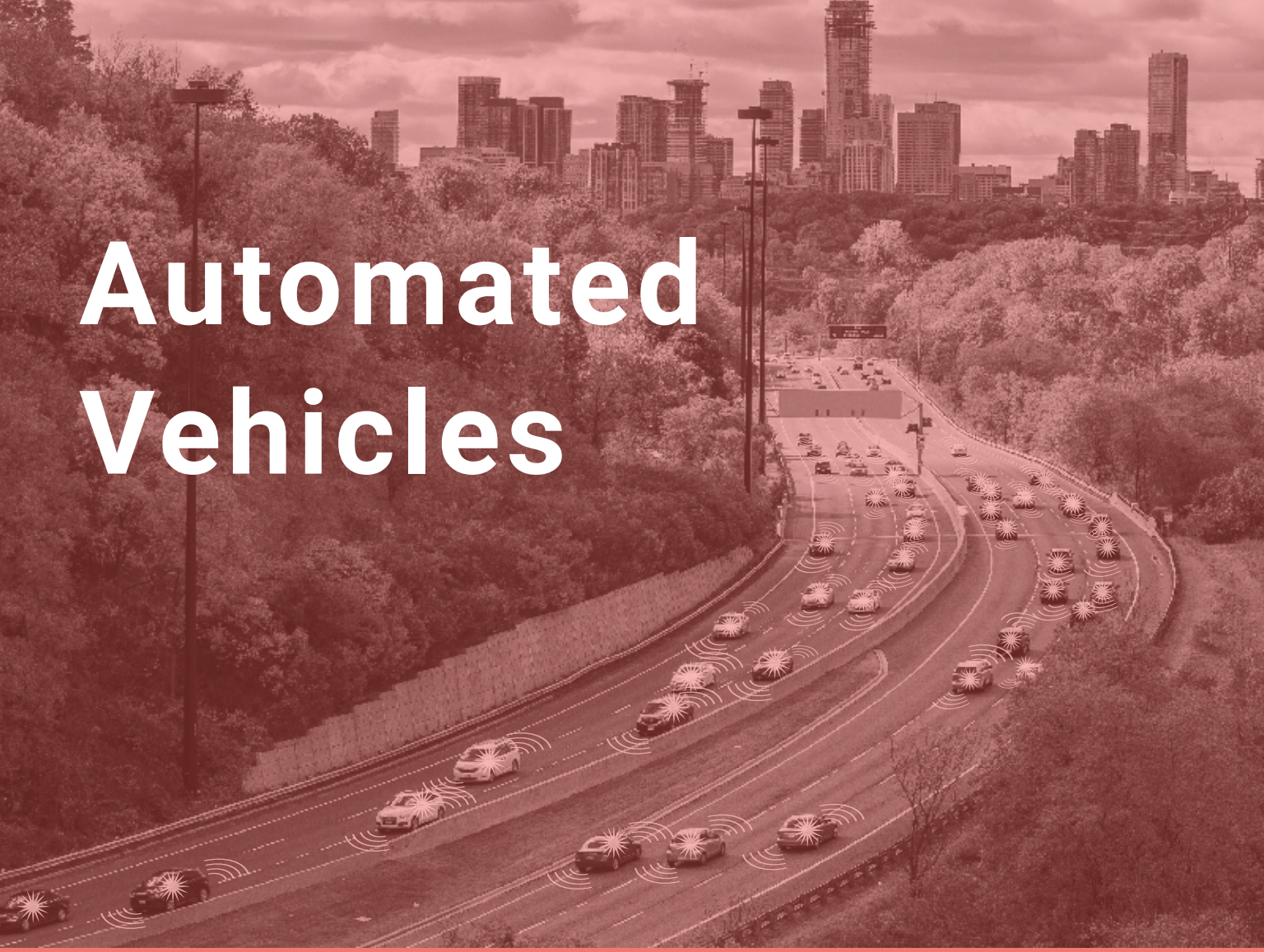

Automated Vehicles

An introduction

Ryerson University

Read me first!

"Automated vehicles are now on Toronto's streets, in various forms and for a variety of purposes. Partially automated vehicles are providing assistance to drivers in the form of cruise control, automated braking, and other safety features included in newer vehicles. Highly automated vehicles - often referred to as driverless or autonomous cars - are being tested on public roads in Ontario, including Toronto, through a permit from the Ministry of Transportation. These more advanced vehicles have the potential to reshape our transportation system, impacting road safety, traffic congestion, mobility equity, and environmental health."

- *Preparing the City of Toronto for Automated Vehicles*, City of Toronto, January 5, 2018

Ryerson University's School of Urban and Regional Planning (SURP), in partnership with the City of Toronto, has prepared this primer to provide you with background information to help you consider our future with automated vehicles.

Acknowledgements

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Key points

Here's what you need to know about automated vehicles, and what they could mean for us in the City of Toronto:

1

Automated, autonomous, driverless and self-driving vehicles are not always the same thing. Know the difference!

Vehicles exist on a scale of automation – from partially to highly to fully automated. Only "autonomous" vehicles are fully automated and capable of driving in every environment without the need for human intervention. They may also be referred to as "driverless" or "self-driving".

2

With features such as adaptive cruise control, blind spot detection & automatic parking, automated vehicles are already on Toronto's streets.

While currently-available vehicles have limited automated features, it is important to understand that automation is already here.

3

Highly automated vehicles have the potential to impact many aspects of life in the City of Toronto and beyond.

Highly automated vehicles have the potential to change driving as we know it – by making it more precise and safer, reducing the cost, and increasing access for those who cannot drive themselves today.

What is an automated vehicle (AV)?

It's useful to think about vehicles as existing on a scale of automation (see Figure 1). **Automated vehicles (AVs)** are vehicles in which at least some aspects of a safety-critical control function (e.g., steering, throttle, or braking) occur without direct driver input. AVs use sensors and computer analytics to monitor their environments and perform varying degrees of driving tasks normally done by humans. AVs can be partially or highly automated (i.e. anywhere between SAE Levels 1 and 5). They can also take any physical form, be it a small 1-2 person car, a minibus, full-sized bus or a truck. Chances are, you or someone you know already owns a car with Level 1 or 2 features.

Highly automated vehicles refer to SAE Level 3-5 technology, wherein limited driver intervention is required. Level 3 AVs can operate autonomously in some driving modes, but a human driver must be engaged and ready to take over when requested. Level 4 AVs can operate without any human input in most driving environments. Level 5 AVs can operate in all driving environments and are also referred to as **autonomous** or **driverless vehicles**, as they are capable of driving completely independently. Level 4 and 5 automated vehicles would have the most disruptive impact on the way our cities operate.

Figure 1: Overview of SAE Levels of Automation (2014)

The Society of Automobile Engineers (SAE) Levels of Automation are a worldwide standard used to indicate a vehicle's level of driving automation. The higher the level, the more the vehicle is capable of monitoring and navigating a driving environment without human intervention.

	Level of Automation	"Driver"	System Control	
	0	Human	None	
Partial	1	Human	OR +	One feature
Partial	2	Human	AND +	Two+ features
	3	Human	AND AND +	Chaperoned
High	4	Vehicle	AND AND	Limited
High	5 (Full)	Vehicle	AND AND	Unlimited

What could AVs look like?

While discussion about automated vehicles usually focuses on personal vehicles for moving people, AVs have the potential to be used in many other applications as well. Below are a few examples of how they may be introduced on our streets.

Move people

Small to mid-size vehicles

Smaller-scale AVs could look like tiny 1-2 person pods, or standard 4-6 person vehicles that we already use.

Shuttles/buses

Shuttles that can hold around 8+ people can be incorporated into our transit network as well. Automated vehicles can also look like coach buses, or transit buses that serve our streets today.

Move freight

Delivery robots

Small robots are being designed to get around on city sidewalks, delivering everything from packages to restaurant take-out deliveries, right to your door.

Trucks

Long-haul AV freight trucks are being tested to closely follow one another in platoons, i.e., driven spaced closely together (nearly bumper-to-bumper), in a line that resembles a train, without the train tracks.

Provide services

Garbage trucks, snow plows and more

Different levels of automation are being tested in numerous types of service vehicles to help improve their efficiency, and safety. Automation could be limited to certain aspects of each service vehicle depending on the job function.

What is the government's role?

Canada

- *Motor Vehicle Safety Act*
- "2030: A Strategic Plan for the Future of Transportation in Canada"
- Program to Advance Connectivity and Automation in the Transportation System (ACATS)

Ontario

- *Highway Traffic Act*
- 2016: Provincial Testing Framework – Ontario Regulation 306/15 Pilot Project on Automated Vehicles
- 2018: Amended Testing Framework
- Connected Vehicle/ Automated Vehicle (CV/AV) Program
- Automated Vehicles Innovation Network (AVIN)

Toronto

- *Municipal Code*
- 2016: "Preparing for Automated Vehicles" Workplan
- 2016: Interdivisional Working Group on Automated Vehicles
- 2018: Draft Automated Vehicle Tactical Plan 2019-2021

How could AVs disrupt motorized transportation?

The emergence of automated vehicles (AVs) could significantly alter how we travel around the city. As AVs are increasingly accepted by the public, and as business models evolve, so will our transportation choices – and their implications.

Car 2.0

- Private transportation that is readily available (e.g., privately-owned vehicle)
- Owned or leased

A small 2-person AV with a person in the driver's seat (Source: Grendelkhan, 2016).

Taxi 2.0

- On-demand private transportation
- Includes taxis, private transportation companies, mobility-as-a-service (MaaS), and bike share
- Company-owned, on-demand types of transportation
- For individual or shared (pool) use

Public transit 2.0

- Scheduled or on-demand AV public transportation
- Municipalities could partner with PTC or taxi services (e.g., Town of Innisfil)
- May be under contract or subsidized
- Could lead to more efficient and reliable services, cost savings for individuals and cities, increased access to mobility, and environmental benefits

Definitions

Mobility-as-a-Service (MaaS) is a business model that offers various forms of transport services (like public transit, ride-, car- or bike-sharing, taxis or car rentals/leasing, or a mix thereof) through a single interface. MaaS can be accessed on a one-time basis, or through ongoing subscription.

Private Transportation Companies (PTCs) connect passengers with drivers of private vehicles through an application, and are more commonly known as Transportation Network Companies (TNCs) and ride-hailing applications. Examples are Uber and Lyft.

A driverless "ultra podcar" named Harry taking part in April 2017 GATEway Project trials in a pedestrianized area of London (Source: Spsmiler, 2017).

Potential impacts of AVs

AV technology could result in many potential economic, social and environmental benefits across Toronto and beyond. However, AVs are also likely to disrupt many aspects of society in complicated and unforeseen ways, and raise new regulatory, practical and ethical questions that do not yet have clear answers. Some of these potential impacts are set out in this section.

Accessibility and equity

Appropriately designed, managed and priced AVs could eventually transform mobility for groups in the City of Toronto that find its transportation system challenging to access, or navigate.[1] For example, affordable AV shuttles could efficiently connect low-income populations from more points of origin to the transit network (addressing the "first mile/ last mile" problem). People with disabilities and less-mobile seniors could enjoy increased mobility and independence through AVs that are designed to be responsive to their physical needs.

Environment and emissions

Motor vehicles have been named the greatest contributor to global warming now and in the near future.[2] Toronto is no exception - motor vehicle traffic is the largest source of air pollution emitted. A 2017 report by the City's Medical Officer of Health confirmed that air pollution contributes to 1,300 premature deaths and 3,550 hospitalizations in our city each year.[3]

Many AVs are being designed as electric-powered vehicles with small, light and quick-charging batteries. AVs would be able to travel more energy efficiently than cars today, particularly as they move into wider use, with the ability to move at continuous speeds, smoother driving dynamics (i.e. less stop-and-go braking and accelerating), and at closer distances to one another.

Safety and collisions

Between 2013-2016, an average of 64 persons were killed per year in Toronto from traffic collisions – a 10-year high.[4] Between 2005-2016, there were more than 2,172 pedestrians, and 539 cyclists killed or seriously injured in a collision with a motor vehicle.[4] Human factors are the principal cause of over 90% of collisions, even when other variables such as road conditions and mechanical failures are at play, with key contributing factors including impaired driving (e.g., alcohol, drugs and fatigue), distracted driving and speeding.[1]

AV trials have overwhelmingly proven that removing the human factor by automating the driving process is an extremely effective way to create safer streets. A 2015 study stated that if 90% of Toronto citizens were to adopt AVs, there could be 12,000 fewer collisions, 38 fewer fatalities and many fewer injuries.[1]

Affordability and efficiency

AVs have the potential to make commuting more convenient and affordable for Torontonians, especially where they opt for shared mobility services, transit and active transportation instead of owning a car. Those users would avoid the upfront purchase, financing and other costs (such as fuel, insurance and maintenance) of car ownership.[1]

AVs also provide the opportunity for more efficient uses of time. As driving tasks become less necessary, Torontonians could use travel time as they choose, whether for productive work, entertainment, socializing or rest.

Traffic and congestion

Congestion is a major challenge in Toronto. In addition to being a source of stress and pollution, as well as a barrier to social interactions, figures show that congestion costs our regional economy as much as $11 billion a year, rising to an estimated $15 billion in 2031 if no action is taken.[5]

Each of the factors that causes traffic jams – like bottlenecked streets, traffic incidents, inconvenient signal timing and weather – could potentially be reduced or mitigated by AVs with smart technologies, especially if combined with public transit. At the same time, the convenience of AVs could also stimulate greater use of cars and minibuses, which could mean more vehicles on the road, unless robust regulations are put in place.[1]

V2V/V2I technology and Intelligent Transportation Systems (ITS)

Technology is being developed to enable individual AVs to communicate both amongst themselves (using Vehicle-to-Vehicle, or V2V, technology) and with transportation infrastructure (using Vehicle-to-Infrastructure, or V2I, technology).

V2I is a type of intelligent transportation system (ITS), designed using information and communication technologies that make transportation infrastructure more connected and responsive. While Torontonians already live with simple ITS applications, like high-occupancy vehicle lane enforcement and red light cameras, governments, researchers and industries are collaborating on V2V and V2I technology development as well. A potential vision is for AVs to be “connected” using both V2V and V2I technologies that maximize the safety and efficiency of trips. V2V and V2I technology would have a major impact on City infrastructure, as well as data security and privacy concerns.[1]

An automated mini-bus called “The Auto Rider” parked on the side of a street in Singapore (Source: Verch, 2017)

Freight industry

AVs could significantly change the freight industry. On-highway trucks are expected to be the first vehicles to use full AV technology on public roads, and are already being tested by various companies in the United States and Europe.[1] AV trucks could drive in platoons on dedicated lanes, with the driver acting as a "chaperone" rather than a dedicated driver and operator (similar to a train). Eventually, it is predicted that platoons will be able to travel unattended. Studies suggest that AV technology will enable freight services to increase productivity by 43%, from 14 hours per day of road time (the current daily limit for a human driver in the United States) to 20 hours.[6]

A platoon of partially-automated tractor trailers being tested on a public highway in Virginia (Source: Saunders, 2017).

Data ownership, privacy and cybersecurity

Automated vehicles would provide an increased opportunity to collect data as a means of providing a safer, more efficient, and greener commute. However, there are many unanswered critical questions around data ownership, privacy and cybersecurity; as well as the role of the government and industry on this issue. Who will oversee the collection and use of data generated by AVs? Who is going to store and process such information? Can personal data be sold? Could AV technology be used for tasks other than driving (for example, to find a lost pet? To track criminals? For general surveillance?)? Who would own and control the data collected by AVs as they navigate the City's roads? Can the City use the data to improve its transportation planning? How will AVs be protected from remote hackers?[7]

Did you know?

If AVs were to be adopted by 90% of Toronto citizens today, the result could be annual savings of $6 billion. This includes $1.2 billion from reduced collisions, $2.7 billion out of congestion costs, $1.6 billion from insurance, and $0.5 billion from parking fees and fines.[1]

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Further Reading

City of Toronto

City of Toronto Transportation Services' Official Website for Automated Vehicles: https://www.toronto.ca/automated-vehicles/.

Visit the official website for general background, information on the Interdivisional Working Group, the draft 2019-2021 Tactical Plan, reports to Council, and other initiatives to date.

Other Helpful Resources

Report titled Driving Change: Technology and the future of the automated vehicle (January 2018), prepared by the Standing Senate Committee on Transport and Communications. For a quick summary and infographic, read the news release dated January 29, 2018: https://sencanada.ca/en/newsroom/trcm-driving-change/.

Report titled The Future of Automated Vehicles in Canada (January 29, 2018), prepared by the PPSC Working Group on Connected and Automated Vehicles: http://comt.ca/reports/autovehicle2018.pdf.

Report titled Ontario Must Prepare for Vehicle Automation: Automated vehicles can influence urban form, congestion and infrastructure delivery (October 2016), prepared for the Residential and Civil Construction Alliance of Ontario (RCCAO). http://www.rccao.com/research/files/RCCAO_Vehicle-Automation_OCT2016_WEB.pdf.

Report titled Ontario Must Prepare for Vehicle Automation: How Skilled Governance Can Influence its Outcome (Part 2) (October 2016), prepared for the Residential and Civil Construction Alliance of Ontario (RCCAO). http://www.rccao.com/research/files/RCCAO_Vehicle-Automation_Part-2_OCT2017_WEB.pdf.

The National Conference of State Legislatures (NCSL) Autonomous Vehicles Legislative Database, which provides up-to-date, real-time information about state AV legislation that has been introduced across the United States: http://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx.

Bloomberg Aspen Initiative on Cities and Autonomous Vehicles, an interactive online guide on AV innovation around the world: https://avsincities.bloomberg.org/.

To get in touch or keep up to date, visit: www.toronto.ca/automated-vehicles