

# AVIN SPECIALIZED REPORTS

DECEMBER 2020



## SMART MOBILITY AND THE FUTURE OF CITIES

Opportunities and Readiness Tactics



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# TABLE OF CONTENTS



03	INTRODUCTION
05	OPPORTUNITIES FOR CITIES
14	CITY READINESS AND ADAPTATION
25	ONTARIO SMART MOBILITY READINESS FORUM
26	CONCLUSIONS
27	MEET THE AVIN TEAM
28	ABOUT AVIN



# INTRODUCTION

Smart mobility solutions<sup>1</sup>, mainly presented in connected and autonomous vehicles (CAVs), will bring great opportunities to cities and their residents. From improving efficiency and safety, and optimizing freight operations to reducing adverse impacts on the environment and enhancing the quality of life, cities can reap countless benefits in the short and long terms.

On the implication side, these new mobility options will be changing the way we plan and build road infrastructure, as they impose required adaptations to accommodate and facilitate their operations on roads. This future of mobility also requires cities to work on creating various design and operational regulations

and guidelines, in collaboration with the provincial and federal governments, to reflect the new requirements of these new mobility technologies. These regulatory changes and updates cover technology piloting, safety, and data management regulations and guidelines. As part of developing city readiness for smart mobility, municipal governments should also work on readying residents to accept these technologies and increase public awareness of their opportunities and implications.

After assessing the required changes, it is recommended that municipal governments devise a tactical plan to act on all these changes. This tactical plan should include all the focus areas to consider in upcoming planning and project initiatives, in alignment with the overarching vision and initiatives that are underway.

**In this report, we focus on discussing the major opportunities of smart mobility technologies that will reshape the future of cities. We also discuss the various areas**

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<sup>1</sup> Smart Mobility is the integration of various technology and mobility elements into a network of smart infrastructure and services capable of moving people and goods in a fast, clean,

accessible and affordable manner. Examples include CAVs, smart parking, electric charging, smart signaling, on-demand mobility, and Mobility-as-a-Service (MaaS).



**that will need to undergo changes in order to reap these future opportunities, and will shed light on these required changes and adaptations.** We remark that the discussed changes need to be worked upon in incremental phases over the coming years. The priority of acting on each required change is dependent on the current status of smart mobility technology maturity and penetration.



# OPPORTUNITIES FOR CITIES

Mobility is a cornerstone of the city's social and economic development. With the rise of smart cities, mobility that is coupled with technology advances and smart applications will deliver significant benefits. In this section, we address some of the major opportunities that smart mobility can bring for cities and their residents.

## Improving Transport System Efficiency and Safety

Traffic congestion is one of the key challenges faced by cities around the world. The consequences include inefficiencies in the overall transport system and negative impacts on the economic development of the city.

The impacts of traffic congestion further affect the quality of life. This is represented in lost personal time and more road collisions. In Canada, over 140 hours per driver are lost every year driving during rush hour in the large cities of Vancouver,



Toronto, and Ottawa<sup>2</sup>. Moreover, road collisions resulted in over 1.3 million deaths globally in 2019<sup>3</sup> (1,922 in Canada in 2018).

Smart mobility and technology solutions have a great potential to ease congestion and improve road safety. Some of these technologies are already delivering efficiency and safety benefits today. Traffic signal coordination allows more efficient traffic flows and reduces gridlocks at intersections. Real-time collision and road work alerts help drivers choose alternative routes and avoid congestion. Similarly, automated tolling and congestion pricing can improve traffic flow and decrease the likelihood of collisions.

Moreover, coupling smart mobility with other advanced technologies such as big data analytics and machine learning algorithms further enables smart traffic control systems to manage traffic more efficiently. When combined with smart physical infrastructures such as sensors and solar panels, these software capabilities can enhance system visibility, support in generating energy, facilitate

communication with autonomous vehicles and monitor road conditions<sup>4</sup>.

Authorities can utilize the data collected from all these communication channels to undertake evidence-based analysis of current mobility issues and inform their planning and decision-making processes. This can bring major efficiency benefits not only for the transport system, but also for other city systems that rely on mobility to function effectively, such as emergency response. Moreover, this data enables the development of analytics and software for travel information and services. Such services enable more integrated solutions and experiences and encourage inter-modal travel as in the case of Mobility-as-a-Service offering.

On the transport safety side, advancements in vehicle autonomy and connectivity using sensors and artificial intelligence enable a shorter reaction time compared to a human driver. In turn, the risks associated with human fallibility will decline dramatically. While not expected to eliminate road traffic collisions completely, adopting CAVs at a sufficient scale is

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<sup>2</sup> TOMTOM. (2019). Traffic Index. Accessed Through [https://www.tomtom.com/en\\_gb/traffic-index/](https://www.tomtom.com/en_gb/traffic-index/)

<sup>3</sup> World Health Organization (WHO). (2019). Death on the roads. Accessed Through <https://extranet.who.int/roadsafety/death-on-the-roads/>

<sup>4</sup> Here Mobility. Smart Road Technology: Paving the Way to the Future. Accessed Through <https://mobility.here.com/learn/smart-transportation/smart-road-technology-paving-way-future>



expected to bring significant improvements to road safety – potentially reducing automobile fatality by almost 80 per cent<sup>5</sup>.

## Enhancing Access to Mobility

Inadequate transportation is one of the key factors contributing to social exclusion<sup>6</sup>. Affordability, availability, and accessibility are key to delivering equitable transport systems. This is especially consequential for low-income groups, youth, seniors, and people with disabilities who are unable to own and/or drive a vehicle and rely on public transport and paratransit. Limited access to mobility services can further limit these groups' access to employment, education, health care, social networks, and other opportunities.

New and smart mobility services that integrate advanced technologies present an opportunity for a more diversified transport offering. With a focus on affordability and accessibility, these services have the potential to reduce

inequality and enhance mobility accessibility across all demographics.

In Canada, transportation is the second-largest expenditure category accounting for 19.9% of total household consumption<sup>7</sup>. Mobility efficiency benefits that are brought by the smart mobility technologies, such as CAVs, can significantly reduce travel times and the associated costs, allowing more affordable mobility options.

Moreover, data-driven mobile applications and mobility platforms can help the mobility impaired and older people access on-demand services, plan and complete their journeys more easily, and become less reliant on others for travel.



<sup>5,5</sup> Canada Senate. (2018). *Driving Change – Technology and the future of the automated vehicle*. Retrieved from [https://sencanada.ca/content/sen/committee/421/TRCM/Reports/COM\\_RPT\\_TRCM\\_AutomatedVehicles\\_e.pdf](https://sencanada.ca/content/sen/committee/421/TRCM/Reports/COM_RPT_TRCM_AutomatedVehicles_e.pdf)

<sup>7</sup> Statistics Canada. (2017). *Survey of Household Spending*. Accessed Through <https://www150.statcan.gc.ca/n1/daily-quotidien/181212/dq181212a-eng.htm>



Data collected from such platforms and other transport systems and infrastructure can be utilized to identify demand patterns and mobility needs. This intelligence is crucial to deliver more efficient, demand responsive and better integrated services.

## Efficient Use of Mobility Infrastructure

With population growth and the subsequent increase in demand for travel, cities need more transportation services, facilities and infrastructure, posing financial and operational challenges to cities. However, this growing need facilitates the emergence of new and smart mobility models that harness technologies to offer better alternative solutions.

If adopted effectively, the technological advancements and changing models of ownership (i.e., shared mobility) can potentially increase car occupancy rates and reduce private car ownership. CAV technologies also promise significant improvements to traffic flow and increased road capacities.

Moreover, the envisaged convergence of shared, autonomous, and connected

technologies is also expected to reduce the demand for parking - rendering a significant portion of available parking space obsolete. In a 2018 study by the World Economic Forum, it was found that the city of Boston will only require about half of the current parking if AVs are to be adopted at a significant rate<sup>8</sup>.

Other emerging concepts such as smart Curbside management can also support the efficient utilization of infrastructure and urban space, while still serving motorists and vulnerable road users.

With all the reclaimed road capacity and parking spaces, investments that would have been allocated to additional road infrastructure and parking supply could be better utilized for other purposes. These could include integrating public transit and active travel (i.e., walking and cycling) for a complete mobility offering.

## Optimizing Freight Operations

Efficient transport infrastructure and facilities are essential for maintaining the operational performance of the freight and logistics sector. The rise of e-commerce

<sup>8</sup> World Economic Forum. (2018). Reshaping Urban Mobility with Autonomous Vehicles: Lessons from the City of Boston. Retrieved from

[http://www3.weforum.org/docs/WEF\\_Reshaping\\_Urban\\_Mobility\\_with\\_Autonomous\\_Vehicles\\_2018.pdf](http://www3.weforum.org/docs/WEF_Reshaping_Urban_Mobility_with_Autonomous_Vehicles_2018.pdf)



and the pressing consumer demands for fast and convenient shipping have imposed serious expectations on goods movement logistics, especially last-mile delivery services.

The emergence of the Internet of Things, which is defined as the interconnection of computing devices embedded in everyday objects, enabling them to send and receive data via the internet, as well as the rise of artificial intelligence technologies have brought major opportunities to both the operational and economic aspects of the industry. Moreover, data gathered by the emerging technological platforms provides a great opportunity to transform freight transportation to a more connected and dynamic system.

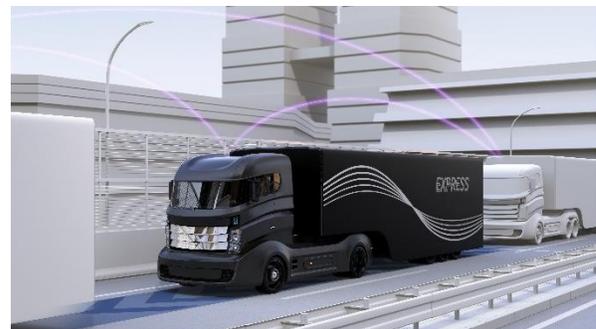
Autonomous vehicles are also expected to massively transform the freight and logistics sector with the advances in automated driving. According to a study by KPMG<sup>9</sup>, autonomy will enable cheaper, faster, and more convenient delivery services.

Similarly, platooning is expected to contribute significantly to more efficient

and safer freight operations. The technology utilizes collision avoidance systems with vehicle-to-vehicle communication to enable two or more trucks to travel in close proximity.

Additionally, the rapid growth in micro-mobility modes for freight operations, such as electric cargo bikes, showed that they have the potential to increase road speeds in congested areas as well as reducing emissions, costs, and delivery time when compared to van-based last-mile delivery services<sup>10</sup>. Drones and delivery robots (known as bots) could also replace vehicles for some types of urban deliveries providing faster and more efficient services and reducing congestion on the road.

The emerging concept of “freight on-demand” has also ignited big companies’ interest and driven them to offer this business model as a part of their services.



<sup>9</sup> KPMG LLP. (2018). *Autonomy delivers: An oncoming revolution in the movement of goods*. Retrieved from <http://tiny.cc/l2c7az>

<sup>10</sup> Pembina Foundation. (2017). *Cyclelogistics – Opportunities for moving goods by bicycle in Toronto*. Retrieved From <https://www.pembina.org/reports/cyclelogistics-final.pdf>



As truck prices get higher due to adopted technological advances, it is anticipated that the adoption of this asset sharing model will continue to rise and that fleet outsourcing will become a trend in freight and logistics. Through this asset sharing model, cities can expect more sustainable, efficient, and demand-responsive freight operations.

## Building a More Resilient System

A resilient transport system is able to maintain continuity of services and functions throughout any shock or stress, without compromising societal well-being.

The ongoing COVID-19 pandemic is a real-world example of major shocks to the transport system. Public transport systems around the globe were particularly hit hard with cities enforcing restrictions on public transport usage to limit the spread of the virus. This has forced an average of 83 per cent drop in demand for transit in Canada in late March of 2020, compared to the same time in past years<sup>11</sup>. The impact is more profound in large urban centres with major reliance on public transport and

limited access to alternatives (in terms of time and cost).

With the gradual re-opening of businesses and increased demand for travel, cities are challenged with a potential fate of going from lockdown to gridlock<sup>12</sup> with more people choosing private cars. More efforts will be required to enhance accessibility to a smart, integrated, and inter-modal system that offers an abundance of alternative options. If not managed properly, the consequences of the pandemic on travel behaviors could add more private vehicles on the roads, jeopardizing previous efforts to build resilient and sustainable transport systems.

New mobility models such as shared bikes and scooters can play a vital role in reinforcing safe and sustainable accessibility in cases where public transport has become less viable.

Lessons learned from this unprecedented experience have also amplified the importance of new technologies in achieving a more resilient system. For instance, using IoT sensors can support predictive maintenance avoiding system

<sup>11</sup> CBC. (2020). How COVID-19 is affecting public transit use. Accessed Through <https://www.cbc.ca/news/canada/coronavirus-covid19-public-transit-1.5509927>

<sup>12</sup> International Growth Centre (IGC). (2020). Impact of COVID-19 on public transport. Accessed Through <https://www.theigc.org/blog/impact-of-covid-19-on-public-transport/>



failures and subsequent delays. Moreover, data analytics can be deployed to better understand travel behavior helping cities make better decisions about transport infrastructure investments and system and service enhancements.

CAVs can also contribute to a more resilient transport system. Artificial intelligence (AI) enables CAVs to detect, foresee, and react to the surrounding environment more efficiently. This eliminates human involvement in the operations, which allows them to be more responsive to risks and hazardous circumstances. Moreover, the benefits brought by CAVs on road efficiency can spare capacity to adapt to disruption and provide alternative routes.

Such flexibility and responsiveness allow transport systems to evolve and adapt to dynamic circumstances and users to make informed decisions - reinforcing the resilience of transport operations.

## Maximizing Environmental Benefits

In 2018, the transportation sector was the second largest source of GHG emissions, accounting for 25 per cent of total national emissions in Canada. Passenger cars and light and heavy trucks contributed to approximately 83 per cent of all transport-related emissions<sup>13</sup>.

Promoting the use of alternative fuel vehicles (electric, hybrid, and hydrogen operated cars) is key to reduce GHG emissions and their adverse effects on the social health and the environment. It is anticipated that the adoption of shared, electric, and autonomous vehicles could reduce the overall individual vehicle emissions by up to 90 per cent<sup>14</sup>.

Emerging mobility models such as demand-based micro-transit or e-hailing services can also contribute to greener transport. Moreover, Intelligent Transport Systems (ITS) applications such as smart traffic lights that enhance traffic flow and reduce

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<sup>13</sup> Government of Canada. (2018). Green House Gas Emissions. Accessed Through <https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions.html>

<sup>14</sup> Berkeley Lab. (2015). Autonomous Taxis Would Deliver Significant Environmental and Economic Benefits. Accessed Through <https://newscenter.lbl.gov/2015/07/06/autonomous-taxis-would-deliver-significant-environmental-and-economic-benefits/>



delays and time spent idling can reduce GHG emissions by 3–8 per cent<sup>15</sup>.

Countries around the world are increasingly realizing the urgency to adopt regulations that allow for a cleaner and greener future cities and healthier communities. Canada has recently joined over 120 countries, including the UK, Germany, Italy, Japan, and France, in committing to net-zero emissions by 2050. The Canadian Net-Zero Emissions Accountability Act legally binds the government to a process to achieve net-zero emissions by 2050 with an obligation to achieve five-year emissions-reduction targets in the interim<sup>16</sup>.

## Improving Quality of Life

At the top of the list of opportunities that smart mobility brings for cities is enhancing the quality of life of their residents. The growing provision of new technologies has already resulted in significant upgrades in our quality of life today. This was evident in the massive remote working shift during the pandemic. Software innovations and better and faster connectivity allowed the

efficient and productive remote working environments.

Moreover, the use of technology can provide more efficient, less stressful commutes. This in turn allows for greater flexibility for people to choose where to live and frees up more time in their day for other activities.

New technologies can also play a crucial role in addressing the first- and last-mile concerns using on-demand services such as autonomous shuttles, e-hailing services, and micro-mobility.

A more sustainable system that prioritizes zero emissions modes will also have significant impacts on the long-term health and well-being of city residents and their overall quality of life.

## Increasing City Competitiveness

Cities that foster and enable new technology development and innovation in all economic sectors become more attractive to highly skilled talents,

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<sup>15</sup> McKinsey Global Institute. (2018). Smart Cities: Digital Solutions for a More Livable Future. Retrieved From <https://www.mckinsey.com/~media/McKinsey/Industries/Public%20and%20Social%20Sector/Our%20Insights/Smart%20cities%20Digital%20solutions%20for%20a%20more%20livable%20future/MGI-Smart-Cities-Full-Report.pdf>

<sup>16</sup> Government of Canada. (2020). Government of Canada charts course for clean growth by introducing bill to legislate net-zero emissions by 2050 Accessed Through <https://www.canada.ca/en/environment-climate-change/news/2020/11/government-of-canada-charts-course-for-clean-growth-by-introducing-bill-to-legislate-net-zero-emissions-by-2050.html>



entrepreneurs, and global investments - generating high-quality jobs in the process.

Ontario was the top-ranked province on The Conference Board of Canada's "How Canada Performs: Innovation" report card released in 2018<sup>17</sup>. The province specifically scores well in R&D and entrepreneurial ambition compared to its international peers making it a desirable innovation hub. More efforts to improve connectivity and overcome the challenges of innovation and technology commercialization can further improve the province's performance in this space.

Harnessing technologies to improve the flow of people and goods can have massive impacts on economic productivity in a city. Moreover, reduced expenditure on transportation due to more affordable options allows households to direct their spend to other economic activities.

Further in-direct economic and social benefits can be reaped from a more integrated inter-modal transport system.

Creating activity hubs at transport interchanges allows for the creation of more income generating opportunities. Improved accessibility to these hubs through first- and last-mile solutions can maximize the economic return from both transport and commercial activities.

## Engaging Communities

Creating efficient and smart city and transport systems that can respond to travel behaviors and needs requires impactful engagement of the users. Technology is increasingly making this process more efficient allowing more citizens to be involved in decision-making. Empowering communities of all demographics to be engaged in building their cities adds to their attractiveness. This not only enhances their social competitiveness but can also act as a strong differentiator in cities' political and economic competitiveness.

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<sup>17</sup> The Conference Board of Canada. (2018). *How Canada Performs: Innovation*. Accessed Through

<https://www.conferenceboard.ca/hcp/provincial/innovation.aspx?AspxAutoDetectCookieSupport=1>



# CITY READINESS AND ADAPTATION

To reap the opportunities brought to cities by adopting smart mobility, several things must be done over the coming years to pave the way forward. The overall goal is to be proactive to prepare cities for these opportunities and ensure that all technology implications are considered in advance. So, what should cities be doing in the near and long term to create an environment accommodating for smart mobility?

We answer this question in this section by walking through the various changes that cities need to focus on, from upgrading the road infrastructure, to devising regulations and guidelines to support piloting and adopting these smart mobility solutions. We also touch upon some of the efforts needed to raise the public awareness and acceptance of these technologies and the importance of having a city tactical plan to act on all these required changes.

## Road Infrastructure

To be able to safely adopt smart mobility solutions and utilize their full potential, cities need first to ensure that the road infrastructure, both physical and digital, is



ready for accommodating these smart vehicles. For CAVs to be able to operate safely and efficiently, they need to be surrounded with a compatible physical infrastructure and connected to a powerful digital infrastructure. Below, we discuss the diverse areas of change and enhancement required to ready the future road infrastructure for the operation of CAVs. These areas of change are better to be considered and planned for sooner rather than later, due to the needed capital planning and long lifecycles of the road infrastructure.

## Physical Infrastructure

One of the critical factors impacting the successful adoption of CAVs is the physical road infrastructure needed for their operation. Some changes and enhancements to the current physical infrastructure are required to facilitate the seamless and safe adoption of CAVs. Cities aiming for having CAVs operate on their roads need to proactively plan for and invest in these changes.

**Road Markings.** CAVs mainly depend on detecting the road markings by their cameras for the sake of orienting

themselves in the middle of a lane and detecting their safe stopping points at intersections. For accurate detection of these road markings, they should be clearly visible to the CAV camera. This requires recurring inspection and maintenance of the road markings to ensure they are identifiable. However, some weather conditions may impact the visibility of road markings, even if they are well-maintained. For example, on rainy days, wet roads can create challenges for in-vehicle cameras to successfully identify road markings. A solution for this challenge can be adopting wet reflective markings. In Ontario, for example, 407 ETR, in partnership with 3M Canada, started this adaptation by testing the use of 3M's pavement marking tapes optimized for Advanced Driver Assistance Systems (ADAS) on 2.5 km of lanes on Highway 407 ETR<sup>18</sup>.

**Smart Crossings.** CAVs are being trained to detect pedestrians at crossings. However,

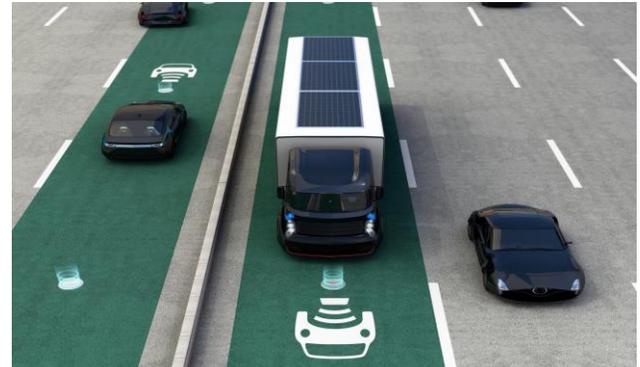
<sup>18</sup> CNW Group Ltd. (2019). 407 ETR and 3M CANADA paving the way with high contrast pavement markings. Retrieved from

<https://www.newswire.ca/news-releases/407-etr-and-3m-canada-paving-the-way-with-high-contrast-pavement-markings-856813767.html>



field tests show that CAVs may fail to detect pedestrians in some cases. Until the detection becomes 100 per cent reliable, CAVs should be assisted from the infrastructure at crossings to guarantee such detection. This can be handled either through road-embedded or mounted sensors. For example, magnetic or pressure sensors can be embedded in crosswalks to carry out the detection. Another example is to detect pedestrians using infrared sensors or cameras mounted at traffic lights or electric poles. Warning lights can be added at crossings as flashing beacons to warn approaching vehicles when crossing pedestrians are detected.

**Charging Facilities.** There is a general assumption that CAVs will be electrically powered. As the industry moves in this direction, investing in more charging stations will enhance the successful operation and adoption of CAVs. This requires planning by cities for the optimal locations to deploy these stations. Locations can include well-visited spots such as service stations and shopping centres. Alternative charging techniques that can accommodate autonomous vehicles with no human on board are also



worth investing in. One of these alternatives can be the 'charging on motion' concept to charge electric vehicles wirelessly. This can be enabled using, for example, in-road charging plates or electric rails that transfer energy wirelessly to vehicles driving on them<sup>19</sup>.

**Safe Spots.** In highly and fully automated CAVs, drivers are assumed to be fully disengaged from the driving task. However, CAVs may require human intervention in abrupt situations such as system malfunctions, unplanned road events, and unusual weather changes that the CAV is not well-trained to handle. In such scenarios, CAVs will need nearby safe spots to resort to until the sudden events are cleared, or human intervention is secured. The location and features of these safe resorts should be well-planned. They should be frequent enough to accommodate urgent

<sup>19</sup> The Guardian. (2018). World's first electrified road for charging vehicles opens in Sweden. Retrieved from

<https://www.theguardian.com/environment/2018/apr/12/worlds-first-electrified-road-for-charging-vehicles-opens-in-sweden>



needs of CAVs to leave the road, and large enough to accommodate at least two vehicles. They should be well-controlled to prohibit their misuse. Also, they should be well-mapped, and their exact locations should be known to vehicles to plan for their stops appropriately.

**Automated Parking.** One of the anticipated advantages of CAVs is the possibility of dropping off their passengers right at their destinations, then going to a parking area on their own. This requires some changes to the current parking lots and parking meters infrastructure. Since CAVs may not have humans on board, automated payment methods should be facilitated. The entrance gates at parking lots and the parking meters on streets should be capable of recognizing vehicle plate numbers. This can be handled using Radio Frequency Identification (RFID) technologies or a camera at the points designated for vehicle recognition. For payment, vehicle owners can pay for their vehicle parking using online payment methods, for example.

**Pick-up and Drop-off Zones.** Since CAVs will not need to park where they drop off or pick up their passengers, dedicated passenger pick-up and drop-off zones need

to be planned for and accommodated on roads. One potential solution can involve converting some existing on-street parking spots into such zones and sharing their locations with CAVs in advance. The location and size of these zones need to be well-planned to avoid idling-caused traffic congestion.

It is worth noting that while planning for and adopting the physical changes above, cities need to take into consideration accommodating the accessibility needs of vulnerable road users when interacting with CAVs. For Ontario municipalities, this involves taking into consideration the Accessibility for Ontarians with Disabilities Act (AODA)<sup>20</sup> requirements, along with practices for safe interaction with pedestrians and cyclists.

## Digital Infrastructure

To achieve the full potential of CAVs, digital infrastructure is needed to complement the physical one. Information technology support can augment the capabilities of both CAVs and their physical infrastructure. Through communication capabilities, along with sufficient data processing and storage resources, a wide scope of services can be provisioned. Below, we highlight the main

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<sup>20</sup> Accessibility for Ontarians with Disabilities Act. Accessed through

<https://www.aoda.ca/>



digital resources needed to facilitate such service provisioning.

**Connectivity.** Without being able to connect to the road infrastructure, CAVs will only have local road information and limited views of the road network. Connected road infrastructure will significantly add to the safety, accuracy, and scope of services offered by and to CAVs. Connected infrastructure can report real-time information about critical on-road events and emergencies, so city authorities can respond in a timely fashion. Real-time traffic information can also be transmitted from the infrastructure to CAVs to enhance their operation. In Waterloo, Fortran Traffic Systems are working on developing an advanced Transit Signal Priority (TSP) system that takes advantage of connected vehicle technology to reduce travel time and delays at intersections for transit vehicles.

Several communication technologies can be used to provide the infrastructure backbone<sup>21</sup> connectivity. Examples include fibre optics, Ethernet, and cellular communications. Deciding on which

technology to use can be based on the existing deployments. For communication with CAVs, the infrastructure needs to support at least one of the vehicular communication technologies; Dedicated Short-Range Communications (DSRC) or Cellular Vehicle-to-Everything (C-V2X).

**Roadside Units (RSUs)** are deployed as parts of the digital infrastructure supporting CAVs. RSUs are stationary nodes deployed along the roadside or at intersections to enhance the operation of CAVs. Through infrastructure-to-vehicle (I2V) communication, RSUs can provide CAVs with safety warnings, real-time traffic and road condition information, maps, and navigation information. RSUs can obtain this information through backbone Internet connections, communication with neighboring RSUs, and/or communication with passing vehicles.

**Computing Resources.** Through its communication and sensing capabilities, the infrastructure collects crucial data. To convert this raw data into meaningful information, the data should be processed and analyzed. It needs also to be stored for

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<sup>21</sup> A backbone connection is a part of a network which interconnects pieces of various networks, providing a path for the exchange of information between subnetworks.



the possibility of later access. Such processing and storage requirements entail the adoption of adequate computing resources. Two major solutions can be considered for acquiring the needed computing resources. Municipal governments can either build data centres and have their own servers or seek outsourced cloud computing services. Either owned or outsourced, these computing resources should have real-time connectivity with the infrastructure. They should also have sufficient capacity to process the received data and store it as long as it is relevant.

**Traffic Management Systems.** Since CAVs depend on traffic and mapping information to enhance their sensing accuracy, traffic management systems are needed to handle the real-time traffic and road updates and convey navigation information to CAVs when required. For example, a vehicle crash may result in road closures that are signaled by authorities at the crash location. However, CAVs may not be able to correctly interpret human signals. Therefore, they need to be updated with such closures and detouring information in real-time through a traffic management system that can be connected to the road authorities and CAVs through mobile applications. This

information can also be helpful for non-autonomous vehicles for better planning of their trips.

It is worth noting that the changes to infrastructure discussed above will need to be gradually made over time, as the penetration and maturity of CAV technologies change. In the near term, and during the phase of pilot programs, there are opportunities to implement lower-cost modifications to infrastructure (e.g., enhancing road signage, adding intelligence to crossings, and expanding infrastructure connectivity), while assessing existing infrastructure assets. Results of pilot programs can inform the planning for the higher-cost modifications and any significant infrastructure design changes needed to accommodate CAVs.

It is also worth mentioning that public-private partnership (PPP) models will play an important role in financing and funding the infrastructure changes. The success of these models will require careful definition and planning for the ownership and revenue



aspects between the public and private entities<sup>22</sup>.

## Regulations and Guidelines

In order to accommodate smart mobility solutions on our roads, city authorities, in coordination with provincial and federal governments, need to create or update various design and operational guidelines, regulations, and standards, in consultation with industry, to reflect new requirements and changes for these new mobility technologies. These needed updates include technology piloting, safety, and data management regulations and guidelines, as highlighted below.

### Regulating and Guiding Pilots

Given the current state of CAV developments, governments need to focus on creating guidelines and enforcing regulations for CAV pilot programs. For the sake of ensuring safety while facilitating technology pilots, cities need to focus on defining conditions for how, where, and when CAVs can be tested and piloted, in accordance with any existing provincial and

federal regulations. An important aspect of these regulations is to ensure that public safety is not compromised and that relevant safety precautions are in place. In Ontario, cities administer AV pilots on their roads in compliance with Ontario's 10-year Automated Vehicle Pilot Program<sup>23</sup> created in 2016 by the Ministry of Transportation to allow for the testing of AVs on Ontario's roads. In response to advances in AV technologies, the program was updated in January 2019 to allow for the testing of more innovative technologies, such as vehicle platooning<sup>24</sup>. As CAV technologies continue to evolve, the level of regulations and enforcement will need to be updated to reflect the requirements and needs of the current level of connectivity and automation.

Accommodating CAV pilots requires cities to also create guidelines and mandates for reporting information from the ongoing pilots to city authorities. This includes reporting on the pilot needs and key performance indicators. This reported information can help build upon successful

<sup>22</sup> McKinsey & Company. (2019). A new look at autonomous-vehicle infrastructure. Read more <https://www.mckinsey.com/industries/travel-logistics-and-transport-infrastructure/our-insights/a-new-look-at-autonomous-vehicle-infrastructure>

<sup>23</sup> Ontario's Ministry of Transportation. Ontario's Automated Vehicle Pilot Program. Retrieved from <http://www.mto.gov.on.ca/english/vehicles/automated-vehicles.shtml>

<sup>24</sup> Government of Ontario. (2019). Changes to Ontario's Automated Vehicle Pilot. Retrieved from <https://news.ontario.ca/en/backgrounder/51013/changes-to-ontarios-automated-vehicle-pilot>



pilots and testing programs, contribute to laying the foundation for future regulations, and identify areas of focus for governments and transportation agencies.

## Safety Regulations

In addition to enforcing regulations and guidelines for ensuring safety of running CAV pilots, cities need to start adopting and enforcing safety regulations for the public use of CAVs. As CAV technologies evolve, some companies, such as Waymo, have acquired permits to operate their commercial driverless vehicles on public roads<sup>25</sup>. Such public uses require design and operational regulations different to the basic ones used for restricted piloting, in terms of safety assessments, requirements, and guidelines. For Canadian cities, this may also require advocating for updates to the Motor Vehicle Safety Act<sup>26</sup> to include specific design and operational safety requirements for CAVs.

Being strictly linked to road users' safety, the licensing, insurance, and liability requirements adopted for regular vehicle use will need to be revisited as well to

reflect the requirements and implications of personal and commercial CAV operations. This will need to happen in coordination with other provincial and federal agencies to identify needs for updates to licensing and insurance requirements.

## Best Practices and Regulations for Cybersecurity and Privacy

As smart mobility deployments evolve, protection, cybersecurity, and privacy of the data collected from and by smart vehicles and infrastructure will be a key priority for all levels of governments. As CAVs are tested and operated, huge amounts of data will be generated and consumed by these vehicles, raising some cybersecurity and privacy concerns. In earlier AVIN specialized reports, we went through the various types of data collected and reported by CAVs and the critical challenges that will accompany them<sup>27,28</sup>. Given the critical nature of this data, cybersecurity and privacy regulations and guidelines need to be clearly stated by the federal government which should work closely with municipal governments to ensure their proper implementation in all

<sup>25</sup> Waymo. (2020). Waymo is opening its fully driverless service to the general public in Phoenix. Retrieved from <https://blog.waymo.com/2020/10/waymo-is-opening-its-fully-driverless.html>

<sup>26</sup> Government of Canada. Motor Vehicle Safety Act. Retrieved from <https://laws-lois.justice.gc.ca/eng/acts/m-10.01/>

<sup>27</sup> Autonomous Vehicle Innovation Network. (2018). Data in the

Context of CAVs - Types and Operational Opportunities. Retrieved from <https://tinyurl.com/y9kkwlqy>

<sup>28</sup> Autonomous Vehicle Innovation Network. (2019). Data in the Context of CAVs - Challenges and Recommendations. Retrieved from <https://tinyurl.com/y57quqj7>



smart mobility municipal projects, and communication to all CAV providers and operators for their consideration.

Various cybersecurity and data privacy best practices for vehicle and infrastructure design and operation will need to be tested. This can be better accommodated by integrating testing of various methods into pilot programs, such as exploring the use of a Security Credential Management System (SCMS) to protect data transfer. Once a method is proved efficient in terms of safety, security, and privacy needs, necessary regulations and legislation should be developed, in coordination with the provincial and federal governments. Developing regulations should also ensure compatibility and interoperability with international best practices and regulations.

## **Data Sharing and Management Environment and Guidelines**

How to share and manage the data collected by and from smart mobility solutions being tested and adopted by municipal projects and approved pilots is also a challenge that cities will need to devise solutions for. Cities will need to adopt open and shared data approaches and build a centralized data sharing and management environment that enables

greater collaboration between government and industry and support ongoing CAV developments.

As mentioned earlier, these smart mobility solutions generate huge amounts of data. These volumes of data may render existing data sharing and management methods used by municipal agencies obsolete. However, not all data collected is of benefit for further use. Therefore, the understanding of data needs and how to effectively manage the collected data will need to be resolved and accommodated in new solutions that meet big data requirements. Pilots are considered a great opportunity for understanding data requirements and testing various data filtering, management, and sharing models. Once successful models are identified, they should be adopted in building a municipal data sharing and management environment. Guidelines should be shared by cities thereafter to guide data collection and use of this municipal data environment. This will also require developing and enforcing a data governance model that defines public data needs, data ownership, and standardized rules for data collection and access.



## Public Awareness and Acceptance

Readiness of cities to accommodate smart mobility solutions is not only about adapting our roads and regulations, but also is strongly about having residents ready to accept and use these innovative solutions. Such public awareness and acceptance can be promoted in various ways. Cities, for example, can run public education campaigns on their different media channels to talk about the smart mobility technologies and the opportunities they bring to road users. An exemplary campaign is the “Driver Assistance Technologies” campaign developed and run by Transport Canada<sup>29</sup>.

Another approach that many cities have already started to follow is engaging the public in approved smart mobility pilots. For example, cities running automated shuttle pilots can offer free rides to the public, while maintaining all the required safety precautions. Following this approach, the City of Toronto, Toronto Transit Commission (TTC), and Metrolinx are, for example, working towards launching an automated shuttle trial to connect local

residents to and from Rouge Hill GO station<sup>30</sup>.

Similarly, Durham Region Transit (DRT) partnered with the Town of Whitby, Metrolinx and others to launch Canada’s first autonomous electric shuttle pilot service. The service, planned for early 2021, will be integrated into DRT network’s schedule, operating standards, service and safety levels.

## Tactical Plans

Acting on the needed adaptations to meet the smart mobility requirements, cities need to put all the intended initiatives together in a working tactical plan. This plan should align and fit all the required changes with the city’s long-term vision, strategy, and investments. Rather than acting on all the intended changes as a single, huge project, the tactical plan should adopt a phased approach with a series of check points to evaluate and reflect on the ongoing projects. The plan should not ignore the existing assets and build on what is already in place, while going through the transition phase. Agility in the plan will be

<sup>29</sup> Transport Canada. (2020). Driver assistance technologies. Retrieved from <https://tc.canada.ca/en/campaigns/driver-assistance-technologies>

<sup>30</sup> City of Toronto. (2020). Automated Shuttle Trial. Retrieved from <https://tinyurl.com/y4alsbqk>



key as maturing smart mobility technologies is still uncertain and will evolve over time<sup>31</sup>.

A prominent example of a city tactical plan to prepare for smart mobility is the City of Toronto's Automated Vehicles Tactical Plan<sup>32</sup>. The plan aims at preparing the city for the deployment of automated vehicles over a span of three to thirty years. The plan consists of seven directions that reflect the City of Toronto's strategic vision for the future of its transportation system. The seven directions are: 1) Social Equity & Health, 2) Environmental Sustainability, 3) Economic Sustainability, 4) Privacy, 5) Road Safety & Security, 6) Integrated Mobility, and 7) Transportation System Efficiency. For each direction, the plan includes guiding policies, strategies, underlying tactics, and key performance indicators (KPIs). These tactics and KPIs are connected to a 2050 goal. In addition to the seven directions, there are three additional sections in this tactical plan that prepare the City's internal operations for AVs. The sections are: Public Service Vehicles, Future-Proofing, and Tactical Plan Data Governance. The plan is concluded with AV Readiness 2022, a section outlining five projects that the city

would act on immediately to keep up with other municipalities and stay ahead of further developments and potential impacts of AVs. These five projects are:

- 1) Undertake and complete an automated shuttle trial project.
- 2) Establish a process and locations for "transportation innovation zones" in the City of Toronto.
- 3) Develop a "Testing Response & Incident Preparedness" system, including the submission of AV TRIP Plans by testers.
- 4) Initiate a collaborative effort to provide opportunities for human discovery and learning on safe use of and interaction with automated vehicles.
- 5) Foster research and development to solve current transportation-related challenges.

<sup>31</sup> PERKINS&WILL. (2018). *Designing for future mobility*. Retrieved from <https://perkinswill.com/project/designing-for-future-mobility/>

<sup>32</sup> City of Toronto. (2019). *Automated Vehicles Tactical Plan*. Retrieved from

[https://www.toronto.ca/wp-content/uploads/2020/02/7ec4-TS\\_AV-Tactical-Plan\\_Technical-Report.pdf](https://www.toronto.ca/wp-content/uploads/2020/02/7ec4-TS_AV-Tactical-Plan_Technical-Report.pdf)

# ONTARIO SMART MOBILITY READINESS FORUM

Through Transport Canada's program to Advance Connectivity and Automation in the Transportation System (ACATS)<sup>33</sup>, over seventy municipal transportation stakeholders were engaged to provide input and key insights on CAV-related challenges and needs. As an outcome of a series of stakeholder engagement workshops, the CAV Readiness Plan<sup>34</sup> was developed in March 2020. This readiness plan describes how transportation agencies can begin to address the paradigm shift in transportation and focus on preparing for a future towards CAV readiness.

In support of ongoing collaboration and to continue the discourse on preparedness for the implementation of CAVs and smart mobility technologies, the Ontario Smart Mobility Readiness Forum<sup>35</sup> was created. The intent of the Forum is to create

dialogue, discuss progress, and evaluate support mechanisms for municipalities, public sector agencies, and infrastructure owner/operators across Ontario in their goal of preparing for the implementation and adoption of smart mobility technologies.

The Forum can be a starting point for cities to plan for the changes discussed in this report. We would like to invite all interested municipalities to join the conversation through the Forum URL: <https://www.avinhub.ca/ontario-smart-mobility-readiness-forum/>



<sup>33</sup> Transport Canada. Program to Advance Connectivity and Automation in the Transportation System. Accessed through <https://tc.canada.ca/en/programs/program-advance-connectivity-automation-transportation-system>

<sup>34</sup> Ontario Ministry of Transportation. (2020). CAV Readiness Plan. Retrieved from

<https://www.avinhub.ca/wp-content/uploads/2020/05/CAV-Readiness-Plan-Final-Report-2020-04-03-1.pdf>

<sup>35</sup> Autonomous Vehicle Innovation Network. Ontario Smart Mobility Readiness Forum. Accessed through <https://www.avinhub.ca/ontario-smart-mobility-readiness-forum/>



# CONCLUSIONS

In this report, we have discussed the various opportunities to be brought to cities and their residents by widely adopting smart mobility solutions such as CAVs. These opportunities cover many aspects including transport system efficiency and safety, access to mobility, resilience, and sustainability, impacts on the environment and quality of life and, city competitiveness.

We have also discussed how cities can be ready for accommodating these smart mobility solutions by walking through the various changes required in the future transportation infrastructure, regulations, and data management environments. We have also touched upon how cities can ready their residents for accommodating these new technologies. Furthermore, we have covered the need of municipal governments for devising a tactical plan to act on all the required changes and align

them with the city's vision and future plans. We have concluded the report with shedding light on the Ontario Smart Mobility Readiness Forum and its focus areas.

Smart mobility solutions and their required changes should be kept in mind while planning for and developing new transportation assets and regulations to avoid costly changes later on. No matter how ready a city is today to move towards wide adoption of smart mobility solutions, municipal officials need to assess city readiness against the required changes and begin developing a vision for how their cities should evolve accordingly. This should comply with the fact that there is no single readiness plan that fits all cities, and that each city should plan for the changes in alignment with their existing assets and vision.

We believe that preparedness for smart mobility should be a collaborative effort between municipal, provincial, and federal governments. Coordination and collaboration between neighboring cities will also be key in identifying common focus areas, avoiding duplication in efforts, and ensuring harmony across the region.

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## ABOUT AVIN

The **Autonomous Vehicle Innovation Network (AVIN)** is a key component of Driving Prosperity, the Government of Ontario's initiative to ensure that the automotive sector remains competitive and continues to thrive. The Government of Ontario has committed \$85 million in innovative programming to support research and development (R&D) funding, talent development, technology acceleration, business and technical support, and testing and demonstration sites. AVIN programs support small- and medium-sized enterprises (SMEs) to develop, test, and commercialize new automotive and transportation products and technologies, and cultivate the capacity of a province-wide network to drive future mobility solutions, reinforcing Ontario's position as a global leader.

AVIN, led by OCE, is supported by the Government of Ontario's Ministry of Economic Development, Job Creation and Trade (MEDJCT) and Ministry of Transportation (MTO). The initiative comprises five distinct programs and a central hub. The AVIN programs are:

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

The AVIN Central Hub is the driving force behind the programming, province-wide coordination of activities and resources, and Ontario's push to lead in the future of the automotive and mobility sector globally. Led by a dedicated team, the Central Hub provides the following key functions:

- A focal point for all stakeholders across the province;
- A bridge for collaborative partnerships between industry, post-secondary institutions, broader public sector agencies, municipalities, and the government;
- A concierge for new entrants into Ontario's thriving ecosystem; and
- A hub that drives public education and thought leadership activities and raises awareness around the potential of automotive and mobility technologies and the opportunities for Ontario and for its partners.

### *AVIN has five objectives:*

01

Foster the commercialization of Ontario-made advanced automotive technologies and smart mobility solutions

02

Showcase Ontario as the leader in the development, testing, piloting and adoption of the latest transportation and infrastructure technologies

03

Drive innovation and collaboration among the growing network of stakeholders at the convergence of automotive and technology

04

Leverage and retain Ontario's highly skilled talent

05

Harness Ontario's regional strengths and capabilities, and support its clusters of automotive and technology



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

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

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