyurl.com/s8g6vq3

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the pieces are connected. Such inter-connectivity certainly can affect the way people access and experience public and private transit[5].

Without ample information in hand, it is hard for transit users to make the best

> **" Such ad hoc vehicle networks could be integrated with other transportation networks, from pedestrian cross-walk systems to connected bicycles, making your car a single node in a giant grid of multi-modal transit intelligence.[6] "**
>
> Bill Ford, Executive Chairman, Ford Motor Company

decisions on time and mode of travel. Bringing real-time connectivity to transit vehicles can help riders get accurate times of vehicle arrival/departure. This adds significant efficiency and convenience to the experience for transit users. It also helps riders choose from and switch smoothly between different modes of transport. Real-time vehicular connectivity can also help traffic authorities, drivers, and riders get up-to-the-minute updates on on-road events, closures, and hazards, improving the overall mobility experience of everyone on the road. Real-time connectivity in vehicles is also a big asset when it comes to fleet management of either public or private transit vehicles.

Furthermore, the access to the Internet offered to connected vehicles can be expanded to their riders, either through in-vehicle infotainment devices/displays or through the riders' personal devices, to enjoy Internet connectivity on the way. This can positively add to the commuter's mobility experience and encourage more access to transit vehicles through facilitating the ability to work on the move.

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[5] **Deloitte. (2012). Digital-Age Transportation: The future of urban mobility.** Retrieved from https://www2.deloitte.com/us/en/insights/industry/automotive/digital-age-transportation.html

[6] **Fitchard, K. (2012). If cars could talk to one another, what could (and should) they say?** Retrieved from https://gigaom.com/2012/02/28/if-cars-could-talk-to-another-what-could-and-should-they-say/

Autonomous Vehicles

The autonomous (i.e., driverless) vehicle is the second and most prominent form of smart vehicles, expected to transform the whole mobility industry and experience. Impacts of autonomous vehicles (AVs) are anticipated to expand beyond the transportation sector to reshape other vital sectors, as discussed in a previous AVIN specialized report[7].

In addition to the **augmented on-road safety** levels anticipated from the deployment of AVs through eliminating human driving errors[8], the adoption of these vehicles is going to affect transit users in other ways. As part of preparing for the future of mobility, many automakers and mobility providers have been showcasing various sizes of driverless transit vehicles, known as **pods**[9,10]. These vehicles are designed with no steering wheel, nor a driver's seat on board. The compartment space is well-utilized for accommodating multiple passengers, while offering a convenient legroom for each.

Pods are also assumed to be connected to the Internet and tailored to offer riders the convenience to work, study, and socialize on the go. This is anticipated to attract more transit riders, and in turn, reduce the number of private vehicles on roads, leading to less congested and greener roads. Waiving dependency on human drivers is also anticipated to boost the use of on-demand transit. This brings major mobility opportunities and advantages, especially for seniors and people with disabilities that may have difficulties moving to a public transit station.

Many jurisdictions across the world have been undertaking demonstrations and initial deployments of low-speed pods/shuttles. A popular and widely

[7] **The Autonomous Vehicle Innovation Network. (2019). Autonomous Vehicles Reshaping the Future: Cross-Sector Opportunities and Considerations. Retrieved from** https://tinyurl.com/s5kurog

[8] **National Highway Traffic Safety Administration. Automated Vehicles for Safety. Retrieved from** https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety

[9] **Toyota Canada. (2018). Toyota unveils e-Palette concept at CES 2018. Retrieved from** https://www.toyota.ca/toyota/en/connect/2000/toyota-e-palette-concept-vehicle-ces-2018

[10] **Cruise LLC. (2020). Introducing the Cruise Origin. Retrieved from** https://www.getcruise.com/

deployed pod is the EasyMile EZ10, which has been deployed in more than 25 countries over 4 continents, so far[11]. EasyMile's EZ10 debuted in Calgary, Canada in 2018 as ELA[12]. In Ontario, the City of Toronto, Toronto Transit Commission (TTC), and Metrolinx are planning to launch an automated shuttle trial in late 2020 to connect local residents to and from Rouge Hill GO station[13].

Future forms of autonomous transit are not restricted to ground vehicles. Active discussions on **air taxis** have been recently going on[14], with some companies starting to release their visions and designs for autonomous air transit. Some companies have taken further steps and started demonstrating their autonomous, aerial vehicles in different jurisdictions across the world. An example is the drone start-up EHang that has demonstrated its two-seat self-flying air taxis in different

parts of Europe, Asia, and North America[15]. In 2019, Boeing also completed the first test flight of its autonomous passenger air vehicle[16]. Volocopter, a German air taxi start-up, has developed VoloCity, which is an autonomous air taxi that riders will be able to hail using their smartphones[17]. Uber also announced plans for offering shared air transportation in 2023 in Dallas, Los Angeles, and Melbourne. Towards that, Uber has recently teamed up with Hyundai and revealed a model of a four-seat, electric flying vehicle that will be initially man-flied, then transformed to a fully autonomous flying vehicle[18].

[11] **EasyMile. EZ10. Retrieved from** https://easymile.com/solutions-easymile/ez10-autonomous-shuttle-easymile/

[12] **EasyMile. (2018). EasyMile's EZ10 Debuts in Western Canada as ELA. Retrieved from** https://easymile.com/ez10-debuts-in-western-canada-as-ela/

[13] **City of Toronto. (2019). Automated Shuttle Trial. Retrieved from** toronto.ca/AVshuttle

[14] **Hornyak, T. (2020). The flying taxi market may be ready for takeoff, changing the travel experience forever. Retrieved from** https://www.cnbc.com/2020/03/06/the-flying-taxi-market-is-ready-to-change-worldwide-travel.html

[15] **Etherington, D. (2020). Air taxi company EHang flies autonomously in the US for the first time. Retrieved from**

https://techcrunch.com/2020/01/08/air-taxi-company-ehang-flies-autonomously-in-the-u-s-for-the-first-time/

[16] **Boeing. (2019). Boeing autonomous passenger air vehicle completes first flight. Retrieved from** https://boeing.mediaroom.com/2019-01-23-Boeing-Autonomous-Passenger-Air-Vehicle-Completes-First-Flight

[17] **Chang, B. (2019). Volocopter has created an autonomous flying taxi you can hail with your smartphone. Retrieved from** https://www.businessinsider.com/volocopter-created-flying-taxi-can-hail-with-smartphone-2019-9

[18] **McFarland, M. (2020). Uber and Hyundai team up to put flying taxis in the sky. Retrieved from** https://www.cnn.com/2020/01/07/tech/uber-hyundai-flying-taxis-trnd/index.html

MICRO-MOBILITY

The rapid population growth continues to pose a global burden on cities in terms of facilitating mobility services. Although mass transit helps mitigate this burden by moving a large number of people for long distances, getting people to and from transit stations remains a challenge that sometimes turns people away from using transit services. This challenge is known as **the first mile/last mile transit problem**[19].

Another challenge is the ever-increasing traffic volumes. Urban roads have become seriously congested, affecting the overall mobility experience. Although cities consider expanding their road infrastructure, when feasible, to accommodate more cars, **there is always a demand for the public to use other smaller and greener means of transport**. These two major challenges have motivated introducing and adopting the concept of "micromobility."

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[19] **Metrolinx. First and Last Mile. Retrieved from** https://www.metrolinxengage.com/en/content/first-and-last-mile

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Micromobility comprises all means of transport that can occupy a space relative to a regular bicycle.

In many markets today, micromobility is available and represented by forms of shared bikes, scooters, and mopeds. These are offered in both human-powered and electric versions, docked and dockless. With the continuing technology advances and mobility innovations, other micromobility forms and designs are anticipated to be seen on roads in the near future[20].

Bikes, scooters, and mopeds are not new; however, the concept of offering them as commercial, shared mobility services has only boomed recently. This has been mainly enabled by

technology advances in connectivity, positioning, tracking, mobile payments, smartphone applications, and electrification.

Since their first commercial launch in France in 2005, bike-share programs have been massively spreading across the globe[21]. In Ontario, Bike Share Toronto has expanded by 450% in the past 4 years. The system has grown from 80 station and 1000 bikes to 465 and 5000 bikes. The system will grow again with the addition of 160 new stations and 1850 new bikes in 2020. Shared e-scooter services have also been recently experiencing a market storm, with companies such as Bird hitting 10 million scooter rides within 12 months of their first operations in Southern California[22].

[20] **Deloitte. (2019). Small is beautiful: Making micromobility work for citizens, cities, and service providers. Retrieved from** https://www2.deloitte.com/us/en/insights/focus/future-of-mobility/micro-mobility-is-the-future-of-urban-transportation.html

[21] **Bike Share Map. Retrieved from** https://bikesharemap.com/
[22] **Dickey, M. R. (2018). Bird hits 10 million scooter rides. Retrieved from** https://techcrunch.com/2018/09/20/bird-hits-10-million-scooter-rides/

According to a recent report by the National Association of City Transportation Officials (NACTO)[23], people took 84 million micromobility trips in the United States in 2018, with shared bikes accounting for 45.5 million trips and shared scooters accounting for the other 38.5 million trips. This is more than double the number of trips taken in the U.S. in 2017.

Such a storm of e-scooters and the increasing number of shared bikes we see every day in cities' bike lanes confirm the high demand and satisfaction of consumers with these forms of mobility. Apparently, the availability of such flexible, door-to-door forms of mobility plays a major role in solving the first mile/last mile transit challenge discussed earlier. Micromobility can cover the mobility legs to/from transit stations, improving and motivating access to mass transit services. This is best realized in communities underserved by city-wide public transit.

Reasons for the wide-spread use of micromobility expand beyond only connecting people to transit. According to a National Household Travel Survey[24] conducted by the Federal Highway Administration (FHWA) of the United States, more than half of the car trips taken annually in the U.S. cover less than five miles. It is usually faster, greener, and more convenient for trip makers to use micromobility options for covering such short-distance trips, compared to accessing public transit or driving their private vehicles and struggling with finding a parking spot. One more reason for the high rise of micromobility is the consumer appetite for being outdoors enjoying the fresh air and its health benefits, while moving. Micromobility is also well-suited for providing mobility services in places where short trips are dominant, such as in university and corporate campuses[20].

The high interest and great potential of micromobility solutions have brought **opportunities and challenges for both mobility providers and government agencies**. On the positive side, micromobility solutions have been considered big-revenue opportunities for mobility providers due to the massive cash and consumer interest these services are attracting. According to a 2019 study by McKinsey & Company, more than $5.7

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[23] **The National Association of City Transportation Officials. (2019). Shared Micromobility in the U.S.: 2018.** Retrieved from https://nacto.org/shared-micromobility-2018/

[24] **The Federal Highway Administration. National Household Travel Survey.** Retrieved from https://nhts.ornl.gov/

billion have been invested in micromobility start-ups since 2015, with the micromobility market progressing nearly two to three times faster than the car sharing and ride hailing markets[25]. In a few years, several micromobility start-ups have managed to boost their business valuation to exceed $1 billion[26]. Furthermore, due to the average unit cost, mobility providers find it more feasible to expand and maintain micromobility services, compared to shared car services. The average e-scooter price is about $375, which is incomparable to the $35,000 average price for purchasing a car in North America. McKinsey & Company revealed a 2030 micromobility market potential of approximately $200 billion to $300 billion in the United States, $100 billion to $150 billion in Europe, and $30 billion to $50 billion in China[25].

Micromobility services bring major opportunities and benefits to cities and government agencies as well. Obviously, shifting big portions of short trips from cars to micromobility solutions results in freeing up significant space on roads. This, in turn, helps cities alleviate traffic congestion and move towards their climate protection goals. Moreover, these mobility solutions, as discussed earlier, have big potential for connecting people to public transit, enhancing cities' overall transit networks and improving residents' mobility experience.

In order to cultivate the industry and government opportunities discussed above, some operational challenges need to be addressed along the way. Since most of these challenges are faced by both government authorities and mobility providers simultaneously, they would be better and faster handled if government and industry work on them hand-in-hand. The most prominent challenge is the inadequacy of road infrastructure needed to accommodate the micromobility solutions. For safety considerations, these forms of mobility are not suitable for sidewalks or for moving on roads occupied by big and fast cars. They need to operate in dedicated lanes similar to the bike lanes we currently see on some urban roads. Unfortunately, these bike lanes are not available city-wide and, in many cases, would be economically challenging for

[25] **McKinsey & Company. (2019). Micromobility's 15,000-mile checkup. Retrieved from** https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/micromobilitys-15000-mile-checkup

[26] **Lime. (2019). Riding into 2019 with new financing to serve more users around the globe. Retrieved from** https://www.li.me/second-street/lime-2019-new-financing-serve-more-users-around-globe

cities to widely offer. One area that is best suited for government and mobility provider collaborations is funding and building micromobility infrastructure[20].

Another challenge is the limitation of these micromobility solutions under some use cases. For example, bikes and scooters are hard to operate on hilly and brick- covered roads[27]. They are also risky to operate on wet and snowy roads. Riders also face some space limitations when using these micromobility solutions for going shopping, for example. Fortunately, some micromobility providers have already started to build partnerships with some manufacturers to improve the design, durability, and capabilities of their micromobility solutions in order to address these operational limitations[28,29]. Another challenge is the concerns received by micromobility providers on the environmental impacts of manufacturing, charging, and disposing their micromobility solutions, especially e-scooters[30].

Addressing these concerns, micromobility companies have been working on solutions to provide greener services[28,31]. Governments can play a major role to further boost the adoption of micromobility services and build on their rewarding potential. For instance, cities can offer incentives to residents to use micromobility options instead of car-based transit. These incentives can be, for example, in the form of e-vouchers sent to riders upon finishing a micromobility trip. Cities can also urge and facilitate offering micromobility hubs close to their major transit stations to better connect riders to

[27] **Boston Consulting Group. (2019). The promise and pitfalls of e-scooter sharing. Retrieved from** https://www.bcg.com/en-ca/publications/2019/promise-pitfalls-e-scooter-sharing.aspx

[28] **Hawkins, A. J. (2019). Bird has a new electric scooter: it's durable, comes in three different colors, and you can buy it. Retrieved from** https://www.theverge.com/2019/5/8/18535698/bird-one-electric-scooter-ride-share-own-price

[29] **Dickey, M. R. (2019). Lyft partners with Segway to deploy more durable scooters. Retrieved from**
https://techcrunch.com/2019/01/10/lyft-partners-with-segway-to-deploy-more-durable-scooters/

[30] **Hawkins, A. J. (2019). Electric scooters aren't quite as climate-friendly as we thought. Retrieved from** https://www.theverge.com/2019/8/2/20751610/scooters-electric-dockless-carbon-emissions-study-life-cycle-analysis

[31] **Lime. (2018). Lime Green: A Commitment to Our Colors. Retrieved from** https://www.li.me/second-street/lime-green-commitment-to-our-colors

public transit as one way to solve the first mile/last mile transit challenge. Accommodating micromobility can also be looked at as an opportunity for cities to experiment adapting to, and benefiting from, other future mobility forms coming over the horizon[20].

E-scooters have the potential to open the Ontario market to a new and growing sector. On January 1, 2020, the province of Ontario launched a 5-year pilot project to allow e-scooters to operate on Ontario's roads. Under the pilot, the province has set out the broad rules and requirements for e-scooters, such as helmet requirements, minimum age, and maximum speed[32]. It is now up to municipalities to pass a by-law to allow e-scooters to operate in their community. Those municipalities that participate in the pilot are to make safety a priority and educate the public about the safe operation and integration of e-scooters in their communities. The Ministry of Transportation has created a guideline for "Best Practices"[33] that will help municipalities do what is best to safely integrate e-scooters in their communities.

[32] **Ontario's Ministry of Transportation. (2020). Electric Kick-Style Scooters (e-scooters). Retrieved from**
http://www.mto.gov.on.ca/english/vehicles/electric/electric-scooters.shtml

[33] **Ontario's Ministry of Transportation. (2020). Ontario e-scooter pilot program – Best Practices. Retrieved from**
http://www.mto.gov.on.ca/english/vehicles/pdf/e-scooter-best-practices.pdf

CASHLESS PAYMENTS

Nowadays, transit riders are experiencing changes to the traditional forms of mobility payments and, as technologies evolve, more innovative payment solutions are expected on the horizon. In this section, we go through several cashless payment solutions that are currently changing the mobility payment experience, along with others that are anticipated to reshape the future of transit payment.

Contactless Cards

Today, riders do not have to pay in cash or line up to buy paper tickets anymore. With the introduction of contactless cards, most riders have gotten rid of the transit payment barriers and have been enjoying the convenience of a seamless pay. Riders load money or a monthly pass onto their card and simply tap it to board a transit facility. These cards can be used for paying in various in-city modes of transport, including shared micromobility[34]. Some transit authorities have also enabled their payment cards to work for transit in other neighboring jurisdictions.

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[34] **Holmes, F. (2019). Contactless payments keep cities in touch with future mobility demands. Retrieved from**

https://www.automotiveworld.com/articles/contactless-payments-keep-cities-in-touch-with-future-mobility-demands/

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To further ease the mobility payment experience, companies such as Visa and Mastercard have started to work with some transit authorities to bring the "Tap to Pay" feature of their cards as options for paying for transit on-board. Visa has introduced its Ready for Transit program to bring Visa contactless solutions to transit payment[35,36]. Mastercard has brought its "Tap & Go" contactless payment feature for transit payment solutions worldwide[37,38]. The two payment giants offer different payment models supporting scenarios where the fare is known at the start of the trip and also where the fare is not known until after the trip is complete.

> "Tap to Pay technology is all about increasing customer convenience, especially for tourists and infrequent riders, who don't have an electronic fare card[39]."
>
> Kevin Desmond, CEO, TransLink

[35] **Visa. Transit - Visa Ready. Retrieved from** https://visaready.visa.com/Transit_Program.html

[36] **Visa. (2019). An Easier Way to Get Around – with a Tap. Retrieved from** https://usa.visa.com/dam/VCOM/global/pay-with-visa/documents/vsa215-10-contactless.pdf

[37] **Mastercard. Connecting people & places with smarter transit solutions. Retrieved from** https://www.mastercard.us/en-us/about-mastercard/what-we-do/global-smart-cities/mastercard-transit-solutions.html

[38] **Insider Studios with Mastercard. (2019). Here's how contactless payments are revolutionizing transit around the world. Retrieved from** https://www.businessinsider.com/sc/contactless-payments-make-transit-easier-2019-1

[39] **Visa. (2018). Visa Collaborates with TransLink to Modernize Mass Transit Payments – No More Fumbling for Cash or Paper Tickets. Retrieved from** https://tinyurl.com/wujhtt2

Mobile Payment

Utilizing the contactless payment technology for transit payment does not have to be only through a physical card. With the advances and wide adoption of smartphones, many services have been offered to utilize these phones for payments. Phone users can load their payment information to a mobile wallet[40] on phone, and utilize a technology named "Near-Field Communication (NFC)[41]" embedded in these smartphones to complete contactless payments in a way similar to using contactless cards.

Another option for mobile payment is to scan a QR code[42] carrying payment information and displayed on a phone screen. **Apple Pay**[43], **Google Pay**[44], and **Samsung Pay**[45] are examples of smartphone services offering mobile wallets and payments. Some transit authorities worldwide have approved using smartphones and mobile wallets for transit payments[46]. Some of these authorities allow to load their proprietary transit cards as well to smartphones for digital payments.

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[40] Referred to also as "digital wallet"

[41] Near-field communication is a technology by which two electronic devices can communicate when they are within 4 cm of each other.

[42] A Quick Response (QR) code is a machine-readable optical code that contains information about a locator, identifier, or tracker that points to a website or application.

[43] **Apple Inc. Use Express Transit with Apple Pay. Retrieved from** https://support.apple.com/en-ca/HT209495

[44] **O'Kane, S. (2018). Google Pay now handles transit tickets. Retrieved from** https://www.theverge.com/2018/3/19/17138776/google-pay-contactless-transit-tickets-las-vegas

[45] **SAMSUNG. (2019). Breeze through your commute with Samsung Pay Tap&Pay. Retrieved from** https://news.samsung.com/us/samsung-pay-tap-and-pay-mta-omny-metro/

[46] **Apple Inc. Where you can ride transit with Apple Pay. Retrieved from** https://support.apple.com/en-ca/HT207958

Transit mobile payment has started to expand beyond the use of smartphones to also include smart watches and wearable technologies. **Fitbit Pay** and **Garmin Pay** are examples of these wearable services that can be used for transit payments in some jurisdictions[47,48].

Transit users in the Greater Toronto and Hamilton Area (GTHA) will likely experience using mobile payments soon. Metrolinx has announced that an open payment trial will commence during 2020 as a first step towards allowing transit users to pay their fares through new payment options, including smartphones (via mobile wallets) and credit/debit cards[49]. Meanwhile, users of transit in the GTHA are enjoying the convenience of contactless payment through their pre-loaded PRESTO[50] cards.

Biometric Payment

With the rapid pace of technological advances, specifically in micro-electro-mechanical systems (MEMS) and artificial intelligence (AI), other innovative forms of mobility payments are on the way. For example, as per a recent interview with MarketWatch, Mastercard has reported that the company is exploring the use of biometric identifiers, such as face and way of walking, to enable commuter identification for a smooth transit fare payment[51]. Important factors; however, will influence the adoption of these identification technologies in transit. A main factor will be the processing time of these technologies, which should be equal or faster than that of the contactless options currently adopted. Other factors may include user concerns on privacy and security of the saved identifiers.

[47] **Business Wire. (2019). Fitbit users can now use Fitbit Pay at seven major transit systems around the world. Retrieved from** https://www.businesswire.com/news/home/20190529005320/en/Fitbit-Users-Fitbit-Pay-Major-Transit-Systems

[48] **Garmin Ltd. (2019). Use Garmin Pay for your transit. Retrieved from** https://www.garmin.com/en-US/blog/fitness/use-garmin-pay-for-your-transit/

[49] **Spurr, B. (2019). Metrolinx to start trial that lets customers tap credit cards, phones on PRESTO readers next year, CEO says. Retrieved from** https://tinyurl.com/w8xh89k

[50] PRESTO is Metrolinx's electronic payment system. PRESTO works across transit in the Greater Toronto and Hamilton Area (GTHA) and Ottawa. More details are available at https://www.prestocard.ca/

[51] **Steiner, R. (2020). Mastercard is pioneering new payment technology that identifies commuters by the way they walk. Retrieved from** https://tinyurl.com/ucfty8v

Integrated Payment

The next step after bringing innovative payment solutions to our various transit options is to integrate payment for all these different options in a single place. If a trip includes multi-modes of transport[52], the ultimate convenience and efficiency is to pay for these different parts of the trip using the same payment system, all at once. This concept is known as "integrated payment" and it has been recently offered and experimented in different jurisdictions. Integrated mobility expands beyond public transit to also include private transit and ride hailing, integrating payment for these different modes of transport all together.

The prevalent access to the Internet and smartphones is a major enabler for offering such innovative digital services. Potential gains in ridership and associated revenues anticipated for transit agencies and mobility providers are also big drivers towards offering integrated payment services. However, a key challenge towards ubiquitously offering integrated payment is

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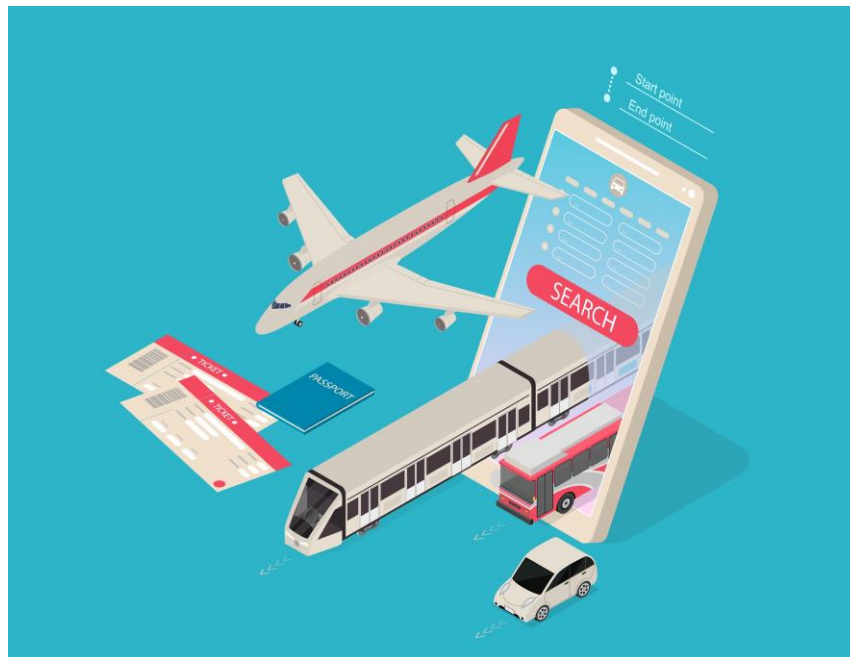
[52] For example, a rider's trip may consist of using a shared bike, followed by a subway ride, that is finished by a bus ride.

handling and distributing the paid fare across the different transit and mobility parties involved in the same multi-modal trip. This can be considered an opportunity for the payment industry to further engage with the future mobility industry, to both benefit from and push for enormous mobility innovations.

Some exciting integrated payment initiatives are currently underway. Many companies have started to rise as well in this space. In January 2020, Uber, the Regional Transportation Commission of Southern Nevada (RTC) and Masabi have started to offer riders in Las Vegas the option to seamlessly pay for and ride public transit using the Uber app[53]. Las Vegas is the second city, after Denver, where Uber offers this service. A further discussion on integrated mobility and other related initiatives and services is covered in the next section on MaaS.

It is worth mentioning that the concept of integrated payment can also involve integrating transit payment systems of different neighboring jurisdictions to enable using the same payment method for cross-jurisdiction trips. Travelers win a

smooth and convenient payment experience, if payment systems across jurisdictions are interoperable. Many jurisdictions around the world have been adopting this concept in their transit payment systems. For example, PRESTO, the Metrolinx payment system, currently works across local transit in the Greater Toronto and Hamilton Area (GTHA) and Ottawa, making paying for cross-jurisdiction regional transit trips smooth and convenient.

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[53] **Kbidy, L. (2020). RTC Transit, now available on Uber for riders in Las Vegas. Retrieved from** https://blog.masabi.com/blog/rtc-transit-now-available-on-uber-for-rider-in-las-vegas

MOBILITY AS A SERVICE
Bringing It All Together

Mobility as a Service (MaaS) provides an integrated mobility service offering travellers access to on-demand public and private transportation services through a single platform[54,55]. The service concept allows customers to replace (or at least significantly displace) ownership of a car, by providing on-demand access to a wide range of services, centred around mobility, while using an attractive pricing model[56]. From the customer's perspective, the service would be accessed from a single application on their mobile phone, allowing them to both plan and pay for multi-modal trips without leaving this application.
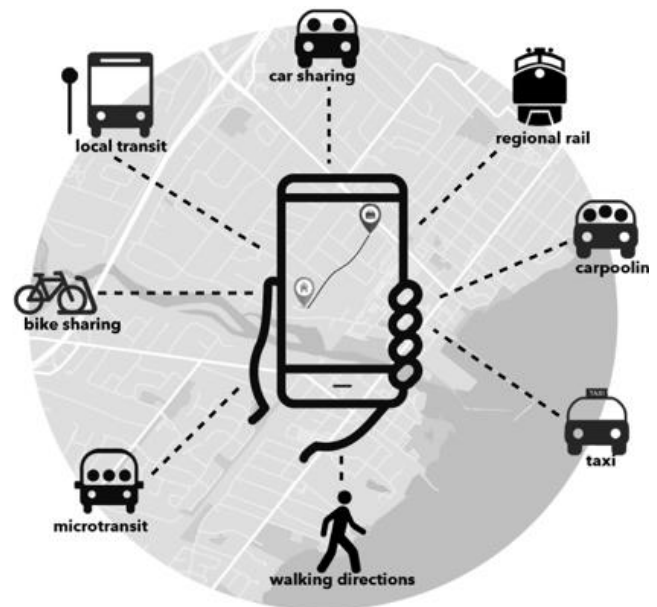
[54] Metrolinx. (2018). 2041 Regional Transportation Plan: For the Greater Toronto and Hamilton Region. Retrieved from http://www.metrolinx.com/en/regionalplanning/rtp/Metrolinx%20-%202041%20Regional%20Transportation%20Plan%20%E2%80%93%20Final.pdf

[55] Maas Alliance. What is MaaS. Retrieved from https://maas-alliance.eu/homepage/what-is-maas/
[56] The pricing model could be a subscription basis (similar to Netflix, Amazon Prime, or mobile phone plans), pay-per-use with monthly cap, or other attractive pricing model.

The key components of a MaaS service are:

1. Application-based: customers access the service on-the-go, on a smartphone[57].

2. Access to multiple services: the application will connect the customer to services such as public transit, bike share, ride share/taxi, and car share, centred around mobility access.

3. Centralized trip routing and fare payment: customers are presented with step-by-step multi-modal trip routing that will show them the most efficient and/or cost-effective routes for their trip and enable paying any additional fees from within the MaaS application.

4. Subscription or packaged pricing model: customers will join as members, opting for a package/ bundling of services that best meets their needs[58]. This may include bundle pricing, price caps, or other means of providing an attractive offer to customers.

MaaS has been tested in a limited number of areas around the globe thus far. Examples are highlighted later in this

section. It is important to first understand the trends that are enabling this type of service and its role in enabling a future of autonomous mobility. **The tech trend of Software as a Service, and the marketing concepts of product bundles or subscription services, along with the rise of the sharing economy have all contributed to MaaS.**

Marketing bundles and subscription services are concepts we are all familiar with. Telecom providers offer a classic example; they offer a bundle of home phone, TV, and Internet access. Insurance companies often use bundling to attract more customers, offering a discount for combined home and auto insurance.

Subscription services provide a convenience to the customer, while delivering recurring revenue to the provider. Amazon Prime, Netflix, and Costco memberships are all examples of subscription-based business models. The key to the success of these subscription services is that they remove a decision point – a concept rooted in behavioural

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[57] Other methods of access may also be made available for accessibility or other purposes – such as desktop web access, phone-in services, etc.

[58] A certain number of trips may be included in the "bundle" that the customer subscribes to, or the services might be offered on a "points" basis.

insights. By removing the decision point, the customer resorts to the service as their default. In transportation, the service that many resort to today is their car. Think about a future where, rather than reaching for your keys in the morning, you reach for your phone, which will connect you to bike share, ride share, car share, and transit as needed to get you to your destination.

The sharing economy is a trend where people are increasingly more comfortable paying for an experience when and where they need it, rather than owning the asset (music and video streaming services, vacation home rentals, tool rentals, etc.). The very familiar examples in the mobility space include Transportation Network Companies (TNCs) such as Uber and Lyft, along with car and bike share services.

The earliest example of MaaS is the UbiGo pilot project in Gothenburg. For 6 months between November 2013 and April 2014, 83 households participated in the pilot where they had access to public transit, car sharing, car rentals, taxis, and bike sharing[59]. Through a smartphone

application, the households could pay for trips, make bookings, and manage their subscription.

A number of additional pilots and trials have occurred since. For example, the Whim App[60] in Finland started in 2016, providing four transportation subscription models that a user can choose from, including pay as you go and unlimited use options. In the unlimited option, for €499 a month, the subscription provides access to unlimited taxi rides under 5kms, bus trips, bike share rides, and car rentals. Now the Whim App is also available in Birmingham – UK, Antwerp – Belgium, Vienna – Austria, Greater Tokyo – Japan, and Singapore. Another example is the Citymapper Pass[61] offered in London, England. The pass combines buses, trains, trams, and bikes into a weekly subscription. Its mobile application can be linked to Apple Pay or Google pay for contactless payment via a smartphone.

Some mapping and ride hailing applications are also moving towards MaaS by adding payment and trip planning capabilities for additional modes

[59] Karlsson, Sochor, and Stromberg. (2016). Developing the 'Service' in Mobility as a Service: Experiences from a Field Trial of an Innovative Travel Brokerage. *Transportation Research Procedia, 14*. Retrieved from https://www.sciencedirect.com/science/article/pii/S2352146516302794

[60] MaaS Global. (2019). A brief history of MaaS Global, the company behind the Whim app. Retrieved from https://whimapp.com/history-of-maas-global/
[61] Citymapper. Citymapper PASS. Retrieved from https://citymapper.com/pass

within their platforms. For instance, the Transit application[62], which originally exclusively provided real-time transit information for trip planning in North America, formed partnerships with Lyft and Uber to enable routing and booking of transit and TNC trips. The application also allows users to view and plan multi-modal trip options based on the fastest route to the user's destination. Additionally, it shows the total cost of the trip and allows the user to access micromobility, such as Bike Share Toronto, through the application.

TNC providers, such as Lyft and Uber, have also started to provide real-time transit information on, access to, and payment for public transit and micromobility services, offering multi-modal trip planning abilities. As mentioned earlier, in some cities in the U.S., Uber has enabled paying for public transit on the Uber app, in hopes that

users will utilize Uber as a first mile/last mile solution. Similarly, Lyft offers its users in some cities across the U.S. the ability to see the different transport modes available in their city, including scooters, bikes, public transit, car rentals, shared rides, and regular rides, through the Lyft app[63]. Moreover, Lyft Pink has offered a $20/month subscription that provides 15% off unlimited ride-hailing trips, priority airport pickups, occasional waived fee for cancellations, and more[64].

In conclusion, MaaS removes major pain points to planning a sustainable multi-modal trip. MaaS enables the user to be increasingly comfortable paying for an experience when and where they need it, rather than owning the asset, reducing the need for car ownership. This trend of use-first, rather than ownership-first, sets customers up for the future of shared mobility, which is vital to reducing congestion and pollutants.

[62] **Transit. Go Your Own Way. Retrieved from** https://transitapp.com/
[63] **Hawkins, A. J. (2019). Lyft tweaks its app to boost bikes, scooters, and mass transit. Retrieved from** https://www.theverge.com/2019/9/24/20881576/lyft-app-redesign-bike-scooter-public-transportation

[64] **Hawkins, A. J. (2019). Lyft simplifies its subscription service with the $20-a-month 'Lyft Pink'. Retrieved from** https://www.theverge.com/2019/10/29/20936982/lyft-pink-subscription-price-discount-perks

HIGHLIGHTS FROM ONTARIO

METROLINX

Metrolinx works with federal, provincial and municipal partners, the private sector and other stakeholders to create an integrated transportation system to support a higher quality of life, a more prosperous economy and a healthier environment. The agency is responsible as well for the implementation and management of the e-fare payment system, PRESTO, that is being used in public transport in the GTHA and Ottawa. In November 2019, Metrolinx announced that an open payment trial will commence during 2020 as a first step toward allowing transit users to pay their fares through new payment options. In 2016, Metrolinx also contributed to the expansion of a micromobility service, Bike Share Toronto, with $4.9 million in funding.

Link: http://www.metrolinx.com

RIDESHARK

RideShark is a mobility company based in Ottawa. It provides software solutions for multi-modal mobility management. For over 15 years, RideShark has been globally providing commute management, multi-modal ridesharing, trip logging, incentive management, and carpool parking solutions. The company builds customized platforms for governments, corporates, and campuses.

Link: https://www.rideshark.com/

PANTONIUM

Pantonium is a technology company based in Toronto. The company was founded in 2010 with a vision to leverage optimization algorithms to solve the vehicle automated routing and on-demand dispatching challenges. Pantonium's EverRun transit software enables agencies to deploy on-demand transit services with full visibility and control. Pantonium also provides rider and driver mobile applications to connect with users on the road.

Link: https://pantonium.com/

JOYRIDE

Joyride, a micromobility start-up based in Toronto, started in 2014 as a bike-share management system. The system has since evolved into a software platform designed to seamlessly manage an unlimited number of e-scooters and e-bikes. The company currently has partnerships with customers in more than 60 markets, including transit agencies and hardware manufacturers.

Link: https://joyride.city/

Note: The organizations highlighted above are only a few examples of the success stories in Ontario in the context of mobility and transit innovation.

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The Autonomous Vehicle Innovation Network (AVIN) is an initiative by the Government of Ontario

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ABOUT AVIN

The **Autonomous Vehicle Innovation Network (AVIN)** initiative is funded by the Government of Ontario to support Ontario's competitive advantage in the automotive sector and to reinforce its position as a North American leader in advanced automotive and mobility technologies, including transportation and infrastructure systems.

This initiative capitalizes on the economic potential of connected and autonomous vehicle (CAV) technologies by supporting the commercialization of best-in-class, made-in-Ontario solutions that create jobs, drive economic growth and enhance global competitiveness. AVIN also helps Ontario's transportation systems and infrastructure adapt to these emerging technologies.

AREAS OF FOCUS

AVIN programs focus on supporting the development and demonstration of CAV technologies in light vehicles (e.g., cars, trucks and vans), heavy-duty vehicles (commercial vehicles, trucks, buses and RVs), transportation infrastructure, intelligent transportation systems (ITS) and transit-supportive systems.

AVIN is administered on behalf of the Government of Ontario by OCE. The initiative comprises five distinct programs and a central hub. The AVIN programs are:

- AV Research and Development Partnership Fund
- WinterTech   • Talent Development
- Demonstration Zone
- Regional Technology Development Sites

The AVIN Central Hub is a dedicated team that supports the delivery and administration of AVIN programming and provides the following key functions:

- A focal point for all stakeholders in the area of CAVs, connecting and convening stakeholders including industry, academia, government and the public;

- Providing thought leadership and identifying opportunities to bridge technology and policy; and

- Awareness and education of AVIN programs and Ontario's growing CAV community, prioritizing focus areas and driving Ontario's global leadership in the automotive and mobility sector.

AVIN has five Objectives:

01 Commercialize C/AV and transportation infrastructure technologies

02 Build awareness, educate and promote Ontario as a leader in C/AV technologies

03 Encourage innovation and collaboration

04 Leverage Ontario talent

05 Support regional auto-brainbelt clusters

We would like to thank the Government of Ontario for supporting AVIN programs and activities.

We would also like to thank the partner organizations that work with OCE to deliver AVIN programs, including the Regional Technology Development Sites and the Demonstration Zone.