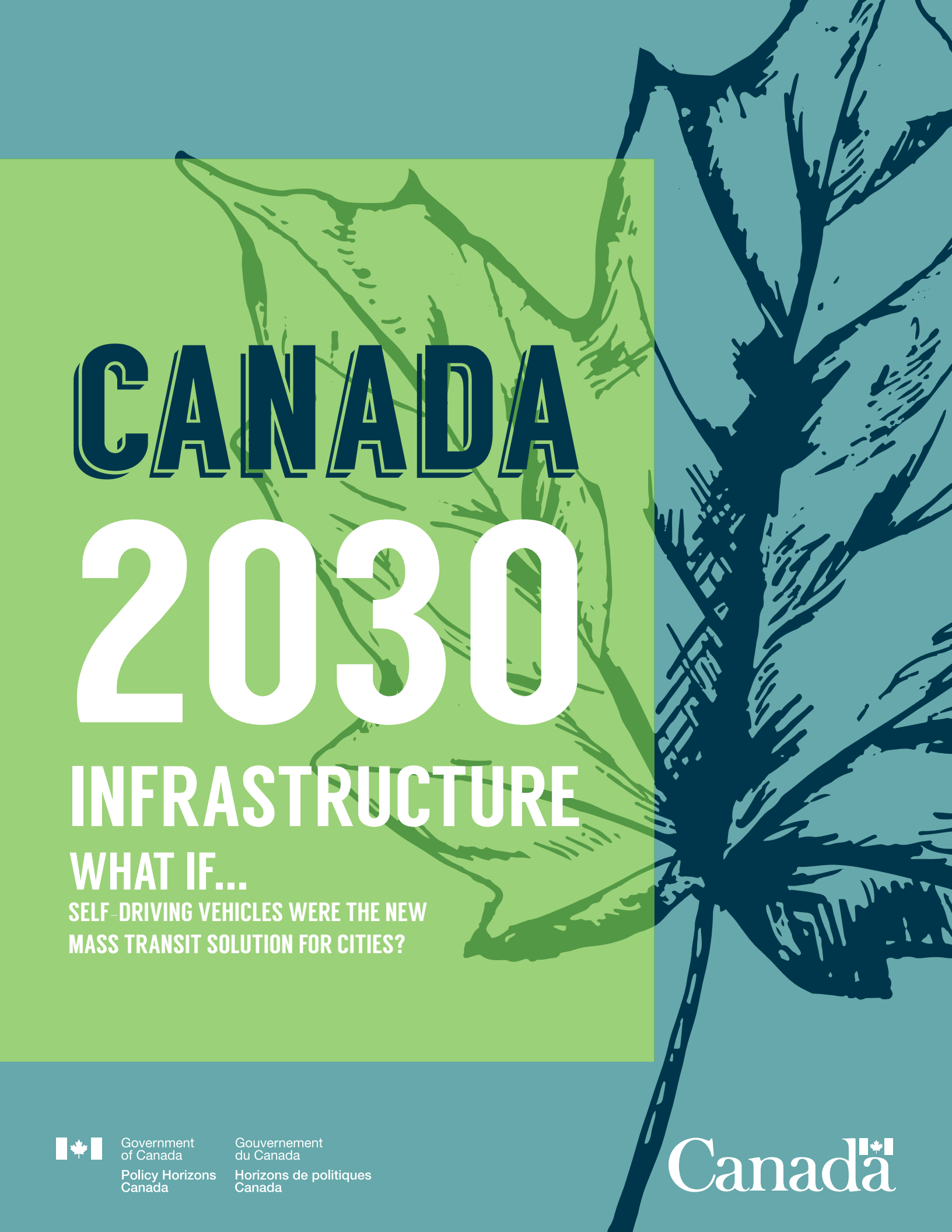
CANADA 2030

INFRASTRUCTURE

WHAT IF...

SELF-DRIVING VEHICLES WERE THE NEW MASS TRANSIT SOLUTION FOR CITIES?



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CANADA 2030 SERIES

Canada is experiencing significant social and technological changes that could disrupt many aspects of society. In this context, the next 10 to 15 years could be a transformative period for the relationship between Canada's government and broader society. This Insight is part of a series developed by Policy Horizons Canada on a variety of topics.

WHO WE ARE

Policy Horizons Canada (Horizons) is a strategic foresight organization within the Public Service of Canada with a mandate to help anticipate emerging policy challenges and opportunities and to experiment with methods and technologies to support resilient policy development. Horizons is exploring plausible futures for Canada over the next 10 to 15 years in the areas of governance, sustainability, infrastructure, and the digital economy. With the active participation of experts from governmental and other organizations, Horizons identifies the key factors driving change, looks for potential surprises, explores plausible futures in the form of scenarios, and surfaces key emerging policy challenges and opportunities.

VISUAL CONCEPT

The *Canada 2030* visual concept juxtaposes the past and the future in a subtle mix of colours, fonts, and imagery. The vibrant colour palette creates a safe space for the reader to open his or her mind. The main imagery found throughout the suite of products is rooted with the leaf of the sugar maple. The maple fruits, the samaras, gracefully fall throughout the Canadian landscape. They hold the potential of growing into trees and forever leaving their mark from coast-to-coast. Just like the Insights surfaced through the foresight methodology, they may one day be part of our reality. The traditional style of ink hatching accentuates the ribs of the leaves and evokes the system maps used in foresight. As we embark on Canada's 150th year, let us embrace our past and consider our plausible futures.

This document does not attempt to predict the future. The purpose is to stimulate reflection and dialogue and support the development of public policy that is more robust and resilient across a range of plausible futures. The views contained in this document do not necessarily represent the views of Horizons, the Government of Canada or participating departments and agencies.

PH4-178/2017E-PDF
978-0-660-07583-9

WHAT IF...

...SELF-DRIVING VEHICLES WERE THE NEW MASS TRANSIT SOLUTION FOR CITIES?

> "95% of traffic fatalities are due to human error"

WHAT'S CHANGING?

Self-driving technologies[1] may establish new safety standards for vehicles and hit the road faster than expected. Major actors in the field of self-driving technologies including Ford, Google, Tesla, Uber, GM, BMW[2], Lyft and others have announced their plans to start testing autonomous vehicles in cities, and have a first road-ready model within the next 5 years. A fatal accident in May 2016 involving a Tesla self-driving car may have convinced several companies to abandon the gradual integration of driver assistance systems, and instead focus on the commercialization of fully autonomous vehicles that can drive without human intervention or a human in the car. Initially, these fully autonomous vehicles may be only available for ride-sharing purposes, and eventually be offered for purchase to the general public.

The U.S. Department of Transportation (USDOT) sees the driverless car as an important tool to reduce the high number of annual traffic fatalities (roughly 35,000 in the U.S, 95% of which are due to human error). Hoping to facilitate the introduction and deployment of autonomous vehicles, the USDOT has unveiled policy outlines for best practices and safe deployment, a policy framework for the State regulators, guidelines from the National Highway Traffic Safety Administration (NHTSA) on self-driving vehicles, and new tools and regulatory structures to support the deployment of self-driving cars. Prior to this announcement, the NHTSA had announced that automakers with the highest safety ratings would be required to integrate collision-avoidance systems, such as forward collision warning, crash imminent braking, dynamic brake support, lane departure warning, rollover resistance, and blind spot detection. This could further boost the development of technologies that would be deployed in self-driving vehicles.[3]

1 The Verge, "Delphi and Mobileye are teaming up to build a self-driving system by 2019, August 23 2016, http://www.theverge.com/2016/8/23/12603624/delphi-mobileye-self-driving-autonomous-car-2019; WSJ, "GM Executive Credits Silicon Valley for Accelerating Development of Self-driving Cars", May 10 2016, "Head of GM's foresight and trends unit says timetable for autonomous vehicles likely moved from 2035 to 2020, if not sooner", http://www.wsj.com/articles/gm-executive-credits-silicon-valley-for-accelerating-development-of-self-driving-cars-1462910491; Business Insider, "10 million self-driving cars will be on the road by 2020", June 15, 2016, http://www.businessinsider.com/report-10-million-self-driving-cars-will-be-on-the-road-by-2020-2015-5-6;

2 Electrek, "BMW will launch the electric and autonomous iNext in 2021, new i* in 2018 and not much in-between",

3 IEEE Spectrum, "Vehicle Safety Ratings Will Soon Include Marks for Crash Avoidance Tech", December 11, 2015, http://spectrum.ieee.org/cars-that-think/transportation/safety/vehicle-safety-ratings-will-include-marks-for-crash-avoidance-tech; Consumer Reports, "Collision-avoidance Systems Are Changing the look of Car Safety", December 2015, http://www.consumerreports.org/car-safety/collision-avoidance-systems-are-changing-the-look-of-car-safety/ ; ibtimes, "Safest Cars for 2016: "Crash Avoidance Technology Takes A Front Seat In New Testing Standard", December 2015, http://www.ibtimes.com/safest-cars-2016-crash-avoidance-technology-takes-front-seat-new-testing-standard-2218919

The combination of ride-hailing applications and self-driving technologies may bring on-demand mass transit to urban areas. For the first time in their history, automakers are moving from a business model based on car ownership to one based on mobility service providers. While the estimated global share of vehicle miles traveled for shared vehicles (including taxis and ride hailing services) was only around 4% in 2015, it is estimated to reach 26% by 2030. As ride-hailing is more 'mile intensive' for vehicles compared to car ownership, the shorter vehicle life cycle could replace the revenue lost from declining car sales.

> **"Some cities are already testing self-driving buses"**

Transit agencies have always faced difficulties in optimizing their transit routes and improving consumer experiences. Ride-hailing and self-driving cars, as part of an integrated transit system, could replace expensive lightly-used bus routes[4], eliminate empty buses outside of rush-hour traffic and bus stops far from home or workplace, as well as replace late night buses. Some cities, such as Helsinki[5], are already testing, alongside traffic, self-driving buses with a carrying capacity up to 12 people that may become an interesting option for commuters. Big data analysis and the use of advanced algorithms will lower the cost of on-demand mobility, allow for precise predictions about demand at different times throughout the day, and reduce traffic and congestion in urban areas by dispatching vehicles on different routes. Incorporating self-driving vehicles, ride sharing technology and on-demand mobility solutions into the public transit model could allow for the provision of on-demand, flexible route, and door-to-door transportation.

Millennials could prefer affordable and 'steering wheel free' mobility options. Over the last decade, there has been a steady decline in the number of people aged 16 to 44 with a driver's license. With the urban millennials' forming 50 percent of the workforce by 2020, their mobility preferences and behaviours could result in more walking, biking, transit, carpooling or other alternatives to driving being proposed in urban areas. Marketing studies on millennials have shown that this generation is usually reluctant to buy items, including cars, and prefers to subscribe to a set of services that provide access to products.

4 The Guardian, "Self-driving buses take to roads alongside commuter traffic in Helsinki", August 18, 2016, https://www.theguardian.com/technology/2016/aug/18/self-driving-buses-helsinki; The Guardian, "Helsinki's ambitious plan to make car ownership pointless in 10 years", July 10, 2014, https://www.theguardian.com/cities/2014/jul/10/helsinki-shared-public-transport-plan-car-ownership-pointless

5 Le Monde, "Les villes s'intéressent de près aux minibus sans chauffeur", September 2016, http://www.lemonde.fr/economie-francaise/article/2016/09/02/les-villes-s-interessent-de-pres-aux-minibus-sans-chauffeur_4991310_1656968.html; RTS Info, "Les navettes autonomes de Sion intéressent des villes du monde entier", August 2016, http://www.rts.ch/info/regions/valais/7919690-les-navettes-autonomes-de-sion-interessent-des-villes-du-monde-entier.html

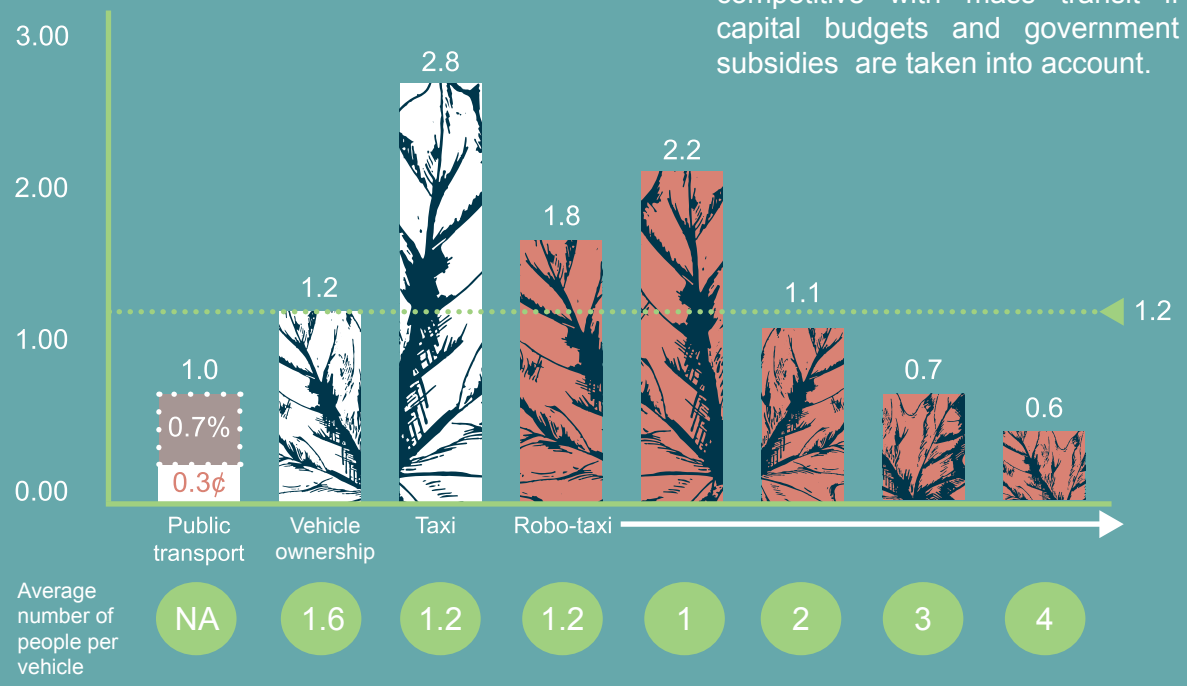
POTENTIAL IMPLICATIONS

New public mass transit projects that are scheduled to break ground over the next 10 to 15 years could fail to meet the expected revenues and substantially extend the payoff timeline. The deployment of self-driving cars could affect the rate of usage as well as the return on investment of new mass transit corridor projects in Canada, including light rail, subways and city buses. Time and cost overruns, overestimated demand and over-complexity are often cited as the main reasons for the failure of big infrastructures projects. With a well-developed road network across North America, cost-competitive micro transit models based on self-driving vehicles could rapidly emerge in urban areas and complement or replace some of the existing public transit routes. Based on Boston Consulting Group cost projections per passenger mile in New York City, self-driving vehicles with at least two passengers on-board could be cost-competitive with mass transit if capital budgets and government subsidies are taken into account (see Table I).

TABLE 1

ROBO-TAXIS COULD REPLACE TRADITIONAL TAXIS AND CARS IN MEGACITIES

NEW YORK CITY CASE STUDY



Sources: BCG analysis: U.S Department of Transportation; NYC Metropolitan Transportation Authority; NYC Taxi & Limousine Commission; Kelley Blue Book

* Does not consider the impact of convenience shorter wait and shorter commute times
* Non-fare-based operating funds received from New York City transit; local, state and federal sources, as well as other sources.
* Annual fare revenues per passenger mile traveled.

> **Self-driving taxis and mass transit could eliminate up to 90% of cars**

The high level of convenience and flexibility that on-demand self-driving vehicles offer may force transport agencies to replace existing services (like bus lines) with ride-hailing or carpooling modes. A potential decrease in popularity of mass transit modes like subway and light rail could be the opportunity for transit agencies to review their business model and potentially offer additional goods and services in high density areas.

Smart mobility may free urban spaces and lead to the repurposing or redesigning of some infrastructure. While sensors, the Internet of Things, and big data analysis may help fleet operators to reduce running and maintenance costs, it could also remove cars and buses from the roads. While driverless cars could increase the average kilometers driven[6] per capita, it could also convince people to get rid of their personal vehicle or to not buy a new one. According to a simulation, deployment of self-driving taxis combined with mass transit systems could eliminate up to 90% of cars[7] in use and reduce commuter times by an average of ten percent. In small and medium-sized cities it could even replace the entire public transport system. The system imagined by researchers is primarily based on mass carpooling and UPS's delivery intelligence, matching carpool demand with available taxi-robots with the help of algorithms and predictive analytics. Autonomous vehicle fleets could also greatly reduce the number of parking spaces required in cities and may allow authorities to repurpose urban highways or other road infrastructure into boulevards for other forms of mobility like biking and walking.[8]

Fully autonomous vehicles could perform multiple tasks and become the new business address. The multipurpose character of self-driving vehicles make them more efficient than mass transit modes in meeting demand during peak hours. Self-driving vehicles, outside of peak hours, could be used for goods or food delivery, for medical transportation, and for tourism tours. If the self-driving fleet is also fully electric (battery only), specific locations in urban areas could be transformed to host a large number of vehicles that would be connected to the grid and act as a utility-scale battery (see video).

Video: Nissan introduces the Fuel station of the Future

6 Le Figaro, "Ces adeptes des VTC qui décident de se débarrasser de leur propre voiture", June 28, 2016, http://www.lefigaro.fr/conso/2016/06/28/05007-20160628ARTFIG00223-ces-adeptes-des-vtc-qui-decident-de-se-debarrasser-de-leur-propre-voiture.php; International Transport Forum, "Shared Mobility :Innovation for liveable Cities", 2016, http://www.itf-oecd.org/sites/default/files/docs/shared-mobility-liveable-cities.pdf ; CleanTechnica, "Simulation Suggests Self-Driving Vehicles Will Make 90% of Urban Cars Redundant", August 23, 2016, http://cleantechnica.com/2016/08/23/simulation-suggests-self-driving-vehicles-will-make-90-urban-cars-redundant/?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+IM-cleantechnica+%28CleanTechnica%29

7 International Transport Forum, "Shared Mobility :Innovation for liveable Cities", 2016, http://www.itf-oecd.org/sites/default/files/docs/shared-mobility-liveable-cities.pdf; CleanTechnica, "Simulation Suggests Self-Driving Vehicles Will Make 90% of Urban Cars Redundant", August 23, 2016, http://cleantechnica.com/2016/08/23/simulation-suggests-self-driving-vehicles-will-make-90-urban-cars-redundant/?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+IM-cleantechnica+%28CleanTechnica%29

8 Le Figaro, "Paris : Le périphérique pourrait être ouvert aux piétons et aux vélo", July 5, 2016, http://www.lefigaro.fr/actualite-france/2016/07/05/01016-20160705ARTFIG00091-paris-le-peripherique-pourrait-etre-ouvert-aux-pietons-et-aux-velos.php; Raconteur, "The rise of city car-sharing", August 4, 2016, http://raconteur.net/technology/the-rise-of-city-car-sharing

Would you like to have breakfast or a coffee while commuting to your workplace? Want to relax on the backseat of a self-driving minivan and watch the hockey highlights of the night before or play your favourite video games against other commuters? Removing the steering wheel as well as the pedals from vehicles will create new opportunities for interior design. Depending on the length of trips, users could call an HD video streaming van (a Netflix van[9]) or a mobile coffee barista. The potential profitability of such a model could convince some businesses to replace their physical commercial spaces with a fleet of their own, which would result in a variety of companies unexpectedly contributing to public transportation.

Governing the transition towards self-driving vehicles to avoid chaos on roads. From road infrastructure maintenance to vehicle safety norms, and managing the logistic around public transportation to regulating traffic flows, the deployment of autonomous vehicles will affect all levels of government in Canada. While legislators review regulations and laws on transportation, governments may also need to rethink their sources of revenue, which traditionally stem from personal vehicle ownership and use.

- **A transition period with multiple mobility providers.** Whether mobility will be provided by public transport agencies, ride-hailing companies, car manufacturers, taxi companies, or a combination thereof, cities may need to coordinate the collection and dissemination of all relevant information for users (cost, expected arrival time, etc.) on one central platform.[10] A requirement for mobility providers to share such information with the city platform may improve the reliability and convenience for users, as well as create a competitive environment to keep prices as low as possible. With a multitude of pricing schemes available, governments may want to develop tools and methods for price comparison to ensure a continuous affordability for the public.[11]
- **Managing the traffic flow.** The combination of self-driving vehicles and smart devices integrated in infrastructure may allow cities to better manage traffic flow during peak hours. With vehicle-to-vehicle and vehicle-to-infrastructure communication capacities and real-time destination demand analysis, transport agencies may be able to set the direction flow and the speed on city streets and urban highway lanes. During peak hours, a required minimum of self-driving vehicles owned by mobility providers could be set, to sustain the demand and to make sure vehicles are not reallocated for more lucrative purposes like goods delivery or storage provision to the power grid.
- **No parking, no tickets, no gas; how to finance the roads infrastructure in the future?** Declining revenue from parking passes and tickets, uncertain real estate values, and, if mobility services are mainly provided with electric self-driving vehicles, the loss from motor fuel taxes are among the items that could negatively affect public revenue and force authorities to look

9 Car and Driver, "Ford Patents Windshield Entertainment System, Brings New Meaning to 'Drive-In Movie'', March 8, 2016, http://blog.caranddriver.com/ford-patents-windshield-entertainment-system-brings-new-meaning-to-drive-in-movie/; Car and Driver, "Volvo and Ericsson Partner on the Real Killer App for Autonomous Cars : Streaming HD Video'', January 4, 2016, http://blog.caranddriver.com/volvo-and-ericsson-partner-on-the-real-killer-app-for-autonomous-cars-streaming-hd-video/.

10 eGovInnovation, "Mobility-as-a-Service : The digital transformation of transportation", September 6, 2016, http://www.enterpriseinnovation.net/article/mobility-service-digital-transformation-transportation-200334529; Google, "Hailing more ride service options in Google Maps", September 8, 2016, https://maps.googleblog.com/2016/09/hailing-more-ride-service-options-in.html; The Verge, "Welcome to Uberville", http://www.theverge.com/2016/9/1/12735666/uber-altamonte-springs-fl-public-transportation-taxi-system

11 Inhabitat, "Uber rolls out unlimited rides in New York City for $100", September 28, 2016, http://inhabitat.com/uber-rolls-out-unlimited-rides-in-new-york-city-for-100/; Business Insider, "This might be the only time it's cheaper to use Uber instead of owning your own car", March 28, 2016, http://www.businessinsider.com/uber-lyft-cost-versus-car-by-metro-area-2016-3; Newsroom, Your Driving Costs, April 7 2016, http://newsroom.aaa.com/auto/your-driving-costs/; WTKR, Uber tests $2 flat rate fares to take on public transit, August 25, 2016, http://wtkr.com/2016/08/25/uber-tests-2-flat-rate-fares-to-take-on-public-transit/ ; Spiri, "Introducing On-Demand Carpooling", September 2016, "Spiri allows people to drive the vehicle for free or be passengers at public transport prices", https://www.youtube.com/watch?v=26eRoPRumrk

for alternative sources of income. Smart infrastructure may allow cities and governments to develop new revenue streams based on benchmarks such as kilometers travelled, time of the day, individual or carpooling, etc.

- **On Kijiji (section used car) in 2025. Corolla 2020 with 25 000km, no rust, AC and electric windows for free.** A rapid shift from car ownership to mobility services over the next 10 to 15 years may also result in a massive oversupply of used cars. While this may greatly affect the second use market for vehicles it will also put pressure on local recycling infrastructures. Since exporting used internal combustion engine vehicles to developing countries may be contested under the Basel Convention for environmental reasons, governments could adopt regulations that would force car producers to recycle their own products (concept of extended producer responsibility) in order to reduce the impacts on the environment.

Low levels or inadequate integration of self-driving vehicles into the public transit system, and changes in the views on ownership, combined with cheap aftermarket self-driving upgrades and new and affordable self-driving cars could place more vehicles on our roads and require higher investments in road infrastructure. The differences in geographic location, population size and sprawl of cities are likely to lead to different uses and adoption levels across the country. With any attempt to provide a solid integration into public transit of self-driving vehicles, whether as part of the official public transit system or by third party providers, a variety of challenges could arise for policy makers and city planners.

> **“The transit rider of the future could have an individualistic view of mobility”**

The first challenge is the transit rider of the future. He or she is likely to have an individualistic view of mobility created by rising interconnectedness. Transit riders could therefore expect seamless integration of different transportation options ranging from bikes to self-driving cars and traditional public transit modes. To support such integration, a multimodal application, a “one-stop shop transit app”, that allows combined payment for multiple modes of transportation could be required.

The levels of reliability, availability and consistency that the new transit rider could expect of “on-demand” shared vehicles as “first and last mile” mode, whether as part of the official transit system or provided by others such as Uber or Lyft, could become a challenge and be negatively influenced by small fleets, inability to meet high demand, or unfavourable regulations or policies that prolong or bar entry into the market.

The notion of “new personal mobility” is likely to be expanded by self-driving cars and could lead to autonomous mini trips, such as food order pickups, last minute “milk runs,” and other errands. This could be aggravated by cheap self-driving cars, whether it is through a shared system or personal ownership. Available aftermarket upgrades to turn non-self-driving into semi-autonomous cars could further increase a fast adoption rate and quickly place large numbers of self-driving cars on our roads, further compounding the number of mini trips empty cars would take. A potential return to the notion of ownership by the next generation, due to convenience of high access to mobility or as a status symbol, could add further volume to our roads.

Recent trends of major automobile makers partnering with or acquiring tech start-ups focused on autonomous driving could lead to them becoming mobility providers *à la Uber*. In their drive to secure market shares, this could lead to a flooding of our streets with more autonomous vehicles, which are likely to be sold to consumers at low prices after their initial use in automakers' self-driving fleets.

TABLE 2. A LIST OF CHALLENGES AND OPPORTUNITIES THAT WILL EMERGE WITH THE INTEGRATION OF SELF-DRIVING CARS INTO URBAN AREAS

CHALLENGES TO THE SUCCESSFUL INTEGRATION OF SELF-DRIVING CARS AND PUBLIC TRANSIT	OPPORTUNITIES TO THE SUCCESSFUL INTEGRATION OF SELF-DRIVING CARS AND PUBLIC TRANSIT
• Public transit systems fail to use self-driving cars as compliments to existing fixed route modes	• Public transit modes include self-driving fleet for on-demand flexible route
• "First and Last Mile" integration into public transit system in low density areas and urban centers not realized	• Suburbs and low-density areas replace bus lines with on-demand self-driving vehicles
• Limited number of shared "on-demand" vehicles due to small fleets, high demand, unfavorable regulations or policies	• Big data and predictive mobility demand AI system determine how many self-driving vehicles are needed in real-time
• Pay structure and ride-hailing are decentralized and inconvenience multimodal trips	• Cities deploy central mobility platform that regroup all mobility providers and different modes of transportation
• Aftermarket upgrades to turn current cars semi-autonomous	• Social pressure intensify about human driver that are seen as road killers
• Cheap self-driving in both purchase price and maintenance	• Cheap self-driving vehicles are replacing new mass transit projects
• Generational shift could return the notion of ownership	• Convenience and cost of on-demand mobility services eliminate car ownership
• Car manufacturers become mobility providers and fill the market demand traditional transit operators fail to meet	• Car manufacturers become mobility providers and partnered with transit operators to improve the efficiency of mass transit infrastructures
• Failure to recognize the transit rider of the future who is interconnected, expects seamless integration of transport options, and has an individualistic view of mobility	• Mass customization potential and connectivity of self-driving car are being recognized as a solution to improve the efficiency of mobility

Current transportation infrastructure investment decisions are based on a set of assumptions:

- The majority of Canadians will continue to travel from their homes to a regular place of work.
- Private vehicles will continue to be the most commonly used mode of transportation.
- For a large portion of workers, 9 a.m. to 5 p.m. will remain the common working hours during the week, meaning that peak hour mobility will continue to serve as a baseline for public transportation logistics and new road infrastructure developments.
- Canadian cities will continue to struggle with traffic and congestion issues.
- Public mass transit operated on fixed routes may remain the cheapest and most sustainable option of transportation.
- More than 60% of the Canadian population will continue to live in suburbs.
- Public transit is an efficient land use planning tool to limit urban sprawl.

These commonly held assumptions about the expected future of private and public transportation in Canada may be uncertain or incorrect. Many signals such as the emerging self-driving technologies, mobility applications and the changing behaviours of commuters may have a significant impact on the public transportation system over the next 10 to 15 years.