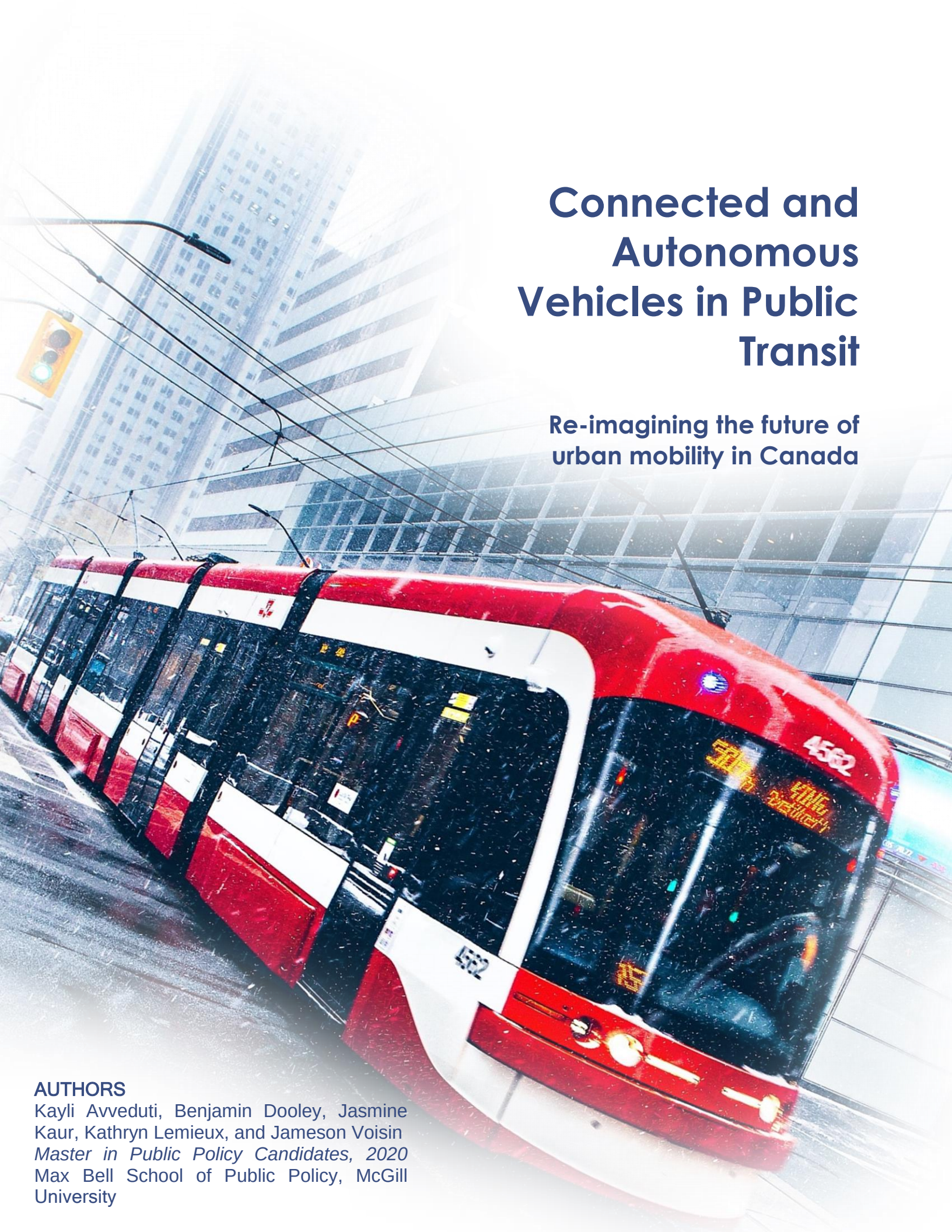
# Connected and Autonomous Vehicles in Public Transit

## Re-imagining the future of urban mobility in Canada




**AUTHORS**
Kayli Avveduti, Benjamin Dooley, Jasmine Kaur, Kathryn Lemieux, and Jameson Voisin
*Master in Public Policy Candidates, 2020*
Max Bell School of Public Policy, McGill University

# ACKNOWLEDGEMENTS

We would like to thank Infrastructure Canada for providing this policy challenge as well as for providing background material and being available throughout the process for consultation.

This document was produced by a Max Bell School student team as part of the course requirements for the Policy Lab, an experiential part of the Master in Public Policy program. The insights and recommendations of this document do not reflect the opinions of McGill University, the Max Bell School, the sponsor organization or the individuals consulted through this process. Materials used for this document were obtained in the public domain, through stakeholder interviews, site visits, and access to information requests.

*Title Page Photo Courtesy of Marcin Skalij*

# TABLE OF CONTENTS

# EXECUTIVE SUMMARY

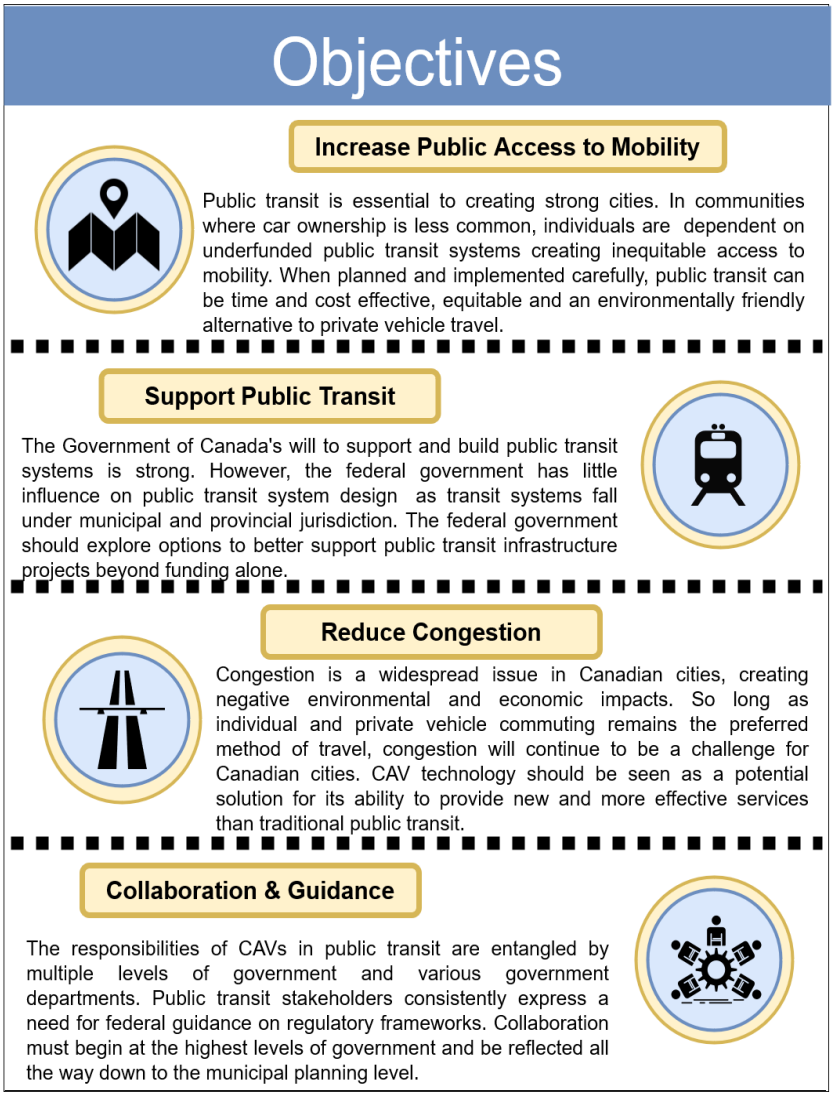
The policy challenge, provided by Infrastructure Canada, focused on how the adoption and integration of connected and autonomous vehicles (CAVs) into Canadian public transit systems will impact urban mobility. The original challenge called for the development of a suite of policy recommendations for each level of government. As the challenge evolved, the objective shifted towards the creation of a jurisdictional dashboard with a focus on policy options for the federal government.

The research for this policy brief was done through a literature review consisting of peer-reviewed journal articles, reports produced by industry associations, technical organizations, and stakeholders in addition to materials produced by federal, provincial, and municipal governments. Our review was complemented by a series of interviews with Infrastructure Canada and industry stakeholders.

This policy brief addresses opportunities and challenges presented by CAV technology. The potential impacts on transit systems and cities are explored in depth. Understanding the impact CAVs will have on land use patterns and infrastructure needs will help guide urban planning for the future of CAVs. Following this is an analysis of important considerations regarding vulnerable populations, the environment, and the economy.

Our research and stakeholder interviews led us to four high-level objectives that we believe all levels of government should strive to achieve with the integration of CAVs into public transit systems.

We believe that these objectives will be integral for



maximizing the potential benefits of CAVs. Each recommendation of the policy brief seeks to realize at least one of these objectives in Canada.

Central to achieving each objective is a clear understanding of the jurisdictional responsibilities of each level of government. The brief details the role each level of government could play in solving this complex policy challenge. We outline each level of government's primary responsibilities and concerns providing policy opportunities available to provincial and municipal governments.

We have determined three categories of recommendations for the federal government:

## RESEARCH & DEVELOPMENT

To ensure successful deployment of CAVs in public transit systems, knowledge gaps need to be addressed. We propose the federal government could divest funding to projects that help support research, knowledge sharing, collaboration, and the development of projects in the following recommendations:

**Recommendation #1:** Establish a CAV Transit Challenge
**Recommendation #2:** Study mobility pricing
**Recommendation #3:** Support solutions to first mile/last mile challenges
**Recommendation #4:** Support the study of CAV impact on urban spaces

## STAKEHOLDER COLLABORATION

Strong collaboration amongst private/public stakeholders and public transit users will be crucial. We propose Infrastructure Canada could lead collaboration in the following recommendations:

**Recommendation #5:** Establish a CAV forum for relevant government departments and create a public and private forum for all stakeholders to collaborate
**Recommendation #6:** Work to increase social acceptability of CAV technology

## SAFETY & TESTING STANDARDS

To optimize the true potential of CAVs, safety standards and adequate testing must be a priority. To ensure that safety and testing remain at the forefront of adoption efforts we propose the following recommendations:

**Recommendation #7:** Assist in the establishment of public transit safety standards
**Recommendation #8:** Support CAV testing facilities

# INTRODUCTION

The development of connected and autonomous vehicle (CAV) technology in Canada is currently underway. Canada must continue to prepare for the introduction of increasingly autonomous vehicles onto roads and remain adaptable to indeterminate timelines. Canada must be particularly prepared for the impact that this disruptive technology will have on public transit systems across the country. Public transit systems are an integral part of Canadian society as they promote social inclusivity, reduce environmental impacts, and improve mobility in urban centres.

In preparing this policy brief, it became clear that there are four main objectives, detailed below, that all levels of government in Canada should seek to achieve when integrating CAVs into public transit networks: increase public access to mobility, support public transit, reduce congestion, and promote collaboration. Achieving each of these objectives will help ensure that Canada maximizes the benefits of CAVs in public transit systems.

These objectives provide a lens through which the brief is presented. The brief begins by providing a base understanding of CAV technology and potential outcomes that will be determined by how governments and industry proceed with policy responses and technology development. How governments and industry proceed should take into consideration the impact their choices will have on public transportation systems and cities. There are overarching considerations that must also be accounted for at every stage of the process; including how policies will impact vulnerable persons, the environment, and the economy. Each level of government will have differing responses to addressing the impacted areas and considerations listed above.

In the jurisdictional dashboard, we have provided an overview of responsibilities, major concerns, and policy opportunities for each level of government, with detailed recommendations for Infrastructure Canada (INFC). Other important non-governmental stakeholders are also identified. It is important to note that data sharing and privacy concerns are central issues to the integration of CAVs into public transit systems that will need to be addressed by governments. Although mentions are made where relevant, those concerns were outside the scope of this policy brief.

## Objectives

### Objective #1 – Increase Public Access to Mobility

How people navigate within their community has major impacts on the environment, the economy, and their quality of life. Since the introduction of automobiles, urban areas have been designed to accommodate them and the needs of drivers. This has shaped the development of cities in terms of housing, infrastructure, and the use of urban space. As a result, there are existing mobility gaps where transit infrastructure does not currently exist as an alternative to automobiles. Automobile oriented, rather than transit oriented, development has led to decreased mobility for those individuals who do not have access

to a personal vehicle in some urban centres. Moving forward, increasing access to public transit will be critical for increasing mobility in Canada.

When implemented effectively, public transit offers a time-effective, cost-effective, and environmentally friendly alternative to passenger vehicle commuting. The nature of transit systems in urban centres in Canada will continue to evolve to meet the needs of each respective community. There is not a one-size fits all development plan. Each level of government will have an important role to play to ensure that the benefits of CAVs are maximized and that they are integrated in a way that meets the mobility needs of their communities.

**Objective #2 – Support Public Transit Systems**

The Government of Canada has the will to support and build public transit systems. To date, this has largely been done through investments. The Public Transit Infrastructure Fund (PTIF) is currently one component of the *Investing in Canada Phase 1 Funding Allocations for Provinces and Territories*[1]. The PTIF focuses on accelerating municipal investments in public transit systems and improving overall system efficiency.

The jurisdictional responsibility for public transit is under provincial and municipal governments. This allows for a more limited federal role. However, there are opportunities for Infrastructure Canada to further expand their influence when determining their funding requirements and what type of projects will receive this funding as well as when determining what and how the accompanying road and digital infrastructure may be developed.

**Objective #3 – Reduce Congestion**

Congestion has serious environmental and economic impacts that can be mitigated through the increased use of public transportation. CAVs can further contribute to reduced congestion as they can provide public transportation options that address regional service gap concerns and encourage individuals to choose public transit over privately-owned vehicles. The continued use of privately-owned vehicles will add to congestion problems.

A research study conducted by Transport Canada found that in large urban areas congestion has risen to acute levels that are imposing “significant annual costs in excess of $4.6 billion on drivers, the economy, the environment, and the quality of life of Canadians, with nearly $3.7 billion associated with congestion in the Toronto, Montreal, and Vancouver regions.”[2]

---

[1] Through the PTIF, Infrastructure Canada (INFC) will distribute $3.4 billion in short-term funding “to shorten commute times, cut air pollution, strengthen communities, and grow Canada’s economy.” Budget 2017 also committed an additional $25.3 billion over the next decade for public transit projects.

[2] Urban Mobility Task Force, “Urban Mobility Task Force Interim Report - Primer 4 Land Use” (Council of Ministers Responsible for Transportation and Highway Safety, 2020), 2.

The 2016 Census found that only 31.4% of Canadians use sustainable transportation as their primary mode of transportation for commuting, with only 12.4% primarily using public transit.[3] This demonstrates the continued dominance of driving personal vehicles as they account for 74% of commuters.[4] Congestion will continue to be an issue as long as driving continues to be more convenient than other modes of transportation. Consequently, building more roads or widening existing ones may not address congestion concerns in the long term as people will adapt to them, and so public transportation must be made a more attractive and convenient option for commuters.

**Objective #4 – Promote Collaboration and Provide Guidance**

Our engagement with various stakeholders identified a need for further regulatory and policy guidance from the federal government in the CAV and public transit sphere. The current state of CAVs and public transit is uncertain. With limited formal guidance from the federal government, some stakeholders are hesitant to invest significant amounts of money into projects and infrastructure that may not meet future standards and regulations. However, there is fear among some industry stakeholders and at various levels of government that imposing guidelines could stifle innovation within the field by imposing restrictions. Balancing the need for a regulatory framework without stifling innovation will be an important responsibility for the federal government. Achieving this balance will promote growth and development in the CAV sector and provide a structure that will maintain a level of consistency in development across the country.

The jurisdictional framework regarding public transit in Canada is complex. It is critical that there is a high level of collaboration between governments at the federal, provincial, territorial, and municipal levels as well as intra-governmental collaboration at the federal level. There will also be a necessity for engagement and collaboration with Indigenous communities, especially those communities on the periphery of urban centres that are serviced by municipal transit systems. Through collaboration, there is an opportunity to share best practices and lessons learned in order to collectively benefit from projects that have already been implemented.

[3] "Commuters using sustainable transportation in census metropolitan areas," Statistics Canada. 2016.
[4] Ibid.

# METHODOLOGY

The purpose of this policy brief is to provide a suite of policy recommendations to Infrastructure Canada on how they could respond to the adoption of CAVs with Canadian public transportations systems to support increased urban mobility.

The authors implemented two primary methods of research to support our analysis and recommendations: a literature review and interviews with Infrastructure Canada and experts in both public transportation and CAVs.

**Literature Review**

This policy brief provides a collection and analysis of the existing literature surrounding the role of CAVs in public transportation, including peer-reviewed journal articles, and reports produced by industry associations, technical organizations and stakeholders, and planning and policy materials produced by federal, provincial, and municipal governments.

**Interviews**

The authors conducted numerous interviews and consultations with Infrastructure Canada and other relevant stakeholders, including representatives working at the provincial and municipal level, and industry associations. Below is listed in alphabetical order the individuals with which we spoke in the preparation of this policy brief:

- Autonomous Vehicle Innovation Network
- Canadian Automated Vehicles Centre of Excellence
- Canadian Urban Transit Association
- City of Montréal
- City of Toronto AV Preparedness Team
- Federation of Canadian Municipalities
- Propulsion Québec
- Transportation Association of Canada

# BACKGROUND OF CAVS

Connected vehicles use various wireless technologies to communicate with their surroundings. The types of connectivity vary, but most new vehicles sold today contain some form of connectivity. The types of connectivity technology vehicles are fitted with drastically impact the features available to them. Connectivity in the future could include connections to other vehicles, infrastructure, and more. An outline of the different types of connectivity currently being explored and considered is provided in **Appendix A.**[5] A visual representation of connectivity types can be found in **Appendix B.**

Automated vehicles utilize sensors and computer analytics to monitor their environments and perform various degrees of the driving task.[6] The degree of automation in vehicles varies based on the systems they are adapted with. **Appendix C** provides an overview of the five levels of automation**.** It is based on the work of SAE International, a non-governmental group of transit orientated engineers, whose taxonomy and definitions are considered the gold standard globally in CAV policymaking.[7]

## Evidence and Experts

While in recent years there has been growing interest in CAVs, it is important to note there is a lack of consensus from experts and policymakers as to when we should expect to see widespread CAV adoption on roads and integration into public transit systems. Low levels of automation can already be seen in personal vehicles that have features such as assisted parking and lane steering. Comparatively, there has been limited integration of automation into public transit systems as of 2020. A leader in the field is the City of Vancouver who operates the driverless light rapid train known as the SkyTrain. Although it is driverless, it is bound to a fixed service route and does not feature technology that would allow for alternative routing found in higher levels of automation. Nevertheless, timelines regarding widespread deployment of higher levels of automation are far from settled as policymakers and manufacturers debate over how ready the technology is for deployment.

There is a discrepancy in expert opinions on the level of safety that can be expected as compared to the current vehicle landscape, and what changes to regulations will be required as the level of automation in road vehicles increases.[8] Similarly, there is still significant outreach and communications work needed by manufacturers and policymakers to educate the public on the benefits and concerns of CAV integration into

---

[5] "Connected and Automated Vehicles," CAAT: Center for Advanced Automotive Technology, http://autocaat.org/Technologies/Automated_and_Connected_Vehicles/.
[6] Driving Change: Technology and the future of the automated vehicle (Jan. 2018). Report of the Standing Senate Committee on Transport and Communications.
[7] Jennifer Shuttleworth, "SAE J3016 Automated-Driving Graphic," SAE International, January 7, 2019, https://www.sae.org/news/2019/01/sae-updates-j3016-automated-driving-graphic.
[8] "Challenges and Approaches to Realizing Autonomous Vehicle Safety and Mobility Benefits," 2017. https://www.rand.org/content/dam/rand/pubs/testimonies/CT400/CT475/RAND_CT475.pdf

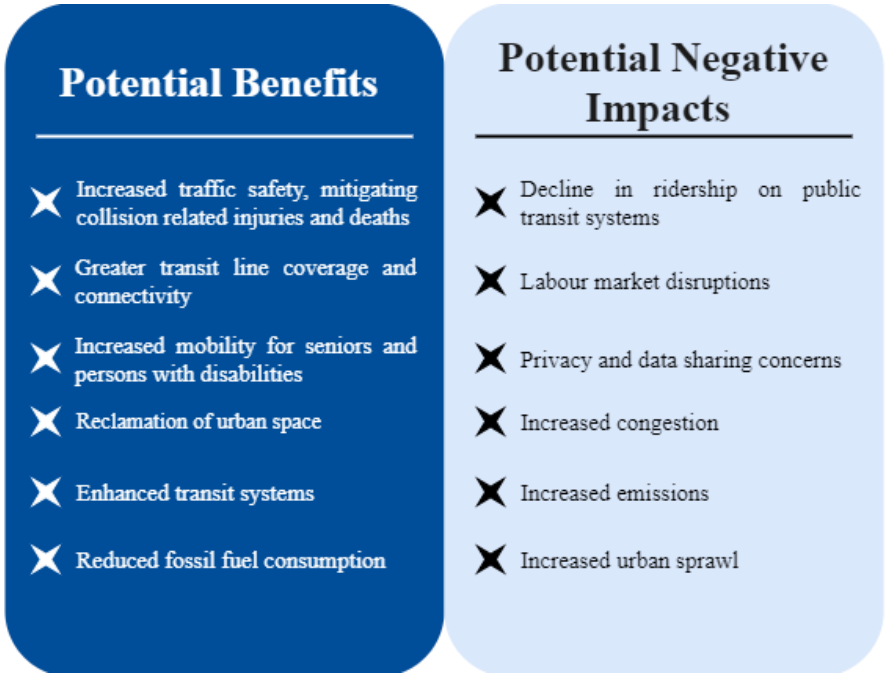
road systems and to reach a widespread consensus on how to continue pursuing this integration.[9]

The impact that public acceptability has on the speed of deployment can already be seen in the United States when in 2018 the death of pedestrians in Arizona caused by an autonomous vehicle significantly reduced policymakers' interest in making needed legislative changes and forced manufacturers to reconsider the technological readiness of the vehicles.[10]

In interviews conducted, stakeholders shared vastly different opinions regarding CAV readiness. Stakeholders, primarily from the private sector, expressed that widespread CAV use is not far away, while other stakeholders indicated that it is a longer-term objective. This lack of consensus is exemplified by the disagreement among experts over the infrastructure that will be required to support CAVs. Various stakeholders claimed no external infrastructure will be needed, and while others placed a high level of emphasis on the signals, signage, and road markings they believe will be needed for implementation and safe deployment.

## Potential Impacts of CAVs

The impacts of CAVs are largely uncertain. There are exogenous factors that will affect the impact of CAVs in society such as social acceptability, market reactions, technological advancement, and regulatory frameworks. The literature examining the potential benefits and concerns of CAVs recognizes two potential scenarios that could emerge: CAV 'Hell' and CAV 'Heaven'.




[9] "What's Ahead for Fully Autonomous Driving Consumer Opinions on Advanced Vehicle Technology" (Deloitte, 2017), https://www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/us-manufacturing-consumer-opinions-on-advanced-vehicle-technology.pdf.
[10] "Issues in Autonomous Vehicle Testing and Deployment" (Congressional Research Service, 2020), https://fas.org/sgp/crs/misc/R45985.pdf.

### CAV 'Hell'

In the CAV 'Hell' scenario, private vehicle ownership becomes more dominant than shared vehicle ownership, leading to an increase in congestion and emissions. As a result of private vehicle ownership, urban sprawl development continues to increase, with people living far distances from their work and essential community services. Public transit systems will not be able to compete with private vehicle ownership, which may cause a continued decline in revenue generation to the point that public transit systems may be eliminated or significantly reduced.

### CAV 'Heaven'

In the CAV 'Heaven' scenario, all potential benefits of CAVs are maximized. CAV integration will result in a reduction of car ownership leading to reduced congestion, emissions, and traffic accidents. In CAV 'Heaven', CAVs are seamlessly integrated into public transit systems and there is mass adoption of shared use vehicles. There will also be an increase in multi-modal transportation options and increased public transit ridership.

### Achieving Heaven

The objectives set out at the onset of this brief will help guide governments to achieve a 'CAV Heaven'. Limiting congestion while promoting public transit use will ensure that access to mobility is increased while avoiding a 'CAV Hell' should be a priority for governments across the country. The actualization of CAV technology in Canada will depend not only on social acceptability and market factors but on the preparedness of all levels of government.

## Safety

CAVs present unique safety risks that must be addressed through a combination of regulation and testing prior to extensive deployment on Canadian roads. The safety risks will change over time as increasingly high levels of automation are introduced, as well as during the transition period where conventional vehicles share roads with CAVs.[11]

This transition period presents a major policy challenge as interaction with human drivers in 'mixed traffic' creates significantly more environmental complexity for CAVs to navigate. There is a potential risk to pedestrians and other road users should the public be uncertain about how to interact and communicate with CAVs as well as how to behave in predictable ways that CAVs will recognize and respond safely to.

The Report of the Standing Senate Committee on Transport and Communications indicates that increased risk during the transition phase is partly due to the possibility of CAV drivers being too technologically reliant and taking risks that they would otherwise

[11] "Canada's Safety Framework for Automated and Connected Vehicles," Transport Canada, February, 2019, https://www.tc.gc.ca/en/services/road/innovative-technologies/automated-connected-vehicles.html.

avoid.[12] Public transit CAVs and other human drivers must be able to understand each other's behaviour consistently and react accordingly. Until full automation is achieved, drivers of partially automated public transit need to be attentive and willing to take control of their vehicles when necessary.

Pedestrians and cyclists will also have to be prepared for interaction with CAVs. Pedestrians and cyclists may base their actions on inaccurate or unjustified assumptions about the behaviour of public transit CAVs.[13] Similarly, these vehicles might not be able to accurately gauge the actions of pedestrians and cyclists, as their behaviour in relation to a public transit CAV could differ from their behaviour in relation to a human-driven vehicle. During the transitional period, effective training for operators and riders on how to properly communicate with other road users will be necessary.

Additionally, public perception of the safety of CAVs will be important for governments to manage. Stringent safety testing will be required before vehicles are permitted on public roads, and risks to public safety must be effectively communicated to the public. As per Canadian Motor Vehicle Traffic Collision Statistics, the number of motor vehicle fatalities was 1,922 in 2018; up 3.6% from 2017.[14] It will be important for the provincial governments to inform the public about the potential of CAVs for eliminating human error and how public transit CAV technologies would provide safety to road users.

According to the report of the *Policy and Planning Support Committee (PPSC) Working Group on Connected and Automated Vehicles*, new federal safety regulations would be required as vehicles become increasingly automated. Unlike partially automated features, existing safety standards do not apply to fully automated vehicles. CAV technology is evolving and is currently being tested on public roads for market readiness. While there is pressure for rapid adoption, safety remains a great concern of regulators. The implementation of CAVs would require participation from all government levels to evaluate the technology and establish safety regulations and standards. Governments would have to continue to work with industry experts and international partners to develop CAV onboarding safety guidelines, particularly for public transit.

---

[12] "Driving Change: Technology and the Future of the Automated Vehicle" (Standing Senate Committee on Transport and Communications, 2018), https://sencanada.ca/content/sen/committee/421/TRCM/Reports/COM_RPT_TRCM_AutomatedVehicles_e.pdf.

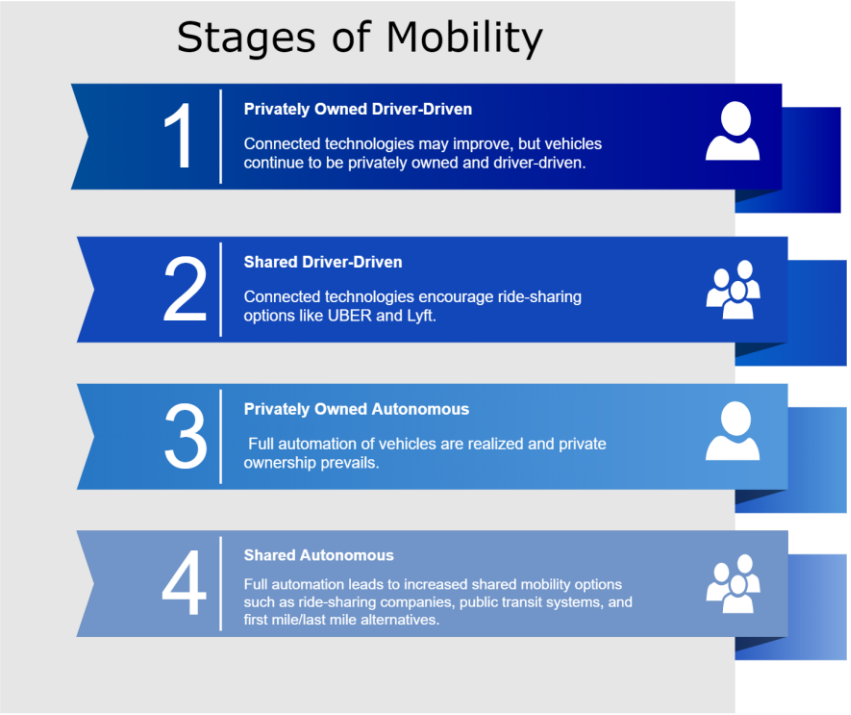
[13] Vissers, Luuk, Sander Van Der Kint, Ingrid Van Schagen, and Marjan P Hagenzieker, "Safe Interaction between Cyclists, Pedestrians and Automated Vehicles. What Do We Know and What Do We Need to Know?" Hague: SWOV Institute for Road Safety Research, (2016): pp. 1-46, https://www.researchgate.net/publication/313165192_Safe_interaction_between_cyclists_pedestrians_and_automated_vehicles_What_do_we_know_and_what_do_we_need_to_know.

[14] Government of Canada, Transport Canada. "Canadian Motor Vehicle Traffic Collision Statistics: 2018". Statistics and Data. https://www.tc.gc.ca/eng/motorvehiclesafety/canadian-motor-vehicle-traffic-collision-statistics-2018.html

# IMPACTS ON PUBLIC TRANSIT

## Transition Period

As automated technology advances, cities will experience transition periods between each stage of mobility. The pace at which each new level of automation is achieved is uncertain, and there will likely be overlaps respecting each stage of mobility (Figure 1).




Managing the transition of human-driven to autonomous vehicles will be important for ensuring the safety of Canadians. Roadways will be filled with vehicles of all levels of connection and automation. Public transit fleets that maintain human driven vehicles will have to navigate busy roads filled with various levels of automation. Public transit systems will have to continue to evolve to be responsive and absorptive to the emergence of new technologies. All levels of government must be prepared to support public transit systems through the transition of mobility stages through investment and policy responses that promote the safety of CAVs.

## First Mile/Last Mile

As seen in pilot projects and underscored in preliminary research, CAV technology has often been identified as the solution to the first mile/last mile problem.[15] In transit terms, the first mile refers to a commuter's trip to reach a transit centre (i.e. home to a bus stop). The last mile is the portion of the commuter's trip from the end of their transit ride to their final destination (i.e. Bus stop to place of work). Commuters use various modes of transportation for the first and last mile portions of their trip, including driving or walking. The first mile/last mile problem refers to the issue that public transit seldomly takes people exactly where they need to be, leaving most users challenged by the first or last mile of

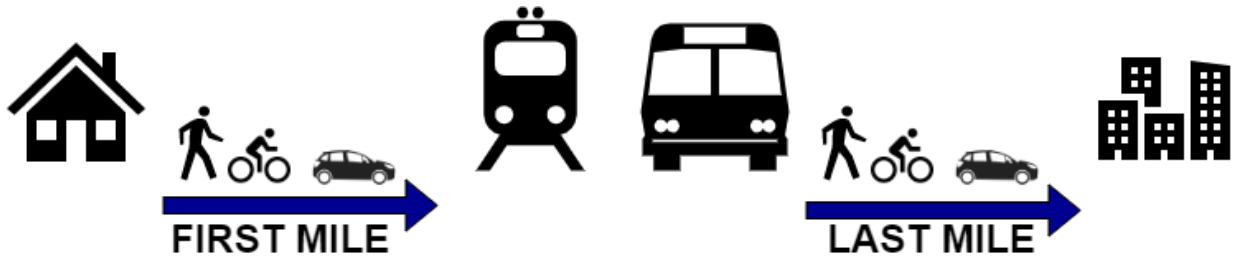
[15] Yu Shen, Hongmou Zhang, and Jinhua Zhao, "Integrating Shared Autonomous Vehicle in Public Transportation System: A Supply-Side Simulation of the First-Mile Service in Singapore," *Transportation Research Part A: Policy and Practice* 113 (2018): pp. 125-136, https://doi.org/10.1016/j.tra.2018.04.004.

their commute. Due to cost and design restrictions, public transit networks cannot go everywhere. Cities are faced with the challenge of ensuring first mile/last mile options are comfortable and convenient to ensure commuters do not turn to driving as an alternative to public transit systems.

Solving the first mile/last mile problem can be challenging for various reasons. First, the last mile for commuters is often in crowded downtown urban centres. Solutions must consider the fact that these areas are already congested, and additional vehicle use may only further obstruct the ease of urban travel, this is a primary reason as to why micro-mobility options like scooters and bikes have gained popularity. In addition, micro-mobility options take up relatively small space and offer flexible routing.

Economic inequality associated with the first mile/last mile problem poses a significant challenge as well. Living close to a public transit line is often considered beneficial, and as a result, landlords or home sellers raise prices, which in turn drives up the cost of living in these areas. Consequently, economically marginalized groups are pushed to areas of the city with less access to public transit options.

Due to the high cost of operating transit lines in areas with greater sprawl and lower density, public transit networks incur large costs to meet the demands of the first mile, with only partial success. A case study conducted in London, England, found that on-demand CAV technology, when produced at a lower cost, has the potential to be more effective than existing transit lines, in that services can begin at or close to one's home and are cheaper, as bus lines would not be operating when not in demand.[16]




## Multi-Modal Transportation

Multi-modal transportation has long been embraced by public transit networks. Multi-modal transportation refers to the use of multiple means of travel within one commute. Given the expensive nature of building public transportation networks, it is rare for large systems to consist of one singular mode of transport. For example, people often drive to their nearest public transportation access point and take a subway to a connecting streetcar or bus for their final leg of their trip.

[16] Richard Forster, "New Report Highlights Advantages of AVs for First and Last Mile Trips," Cities Today, July 17, 2018, https://cities-today.com/new-report-highlights-advantages-of-avs-for-first-and-last-mile-trips/.

However, multi-modal transportation is not limited solely to public transit, private companies have also begun providing options as well. Micro-mobility options such as private scooter and bike sharing companies have gained popularity in Canadian urban centres. The benefit of these micro-mobility options is that they provide users with flexible routing options. Winter conditions however mean that these services cannot be offered year-round.

Should public transit systems embrace CAV technology, it will likely be effective to integrate new transit options into existing networks. Providing alternatives or competition may decrease efficiencies and further deter commuters from giving up their private vehicles as their preferred method of travel. Similarly, public transit systems need to recognize the growing demand for flexible routing options that exist within multimodal transit and find ways that it can integrate.

## Mobility as a Service (MaaS)

As transit options grow, both in terms of means provided and locations serviced, public transit networks must prioritize interconnectivity. A perceived lack of convenience in public transit systems is a key reason why people are motivated to own vehicles. Travelling to access points, changing transportations means, wait times, and the different payment methods required are simply too cumbersome for many people. Mobility as a Service (MaaS) is considered to be critical in shifting demand away from personally owned vehicles to shared methods of travel.[17] MaaS facilitates ease of travel by combining multi-modal means of transportation within a single system that can be curated to one's specific needs (departure times, destinations, etc.) as well as one synchronized payment.

A key feature of MaaS is the on-demand nature, which helps solve first mile/last mile problems. Similar private systems like Uber and Lyft have already shown how user-friendly applications can easily facilitate payments while getting people to exactly where they need to go.

Connectivity technology that actively tracks available transit options and optimal routing from vehicles and smart infrastructure would help harness the benefits of CAVs to service public transit. Technology that utilizes connected capabilities would allow for systems to be synchronized to facilitate greater efficiencies so that people can get to where they need to go more seamlessly, especially when multi-modal transportation is needed. This would benefit cities because it could help drive ridership up while driving congestion down. Vehicles would have the means to identify traffic, construction, or accidents while being connected with lights allowing the flow of traffic to move efficiently utilizing better routes, which would help reduce emissions. Finally, MaaS systems would provide valuable data regarding travel routes, occupancy, and times demanded. The data acquired from MaaS systems would enable infrastructure planning to be conducted

[17] "Mobility 2030: Transforming the Mobility Landscape" (KPMG, September 2018), https://assets.kpmg/content/dam/kpmg/uk/pdf/2019/02/mobility-2030-transforming-the-mobility-landscape.pdf.

optimally. It will be important that future public transit lines incorporate an element of MaaS, or an ability to adapt to systems in the future. Similarly, government policymakers must understand the need to provide on-par service with that which is already being provided by private transit providers that use elements of MaaS already.

## Transit Employment Impacts

Labour disruptions will be inevitable as disruptive technologies become adopted. In the realm of public transit, this could be particularly true as CAV technology would lead to job losses for employees of public transit systems, the full scope of which is currently unknown. The reception of CAVs in Canada may be impacted by negative perceptions of jobs lost to these new technologies. Governments will be responsible for managing the perception of job losses to ensure public acceptance of CAVs.

Some labour losses may be offset due to job retraining. Job sectors that require professionally trained drivers may also be impacted gradually, as software would initially control only certain aspects of driving, with human operators conducting other functions, like close maneuvering.[18] New jobs may also be created in planning, communications and customer service, as well as in maintenance and security.[19] Operators may also need to be on call for emergencies while human oversight may be needed for repairs.

Ideally, the wide adoption of CAV technology into public transit would make it a more viable option to compete with private vehicles, thereby creating more service jobs.[20] These disruptions have potentially significant ramifications, and federal, provincial, and municipal governments could mitigate these effects through further research and promotion of retraining programs.[21] The full effects on the wider transportation ecosystem, as well as on the economy at large, should be well-studied and considered as part of any adaptive phase of regulation.

## Risk of Privatization

The rising interest in CAV technologies amongst private sector actors is well known. Globally, car manufacturers are investing billions of dollars into research and development efforts to position themselves as leaders in the CAV space. In Canada, Ford and GM each have committed to over $300 million in research and development in Ontario alone. Outside of manufacturing, car share providers, Uber and Lyft have made investments in driverless pilot projects in the United States and Canada.[22]

---

[18] "KPMG- 2019 Autonomous Vehicles Readiness Index: Assessing Countries' Preparedness for Autonomous Vehicles" (KPMG Cooperative, 2019), https://home.kpmg/content/dam/kpmg/uk/pdf/2019/08/kpmg-2019-autonomous-vehicles-readiness-index.pdf, pg. 6.
[19] Corrine Kisner et al., "Blueprint for Autonomous Urbanism" (National Association of City Transportation Officials (NACTO), n.d.), nacto.org, 52.
[20] Ibid.
[21] Ibid.
[22] "Canadian Automotive Industry," Innovation, Science and Economic Development Canada, January 10, 2019, https://www.ic.gc.ca/eic/site/auto-auto.nsf/eng/home.

Building private momentum may have significant impacts on public transit. Private companies, because of route flexibility and convenient door to door service offerings, may be faster than multimodal public transit. Thus, offerings made by private companies may undermine the services provided by public transit. A 2016 research conducted in the United States found a 6% reduction in public bus use and a 3% reduction in light rail use following the widespread introduction of private ride sharing services in urban markets.[23] There is a concern in many Canadian cities that private ride-sharing companies could cripple existing taxi and public transit demands. These concerns have led to widespread debate concerning whether or not private ride sharing companies should be allowed to operate in some cities.

Should the private sector begin offering shared transit options before public transit systems, ridership will fall and disinvestment from public transit is likely to occur, resulting in disadvantages for low-income communities unable to incur the cost of private options, and who may live in areas where private services are less likely to be offered.[24] Additionally, private services may be limited to only able-body individuals and smartphone users, which poses a significant problem for vulnerable communities.

Public transit systems help foster inclusivity, are held accountable by the public, and ensure that routes that are needed but are unpopular exist. Alternatively, private transit would only be accountable to customers, leaving those who are not using the system or who are unable to afford it out of important mobility conversations.[25]

The government will have to be mindful of consequences that could arise should private companies' better position themselves for transit offerings that incorporate CAV technology. Opportunities to integrate private and public systems exist with mutually beneficial results, and MaaS technology has been viewed as a solution. In Finland, a MaaS application was launched which incorporated private and public transit when suggesting travel routes. Following the adoption of the MaaS application, there was a 50% increase in public transit ridership, while private car use for commuting declined.[26]

---

[23]Mark Wilding, "Private Companies Want to Replace Public Transport. Should We Let Them?," *The Guardian*, May 29, 2019, https://www.theguardian.com/cities/2018/mar/29/public-transport-transit-private-companies-citymapper-uber-whim-smart-buses.

[24] Alana Semuels, "The End of Public Transit?," *The Atlantic*, October 28, 2016, https://www.theatlantic.com/business/archive/2016/10/public-transportation-uber-chariot/505658/.

[25] Ibid.

[26]Mark Wilding, "Private Companies Want to Replace Public Transport. Should We Let Them?," *The Guardian*, May 29, 2019, https://www.theguardian.com/cities/2018/mar/29/public-transport-transit-private-companies-citymapper-uber-whim-smart-buses.

# IMPACTS ON CITIES

CAVs will forever change Canadian cities. How we travel, do business, and conduct urban planning will be impacted by the integration of CAVs. As technological advances approach complete automation, the impact on the way individuals commute will be transformed. CAVs may lead to new trends in land use and design, providing new opportunities for urban planners to rethink urban centres across Canada.

CAVs will also likely bring change to current infrastructure within cities. Public transit infrastructure requirements for CAV adaptation are relatively unknown but will likely have an important impact on the future planning of Canadian cities. The introduction of CAVs will bring new challenges to cities that will require adequate planning to address changing land use patterns, infrastructure needs, and limitations on data collection.

## Land Use Patterns

There are two land use patterns that will likely arise due to the introduction of CAVs: greater urban sprawl or greater densification. Many Canadian cities already have extensive urban sprawl, yet the pros and cons of each land use pattern continue to be widely debated. CAVs have the potential to intensify urban sprawl or increase densification, but the outcome of these dueling realities will be entirely dependent on the policy response of governments. Greater study on the impact of CAVs on urban space will be required for all levels of government to make informed policy decisions that will best suit their communities.

### Urban Sprawl

Private CAV ownership may make it possible for individuals to live further from their place of work, as CAVs will save valuable time commuting. Completely autonomous vehicles will allow the passenger to rest or complete work tasks while on the way to work. CAVs will allow Canadians to gain back valuable time spent driving, thus encouraging longer commutes. This could lead to more Canadians seeking homes in residential, suburban areas. The increased demand for suburban residences will increase urban sprawl in Canadian cities.

The introduction of CAVs may allow businesses to save on costs by moving away from downtown locations. Complete automation and private vehicle ownership will allow employees to travel to business locations that may not be on existing public transit routes. The prospect of relocating outside the downtown core may encourage greater urban sprawl.

Urban sprawl is often viewed as a negative as it will encourage greater congestion on roadways, increase social and economic disparity, increase land use, and increase air and water pollution. The environmental and economic challenges urban sprawl poses are of great concern for all levels of government as these concerns will have to be weighed against the benefits CAVs will provide to commuters.

### Densification

The alternative outcome of CAV integration is greater densification in urban centers. CAVs could be utilized to increase the functionality of public transit systems and fill service gaps. CAVs in public transit systems, such as through first mile/last mile options, could increase the reliability and cost effectiveness of public transit systems. Greater reliability will encourage commuters to utilize public transit systems over privately owned vehicles. Strong public transit networks will encourage Canadians to continue to live in urban centers. Additionally, land that becomes available as a result of reduced parking needs could be utilized for the development of new affordable housing complexes and services for individuals. Creating new and affordable places to live will encourage Canadians to stay within urban centres.

### Parking

The introduction of CAVs may allow for the reclamation of space currently utilized for parking in urban centres. When technological adoption of CAVs reaches complete automation, privately owned CAVs may not require parking in urban centres, leading to a transformation in curbside drop off and pick up. In a fully autonomous world, private CAVs would drop passengers off and return home to the passengers' residence where the vehicle will remain parked until pick up time. Additionally, the integration of CAVs into public transit systems may lead to an increased usage of public transit systems by Canadians, reducing the number of privately-owned vehicles, minimizing the need for parking.

Many cities in Canada currently have parking allotment quotas for businesses which accounts for a significant use of urban space. The introduction of CAVs could encourage policymakers to change current parking standards allowing urban planners to reimagine large parking structures into new green spaces or affordable living complexes.

Cities in North America have already begun to make changes to their parking standards in an effort to reclaim urban space. For instance, the Edmonton City Council recently voted to remove mandatory parking minimums within the city.[27] Mandatory minimums require businesses to provide a minimum number of parking spaces to their customers. This move to remove parking minimums in Edmonton was an effort on the part of the City Council to support more diverse transit options while reducing economic barriers for homeownership. Parking spaces have great environmental, social, and economic impacts on urban centres. The introduction of CAVs will provide cities with the opportunity to reimagine these spaces.

---

[27] "Edmonton City Council Votes to Remove Minimum Parking Requirements | CBC News," June 24, 2020, https://www.cbc.ca/news/canada/edmonton/edmonton-parking-requirements-1.5624754.

## Infrastructure

As mentioned in the Evidence and Experts section, there are varying expert opinions on the degree to which infrastructure changes will be required initially. Through our research, we have identified current infrastructure needs based on the existing level of automation available in CAVs. The type and amount of infrastructure required can be expected to change as technology advances. There is an opportunity for Infrastructure Canada to lead the identification and deployment of both the physical and digital infrastructure technology that will be required.

The type and amount of infrastructure that is needed in cities is highly context specific and will depend on the existing infrastructure as well as the type of CAV public transit being adopted. However, recognizing the role that Infrastructure Canada plays in creating stronger networks and physical infrastructure as a pure public good, it is recommended that there be a targeted focus on vehicle to infrastructure technology as infrastructure (even if more computerized and connected) that should be provided by the government. The development of this infrastructure will be important for managing mixed traffic as well as for collecting data that can be analyzed to support long-term optimization.

In the early deployment phase, there are infrastructure options that involve low levels of technology but instead provide space for CAVs to operate separately from other road users. Dedicated lanes for CAV public transit can be used to promote safety for all. These lanes would not require additional road expansions, and in mixed traffic conditions they would lower vehicle speeds and discourage risky driving behaviour, thus increasing safety.[28]

Vehicle to infrastructure technology has two components, physical road infrastructure and digital infrastructure. Road infrastructure is primarily focused on localization and managing traffic flow and may replace road signs and signal functions. Road indications could be transmitted via dedicated short-range communication to the CAVs. Traffic signs could also be updated to allow V2I applications, which could help improve traffic flow and optimize speeds.

Digital infrastructure will also be needed to support road infrastructure. Digital infrastructure is also known as smart roadway infrastructure (SRI) and contributes to enhancing traffic flow and road safety. Examples of SRI include mapping systems, sensor data, and vehicle localization. There is an opportunity for collaboration with industry partners and provincial, territorial, and municipal governments on the management and use of the information collected through this infrastructure.

Canada's climate also presents significant challenges for CAV infrastructure technology. The presence of snow and ice create additional environmental challenges that must be considered in the development of all infrastructure that will be used on Canadian roads.

---

[28] "Planning for Connected and Automated Vehicles" (Public Sector Consultants And Center For Automotive Research, March 2017), https://www.cargroup.org/wp-content/uploads/2017/03/Planning-for-Connected-and-Automated-Vehicles-Report.pdf.

These conditions may impact the behaviour and connectivity of other vehicles, pedestrians, and infrastructure. Extensive safety testing conducted in winter weather conditions prior to deployment will be imperative.

## Data Limitations

CAVs will significantly impact mobility within Canadian cities in the future, and the ensuing changes in mobility conditions will certainly impact location choices for urban development land use organization and infrastructure requirements for these CAVs. However, there is not enough data for a real-life assessment of CAVs. The lack of city planning databases will lead to ambiguities in assessing the expected implications of CAVs on the urban landscape of cities. Building city planning databases to have more robust information and data on collisions, traffic citations, curb and signage issues would be helpful to ensure that city planners can better adjust for the impacts of CAVs.

Some jurisdictions across Canada have initiated pilot programs to pursue research and city data collection to understand the impacts of CAVs. One solution for the successful deployment of CAVs on public roads is to gather urban administrative data, which could include data from municipal authorities and transportation agencies on urban planning and infrastructure. Urban data will become a pillar for risk management and implementation strategies for CAVs. This information will help governments adopt and improve infrastructure and regional long-term transport plans to facilitate the potential widespread deployment of CAVs.

Coherent urban databases will also help optimize the range of benefits these technologies can offer if governments are prepared to use the data to improve public transit systems. This data has the potential to significantly alter how provincial and municipal governments plan, design, and modify the infrastructure of CAVs in public transit.

# CONSIDERATIONS

## Impact on Vulnerable Communities

### Persons with disabilities

Many public transit systems in Canada are not fully accessible for persons with disabilities. The lack of access creates inequality as persons with disabilities face greater hurdles to access services. CAVs offer a unique opportunity to remedy accessibility issues in public transit systems. Door-to-door shuttles or other MaaS options could help provide greater access to public transit systems for persons with disabilities.

Public Transit CAVs must be designed to accommodate persons with disabilities to allow easy access to vehicles. It is recommended that all CAVs used for public transit should be low-floor and accessible.[29] Public transit networks could also hire onboard attendants to assist those who require additional assistance.[30] Many public transit services are specifically designed for the needs of persons with disabilities today provide on-demand services with trained attendants that can assist passengers which should be a feature of all CAVs.

### Seniors

Seniors are one of the most rapidly growing segments of Canada's population. As of 2010, Canada's senior population was 4.8 million, and that number is expected to rise to between 9.9 and 10.9 million by 2036, according to Statistics Canada.[31] Seniors living within varying proximities to medical care and other essential services may increasingly rely on public transit networks, and so will need greater access to public transit systems. Like other vulnerable communities, seniors often face numerous barriers to accessing public transit systems, such as living a significant distance from bus stops and long wait times. CAVs could enable increased public transit accessibility for seniors through shuttle services.

### Low-Income

Approximately one million people in major Canadian cities are currently underserved by their public transit systems.[32] In many municipalities the poorest neighbourhoods often

---

[29] "Automated Vehicle Tactical Plan," Automated Vehicle Tactical Plan (2019), https://www.toronto.ca/wp-content/uploads/2020/02/7ec4-TS_AV-Tactical-Plan_Technical-Report.pdf, pgs. 44-47.
[30] Ibid, pgs 45-47.
[31] "Seniors," Statistics Canada: Canada's national statistical agency / Statistique Canada : Organisme statistique national du Canada, January 17, 2018, https://www150.statcan.gc.ca/n1/pub/11-402-x/2011000/chap/seniors-aines/seniors-aines-eng.htm.
[32] "Stranded without Transit? U of T Researchers Say One Million Urban Canadians Suffer from 'Transport Poverty'," University of Toronto News (University of Toronto News), https://www.utoronto.ca/news/stranded-without-transit-u-t-researchers-say-one-million-canadians-suffer-transport-poverty.

are the most underserved by public transit systems, making it difficult for low-income individuals and youth to access services and employment.[33]

Ageing and inadequate infrastructure combined with the inability to afford a personal vehicle makes mobility an important issue for low-income communities. People require the means to gain access to affordable and convenient public transportation to gain further opportunities. CAV technology could provide equitable service options for parts of urban centres that are underserved and unreliable.

According to the 2016 census, 12.4% of Canadians rely on public transit to get to work.[34] Many publicly available modes of transportation require some form of credit debit card to pay for fares. It is estimated that between 1-5% of Canada's population either has limited or no access to banking services.[35] Transportation is limited for people who do not have adequate bank access, as certain modes of transportation, like bike rentals, require credit services and studies have shown that in Canada bike kiosks tend to be placed in more affluent neighbourhoods.[36]

Furthermore, low-income persons may lack access to internet and mobility devices, which may disadvantage their access to increasingly include digital features of transit. The City of Toronto's CAV Preparedness Plan states that if CAV services require cellular connectivity it may disproportionately affect low-income persons.[37] CAV public transit services must, therefore, have payment premium options which are predictable, and which can be paid for using traditional modes of payment like cash. Toronto streetcars have been retrofitted with payment machines that dispense tickets and can easily process credit, debit and cash as payment, and so public CAV fleets could be fitted with similar designs.[38]

## Environmental Concerns

If public transit networks adopt CAVs which utilize low emissions technology, there may be a reduction of emissions and other pollutants associated with transportation. Vehicle automation and infrastructure connectivity may also lessen components of traffic that traditionally contribute to congestion. Furthermore, the wider adoption of CAV technology may increase incentives for ridesharing, as well as decreases in purchases of private,

---

[33] Gillian B. White, "Our Struggling Public Transportation System Is Failing America's Poor," The Atlantic (Atlantic Media Company, February 12, 2016),

[34]Government of Canada, Statistics Canada. "2016 Census Topic: Journey to Work." 2016 Census Topic: Journey to work. Statistics Canada, November 25, 2019. https://www12.statcan.gc.ca/census-recensement/2016/rt-td/jtw-ddt-eng.cfm.

[35] "Automated Vehicle Tactical Plan," Automated Vehicle Tactical Plan § (2019), https://www.toronto.ca/wp-content/uploads/2020/02/7ec4-TS_AV-Tactical-Plan_Technical-Report.pdf, pgs. 45-47.

[36] Kate Hosford and Meghan Winters, "Who Are Public Bicycle Share Programs Serving? An Evaluation of the Equity of Spatial Access to Bicycle Share Service Areas in Canadian Cities," *Transportation Research Record: Journal of the Transportation Research Board* 2672, no. 36 (2018): pp. 42-50, https://doi.org/10.1177/0361198118783107, Pgs 42-50.

[37] "Automated Vehicle Tactical Plan," Automated Vehicle Tactical Plan § (2019), https://www.toronto.ca/wp-content/uploads/2020/02/7ec4-TS_AV-Tactical-Plan_Technical-Report.pdf, pgs. 45-47.

[38] Dilshad Burman, "New Fare Machines Coming to TTC Streetcars," Toronto.citynews.ca, May 2, 2018, https://toronto.citynews.ca/2018/05/02/new-fare-machines-coming-ttc-streetcars/.

greenhouse gas-producing vehicles.[39] Through engagement with stakeholders, we have learned that there is a consensus that the adoption of CAVs for public transit will be superseded by the broad adoption of electric vehicles. Should public transit networks adopt electrically powered CAVs for its fleets, and should rollout be accompanied or superseded by a rise in ownership of electric vehicles, the adoption of electrically powered CAVs may significantly assist in the reduction of Canada's GHG emissions. However, municipalities employing CAV technology for public transit networks will have to contend with the disposal of rare-earth minerals used in electric motors, particularly lithium-ion batteries.[40]

While CAVs create better efficiency in terms of movement and fuel usage, these factors may decrease the lifespans of vehicles, thus creating a waste disposal burden for cities.[41]

One way to ensure that CAVs have a positive impact on the environment is by utilizing Infrastructure Canada's *Climate Lens* on all CAV-related projects. The *Climate Lens* is a requirement for projects receiving funding by INFC which involves an assessment of the GHG emissions of a given infrastructure project, and its long-term impact with respect to climate change. It is intended to incentivize planners of infrastructure projects to familiarize themselves with key strategies in climate change mitigation, to account for climate change considerations in their design and planning and help pivot Canada towards a low-carbon economy. It also acts as a means for the Government of Canada to better gather data and communicate the forecasted outcomes of federally sponsored climate change mitigation. Winners of the *Smart Cities Challenges* must adhere to relevant Climate Lens assessments if their projects entail GHG emissions, and accordingly incorporate climate change impacts and mitigation strategies.[42]

According to Infrastructure Canada's *Climate Lens*, projects which may be granted support from the Ministry of Infrastructure are required to meet several criteria to receive funding. CAV projects funded through Infrastructure Canada will also have to meet the requirements of the *Climate Lens*, which will help bring about greater environmental impacts in Canada.[43]

## Economy and Development

### Supporting the Canadian Economy

Automotive manufacturing is integral to the Canadian economy, generating nearly $20 billion each year.[44] Automotive manufacturing is particularly important to Ontario, where it is responsible for over 20% of the provincial GDP but the benefits the industry yields

---

[39] "Automated Vehicle Tactical Plan," Automated Vehicle Tactical Plan § (2019), https://www.toronto.ca/wp-content/uploads/2020/02/7ec4-TS_AV-Tactical-Plan_Technical-Report.pdf, pgs. 52-56.
[40] Ibid.
[41] Ibid.
[42] Infrastructure Canada Government of Canada, "Climate Lens - General Guidance," Infrastructure Canada, October 31, 2019, https://www.infrastructure.gc.ca/pub/other-autre/cl-occ-eng.html.
[43] Ibid.
[44] "Canadian Automotive Industry," Innovation, Science and Economic Development Canada, January 10, 2019, https://www.ic.gc.ca/eic/site/auto-auto.nsf/eng/home

are felt nation-wide.[45] The evolution of connected and autonomous technologies provides a unique opportunity for Canadian businesses to lead not only within Canada but internationally.

With Canada's proven experience as a vehicle manufacturer, coupled with strong technology and innovation companies and an emerging artificial intelligence (AI) sector, Canadian firms have already received billions in investments towards CAV research and development from companies including Ford, General Motors, Uber, and Google. This support will help ensure that Canada is well positioned to be a competitive market player. Similarly, as seen in Oshawa, Ontario - General Motors has begun planning to retrofit existing facilities and retraining employees to be better positioned for CAV demands.[46] Beyond personal vehicles, Canada has the expertise and experience in producing public transit vehicles and systems. Harnessing the potential of Canada's well-established mass vehicle manufacturing with other tech strengths will provide Canada with the ability to export public transit vehicles and CAV technologies abroad.[47]

Recognizing this potential, the federal government and provincial governments have supported the industry through the creation and funding of provincial agencies. Propulsion Québec, the provincial cluster for electric and smart transportation, seeks to make Québec a global leader in smart transportation and support businesses that can contribute to the advancement of technology both at home and abroad. Similarly, the Autonomous Vehicle Innovation Network (AVIN), funded by the Ontario government through their Ontario Centres of Excellence (OCE), looks to capitalize on the province's existing rich knowledge and experience in the automotive industry to support small and medium sized businesses and entrepreneurs with research and development funds, internships and fellowships to develop talent, and access to the Demonstration Zone in Stratford Ontario and the various Regional Technology Development Sites where technologies can be tested and developed.[48] Together, organizations like Propulsion Québec and AVIN work under the assumption that when governments assist in the development of CAV technologies greater opportunities emerge for CAV technology to be utilized in future infrastructure projects in Canada while also strengthening the likelihood of exporting abroad.

### Managing Labour Disruption

According to the Senate Report on CAV technology, the adoption of CAVs may lead to a loss of 1.1 million jobs.[49] These job losses would include, but not limited to, bus drivers traffic and police wardens, snow-plow drivers, driving instructors, taxi drivers, tow truck

---

[45] "Important Facts," Canadian Vehicle Manufacturers' Association, http://www.cvma.ca/industry/facts/.
[46] "GM Announces $170M Investment in Oshawa Plant That Will save 300 Jobs," CBC News, May 8, 2019, https://www.cbc.ca/news/canada/toronto/gm-unifor-oshawa-operations-1.5127356)
[47] "Canadian Automotive Industry," Innovation, Science and Economic Development Canada, January 10, 2019, https://www.ic.gc.ca/eic/site/auto-auto.nsf/eng/home
[48] "Driving Ontario Forward" (AVIN, June 2018), https://www.oce-ontario.org/docs/default-source/publications/driving-ontario-forward---ontario-centres-of-excellence---june-2018.pdf?sfvrsn=2.
[49] "Driving Change: Technology and the Future of the Automated Vehicle" (Standing Senate Committee on Transport and Communications, 2018), https://sencanada.ca/content/sen/committee/421/TRCM/Reports/COM_RPT_TRCM_AutomatedVehicles_e.pdf.

drivers and auto body mechanics.[50] Private ridesharing services, as well as taxi and limousine services, are also expected to suffer.[51] Should the adoption of CAV technology favour ridesharing and public transportation, motor vehicle manufacturing might also suffer due to decreased demand for personal vehicles, though with increased ridership, publicly used CAVs would have shorter lifespans.[52] Other areas of employment that may be affected by CAV technology, for instance policing, may redistribute resources.[53]

Incorporating CAV technologies into public transit systems will be a costly endeavour for the federal government. Thoughtful infrastructure planning, construction, and implementation have the potential for communities to benefit from government spending. To better facilitate this, in 2018, Infrastructure Canada began embedding Community Employee Benefit (CEB) requirements into the provincial bilateral agreements. CEB facilitates positive social impacts by contractually obliging provinces to incorporate employment and procurement processes that support individuals and local businesses where the infrastructure project is being implemented. This way federal spending will more holistically support communities.

The CEB initiative is designed to ensure that projects make communities stronger by providing jobs and training, especially for underrepresented or marginalized groups when infrastructure funds are provided, and projects begin. Similarly, it contractually ensures that projects must consider opportunities to partner with local small and medium-sized businesses for goods and services. While pertaining to contracts resulting from federal government spending, provinces have the autonomy to determine targets.
The benefit of having CEB as part of financial transfers to the provinces is twofold: First, it will provide new jobs and training opportunities in technologically emerging fields that will carry benefits beyond the construction of said projects. Second, CEBs provide a chance for those that would be potentially displaced by CAVs, such as station pay attendants and bus drivers, to receive new skills training that may help ease employee displacement by transferring skills that new CAV systems will require such as system operators.

---

[50] Ibid.
[51] Jed Chong, “Automated and Connected Vehicles: Status of the Technology and Key Policy Issues for Canadian Governments” (Parliamentary Information and Research Service, September 29, 2016), https://lop.parl.ca/staticfiles/PublicWebsite/Home/ResearchPublications/BackgroundPapers/PDF/2016-98-e.pdf.
[52] Ibid.
[53] “Driving Change: Technology and the Future of the Automated Vehicle” (Standing Senate Committee on Transport and Communications, 2018), https://sencanada.ca/content/sen/committee/421/TRCM/Reports/COM_RPT_TRCM_AutomatedVehicles_e.pdf.

# JURISDICTIONAL DASHBOARD

Central to addressing the unique policy challenges presented by the integration of CAVs is understanding the responsibilities of each level of government. Transportation in Canada is a shared responsibility between all levels of government and each level has important responsibilities that ensure the safety of all Canadians. This jurisdictional dashboard provides details on each level of government's responsibility regarding CAVs as well as particular concerns each level may have. Finally, the dashboard provides policy opportunities available to provincial/territorial and municipal governments to help achieve the objectives set out at the start of the brief.

## Municipal Government

### Responsibilities

The scope of the jurisdictional authority of municipal governments in Canada is granted to them by the respective provincial and territorial legislatures. Municipal governments have a wide range of responsibilities including public transportation, maintaining roads and sidewalks, policing, and urban planning. They have the power to tax and legislate through bylaws and ordinances to provide public services and facilities. As municipalities derive their power from their respective provincial or territorial legislature, their autonomy is not guaranteed. However, their powers are set out in provincial and territorial Municipal Acts that apply to all the municipalities in a given jurisdiction.[54] These powers are subject to change and may include the designation of city boundaries, the altering of financial resources, and the degree of autonomy granted to cities. This autonomy is severely restricted, as many municipal bylaws require provincial approval to be effective.[55]

#### *Municipal Planning*

Incorporating CAV technology into public transit systems will have unique impacts on urban space. Municipalities have the responsibility of managing urban planning; as such, they will need to consider the impact CAVs will have on sidewalks, parking lots, and roads. The full scope of CAV technology is currently unknown and depends largely on how CAVs are adopted and disseminated, travel demand, transportation costs, private investment, and government regulation. Nevertheless, CAV technology is likely to have a profound impact on municipal planning and design.

Increased convenience in travel may lead to greater urban sprawl as more people accept longer travel times. The need for on-site parking may lessen or become obsolete, and

---

[54] O'Brien, Allan. “Municipal-Provincial Relations.” Municipal-Provincial Relations | The Canadian Encyclopedia. The Canadian Encyclopedia, February 7, 2006. https://www.thecanadianencyclopedia.ca/en/article/municipal-provincial-relations.

[55] City Solicitor, Powers of Canadian Cities - The legal framework (2001). https://www.toronto.ca/ext/digital_comm/inquiry/inquiry_site/cd/gg/add_pdf/77/Governance/Electronic_Documents/Other_CDN_Jurisdictions/Powers_of_Canadian_Cities.pdf.

parking may be designated to areas with lower land values.[56] Areas previously used for parking may be opened up for redevelopment, and less need for curb space may result in narrower laneways, resulting in more space for urban development.

### *Public Transit System Management*

There is significant administrative work at the municipal level associated with running a public transit system. Municipalities are responsible for the day-to-day operation of vehicle fleets, maintenance and repairs, and long-term planning. Municipalities often work with third-party transit groups to leverage external expertise.

Cities that adopt CAV technology in public transit systems will need to design a network of designated drop-off and pick up areas. Public transportation systems will face extraordinary challenges in operating CAVs during peak congestion periods, and will, therefore, need to design a well-timed system which is not overwhelmed during such periods. Cities will also need to ensure there are minimal barriers for CAV use in public transit and must account for the needs of the elderly, low-income groups, and other vulnerable communities.

If personal vehicles remain the widely preferred mode of transportation, and people do not opt for taking public transit, once CAVs are integrated there will be significant adjustments required in how public transit systems are managed. System redesigns will be required to encourage people to switch to public transit, as well as promote 'mobility neutrality'. 'Mobility neutrality' refers to the notion that certain classes of commuters should not gain preferential treatment based on their ability to pay for a premium service.[57] Promoting 'mobility' neutrality will reduce the prioritization of personal vehicles in the design of roads and urban space.

### *Funding for Infrastructure*

Funding for public transit systems is the shared responsibility of federal, provincial, and municipal governments.

### *Emergency Services*

Police services are the responsibility of municipalities and may require funding adjustments as CAVs are implemented. If there is a reduction in traffic accidents and road violations, then the police will have a more limited role in bylaw and regulation enforcement. Municipal police are responsible for enforcing federal and provincial legislation and will need to adapt their practices to reflect changes made to legislation done as part of the CAV integration process. There will also be opportunities for emergency response vehicles, police, ambulances, and firetrucks to be converted to CAVs which will impact their ability to provide services and reach those in need.

---

[56] "Planning for Connected and Automated Vehicles" (Public Sector Consultants & Center for Automotive Research & Greater Ann Arbor Region Prosperity Region 9, March 2017), https://www.cargroup.org/wp-content/uploads/2017/03/Planning-for-Connected-and-Automated-Vehicles-Report.pdf, 22-25.
[57] "Automated Vehicle Tactical Plan," Automated Vehicle Tactical Plan § (2019), https://www.toronto.ca/wp-content/uploads/2020/02/7ec4-TS_AV-Tactical-Plan_Technical-Report.pdf, pg.48.

### Concerns

*Congestion*

If CAVs are widely adopted as personal vehicles, there will likely be an increase in congestion. There is potential for zero-occupancy vehicles on the road, which will significantly increase the overall vehicle kilometres travelled on the Canadian road network. If people can reclaim the time spent in traffic, they may decide that congestion is no longer a deterrent and choose away from public transit options.

*Competition with private transit providers*

Light rail and subways are an integral part of public transit systems, as they can move large numbers of people. However, there is potential for the private sector to compete with public transit networks by providing more direct service options. Therefore, municipalities must consider the development of first mile/last mile solutions to incentivize people to continue to use public transit systems and multimodal travel.

*Transit to Extra-Urban Areas*

Areas that are peripheral to urban areas are less connected to public transit networks due to their lower populations. There is an opportunity for CAVs to provide significant value to these areas by providing a public transit option that can operate at a lower cost margin. This could serve to better connect rural areas peripheral to cities to denser urban areas and improve overall mobility and service availability. Increased public transit in rural regions will need to account for infrastructure differences as compared to urban centres and their impacts on connectivity.

### Policy Opportunities

- Remove parking minimums in municipalities to reclaim urban space currently monopolized by parking.
- Broaden the scope of urban planning activities to include space that is currently allocated to personal vehicles, including parking lots, and curb space.
- Design a system of designated loading areas to support businesses that are separated from high-pedestrian and public transit zones.
- Invest in MaaS technology to improve the reliability and accuracy of connected applications.
- Create alternative payment and access options for public transit that does not require internet connectivity or access to personal phones.
- Coordinate with other municipalities on extending existing transit lines to suburban and, where feasible, peripheral areas using CAVs and First Mile/Last mile services.
- Shift focus towards transit-oriented development that allows for space for active modes of transportation.

## Provincial and Territorial Governments

### Responsibilities

*CAV Testing and Deployment Regulations*

Provinces and territories are responsible for creating the legislative framework for CAV testing and road use while incorporating vehicle safety requirements. They also enforce and manage traffic laws and regulations for the safe operation of CAVs on highways.

Several provinces have already proposed or passed legislation to allow CAVs on public roads. In 2016, Ontario introduced a 10-year pilot framework for autonomous vehicles to facilitate the establishment of rules, monitor industry and technology developments, and evaluate the safety of autonomous vehicles before they become widely available to the public.[58] This framework will set the foundation for CAVs to be integrated into public transit networks.

Provincial and territorial road transport agencies are responsible for approving and overseeing trials of automated vehicles that take place within their jurisdiction; sometimes in consultation with Transport Canada. If trial organizations violate any terms of the approval process, the road transport agency has the authority to suspend the trials. In case of a serious incident, such as a collision during trial, the agency directs the trial organizations on the procedures for reaching out to local law enforcement and emergency services.

*Driver Licensing, Vehicle Registration, and Insurance*

The provinces and territories are responsible for driver licensing, vehicle registration, vehicle and collision insurance, and liability issues.

*Infrastructure Planning*

Provincial and territorial governments are also responsible for planning, developing, and budgeting CAV infrastructure that may be required to support safe deployment.

*Public Awareness*

In order to notify the public of trials, provincial and territorial road transport agencies must develop communication plans to engage and educate the public regarding vehicle technologies.

*Research and Development and Information Sharing*

Provincial and territorial road transport agencies coordinate the research and development activities of CAVs. They also supervise trial organizations, while ensuring end-of-trial report information is provided regarding trial outcomes, informing future policies for CAV testing, and deployment.

---

[58] Garreth Rempel, and David Michelson, “Connected and Automated Vehicle Activities in Canada”, (2018): pp. 10-18, http://onlinepubs.trb.org/onlinepubs/trnews/trnews317RempelMichelson.pdf.

## Concerns

### *Autonomy*

In 2017, Transport Canada allocated significant funding to help foster CAV technology to ease future implementation through the *Program to Advance Connectivity and Automation in the Transportation System*; however, implementation will ultimately fall on the provinces.[59] Federal legislation must work within provincial frameworks to aid adoption, not hinder it.

### *Insurance & Liability*

As CAV technology advances, significant shifts in insurance liability are expected to move away from drivers to manufacturers and managers of CAV networks. Should individual ownership decline, and private providers like Uber and Lyft fill the void with shared public transit, changes to insurance needs are to be expected.[60] As insurance regulations fall under the responsibilities of provinces and territories, they will need to ensure that they are preparing for the demand of new types of insurance packages.

### *Municipal and Provincial Harmonization*

For decades, public transit systems have gone beyond traditional municipal boundaries with services provided to nearby periphery communities. Designs must take into account future growth projections which will allow for different municipalities to be synchronized and connect with future lines that may be built.

This will be further complicated in municipalities that have public transit systems that offer services into neighbouring jurisdictions like Ottawa/Gatineau. Provinces will have to work together to ensure vehicles have interprovincial capabilities.

### *Policing and Safety*

While significant advances in technology will decrease the likelihood of traffic violations and collisions, there are still obstacles and concerns that will have to be addressed regarding safety. Policing will have to adapt to a new landscape, which will be of particular concern during the transitional period from traditional vehicles to CAVs. Network operators and systems will play a more significant role in directing traffic as drivers of public transit are replaced. New types of negligence and liability issues may arise and as a result, provincial governments will need to implement new systems for policing and monitoring roads.

### *Employment Disruption*

Once widely adopted, CAV technology may have significant disruptions for employment. Efforts can be proactively made to ensure jobs potentially replaced with new technologies

---

[59] "Transportation in Canada 2018," Transport Canada, July 22, 2019, https://www.tc.gc.ca/eng/policy/transportation-canada-2018.html.

[60] *"Connected and Autonomous Vehicles in Ontario Implications for the Insurance Industry" (KPMG), accessed July 3, 2020, https://www2.deloitte.com/content/dam/Deloitte/ca/Documents/consulting/ca-EN-CVAV-Research-Insurance-Report-2018Apr25-Final-AODA.PDF.*

receive access to training programs. From a public transit perspective, this is particularly relevant to jobs like bus drivers and station operators. Changes will also impact Canada's automobile manufacturing industry, especially if individual car ownership declines.

### Provincial Highlights

Several provinces have already proposed or passed legislation to accommodate autonomous vehicles. A broad look at what specific provinces have done can be found in **Appendix D.**

.

### Policy Opportunities

- Update Municipal Acts to include regulations on the management of autonomous vehicles and their complementary technologies.
- Invest in public awareness campaigns designed to educate the public on the benefits and threats of CAVs.
- Update standards for driver's licenses and training to include materials on the transition period of CAVs and the appropriate ways to interact with and operate them.
- Work with municipalities to incorporate CAV technologies into their future infrastructure proposals.
- Establish retraining programs to support individuals who lose their jobs as a result of CAV disruption.

## Federal Government

### Departmental Responsibilities

The federal government has an important role to play in ensuring harmonization of policies pertaining to CAVs as multiple federal departments are responsible for aspects of their introduction and adoption. The Senate Report on Autonomous Vehicles detailed the need for strong leadership from the federal government to ensure collaboration and coordination of policies. While Transport Canada (TC) and Innovation, Science, and Economic Development (ISED) are the departmental leads on CAVs, the successful and safe implementation of CAVs will require a cross government approach.

#### *Transport Canada*

Transport Canada is responsible for the safety standards of vehicles on the road in Canada, including public transit bus fleets. The *Motor Vehicle Safety Act* details the safety regulations for vehicles as we currently understand them. According to *Canada's Safety Framework for Automated and Connected Vehicles* the introduction of CAVs has and will continue to require changes to existing legislation or the introduction of new safety regulation legislation that "apply to the importation of motor vehicles and designated motor vehicle equipment, and the shipment of newly manufactured motor vehicles and designated equipment across provincial/territorial boundaries."[61]

---

[61] *Canada's Safety Framework for Automated and Connected Vehicles.* Transport Canada, February, 2019. https://www.tc.gc.ca/en/services/road/innovative-technologies/automated-connected-vehicles.html.

### *Innovation, Science, and Economic Development*

ISED is responsible for the allocation of the radio frequency spectrum in Canada; which will be necessary for the deployment of CAVs. ISED is also responsible for the issuing of developmental licenses for the experimentation of connected and autonomous vehicles to interested parties.

ISED sets and enforces the compliance of technical standards in Canada, which will be important for the adoption of CAVs.

Finally, ISED seeks to encourage innovation through the operation of funds such as the *Strategic Innovation Fund* and programs such as *Innovative Solutions Canada*. Companies seeking to test CAV pilot projects may access funds through these two sources.

### *Public Safety Canada*

Public Safety Canada manages digital and cybersecurity concerns. CAVs will incorporate new technology that requires the sending and receiving of digitally transmitted information. Cybersecurity and data privacy regulations will be necessary when autonomous vehicles are deployed in Canada.

### Employment and Social Development Canada

The deployment of connected and autonomous vehicles will disrupt jobs in numerous sectors of the economy. Employment and Social Development Canada will be responsible for collaborating with provinces and territories to develop retraining programs for those whose jobs are at risk due to connected and autonomous vehicles.

### *Natural Resources Canada*

Natural Resources Canada is involved with the development of electric vehicles and the infrastructure required to support them, such as charging stations. As new public transit systems are designed and implemented with CAV technology, the positive impacts of electrification of vehicle fleets should also be leveraged. The electrification of CAVs will contribute to decarbonizing the transit sector and to the national goal of a low-carbon future.

### Infrastructure Canada

Infrastructure Canada is responsible for the funding of public transit infrastructure projects. Infrastructure Canada also manages the Research and Knowledge Initiative (RKI). The initiative began in 2018-2019, and will end in 2024-2025 and seeks to “support research, knowledge-sharing, collaborations, and partnerships to deepen understanding of infrastructure needs, challenges, and opportunities relevant to Canadians.”[62] There is an opportunity to create a CAV and public transit-focused contribution agreement within

[62] Ibid.

the RKI which can broaden Infrastructure Canada's support to public transit projects beyond funding.

### Funding Responsibilities

Infrastructure Canada has an important funding responsibility for the deployment of CAVs. Infrastructure Canada will support public transit and provincial infrastructure projects by providing funding for projects that meet the priorities of the federal government. Budget commitments for the next decade will expand, improve, and rehabilitate public transit infrastructure and active transportation projects.

As Canada moves closer to a CAV future, the need for research and development will increase. The federal government, alongside provincial governments, will be responsible for the funding of research on the impacts CAVs will have in the Canadian context.

### Concerns

#### *Environmental*

The federal government has strong environmental commitments that include the goal of net-zero emissions by 2050.[63] Achieving that goal will require new and innovative approaches to diversify Canada away from reliance on carbon-intensive energy sources. New technologies incorporated into CAVs could play an important role in reducing emissions.

Furthermore, the utilization of CAV technology in public transit and MaaS could reduce vehicle ownership and single occupancy vehicle usage.

#### *Social Acceptability*

The successful deployment of CAVs is dependent on social acceptability. If Canadians do not perceive driverless vehicles as a safe option, it is unlikely that the deployment of CAVs will lead to an increase in ridership for public transit systems utilizing this technology. Social acceptability will be a concern of every level of government in Canada.

#### *Risk of a Do-Nothing Approach*

Widespread integration of CAVs will bring incredible changes to the way people and goods move around Canada. Achieving peak optimization will be unlikely to occur if the federal government does not take a leadership role to support research, manufacturing, and deployment of CAVs. Failing to provide leadership to provinces and municipalities will result in fragmented policies across jurisdictions. Complete harmonization of policies will allow all Canadians to enjoy the full benefits of CAVs.

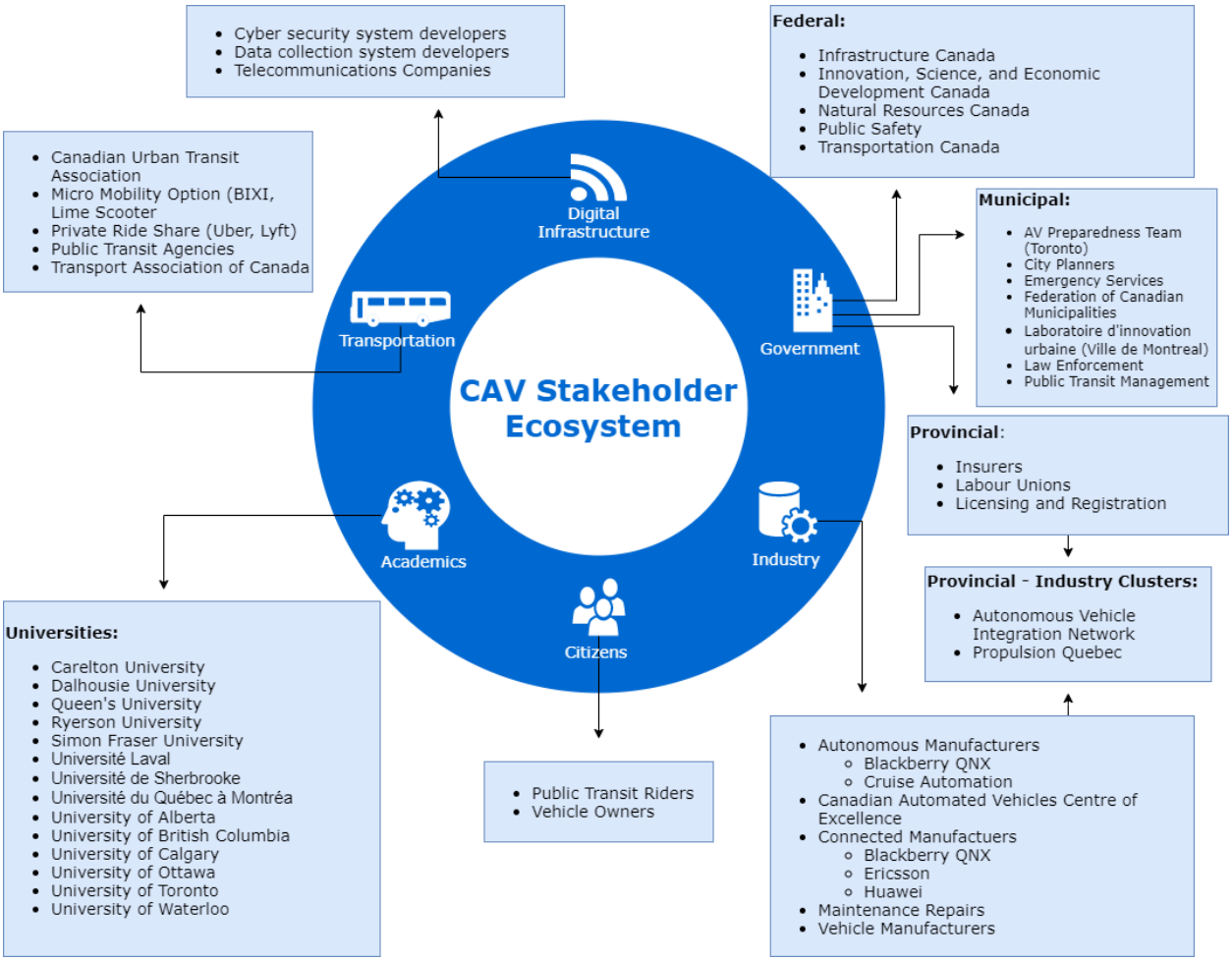
---

[63] Justin Trudeau, "Minister of Environment and Climate Change Mandate Letter," Prime Minister of Canada, December 13, 2019, https://pm.gc.ca/en/mandate-letters/2019/12/13/minister-environment-and-climate-change-mandate-letter.

# STAKEHOLDER IDENTIFCATION

Pictured here is a non-exhaustive stakeholder ecosystem for the CAV sphere. Included in the illustration are various stakeholders we have engaged with during this process and other important stakeholders or types of stakeholders we have identified.

Two important stakeholders we sought to identify in greater depth were international actors and academic institutions. Further information about each can found in the next section.



## International Actors

Cooperation at the international level is underway regarding CAVs. Given that vehicle technology will potentially pose new threats and concerns to other countries, cybersecurity, privacy, and data sharing have been at the forefront of international collaboration thus far. Nevertheless, significant collaboration has also begun regarding policy harmonization and vehicle interoperability to ensure vehicles produced in one country will function elsewhere.

As Canada's only neighbouring country connected by land, and strongest trade partner, collaboration with the United States on CAV technology will be crucial. The Regulator Cooperation Council is currently facilitating collaboration between Transport Canada and the US Department of Transportation. This will help to ensure that vehicles can operate in both countries. *Canada's Motor Vehicle Safety Standards Work Plan* has been created to reflect standards being set in the United States.

Given the international nature of digital data collection and privacy concerns, in addition to the thousands of immigrants and tourists that find themselves on Canadian roads each year, global regulatory harmonization is important. In 2017, the G7 countries created the Working Group on Autonomous and Connected Vehicles. Their purpose is to ensure that transport ministers and leaders in vehicle manufacturing have a forum to share best practices and exchange ideas that can facilitate interoperability and therefore strengthen international trade potential[64]

The United Nations Economic Commission for Europe oversees the World Forum for the Harmonization of Vehicle Regulations (WP.29). The WP.29 includes representatives of over 60 countries including the United Kingdom, Australia and major car manufacturing countries like Germany, Japan, and South Korea. The WP.29's work has led to international agreements on certification standards, safety features (including brake lights and seat belt specifications) and emission levels. In June 2018 a subsidiary group was created - The Working Party on Automated/Autonomous and Connected Vehicles (GRVA). While Canada does not abide by agreements reached by WP.29, given that Canada requires independent testing that follows *Canada's Motor Vehicle Safety Standards*, their work is closely followed and has signaled regulation changes in the past.[65]

## Academic Institutions

Many Canadian academic institutions are actively engaged in the development of CAVs and associated infrastructure technology. Interaction between government and academia is primarily occurring at the provincial level, but there is an opportunity for further involvement at the federal level.

---

[64] "Canada's Safety Framework for Automated and Connected Vehicles" (Transport Canada, February 2019), https://www.tc.gc.ca/en/services/road/documents/tc_safety_framework_for_acv-s.pdf.
[65] "Canada's Safety Framework for Automated and Connected Vehicles" (Transport Canada, February 2019), https://www.tc.gc.ca/en/services/road/documents/tc_safety_framework_for_acv-s.pdf.

The opportunity for collaboration between governments and universities that could be broadened to the federal level is exemplified by the province of Ontario and the Autonomous Vehicle Innovation Network (AVIN). Together they deliver an initiative through the Ontario Centres of Excellence which includes partnerships with the University of Toronto, Ryerson University, and York University.[66] By collaborating with academic institutions, there is an opportunity to incorporate cutting-edge technology into future projects and designs, in addition to lessons learned from research.

Colleges are also a valuable resource for CAV research and development. A strong example of this is the work being done at the L5 test facility in Ottawa, which includes experts from Algonquin College and La Cité collegial, the University of Ottawa, and Carleton University.[67] Research on CAVs and public transit is being done at academic institutions across the country and is a resource that Infrastructure Canada could benefit from.

A snapshot detailing CAV related work underway in Canadian academic institutions can be found in **Appendix E.**

[66] "Automated Vehicle Tactical Plan," Automated Vehicle Tactical Plan § (2019), https://www.toronto.ca/wp-content/uploads/2020/02/7ec4-TS_AV-Tactical-Plan_Technical-Report.pdf, pg. 29.
[67] Transportation Association of Canada. Rep. *Discussion Paper on Connected and Automated Vehicles*, 2019.

# POLICY RECOMMENDATIONS

The following recommendations are being presented to Infrastructure Canada as a suite of options that will help INFC be a leader on the CAV file. The policy recommendations put forth could also help INFC achieve the four objectives set out at the outset of this brief. The recommendations have been organized into three categories based on the actions required; supporting research and development, increasing collaboration, and improving CAV safety.

## Research and Development

In coordination with the work being done through the Research and Knowledge Initiative, the federal government could divest funding through contribution agreements to help support research, knowledge sharing, collaboration, and the development of projects.

### Recommendation #1 - CAV Transit Challenge

*Infrastructure Canada could explore the creation of a CAV Transit Challenge modelled after the existing Smart Cities Challenge. This would provide Infrastructure Canada with a merit-based grants and contributions funding model to effectively target their funding to stakeholders with innovative and deserving projects.*

#### Rationale

The CAV Transit Challenge will provide opportunities for innovation; re-imagining how CAV technology can be incorporated into public transit to improve urban mobility. CAV technology is a growing sector, and through the creation of such a challenge, INFC will foster further growth in Canadian cities, providing them with the funding required to invest in innovative technologies and public transit models that will position Canada as an international leader in the field. The environmental diversity across Canada poses significant challenges for the implementation of CAV technology, but through the CAV Transit Challenge model, projects could be undertaken across the country to develop vehicles capable of operating safely in a variety of weather conditions, particularly during the winter.

As the *Smart Cities Challenge* has demonstrated, this funding model is highly receptive to the needs of stakeholders. Structured requirements and evaluation criteria will streamline the application process for municipalities in addition to regions, and Indigenous communities close to urban centres. They will also allow industry partners to connect with communities that are not selected for funding but have innovative ideas about future collaboration. Showcasing ideas and leaders in the field will enhance the collaborative ecosystem in the CAV technology sector and allow for mutual learning among stakeholders. This program can also create long-term benefits. By sharing project proposals and conducting follow up amongst investors and applicants, INFC will be able to showcase successes, challenges, and lessons learned that can inform the development and implementation of future projects.

This recommendation provides an opportunity for the federal government to strengthen its relationship with municipalities. By participating in the program, municipalities as well as regions, and Indigenous communities close to urban centres, can collaborate with the federal government and increase communication and knowledge sharing between them. This connection is limited under the current funding models that are primarily focused on provincial funding distribution.

### Implications

This challenge would function structurally like the *Smart Cities Challenge*, allowing INFC to capitalize on internal knowledge and to implement established best practices in the new program.

The challenge would require transferring funds from the federal government to municipalities for their projects. Incorporating various funding levels will be critical to this program, as communities have varying levels of administrative and financial capacity, as well as different public transit needs. This will help to ensure that small and medium-sized projects also have access to funding, and major cities such as Toronto, Montreal, and Vancouver will not monopolize the funding due to their ability to support major projects. By accommodating projects with varying scopes, there will also be room to learn how systems can work in diversely structured communities that can then be transferred across Canada. This will significantly increase the harmonization of the technology developed and the lessons learned through this program and allow for greater specification in projects.

The assessment criteria established in the early phases of the challenge could be used to promote the submission of projects that align with the goals of INFC. They could be used to encourage projects to consider how to better integrate into active transportation modes, support the electrification of public transportation fleets, or to innovate transportation methods that are not currently in use. Furthermore, the criteria could also encourage the development of first mile/last mile projects. First mile/last mile models will be a critical part of the future for CAVs as they will be able to fill gaps that are left by major fixed-route public transit lines.

## Recommendation #2 - Mobility Pricing

*Infrastructure Canada could consult with provinces, territories and municipalities on the development and implementation of a mobility pricing policy once CAV technology has been fully integrated into urban centers. Infrastructure Canada could provide research funding for the development of mobility pricing policies tailored to individual provincial and territorial contexts.*

### Rationale

Mobility pricing is a policy tool that places a price on users for road use or parking in an effort to reduce congestion.[68] Mobility pricing has been used in other jurisdictions to reduce congestion and to encourage the use of public and active transportation. Mobility pricing systems can take various forms including toll lanes, distance travelled pricing and single entity pricing.[69] This recommendation aligns closely with the objectives of INFC. The implementation of mobility pricing would discourage the use of personal vehicles, helping to avoid some of the concerns associated with an increase in CAV use.

Congestion is a major issue that all levels of government must address, both for environmental and quality of life reasons. However, financial incentives alone will not reduce it. Instead, it must become more convenient for individuals to take public transit than to drive a personal vehicle to their destination. To increase the convenience of public transit and encourage this behavioural shift, the revenue generated from mobility pricing could be invested in improving public transit, particularly for developing CAV public transit initiatives.

### Implications

Similar to carbon pricing systems, the federal government has limited jurisdiction over the implementation of a mobility pricing policy. Supporting provinces and municipalities in the exploration of mobility pricing systems could help foster strong working relationships with other levels of government. This could be done by supporting studies on the various mobility pricing systems in different parts of the world that have undertaken varying implementation methods, including license plate scanning. There is existing literature that could be analyzed for how adaptable it would be to provincial markets. Furthermore, research could be done to identify other positive impacts of such initiatives. These studies will allow for better decision-making at the provincial level to potentially choose a mobility pricing system that will encourage public transportation usage.

There would be significant financial implications if a mobility pricing policy were adopted. Revenue generated from such an initiative would provide positive financial benefits to provinces and territories. Further research would be required on how best to structure the program.

Mobility pricing systems will have a positive impact on the environment, an important government priority. Mobility pricing systems will encourage a change of behaviour away from single passenger vehicle use towards public transit alternatives. Reduced congestion will lead to a decrease in carbon emissions.

---

[68] Ecofiscal Commission, “We Can't Get There from Here: Why Pricing Traffic Congestion Is Critical to Beating It” (Montreal, Quebec: McGill University, 2015), pp. 10, https://ecofiscal.ca/reports/traffic/.
[69] Ibid.

**Recommendation #3 - First Mile/Last Mile**

*Infrastructure Canada could prioritize CAV first mile/last mile research and development projects by considering the following:*

*A) Support and conduct research on how first mile/last mile projects can be integrated with public transit systems, and how MaaS can complement first mile/last mile projects.*

*B) Support and conduct research that seeks to understand the impacts first mile/last mile projects can have on increasing ridership in urban centers, particularly among marginalized and underserved communities.*

*C) Create and implement a program similar to the Climate Lens that prioritizes the funding of first mile/last mile projects that service marginalized and underserved communities.*

**Rationale**

A) MaaS enables a network of transportation that integrates multiple modes of transit into one accessible platform. The issues impacting the first and last mile of transit vary from city to city and can also differ within cities. Multi-modal transit can adapt to the specificities of first mile/last mile challenges by providing appropriate methods of transportation for people within city centres to be effectively connected with peripheral regions while remaining within a single system. Linking different modes of transit into one incorporated system and utilizing MaaS technologies are critical to gaining public buy-in to public transit systems. Based on current public transit ridership trends, it could be assumed that the public will not be motivated to use CAVs in the first or last mile unless it makes their lives easier to do so.

Investment in research and development of MaaS technology entails that once CAVs and CAV technology are part of public transit systems, the whole commuting network will become more harmonious, and ridership is likely to increase.

B) If harnessed correctly, CAVs have the potential to alleviate issues arising from first mile/last mile problems that prevent public transit ridership at various socioeconomic levels. For some, a key incentive for car ownership is the lost convenience that occurs when public commuters wait for transit or are required to make multiple transfers resulting in additional travel time. For others, providing public transit networks to particular regions is considered too costly. In both instances, the first mile/last mile problem is exacerbated. An oft-advanced notion is that CAV technology can mitigate first mile/last mile issues by better connecting the peripherals of a city or connecting underserved neighbourhoods within the existing transit network. Doing so has the potential to benefit marginalized communities that are not well served.

However, first mile/last mile issues are complex. While some common challenges persist across many Canadian municipalities, some issues are contextually unique to the specific municipalities. By supporting research to better analyze the impacts CAV technology can have on the first mile/last mile problem, specifically regarding cost, public transit systems can become stronger.
Once underserved areas receive access to transit, the public transit system will become stronger, ridership may increase, road congestion may be alleviated, vehicle pollution may subside, and marginalized communities can benefit from access. Finally, it will help avoid a 'CAV Hell' scenario where car ownership increases, public ridership decreases, and the benefits of first/mile last mile do not materialize.

Further research into understanding the impacts that CAV technologies can have on first mile/last mile challenges will propel interest in using the technology as part of public transit systems, aid with densification, and strengthen communities.

C) The introduction of CAVs could have severe impacts on public transit systems if the technology is not harnessed in a way that promotes and prioritizes them as the best and most efficient option for travel. First mile/last mile projects could provide an opportunity to extend transit networks into underserved communities, further promoting public transit usage.

Similar to the Climate Lens, a first mile/last mile program should intend to facilitate a behavioural change and enable performance measurements and evidence-based policy. A first mile/last mile program could influence behaviour that prioritizes marginalized communities within urban centers. Seniors, persons with disabilities, and low-income communities are often absent from important conversations about public transit connectivity. The absence of these voices can be rectified by requiring first mile/last mile public transit projects to demonstrate how they will impact marginalized communities. Projects could be required to consider the social and economic impacts first mile/last mile projects will have within urban centres and provide necessary and measurable outcomes.

### Implications

*Social*

Public transit systems can limit or expand opportunities for people within an urban centre. Underserved communities may have a more difficult time accessing jobs and services. Studying the impact that first mile/last mile projects can have on marginalized communities could lead to greater social benefits for all. First mile/last mile projects could potentially fill necessary transit gaps for underserved communities.

*Ridership*

Providing greater connectivity to underserved and marginalized communities through first mile/last mile projects could increase the ridership of public transit systems in urban centres. Greater ridership will likely be beneficial to society as it means more people are relying on public transit as a form of travel rather than car ownership or rideshare

alternatives. Increased usage of public transit systems will help offset the costs of public transit systems.

*Economic*

First mile/last mile projects could be designed to reduce the need for fixed physical infrastructure such as rail lines and streetcar tracks. This could increase their overall cost-efficiency. The lower cost could result in a larger number of projects being funded by Infrastructure Canada. The federal government will be better positioned to help more municipalities and provinces in their public transit infrastructure projects.

*Innovation*

Prioritizing first mile/last mile projects will encourage innovation in the CAV public transit sector. Manufacturing companies will be incentivized to continue to develop new and innovative ideas for first mile/last mile alternatives that can connect individuals to public transit networks.

## Recommendation #4 - Urban Space

*Infrastructure Canada could support urban impact studies to better understand the challenges regarding urban space and CAVs. These studies could examine how incorporating CAVs into public transit systems could contribute to better usage of available urban space. Infrastructure Canada could utilize the Research and Knowledge Initiative to fund urban impact studies.*

### Rationale

The introduction of CAV technology has considerable implications for cities, particularly in the realm of public transit. Vehicles with increasingly high levels of automation will be introduced to the market in the coming decades and will bring with them transformative changes to mobility and accessibility in urban areas. CAV technology has the potential to cause large-scale reorganization of urban centres, such as the locations of businesses, households, and public access to roadways. Urban infrastructure may require broad redesign to accommodate CAV technology. New infrastructure may be needed to accommodate CAVs and connect them to a broad telecommunications network.

To ensure that there is not a duplication of efforts, Infrastructure Canada could support the work currently being done by the Federation of Canadian Municipalities (FCM). INFC could do this through the creation of a long-term funding scheme. FCM is currently supporting municipalities across Canada to fund projects that study the relationship between CAV technology and congestion in downtown areas. The particular research topics are highly specific to local challenges and cover areas such as how parking spaces

can be converted to serve other needs, and the effects improved transit will have on housing developments and local demographics.[70]

Research will be imperative in determining best practices for implementing a first mile/last mile policy that utilizes existing transit systems in urban areas. CAV technology may be used to integrate with existing fleets that include shuttles, carpooling, and rapid bus transit, encouraging a behavioural change away from private transportation options.

The adoption of CAV technology in public transit systems could allow for greater utilization of urban spaces and lessen the need for parking spaces as individuals opt for carpooling and ridesharing options as opposed to personal vehicles. Municipalities could conduct more urban studies on how to prioritize space and reduce urban sprawl. Furthermore, cities could also benefit from researching best practices on safety management for roads and municipally owned highways. Their findings regarding these concerns could entail implications for similar infrastructure owned federally and provincially.

### Implications

Regional and municipal considerations may carry economic considerations for the federal government, thus underscoring the need for greater quantities of research on the impacts of CAV technology. Matters of congestion within city centres may prove to have great significance for the economies of Canada's cities, and therefore on the economic well-being of the country as a whole. Developments pertaining to first mile/last mile challenges for municipalities may have further regulatory implications for liability and safety, privacy and cybersecurity across the country. The impact of CAV technology on employment, and how cities and regions adapt to any developments in the labour market, would have indelible implications for Canada. Municipalities may prove invaluable incubators for policy alternatives to be applied provincially or nationally; therefore, support by the federal government could be a worthy endeavour.

The arrival of CAV technology portends evolutions which will affect the social, economic, and environmental ecosystems of cities. Regions and municipalities must prepare for the impact of this technology on sustainable urban development. Through funding research for urban impact studies, the federal government could greatly enhance municipal planning capacities for the introduction of CAV technology. Municipalities around the country are presently funding projects at a considerable cost and would welcome support from the federal government in this endeavour. The federal government can alleviate the financial burden for municipalities by funding research and development in the sector. Through concerted cooperation with municipalities in this regard, the federal government can assist municipalities in gaining the utmost preparedness to meet the challenges and opportunities of this new frontier.

---

[70]"Federation of Canadian Municipalities (FCM)," n.d., pp. 1-16.

## Collaboration

Addressing the challenges of CAV technology will incorporate a wide array of both private and public sector stakeholders that together will shape the future of public transit in Canada. Strong collaboration will ensure that continuing efforts are being made throughout Canada, in all sectors, that capitalize on existing momentum and provide valuable information and lessons learned, while minimizing duplication.

**Recommendation #5 - Stakeholder Collaboration**

*Infrastructure Canada could play an increased role in promoting greater collaboration among key industry stakeholders involved in the CAV sector through the following:*

*A) In partnership with other federal government departments, Infrastructure Canada could establish an autonomous vehicle network forum among the federal, provincial, and municipal governments. This could provide opportunities for participants to share insights and perspectives on autonomous vehicle standards, policies, regulations, and best practices.*

*B) Infrastructure Canada could establish a second forum that invites non-governmental actors to participate in the dialogue. This could provide opportunities for private enterprises and other stakeholders to learn from one another and work with the government to address issues. The forum could also lay the foundation for future collaboration, potentially culminating in the creation of an industrial supercluster for CAVs, which would enhance the development of the industry.*

**Rationale**

A) As new CAV technologies emerge and full automation appears closer, federal, provincial and municipal governments will need to collaborate to assess technologies, standards and regulations which will ensure the safe deployment of CAVs on public roads. To facilitate this collaboration, the federal government could provide a forum for provinces and municipalities to share information and issues associated with CAV technologies.

B) Understanding the necessity to collaborate with non-governmental actors to successfully deploy CAV use in public transit systems, Infrastructure Canada could provide a forum for the government, private sector, universities and think tanks to collaborate. It could serve as a means for stakeholders to collaborate and support the development of best practices for vehicle policy which could be useful for different jurisdictions. The platform could also serve as a conduit for discussions with all levels of government, and allow key organizations to exchange ideas and information, develop awareness, and collaborate to address issues and policy challenges.

A possible outcome of this endeavour could be the creation of an industrial supercluster for the CAV industry, to act as a catalyst to enhance development and innovation within the industry in Canada. Superclusters are collaborative associations that enlist large,

medium-sized and small companies, as well as universities, colleges, technical schools and not-for-profit organizations to create market-oriented innovation hubs. They act as a platform to connect different stakeholders across a single sector and can be a central tool to create business opportunities. Superclusters can also enhance the visibility of industry players of different sizes, both within Canada and abroad, showcasing Canadian innovation in the sector.[71] The model has proliferated nationally, harnessed resources and industry knowledge to create new opportunities, such as the Digital Technology Supercluster based in British Columbia and the Scale AI Supercluster, based in Quebec.[72]

### Implications

Through the establishment of an autonomous vehicle network government forum, the three levels of government will become informed of new technologies and their associated issues as they review and assess options for safe testing and deployment of CAVs, particularly for public transit. Creating a forum for these governments to meet and exchange ideas with other stakeholders could lead to greater safety outcomes and improved transit systems across the country.

A forum that includes government and non-governmental stakeholders will foster stronger collaboration, which could lead to greater harmonization of standards and regulations, especially as they pertain to public transit systems. Continued engagements will also allow provinces and municipalities to identify, assess, and integrate best practices of CAVs. Greater cooperation among all relevant stakeholders will help Canada leverage its leadership and expertise in automated vehicle technologies internationally.

Superclusters carry the benefit of creating more business opportunities and jobs and aiding research which has created opportunities for Canadian businesses to be world leaders in their respective industries.

Creating a supercluster would allow for experts, innovators and institutions of higher learning to collaborate in the field of CAV technology. This effort could create new jobs, apprenticeships, and business opportunities across Canada. It could also allow for greater harmonization across different regions and create a more coherent ecosystem for innovation. This could create more opportunities for interprovincial collaboration and new possibilities for Canada’s manufacturing and automotive industries.

The creation of a CAV industry supercluster could create better engagement between legislators, regulators and industry to collaborate and remain at pace with developments in the CAV sector. Government backing in this area eases the pressure for the industry in terms of lobbying for more funding, which has been the practice of traditional industry associations. This would allow the private sector to support the government in designing strategies for the adoption of CAVs, as well as allow for greater communication of issues

---

[71] Industry Sector, “Canada's New Superclusters,” Innovation Superclusters Initiative (Innovation, Science and Economic Development Canada, January 27, 2020), https://www.ic.gc.ca/eic/site/093.nsf/eng/00008.html.
[72] Ibid.

and potential roadblocks which could hinder the development of the industry. These developments would carry implications for how cities and regions adapt to CAV technology, and how they integrate new technologies into their public transportation networks.

In this regard, the federal government could continue to support scale-up programs like AVIN, OCE, and Ottawa Invest, but allow for greater linkages and harmonization between them, as well as develop methods for including public transportation in their enterprises.[73]

### Recommendation #6 - Social Acceptability

*Infrastructure Canada could help promote social acceptability and awareness of CAVs through public education initiatives. These efforts could be vital in educating Canadians about the safety and benefits needed to promote confidence in public transit systems that utilize CAV technology.*

#### Rationale

CAVs could have a positive impact on the Canadian transit sector by making travel safer while encouraging greater overall mobility. The Canadian public will need to be better informed on the safety and benefits of CAVs and the impacts they will have on urban areas.

Social acceptability concerns were raised by the Standing Senate Committee on Transport and Communications, which indicated that the lack of public acceptance to support CAV technology will prove to be a barrier to the deployment of CAVs.[74] As vehicles approach full automation, public outreach will be increasingly important in educating Canadians.

Adopting CAV technology throughout public transit systems will be a costly endeavour. Before making these investments, it is critical that Canadians have a high degree of social acceptance of CAVs to encourage ridership on public transit systems integrated with CAV technology. If Canadians do not accept that the technology is safe, CAV deployment will fail. Therefore, campaigns should focus on the benefits of CAV technology such as increased safety, efficiency and mobility.

#### Implications

All levels of government will have a major role to play in increasing public awareness when CAV technology is adopted by public transit systems. Throughout the early stages of adoption, federal, provincial, territorial, and municipal governments will need to

---

[73] "Ottawa L5 Press- Going Autonomous on the Greens: Connected and Autonomous Vehicle (CAV) Trial Launched in Canada's Largest Technology Park," Invest Ottawa (Invest Ottawa, October 17, 2019), https://www.investottawa.ca/ottawal5-press/.

[74] Canada. Parliament. Senate. Standing Senate Committee on Transport and Communications. Report on the Driving Change: Technology and the Future of Automated Vehicle, 2018. https://sencanada.ca/content/sen/committee/421/TRCM/Reports/COM_RPT_TRCM_AutomatedVehicles_e.pdf

promote public acceptance of CAVs by proactively engaging the public to resolve their uncertainties.

Public awareness interventions through polls and surveys will help governments to better understand the perspectives of the public about emerging technologies, as well as their confidence in CAVs.

Public education initiatives may increase the likelihood of public acceptance and encourage positive social norms about CAVs that will reflect community support for the integration of CAVs in public transit networks. Public education initiatives may also be beneficial to cities as it will enable them to identify and assess the information and acceptability gaps that will need to be addressed for public transit efforts to be a success. Engagement through public education initiatives will also help governments identify key areas most likely to be impacted by CAVs, and thereby develop strategies to address these concerns, ultimately advancing technological development.

Increased social acceptability will have positive effects on the CAV technology sector as a whole. Greater acceptability will increase the success of CAV deployment, leading to greater innovation in urban centres and greater employment opportunities for the manufacturing of CAV technologies. Increased acceptability of CAVs in public transit systems will also increase ridership, further offsetting the cost of operating public transit systems.

## Safety and Testing

CAVs will revolutionize the capabilities of public transit systems. If the technology is harnessed correctly, collisions and accidents will be greatly reduced, and Canadian roads will be safer for drivers, passengers and pedestrians alike. Perfecting CAV technology to ensure the full optimization will require updating safety and testing standards.

### Recommendation #7 - Safety Standards

*In partnership with other federal government departments, Infrastructure Canada could lead the research into safety standards required for the adaptation of CAVs in public transit systems. Using the Research Knowledge Initiative, Infrastructure Canada could facilitate conversations with provinces, territories, and municipalities as part of their research efforts. This research could support Transport Canada's ongoing work to establish a pan-Canadian framework for the development, testing, and deployment of CAVs in Canada.*

#### Rationale

Transport Canada has outlined a multi-pronged approach that will foster CAV innovation while ensuring the safety of Canadians. Their approach includes the modernization of legislation, regulations, and the development of flexible regulatory frameworks and standards. Absent in the current framework are specific safety standards pertaining to necessary infrastructure changes CAVs will require, especially for the integration of CAVs into public transit systems.

As funders of public transit projects, it is imperative the federal government ensures that CAV projects are integrated into public transit systems in a way that is safe for Canadians. Such standards still need to be developed, and Infrastructure Canada could guide research initiatives that analyze safety standards needed for the deployment of CAVs in public transit systems.

Infrastructure Canada could engage with provinces, territories, and municipalities to support research efforts and to ensure the inclusion of different jurisdictions' perspectives in the important conversation of public transit safety and CAVs. The inclusion of provinces and municipalities could foster greater harmonization of policies across jurisdictions.

A scheme of provincial outreach could include establishing a forum for academic institutions to support their research efforts and create a space for the sharing of their findings.

Learnings from engagements with the provinces, territories, and municipalities could feed directly into Transport Canada's current framework: *Canada's Safety Framework for Automated and Connected Vehicles*.

### Implications

*Intragovernmental*

The deployment of connected and autonomous vehicles, including in public transit systems, requires a cross government approach to ensure success. Supporting Transport Canada will help foster strong working relationships between government departments while providing a sense of direction for the provinces that are slower to adopt.

*Intergovernmental*

Engagement with provinces and municipalities in research and development could help the federal government demonstrate their desire to prioritize harmonization. Intra-provincial travel is the responsibility of provincial governments, but the safety and efficiency of transportation in Canada requires cooperation between all levels of government. Engaging provinces, territories, and municipalities in the study of safety standards for connected and autonomous public transit systems will help foster cooperation for the deployment of this technology. This will be paramount in ensuring the safety features on vehicles have interoperability capabilities between provinces. It would also likely lead to valuable harmonization of other infrastructure, such as road markings and signage.

*Academic Institutions*

Collaborative work with universities and colleges could help facilitate the sharing of research, best practices, and findings. As these institutions are under provincial jurisdiction, close collaboration with provinces will be necessary.

*Safety*

Transport Canada has made important strides in ensuring the safety of Canadians for the future deployment of CAVs. However, there is a literature gap regarding safety standards for public transit vehicles. Infrastructure Canada could provide important direction to Transport Canada on the intersection of public transit systems, autonomous vehicles, and safety.

*Social Acceptability*

Social acceptability will be vital to the successful deployment of CAVs. Establishing safety standard recommendations for public transit could help alleviate the concerns of Canadians regarding CAV safety. If Canadians do not believe that connected and autonomous public transit systems are safe, they are likely to choose alternatives. Ensuring public transit is the safest option for moving around urban centres can help increase ridership. Canadians could be comforted by the federal government’s leadership to produce and maintain safety standards prior to the deployment of connected and autonomous vehicle technology.

**Recommendation #8 - CAV Testing Facilities**

*Infrastructure Canada could collaborate with Transport Canada to strengthen opportunities for CAV technology testing for vehicles and smart infrastructure which will help facilitate testing methodologies that have yet to be established. Infrastructure Canada could support and fund the testing of CAVs at Transport Canada's Motor Vehicle Test Centre (MVTC) facility. INFC could also provide funding to provincial technology testing and demonstration centres for the testing of CAV technology.*

**Rationale**

This recommendation aligns with recommendations made by Transport Canada's Evaluation and Advisory Services. While Canadian safety standards largely reflect those set by the US, all Canadian vehicles must undergo independent testing and approval by MVTC. This is necessary to ensure vehicles meet Canadian standards - even though they may have been validated elsewhere first.

The reason for enhancing testing in Canada is threefold. First, Canada's winter weather conditions differ greatly from those in the southern United States, where much testing is currently done. It is important that technologies are tested in environments with snow, ice and fog to ensure that they will be safe year-round. Second, CAV technology is expected to rapidly change with advancements in technology. Therefore, it is important that technologies are adaptable, allowing for necessary upgrades as they become available. Finally, increasing the testing capacity of the MVTC will help to better identify the various factors of CAV technology that need to be refined before being deemed safe for roads. This is particularly important in a transit context, as it is a service with liabilities to which the government is accountable.

Although the federal government is responsible for final testing - public and private testing centers exist in a number of provinces. These centres help refine technologies before final testing. Infrastructure Canada could assist these centres with funding, especially those pursuing public transit focused technologies.

CAVs have several challenges that must be overcome before meeting Canadian safety standards. Having a suitable space for the technologies to be tested and approved is the first step in the adoption of CAV technology. Similarly, smart infrastructure has proven to be crucial to making CAV technology safer. There must be a space that tests not only the vehicles themselves but their connected infrastructure.

Increasing the testing capacity for CAVs and complimentary smart infrastructure technology would facilitate a smooth CAV adoption. Testing facilities could evaluate public transit vehicles that have unique challenges as compared to standard passenger vehicles. Once the technology is proven to be adept for Canadian roads, municipalities can begin to include CAVs as part of their public transit networks.

Providing funding to the MVTC and provincial technology testing centres would help facilitate enhanced testing in Canada. Rigorous testing is required before investments are made in expensive CAV technology and infrastructure.

### Implications

Enhancing the testing of CAVs and smart infrastructure technology will enable the government to establish a methodology for CAV testing and deployment. In a May 2016 evaluation of the MVTC, it was suggested that Transport Canada develop a strategic plan for the facility that incorporates and fosters the inclusion of testing technological advancements in the automotive industry. In response, Transport Canada is undertaking the development of a plan for CAV advancements in testing. This report supports this recommendation and goes further to suggest investments be made that would allow the testing facility to be better suited for the testing of CAV technology.

If implemented, this recommendation would require substantial investments to the MVTC to outfit the site in a manner that includes more smart infrastructure. This would include, but not be limited to, traffic lights, signs, and lane sensors for testing in conjunction with CAVs.

# CONCLUSION

Connected and Autonomous vehicle technology has the potential to profoundly impact the way Canadians design our urban spaces, commute, and interact. Should the development of CAV technology for public transportation services be guided by appropriate regulation and proper encouragement on the part of the federal government the technology may be harnessed in a way that will be of greater benefit to all Canadians.

We have provided a brief outline of the complexities related to CAV technology, and how best governments and private industry can prepare for its arrival. This report has identified key objectives and made recommendations with the aim of guiding the federal government's efforts in mobilizing its resources to increase public access to mobility, reduce congestion, invest in public transit systems, and promote collaboration.

Infrastructure Canada can invest in collaboration with other federal departments to target expertise in the field and increase funding in research and development to accelerate Canada's competitiveness and knowledge base. INFC can enact a *CAV Transit Challenge* to effectively target stakeholders and harness Canada's innovation sector. It can consult with provinces, territories and municipalities to develop mobility pricing policies tailored to each jurisdiction, which advance efforts to reduce congestion. Infrastructure Canada can also support research and development for first mile/last mile transit and Mobility as a Service designs and their impacts to promote public access. Furthermore, Infrastructure Canada can invest in urban impact studies to better understand the challenges for cities regarding CAV technology and how best to utilize urban space. Existing initiatives like the Research and Knowledge Initiative can be useful towards that endeavour.

Infrastructure Canada and the federal government can explore further ways to enhance collaboration among various relevant stakeholders by creating a forum for the government, the private sector, and academia to better propel Canada towards a CAV future. Infrastructure Canada can create these linkages with a view towards the creation of a supercluster dedicated to innovation in CAV technology, enhancing Canada's knowledge base and reputation domestically and internationally. INFC can help promote public education campaigns about the benefits of CAVs, promoting public confidence in and acceptability of the technology.

Finally, Infrastructure Canada can partner with other federal departments and facilitate engagements among different stakeholders to develop research into safety standards and support ongoing efforts towards a pan-Canadian framework for developing, testing and deploying CAVs. Infrastructure Canada can support Transport Canada to strengthen ongoing testing for vehicles and smart infrastructure and help facilitate new forms of testing. Infrastructure Canada can also support ongoing testing conducted by provinces to better foster innovation in the sector.

# SCOPE LIMITATIONS

This report has extensively covered areas that are of critical importance for the federal government and Infrastructure Canada to prepare for the advent of CAV technology. However, we have identified several areas that, while outside the scope of this report, are deserving of further attention and consideration in the future.

### Data collection and privacy

Data collection and privacy will increasingly challenge policymakers as CAVs further integrate into public roads. There will be significant work required to create laws and regulations that will protect the personal information of Canadians. The plurality of, and the discrepancy between, provincial laws as well as the demarcation with federal law creates a complex legal environment for policymakers to operate within.[75] There will be a considerable collaborative effort required from federal, provincial, and territorial governments to identify opportunities to amend existing legislation and to write new legislation that will protect Canadians as CAV technology continues to advance.

### COVID-19 Impacts

The effects of the COVID-19 pandemic have significantly impacted the public transit sector and the long-term implications are not yet known. There has been a significant decrease in ridership since the beginning of the pandemic that may impact the ability of public transit systems to maintain service levels over the long-term.

COVID-19 may also shape the way Canadians work in the future. Increases in remote work may result in fewer commuters and less need for public transit systems. The staying power of many currently implemented social distancing policies are also unknown, and future study will be required to better understand the impact COVID 19 will have on the way Canadians work and commute.

[75] Office of the Privacy Commissioner of Canada, "PIPEDA in Brief," Office of the Privacy Commissioner of Canada (Office of the Privacy Commissioner of Canada, June 7, 2019), https://www.priv.gc.ca/en/privacy-topics/privacy-laws-in-canada/the-personal-information-protection-and-electronic-documents-act-pipeda/pipeda_brief/.

# ABBREVIATIONS

| | |
|---|---|
| AI | Artificial Intelligence |
| AVIN | Autonomous Vehicle Innovation Network |
| CAV | Connected and Autonomous Vehicle |
| CCTMA | Canadian Council of Motor Transportation Administrators |
| CEB | Community Employee Benefit |
| CoMT | Council of Ministers Responsible for Transportation and Highway Safety |
| FCM | Federation of Canadian Municipalities |
| GRVA | Working Group on Autonomous Vehicle (Group de Rapporteurs Véhicules Autonomes) |
| INFC | Infrastructure Canada |
| ISED | Innovation, Science, and Economic Development |
| MaaS | Mobility as a Service |
| MVTC | Motor Vehicle Test Centre |
| OCE | Ontario Centres of Excellence |
| PPSC | Policy and Planning Support Committee |
| PTIF | Public Transit Infrastructure Fund |
| RKI | Research and Knowledge Initiative |
| SGI | Saskatchewan Government Insurance |
| SRI | Smart Roadway Infrastructure |
| TC | Transport Canada |
| V2C | Vehicle to Cloud |
| V2I | Vehicle to Infrastructure |
| V2P | Vehicle to Pedestrian |
| V2V | Vehicle to Vehicle |
| V2X | Vehicle to Everything |
| WP.29 | World Forum for the Harmonization of Vehicle Regulations |

# GLOSSARY

***Artificial Intelligence (AI)***
Artificial Intelligence is used to describe machines that mimic “cognitive” functions that humans associate with other human minds, such as “learning” and “problem solving”.

***Automated Driving System (ADS)***
A combination of various components that can be defined as systems where perception, decision making, and operation of the automobile are performed by electronics and machinery instead of a human driver, and as an introduction of automation into road traffic.

***Automated Vehicles (AV)***
Vehicles that rely on sensors and computer analytics to sense their environments and perform varying degrees of the driving task.

***CAV Heaven***
The CAV deployment scenario in which all potential benefits of CAVs are maximized. CAV integration will result in a reduction of car ownership leading to reduced congestion, emissions, and traffic accidents.

***CAV Hell***
The CAV deployment scenario in which private vehicle ownership becomes more dominant than shared vehicle ownership, leading to an increase in congestion and emissions.

***Connected Vehicles***
Vehicles that are connected to the Internet to offer consumer convenience and infotainment services and/or vehicles that are connected to each other (vehicle to vehicle) or to infrastructure (vehicle to infrastructure) through dedicated short-range communications.

***Cybersecurity***
A broad term referring to the processes and practices designed to protect networks, computers, programs and data from attack or unauthorized access.

***Densification***
The implication for land use which will arise due to increased public transit CAVs systems. Strong public transit systems will encourage people to continue to live in urban centres rather than shift to suburbs.

***Digital infrastructure***
Digital infrastructure comprises smart roadway infrastructure (SRI) and contributes to enhancing traffic flow and road safety. Examples of digital infrastructure include mapping systems, sensor data, and vehicle localization.

***Driverless Vehicle***
A driverless car (sometimes called a self-driving car, an automated car or an autonomous vehicle) is a robotic vehicle that is designed to travel between destinations without a human operator.

***First mile/last mile***
In transit terms, the first mile refers to a commuter's trip to reach a transit centre (i.e. home to a bus stop). The last mile is the portion of the commuter's trip from the end of their transit ride to their destination (i.e. Bus stop to place of work).

***Human-driven vehicle (HV)***
Vehicles in which the driver performs all operating tasks like steering, braking, and accelerating.

***Mobility as a Service (MaaS)***
Mobility as a Service or Transportation as a Service describes a shift away from personally owned modes of transportation and towards mobility solutions that are consumed as a service.

***Mixed Traffic***
A traffic scenario where traditional vehicles and CAVs will use the roads at the same time.

***Multi-modal transportation***
Multi-modal transportation refers to the use of multiple means of travel within one commute. For example, people often drive to their nearest public transportation access point and take a subway to a connecting streetcar or bus for their final leg of their trip.

***Levels of Automation***
The six levels of automation defined in the "Standard J3016: Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems" by the Society of Automotive Engineers (SAE).

***Supercluster***
Superclusters are collaborative associations consisting of large, medium-sized and small companies, as well as universities, colleges, technical schools and not-for-profit organizations to create market-oriented innovation hubs.

***Physical infrastructure***
The physical infrastructure is primarily focused on localization and managing traffic flow. This may replace road signs and signal functions. Road indications could be transmitted via dedicated short-range communication to the CAVs. Traffic signs could also be updated to allow V2I applications, which could help improve traffic flow and optimize speeds.

***Privacy***
The ability of an individual or group to seclude themselves or seclude information about themselves, thereby revealing themselves selectively. Privacy is considered a huge

concern with connected vehicle operation since a lot of communication takes place in an environment that may risk the privacy of users.

***Ridesharing***
The act of sharing a private vehicle with another known or unknown passenger and sharing the cost of operating the vehicle such as carpooling.

***Transit oriented development***
An urban planning approach to development that integrates public transit into areas of dense residential, business, and public space.

***Transition Period***
The period during which, personally owned and shared, partially and fully connected and automated vehicles will coexist.

***Urban sprawl***
The implication for land use which will arise due to increased private CAV ownership and leading individuals and businesses to shift away from urban centres to suburbs, thus encouraging a greater urban sprawl in the cities.

***Vehicle to cloud (V2C)***
Allows for the exchange of information between the car and other applications that it may be connected to via the internet. V2C technology allows for connectivity beyond the vehicle's immediate surroundings or directly connected systems.

***Vehicle to infrastructure (V2I)***
A means of communication that promotes the exchange of information between the vehicles and the infrastructure.

***Vehicle to vehicle (V2V)***
A means of communication that promotes the exchange of information between vehicles on their location and speed, which can help mitigate vehicle collisions and assist with congestion issues.

***Vehicle to pedestrian (V2P)***
A means of communication through which the vehicle can transmit information to handheld mobile devices that would warn them should a vehicle be dangerously approaching.

***Vehicle to everything (V2X)***
A means of communication between a vehicle and the cloud, other cars (vehicle to-vehicle), and infrastructure (vehicle to infrastructure).

# BIBLIOGRAPHY


*2019 Autonomous Vehicles Readiness Index*. KPMG, 2019. https://assets.kpmg/content/dam/kpmg/xx/pdf/2019/02/2019-autonomous-vehicles-readiness-index.pdf.

Arcadis. Rep. *Citizens in Motion*, 2019. https://www.arcadis.com/en/global/our-perspectives/connected-and-autonomous-vehicles/citizens-in-motion/ - group-download-the-report-rFghFcPDa9

*Automated and Connected Vehicles Policy Framework for Canada*. Policy and Planning Support Committee Working group, Jan 2019. https://comt.ca/reports/avcv-policy-e.pdf.

*Automated and Connected Vehicle Testing and Research*. Transport Canada. November 1, 2019. https://www.tc.gc.ca/en/services/road/innovative-technologies/automated-connected-vehicles/testing-research.html.

Bliss, Laura. "Older People Will Need Much Better Transit." *Bloomberg CityLab*. August 4, 2017. https://www.bloomberg.com/news/articles/2017-08-04/why-aging-americans-need-better-transit.

Brault, Josiane. "Driverless Vehicles: Two Years of Autonomy on Québec Roads". Borden Ladner Gervais LLP. June 09, 2020. https://www.mondaq.com/canada/rail-road-cycling/950082/driverless-vehicles-two-years-of-autonomy-on-qubec-roads-.

*Building Better Lives Together First 100 Days of Federal Government: A Municipal Call to Action.* Federation of Canadian Municipalities (FCM), 2019. https://data.fcm.ca/documents/resources/building-better-lives-together.pdf.

Burman, Dilshad. "New Fare Machines Coming to TTC Streetcars." *Toronto.citynews.ca*. May 2, 2018. https://toronto.citynews.ca/2018/05/02/new-fare-machines-coming-ttc-streetcars/.

"Canadian Automotive Industry." Innovation, Science and Economic Development Canada, January 10, 2019. https://www.ic.gc.ca/eic/site/auto-auto.nsf/eng/home.

"Canada's New Superclusters." Innovation Superclusters Initiative. Innovation, Science and Economic Development Canada, January 27, 2020. https://www.ic.gc.ca/eic/site/093.nsf/eng/00008.html.

*Canada's Safety Framework for Automated and Connected Vehicles.* Transport Canada, February, 2019. https://www.tc.gc.ca/en/services/road/innovative-technologies/automated-connected-vehicles.html.

City of Toronto, Automated Vehicle Tactical Plan § (2019). https://www.toronto.ca/wp-content/uploads/2020/02/7ec4-TS_AV-Tactical-Plan_Technical-Report.pdf.

City of Toronto. Rep. *City of Toronto Electric Vehicle Strategy*, 2019.

City Solicitor, Powers of Canadian Cities - The legal framework § (2001). https://www.toronto.ca/ext/digital_comm/inquiry/inquiry_site/cd/gg/add_pdf/77/Governance/Electronic_Documents/Other_CDN_Jurisdictions/Powers_of_Canadian_Cities.pdf.

"Challenges and Approaches to Realizing Autonomous Vehicle Safety and Mobility Benefits," 2017.

Chong, Jed. Rep. *Automated and Connected Vehicles: Status of the Technology and Key Policy Issues for Canadian Governments*. Parliamentary Information and Research Service, September 29, 2016. https://lop.parl.ca/staticfiles/PublicWebsite/Home/ResearchPublications/BackgroundPapers/PDF/2016-98-e.pdf.

"Comparative Study on Regulation and Public Policy." Propulsion Quebec, May 2019. https://propulsionquebec.com/en/project/comparative-study-on-regulation-and-public-policy/.

"Connected and Automated Vehicles." CAAT: Center for Advanced Automotive Technology Accessed July 5, 2020. http://autocaat.org/Technologies/Automated_and_Connected_Vehicles/.

*Connected and Autonomous Vehicles in Ontario Implications for the Insurance Industry*. KPMG. Accessed July 3, 2020. https://www2.deloitte.com/content/dam/Deloitte/ca/Documents/consulting/ca-EN-CVAV-Research-Insurance-Report-2018Apr25-Final-AODA.PDF.

Deloitte LLP. Connected and autonomous vehicles in Ontario: Implications for data access, ownership, privacy and security." April 25, 2018.

*Driving Change: Technology and the Future of the Automated Vehicle*. Standing Senate Committee on Transport and Communications, 2018. https://sencanada.ca/content/sen/committee/421/TRCM/Reports/COM_RPT_TRCM_AutomatedVehicles_e.pdf.

*Driving Ontario Forward*. AVIN, June 2018. https://www.oce-ontario.org/docs/default-source/publications/driving-ontario-forward---ontario-centres-of-excellence---june-2018.pdf?sfvrsn=2.

*Driving Prosperity: The Future of Ontario's Automotive Sector*. Toronto, Ontario: Government of Ontario, 2019. https://files.ontario.ca/auto-strategy-en-final.pdf.

Ecofiscal Commission. *We Can't Get There from Here: Why Pricing Traffic Congestion Is Critical to Beating It*. Montreal, Quebec: McGill University, 2015. https://ecofiscal.ca/reports/traffic/.

"Edmonton City Council Votes to Remove Minimum Parking Requirements | CBC News," June 24, 2020. https://www.cbc.ca/news/canada/edmonton/edmonton-parking-requirements-1.5624754.

Forster, Richard. “New Report Highlights Advantages of AVs for First and Last Mile Trips.” *Cities Today*, July 17, 2018. https://cities-today.com/new-report-highlights-advantages-of-avs-for-first-and-last-mile-trips/.

Government of British Columbia, MUNICIPAL ACT [RSBC 1996] CHAPTER 323 § (n.d.). http://www.bclaws.ca/civix/document/id/consol1/consol1/96323_00.

Government of Canada, Infrastructure Canada. “Climate Lens - General Guidance.” Infrastructure Canada, October 31, 2019. https://www.infrastructure.gc.ca/pub/other-autre/cl-occ-eng.html.

Government of Canada, Infrastructure Canada. “Investing in Canada Plan.” Infrastructure Canada, 2020. https://www.infrastructure.gc.ca/plan/about-invest-apropos-eng.html.

Government of Canada, Justice Laws Canada- Canada Transportation Act S.C. 1996, c. 10 § (2020). https://laws-lois.justice.gc.ca/eng/acts/c-10.4/FullText.html.

Government of Canada, Statistics Canada. “2016 Census Topic: Journey to Work.” 2016 Census Topic: Journey to work. Statistics Canada, November 25, 2019. https://www12.statcan.gc.ca/census-recensement/2016/rt-td/jtw-ddt-eng.cfm.

Government of Canada, Statistics Canada. “Commuters using sustainable transportation in census metropolitan areas.” 2016 Census Topic: Journey to work. Statistics Canada, November 29, 2017.

Government of Canada, Transport Canada. “Canadian Motor Vehicle Traffic Collision Statistics: 2018”. Statistics and Data. https://www.tc.gc.ca/eng/motorvehiclesafety/canadian-motor-vehicle-traffic-collision-statistics-2018.html

Hausler, Saskia, Kersten Heineke, Russell Hensley, Timo Möller, Dennis Schwedhelm, and Pei Shen. “The Impact of COVID-19 on Future Mobility Solutions.” mckinsey.com. McKinsey & Company- McKinsey Center for Future Mobility, May 2020. https://www.mckinsey.com/~/media/McKinsey/Industries/Automotive%20and%20Assembly/Our%20Insights/The%20impact%20of%20COVID-19%20on%20future%20mobility%20solutions/The-impact-of-COVID-19-on-future-mobility-solutions-vF.ashx.

Henaghan, Jennifer. “Preparing communities for autonomous vehicles.” American Planning Association. February 23, 2018.

Heinsen, Patrick, and Makson Sarah. “The Sensor: Legal Insights into Autonomous Vehicles”. Borden Ladner Gervais LLP. October 01, 2019. https://www.mondaq.com/canada/rail-road-cycling/849870/the-sensor-the-state-of-autonomous-vehicles-in-saskatchewan.

Hosford, Kate, and Meghan Winters. “Who Are Public Bicycle Share Programs Serving? An Evaluation of the Equity of Spatial Access to Bicycle Share Service Areas in Canadian Cities.” *Transportation Research Record: Journal of the Transportation Research Board* 2672, no. 36 (2018): 42–50. https://doi.org/10.1177/0361198118783107.

“Important Facts.” Canadian Vehicle Manufacturers' Association, 0AD. http://www.cvma.ca/industry/facts/.

Ingram, Katie. “Canada's Autonomous Vehicle Pilots,” September 17, 2019. https://electricautonomy.ca/2019/09/17/canadas-autonomous-vehicle-pilots/.

“In It Together: Clarifying Provincial-Municipal Responsibilities in Ontario.” Ontario 360. Munk School of Global Affairs. Accessed July 4, 2020. https://on360.ca/policy-papers/in-it-together-clarifying-provincial-municipal-responsibilities-in-ontario/?fbclid=IwAR3aELP3bUTYjUGlZsCdQQ3Ch8570xgwHF__h6kWNplZkooyxwLGyXv4yKE.

Institut du Nouveau Monde. Rep. *Public Debate on Driverless Mobility*, 2019.

*Issues in Autonomous Vehicle Testing and Deployment*. Congressional Research Service, 2020. https://fas.org/sgp/crs/misc/R45985.pdf.

Kisner, Corrine, Kate Fillen-Yeh, Sindhu Bharadwaj, Celine Schmidt, Majed Abdulsamad, and Alex Engel. Publication. *Blueprint for Autonomous Urbanism*. National Association of City Transportation Officials (NACTO), n.d. nacto.org.

“Law Document English View-Municipal Act, 2001, S.O. 2001, c. 25.” Ontario.ca. Government of Ontario, November 19, 2018. https://www.ontario.ca/laws/statute/01m25.

Library of Parliament, and Jed Chong, https://lop.parl.ca/staticfiles/PublicWebsite/Home/ResearchPublications/BackgroundPapers/PDF/2016-98-e.pdf § (2016). https://lop.parl.ca/staticfiles/PublicWebsite/Home/ResearchPublications/BackgroundPapers/PDF/2016-98-e.pdf.

“Literature Review: 'AV Heaven’ or ‘AV Hell?" Autonomous Vehicles, Public Transit, and the Future of Urban Mobility,” n.d.

Luuk, Vissers, Kint Sander Van De, Schagen Ingrid Van, and Hagenzieker Marjan P. “Safe Interaction between Cyclists, Pedestrians and Automated Vehicles. What Do We Know and What Do We Need to Know?”. (2016): 1-46. https://www.researchgate.net/publication/313165192_Safe_interaction_between_cyclists_pedestrians_and_automated_vehicles_What_do_we_know_and_what_do_we_need_to_know.

MacInnis, Marla. “New Traffic Safety Act”. Nova Scotia News Release. May 11, 2018. https://novascotia.ca/news/release/?id=20181003005.

“Manitoba to Move Forward with Autonomous Vehicle Testing”. Manitoba News Release. January 29, 2018. https://news.gov.mb.ca/news/index.html?item=43033&posted=2018-01-29.

Mellor, Luke. “Initial Results from Belleville Transit Pilot.” Pantonium. Pantonium, January 11, 2019. https://pantonium.com/initial-results-from-belleville-on-demand-transit/.

*Mobility 2030: Transforming the Mobility Landscape*. KPMG, September 2018. https://assets.kpmg/content/dam/kpmg/uk/pdf/2019/02/mobility-2030-transforming-the-mobility-landscape.pdf.

Ng, Charles. “Connected and Autonomous Vehicles: Implications for Policy and Practice in City and Transportation Planning.” York Space , 2018. https://yorkspace.library.yorku.ca/xmlui/handle/10315/35139?show=full.

O'Brien, Allan. “Municipal-Provincial Relations.” Municipal-Provincial Relations | The Canadian Encyclopedia. The Canadian Encyclopedia, February 7, 2006. https://www.thecanadianencyclopedia.ca/en/article/municipal-provincial-relations.

Office of the Privacy Commissioner of Canada. “PIPEDA in Brief.” Office of the Privacy Commissioner of Canada. Office of the Privacy Commissioner of Canada, June 7, 2019. https://www.priv.gc.ca/en/privacy-topics/privacy-laws-in-canada/the-personal-information-protection-and-electronic-documents-act-pipeda/pipeda_brief/.

Office of the Privacy Commissioner of Canada. “Privacy Laws in Canada.” Office of the Privacy Commissioner of Canada. Office of the Privacy Commissioner of Canada, September 16, 2019. https://www.priv.gc.ca/en/privacy-topics/privacy-laws-in-canada/.

*Ontario CAV Ecosystem Analysis*. AVIN, June 2019. https://www.oce-ontario.org/docs/default-source/publications/avin-ecosystem-analysis-final-report-2019.pdf?sfvrsn=2.

“Ottawa L5 Press- Going Autonomous on the Greens: Connected and Autonomous Vehicle (CAV) Trial Launched in Canada’s Largest Technology Park.” Invest Ottawa. Invest Ottawa, October 17, 2019. https://www.investottawa.ca/ottawal5-press/.

*Planning for Connected and Automated Vehicles*. Public Sector Consultants & Center for Automotive Research & Greater Ann Arbor Region Prosperity Region 9, March 2017. https://www.cargroup.org/wp-content/uploads/2017/03/Planning-for-Connected-and-Automated-Vehicles-Report.pdf.

Policy and Planning Support Committee Working Group on Connected and Automated Vehicles. *The Future of Automated Vehicles in Canada*. Council of Ministers Responsible for Transportation and Highway Safety, 2018.

Propulsion Québec, and la Chambre de commeerce du Montréal métropolitain. Rep. *Positionner Le Québec Et Sa Métropole Comme Leaders Des Transports Électriques Et Intelligents*, 2019.

“Quebec's Assets.” propulsionquebec.com. Propulsion Quebec. Accessed July 4, 2020. https://propulsionquebec.com/en/industry/quebec/.

Rempel, Garreth, and Michelson David. “Connected and Automated Vehicle Activities in Canada”. (2018): pp. 10-18. http://onlinepubs.trb.org/onlinepubs/trnews/trnews317RempelMichelson.pdf

Semuels, Alana. “The End of Public Transit?” *The Atlantic*, October 28, 2016. https://www.theatlantic.com/business/archive/2016/10/public-transportation-uber-chariot/505658/.

“Seniors.” Statistics Canada: Canada's national statistical agency / Statistique Canada : Organisme statistique national du Canada, January 17, 2018. https://www150.statcan.gc.ca/n1/pub/11-402-x/2011000/chap/seniors-aines/seniors-aines-eng.htm.

Siddall, Evan. “Affordable Housing for Everyone in Canada.” Canada Mortgage and Housing Corporation, 2019. https://www.cmhc-schl.gc.ca/en/Media-Newsroom/Speeches/2019/affordable-housing-everyone-canada.

Shen, Yu, Hongmou Zhang, and Jinhua Zhao. “Integrating Shared Autonomous Vehicle in Public Transportation System: A Supply-Side Simulation of the First-Mile Service in Singapore.” *Transportation Research Part A: Policy and Practice* 113 (2018): 125–36. https://doi.org/10.1016/j.tra.2018.04.004.

Shuttleworth, Jennifer. “SAE J3016 Automated-Driving Graphic.” SAE International, January 7, 2019. https://www.sae.org/news/2019/01/sae-updates-j3016-automated-driving-graphic.

“Stranded without Transit? U of T Researchers Say One Million Urban Canadians Suffer from 'Transport Poverty'.” University of Toronto News. University of Toronto News. Accessed July 4, 2020. https://www.utoronto.ca/news/stranded-without-transit-u-t-researchers-say-one-million-canadians-suffer-transport-poverty.

Sun, Yang. “Pedestrians in Low-Income Areas Face Higher Risk of Getting Killed or Injured in Collisions.” *CBC Investigates*. June 3, 2019. https://www.cbc.ca/news/canada/toronto/pedestrians-collisions-1.5158415.

Taylor, Zack, and Alec Dobson. “Power and Purpose: Canadian Municipal Law in Transition.” The Urban Project & Institute on Municipal Finance and Governance & Centre for Urban Policy and Local Governance- University of Western Ontario & Munk School of Global Affairs. Accessed July 3, 2020. https://tspace.library.utoronto.ca/bitstream/1807/99780/1/IMFG_Paper_No47_Power_and_Purpose_Taylor_Dobson.pdf.

*The Future of Automated Vehicles in Canada*. Policy and Planning Support Committee Working group, Jan 2018. https://www.comt.ca/Reports/The%20Future%20of%20Automated%20Vehicles%20in%20Canada%202018.pdf.

*The Future of Transit -Disruptive Trends Reshaping Transit Services*. AVIN, March 30, 2020. https://oce-ontario.org/docs/default-source/publications/avin_quarterly-specialized-report_mar-2020_final.pdf?sfvrsn=2.

“Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation.” Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation: Chapter 2. 2020. https://ops.fhwa.dot.gov/congestion_report/chapter2.htm.

“Transport Act.” Légis Québec. Gouvernement du Québec-Légis Québec. Accessed July 4, 2020. http://legisquebec.gouv.qc.ca/en/ShowDoc/cs/T-12.

Transportation Association of Canada. Rep. *Discussion Paper on Connected and Automated Vehicles*, 2019.

Transportation Association of Canada. Rep. *Urban Transportation Indicators Fifth Survey*, 2016.

“Transportation in Canada 2018.” Transport Canada, July 22, 2019. https://www.tc.gc.ca/eng/policy/transportation-canada-2018.html.

Trudeau, Justin. “Minister of Environment and Climate Change Mandate Letter.” Prime Minister of Canada, December 13, 2019. https://pm.gc.ca/en/mandate-letters/2019/12/13/minister-environment-and-climate-change-mandate-letter.

Urban Mobility Task Force. *Urban Mobility Task Force Interim Report - Primer 4 Land Use*. Council of Ministers Responsible for Transportation and Highway Safety, 2020.

Urban Transportation Task Force. *The High Cost of Congestion in Canadian Cities*. Council of Ministers Responsible for Transportation and Highway Safety, 2012.

*What's Ahead for Fully Autonomous Driving Consumer Opinions on Advanced Vehicle Technology*. Deloitte, 2017. https://www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/us-manufacturing-consumer-opinions-on-advanced-vehicle-technology.pdf.

White, Gillian B. “Our Struggling Public Transportation System Is Failing America's Poor.” The Atlantic. Atlantic Media Company, February 12, 2016. https://www.theatlantic.com/business/archive/2015/05/stranded-how-americas-failing-public-transportation-increases-inequality/393419/.

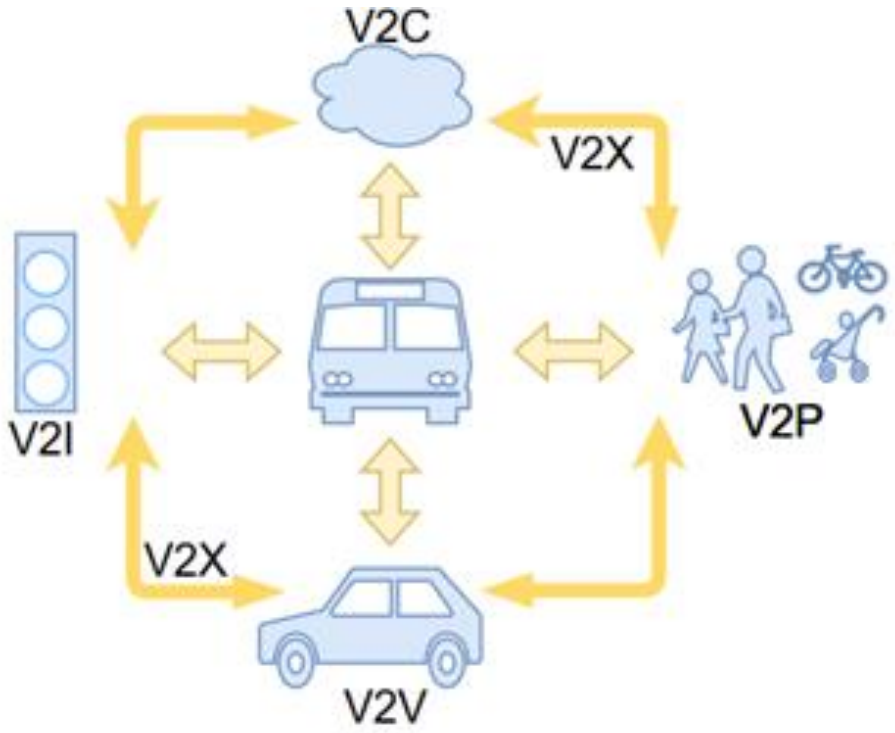
Wilding, Mark. “Private Companies Want to Replace Public Transport. Should We Let Them?” *The Guardian*, May 29, 2019. https://www.theguardian.com/cities/2018/mar/29/public-transport-transit-private-companies-citymapper-uber-whim-smart-buses.

Woudsma, Clarence, and Lucas Braun. Rep. *Tomorrow Has Arrived: Cities and Autonomous Vehicles*. Pragma City Council , 2017. https://uwaterloo.ca/planning/events/spring-2017-pragma-council-conference-dinner.

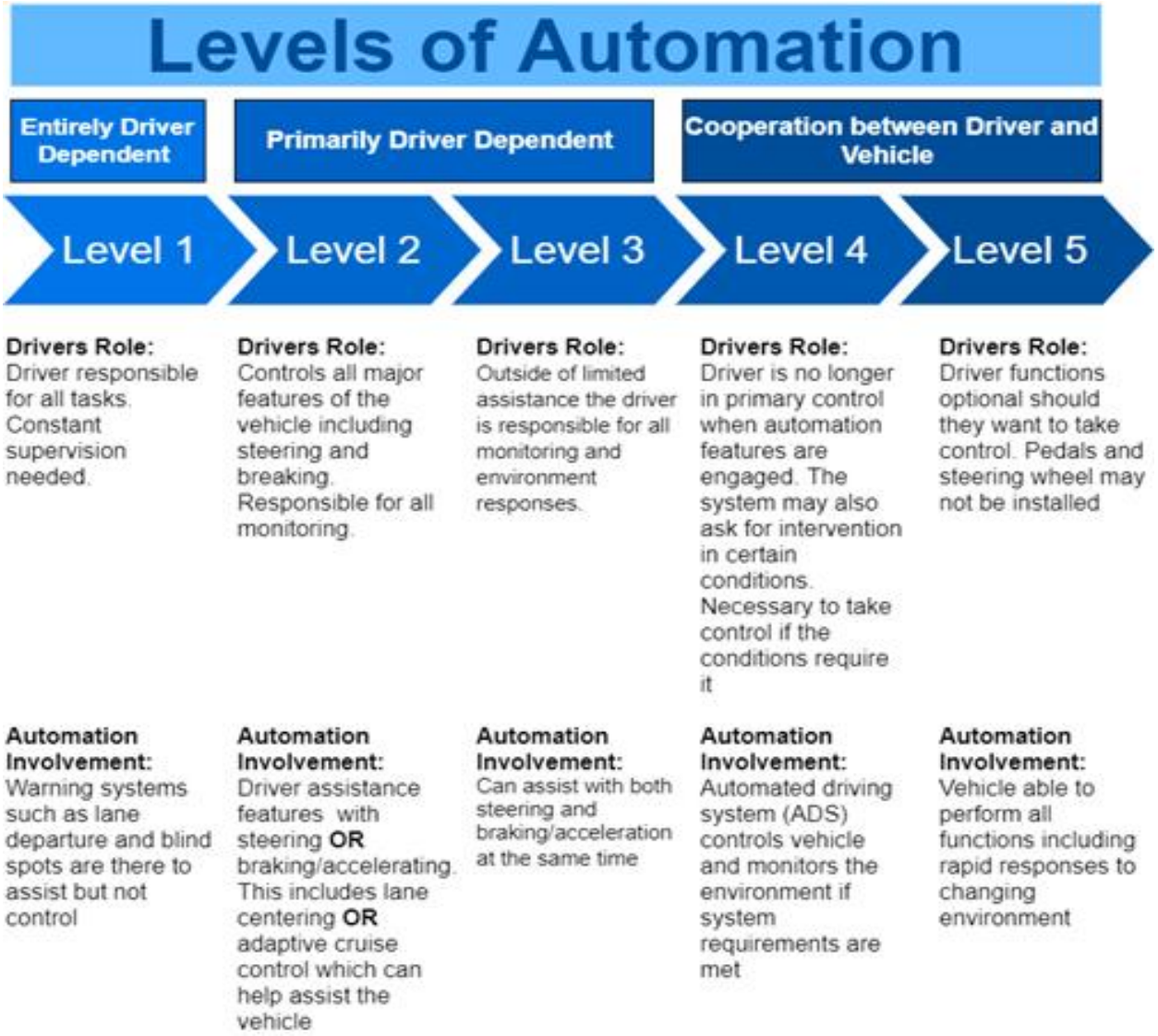
# APPENDIX A - TYPES OF CONNECTIVITY

| Types of Connectivity | Description |
|---|---|
| Vehicle to infrastructure (V2I) | Wireless transmission of information to and from infrastructure such as traffic data, environment conditions, and collision updates. |
| Vehicle to vehicle (V2V) | Wireless exchange between vehicles on their location and speed, which can help mitigate vehicle collisions and assist with congestion issues. |
| Vehicle to cloud (V2C) | Allows for the exchange of information between the car and other applications that it may be connected to via the internet. V2C technology allows for connectivity beyond the vehicle's immediate surroundings or directly connected systems. |
| Vehicle to pedestrian (V2P) | The vehicle is able to transmit information to handheld mobile devices that would warn them should a vehicle be dangerously approaching. Other potential future adoptions could include connecting to strollers, wheelchairs, bicycles, crosswalk systems, or to riders exiting public transit vehicles. |
| Vehicle to everything (V2X) | V2X connects all systems together. |

# APPENDIX B - TYPES OF CONNECTIVITY VISUAL REPRESENTATION



# APPENDIX C - LEVELS OF AUTOMATION



# APPENDIX D - PROVINCIAL SNAPSHOT

### Alberta

Alberta is in the process of laying the legislative groundwork to ensure the effective deployment of autonomous vehicles. Testing on Alberta roads is determined on a case by case basis with each new testing project needing to seek approval.

### British Columbia

The British Columbia Ministry of Transportation and Infrastructure and the Insurance Corporation of British Columbia both have autonomous vehicle working groups, are monitoring the development of CAVs, and are allowing for approved pilot projects. In the 2018 *INFC Smart City Challenge Award* won by Vancouver and Surrey proposed autonomous shuttles along the multimodal transport corridors linking these two cities.[76]

### Manitoba

Manitoba amended the *Manitoba Highway Traffic Act* which enabled testing of autonomous vehicles and systems (levels 3 to 5) on roads, in 2018.[77] The testing of self-driving snowplows at Winnipeg Richardson International Airport began in early 2019.

### Nova Scotia

In October 2018, Nova Scotia created the *Traffic Safety Act* to modernize previous motor vehicle legislation.[78] The new act addresses the advancement of autonomous vehicles.

### Ontario

Ontario became the first province to allow the testing of autonomous vehicles by initiating a 10-year pilot project under the *Ontario Highway Traffic Act*, in 2016.[79] This framework assists the province in setting guidelines, monitoring the industry for technological advancements, and determining autonomous vehicle safety needed before the vehicles are widely available. In January 2019, the pilot project was revised to make the public use of automated vehicles equipped with level 3 technology available for sale to be used on Ontario roads.

---

[76] Garreth Rempel, and David Michelson, "Connected and Automated Vehicle Activities in Canada", (2018): pp. 10-18, http://onlinepubs.trb.org/onlinepubs/trnews/trnews317RempelMichelson.pdf.
[77] "Manitoba to Move Forward with Autonomous Vehicle Testing", *Manitoba News Release*, January 29, 2018, https://news.gov.mb.ca/news/index.html?item=43033&posted=2018-01-29.
[78] Marla MacInnis, "New Traffic Safety Act", *Nova Scotia News Release*, May 11, 2018, https://novascotia.ca/news/release/?id=20181003005.
[79] Garreth Rempel, and David Michelson, "Connected and Automated Vehicle Activities in Canada", (2018): pp. 10-18, http://onlinepubs.trb.org/onlinepubs/trnews/trnews317RempelMichelson.pdf.

### Québec

In April 2018, Québec created legislation that allowed for CAV pilot projects to be conducted. This resulted in two projects: an autonomous shuttle project in Candiac, and a driverless shuttle project in Montréal's Olympic Park, both launched in 2018.[80] In May 2018, Level 3 autonomous vehicles were then allowed to be operated on Québec roads.

### Saskatchewan

Saskatchewan is in the early stages of proposing legislative amendments to regulate autonomous vehicles, as stated in the September 2019 *Borden Ladner Gervais* issue on *The State of Autonomous Vehicles in Saskatchewan*.[81] It is expected that the proposed changes will grant Saskatchewan Government Insurance (SGI) broad authority to regulate autonomous vehicles, and more detailed regulatory amendments would follow this legislative reform.

### Other Provinces/Territories

Other jurisdictions, including Newfoundland and Labrador, the Northwest Territories, and Prince Edward Island, have not yet implemented any initiatives related to CAVs but are active participants in forums like CCTMA and Council of Ministers Responsible for Transportation and Highway Safety (CoMT). Similarly, New Brunswick, Nunavut and Yukon haven't made any formal progress on CAVs.

---

[80] Josiane Brault, “Driverless Vehicles: Two Years of Autonomy on Québec Roads”, *Borden Ladner Gervais LLP*, June 09, 2020, https://www.mondaq.com/canada/rail-road-cycling/950082/driverless-vehicles-two-years-of-autonomy-on-qubec-roads-.

[81] Patrick Heinsen, and Sarah Makson, “The Sensor: Legal Insights into Autonomous Vehicles”, *Borden Ladner Gervais LLP*, October 01, 2019, https://www.mondaq.com/canada/rail-road-cycling/849870/the-sensor-the-state-of-autonomous-vehicles-in-saskatchewan.

# APPENDIX E - ACADEMIC INSTITUTIONS SNAPSHOT

| Academic Institution | Initiative | Additional Information |
|---|---|---|
| Alberta | | |
| University of Alberta | Autonomous Systems Initiative (ASI) | Two major projects are in progress within the ASI: Automated Transportation System with Enhanced Vehicle Intelligence and Infrastructure Digitization and the Autonomous Road Vehicles Systems for Improving the Emissions Footprint of Urban Passenger Transportation |
| University of Calgary | Intelligent and Autonomous Systems | A designated research theme within the Schulich School of Engineering. Their work on autonomous systems includes vehicles and transportation systems including planning and coordination as well as technology development and application for driverless cars. |
| British Columbia | | |
| Simon Fraser University | Autonomous and Intelligent Systems Laboratory | Engaged in projects focused on driverless cars and driver assistance systems within the following four sub-categories: driver modelling, situation awareness, lane changing, and condition monitoring. |
| University of British Columbia | Transportation Infrastructure and Public Space Lab (TIPS Lab) | An interdisciplinary research group focused on the potential of future transportation infrastructure and how social and environmental considerations can be integrated into design methodologies. |
| | Advanced Control and Intelligent Systems Laboratory (ACIS) | Working to develop CAV technology that will be combined with electric vehicle technology with the overall goal of establishing a cooperative driving transportation network. This research has five project streams: localization and mapping, object detection and tracking, dedicated short-range communication, high-level decision making, and hybrid control. |

| | | |
|---|---|---|
| Nova Scotia | | |
| Dalhousie University | Connect Smart | There are three major research themes: Future Mobility, Integrated Mobility, and Transport and Land Use Integration. The Future Mobility theme involves work on autonomous vehicles, electric vehicles, shared mobility, and mobility as a service. |
| Ontario | | |
| Carleton University | Connected and Autonomous Systems | Actively involved in cross-disciplinary research on connected and autonomous systems across four faculties. The major research areas are autonomous operations, data processing and management, sensor network technologies, wireless connectivity, cybersecurity, software engineering and computational linguistics, and road and vehicle safety. |
| Ontario College of Art and Design University | Interactive Futures Lab | An interdisciplinary group focused on the design of technology for meaningful user experiences. This specifically includes vehicle to pedestrian interactions. |
| Ontario Tech University | Automotive Centre of Excellence | A multi-level testing and research centre with the ability to conduct full climate, structural durability, and life cycle testing. |
| Ryerson University | Centre for Urban Innovation | Includes the Laboratory of Innovations in Transportation which studies the cyber-physical future of urban mobility through the following research themes: cybersecurity and privacy, machine learning and mobility, smart mobility, urban flux, and virtual reality. |
| University of Ottawa | Networked Systems and Communications Research (NETCORE) Lab | Working in partnership with supporting organizations including Natural Resources Canada and the Natural Sciences and Engineering Research Council, major research themes include AI-enabled networks, smart grid, electric vehicles, cybersecurity, and localization. |

| | | |
|---|---|---|
| University of Toronto | Transportation Research Institute | A cross-disciplinary research team combining engineering, policy, urban geography and planning, and computer science. Research areas include integrated mobility and integrated travel demand and land use modelling. There are several labs also included that have broader research goals as detailed below. |
| | Intelligent Transportation Systems | Research themes include adaptive traffic signal control, congestion pricing, and traffic impacts of CAVs. |
| | Public Transportation Planning and Operation | Research involves how advanced public transit systems can apply information technology to increase safety and efficiency. |
| | iCity Centre for Automated and Transformative Transportation Systems | Studies the large-scale impacts that disruptive transportation may have on cities with a focus on analyzing and quantifying the impacts and transformation. |
| | Transit Analytics Lab | Research involves the combination of transportation and software to develop advanced transit analytics as applicable to public transit decision making. |
| | ITS Centre and Testbed | In collaboration with the City of Toronto and the Ministry of Transportation of Ontario, their research focuses on the complex interdisciplinary problems facing transit systems and how advanced methods can be used to improve system performance. |
| University of Waterloo | Smart Hybrid and Electric Vehicles Systems Lab | Conducting research focused on the development of environmental sensing technologies that will be able to operate without human inputs. |
| University of Western Ontario | Optimized Computing and Communications Lab | Research project on the management and security of autonomous vehicles that examines the cybersecurity challenges faced by CAVs. Additionally, they look at the sensing technology that will be needed for autonomous vehicles to function. |

| | | |
|---|---|---|
| University of Windsor | Accessibility in Autonomous Transit Policy | The Law Faculty's Law and Technology area has ongoing research into how CAV experts, disability rights scholars, and transit policymakers can collaborate to create accessible transit systems. |
| York University | Tsotsos Lab | Research on CAVs is focused on vehicle to pedestrian interactions and spatial cognition. |
| Quebec | | |
| Université de Sherbrooke | Laboratoire Intelligence Véhiculaire/ Laboratory on Intelligent Vehicles | A research lab based in the Faculty of Engineering with a focus on the development and integration of artificial intelligence and information processing systems in vehicles. |
| Université du Québec à Montréal | DESS en design d'équipement de transport | Housed in the Faculty of Fine Art, research areas include assisted driving as well as mobility and public transit for all. |
| Université Laval | Transport et services publics | Research units include bus rapid transit, public transportation systems, sensors, semi-autonomous vehicles, and 3D perception and mapping of autonomous vehicles. |
| Collaborative | | |
| Algonquin College<br>Carleton University<br>La Cité<br>University of Ottawa | L5 Testing Facility | The academic institutions involved in this initiative are working with technology and ecosystem partners to operate an integrated testing facility for the safe implementation of CAVs. This facility is the first integrated test environment in North America, and includes networking infrastructure, leading sensing technology and allows for four-season testing. |

| | | |
|---|---|---|
| Carleton University<br>Ontario Tech University<br>University of Alberta<br>University of Ottawa | Training and Research in Advanced Network Systems for Intelligent Transportation (TRANSIT) | In partnership with the Natural Sciences and Engineering Research Council, TRANSIT provides training in intelligent transport systems technology and how it can be implemented as part of smart city design. |
| Concordia University<br>HEC Montréal<br>McGill University<br>Polytechnique Montréal<br>Université Laval<br>Université du Québec à Montréal | Centre interuniversitaire de recherche sur les réseaux d'entreprise, la logistique et le transport (CIRRELT) | Laboratory focus areas include Transportation Safety and Intelligent Transportation Systems. |