SENATE | SÉNAT
CANADA

JANUARY 2018

DRIVING CHANGE

Technology and the future of the automated vehicle

Report of the
Standing Senate Committee
on Transport and Communications

The Honourable David Tkachuk, Chair
The Honourable Dennis Dawson, Deputy Chair
The Honourable Patricia Bovey, Deputy Chair

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PREFACE

"[W]e are approaching the end of the automotive era. […] the end of the line for the automobile because travel will be in standardized modules. The end state will be the fully autonomous module with no capability for the driver to exercise command." – Bob Lutz (former Vice Chairman of General Motors), "Kiss the good times goodbye," Automotive News, November 2017.

At the request of the Minister of Transport, the Standing Senate Committee on Transport and Communications undertook this study, "Driving Change: Technology and the Future of the Automated Vehicle", on the regulatory and technical issues related to the deployment of automated (i.e. driverless) and connected vehicles. The Committee heard from over 78 witnesses from across Canada and the United States, received a number of written submissions from various sectors involved, and participated in many impressive demonstrations of this quickly developing technology.

With the converging automotive and technology industries, modern vehicles already contain considerable levels of automation, including millions of lines of code. New players, including Tesla and Google, have shaken up the automotive industry, and taken major steps towards a driverless and connected future.

We are approaching the end of an era for the traditional, individually-owned, human-driven automobile. In the not-too-distant future, people will be able to summon a driverless taxi from their smartphone and may therefore decide to forego vehicle ownership in favour of these shared automated vehicles.

The trucking sector will also be affected by this technology. Automation and connectivity will allow trucks to drive in "platoons". A driver will be in the first vehicle. The subsequent vehicles, without a human driver, will automatically follow behind the first at a predetermined distance.

These technologies will come with substantial benefits, not the least of which is safety. With human error now causing the vast majority (about 94%) of traffic collisions, there is no doubt that automated and connected vehicles will save lives.

However, these technologies also raise a number of concerns in terms of job losses, privacy, cybersecurity, urban sprawl and infrastructure. In particular, these vehicles collect a vast amount of data and could be the target of hackers who want to use the vehicles for nefarious purposes.

There is an urgent need for all three levels of government to start planning for the arrival of these technologies in order to address concerns and to ensure that Canadians realize the full potential of automated and connected vehicles. Indeed, without such action, governments will be left playing catch-up with this technology.

Given the pressing need for government action, the Committee is making 16 recommendations to the federal government, recommendations we believe will help build a coordinated national strategy on automated and connected vehicles.

On behalf of the committee members, we would like to express our thanks and appreciation to the committee's staff for their work. In particular we would like to thank Jed Chong and Nicole Sweeney, analysts of the Library of Parliament, Victor Senna and Barbara Reynolds, committee clerks, and Lyne Héroux, administrative assistant.

The Honourable David Tkachuk, Chair
The Honourable Dennis Dawson, Deputy Chair
The Honourable Patricia Bovey, Deputy Chair
The Honourable Michael L. MacDonald, member of the Committee

THE COMMITTEE MEMBERSHIP

David Tkachuk
Chair

Dennis Dawson
Deputy Chair

Patricia Bovey
Deputy Chair

Pierre-Hugues Boisvenu

René Cormier

Raymonde Gagné

Rosa Galvez

Diane F. Griffin

Michael L. MacDonald

Terry M. Mercer

Thanh Hai Ngo

Donald Neil Plett

Ex officio members:

Peter Harder, P.C. (or Diane Bellemare),
(or Grant Mitchell)
Larry W. Smith (or Yonah Martin)
Yuen Pau Woo (or Raymonde Saint-Germain)
Joseph Day (or Terry M. Mercer)

Other Senators who have participated from time to time in the study:

Lynn Beyak, Jean-Guy Dagenais, Tony Dean, Norman E. Doyle, Michael Duffy, Art Eggleton P.C., Marc Gold, Stephen Greene, Nancy J. Hartling, Ghislain Maltais, Bob Runciman, Raymonde Saint-Germain, Betty Unger and Ratna Omidvar.

Parliamentary Information and Research Service, Library of Parliament:

Jed Chong, Analyst
Nicole Sweeney, Analyst

Clerk of the Committee:

Victor Senna

Senate Committees Directorate:

Daniel Charbonneau, Procedural Clerk
Barbara Reynolds, Procedural Clerk
Lyne Héroux, Administrative Assistant

ORDER OF REFERENCE

Extract from the *Journals of the Senate*
Wednesday, March 9, 2016:

The Honourable Senator Dawson moved, seconded by the Honourable Senator Moore:

That the Standing Senate Committee on Transport and Communications be authorized to examine and report on the regulatory and technical issues related to the deployment of connected and automated vehicles.
In particular, the study would consider the long-term implications and challenges of these technologies, such as the impacts on privacy, energy, land use, transportation demand and employment; and

That the Committee report to the Senate no later than March 30, 2017, and that it retain all powers necessary to publicize its findings until 180 days after the tabling of the final report.

The question being put on the motion, it was adopted.

Charles Robert
Clerk of the Senate

Extract from the *Journals of the Senate*
Thursday, March 9, 2017:

The Honourable Senator MacDonald moved, seconded by the Honourable Senator Marshall:

That, notwithstanding the order of the Senate adopted on Wednesday, March 9, 2016, the date for the final report of the Standing Senate Committee on Transport and Communications in relation to its study on the regulatory and technical issues related to the deployment of connected and automated vehicles be extended from March 30, 2017 to December 31, 2017.

The question being put on the motion, it was adopted.

Charles Robert
Clerk of the Senate

Extract from the *Journals of the Senate*
Tuesday, December 5, 2017:

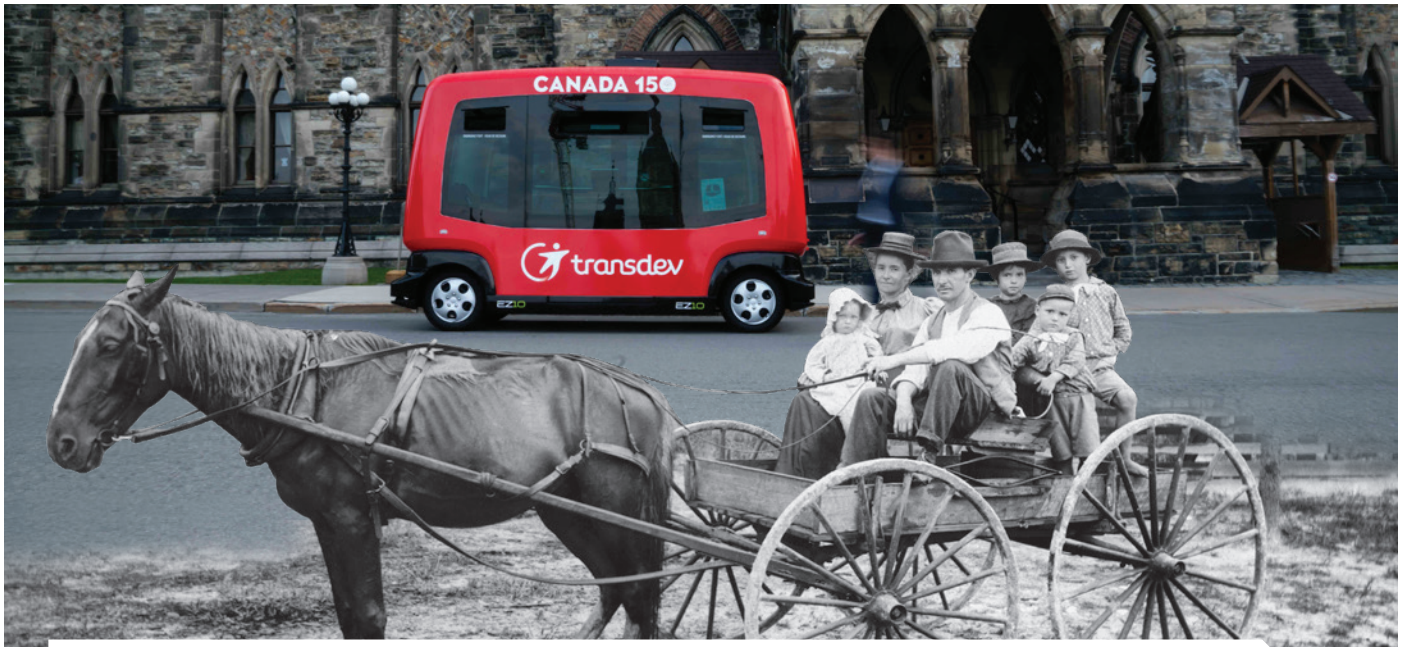
The Honourable Senator Tkachuk moved, seconded by the Honourable Senator Patterson:

That, notwithstanding the order of the Senate adopted on Thursday, March 9, 2017, the date for the final report of the Standing Senate Committee on Transport and Communications in relation to its study on the regulatory and technical issues related to the deployment of connected and automated vehicles be extended from December 31, 2017 to March 1, 2018.

After debate,

The question being put on the motion, it was adopted.

Nicole Proulx
Clerk of the Senate



REPORT HIGHLIGHTS

AUTOMATED VEHICLES

These vehicles make use of sensors and computer analytics to assess their environment and perform varying degrees of driving tasks. There are five levels of automation that range from driver-assistance systems that can help with steering to fully automated, self-driving cars in which passengers need pay no attention to the road.

CONNECTED VEHICLES

There are two types of connected technologies: consumer convenience and infotainment, and vehicle-to-vehicle and vehicle-to-infrastructure communications. In practice, this means your car could receive restaurant recommendations for a given route, get a countdown for when the next traffic light is turning red, or have the car ahead of you warn that you're following too closely.

- Canada is ill-prepared for the fast-approaching future of transportation.
- Early generations of self-driving cars are already on our roads and connected vehicle technology is featured in newer cars, even as researchers work to expand its potential.
- Experts say self-driving transportation could take root in urban areas in as few as 10 to 15 years.
- This could herald the beginning of a new age of transportation, where, for instance, the nearly 1,700 road deaths and 117,000 injuries that occurred in 2015 because of human error become grim relics of a primitive past, and cars weave through the country's streets with a computer-run efficiency.

Senators believe Canada must start preparing for the arrival of this technology now to ensure the country is ready for this upcoming period of technological change.

- At the same time it could also become a nightmare of significant job losses, car hacking and the erosion of personal privacy.
- The Senate Committee on Transport and Communications has been carefully studying the great potential and real risks arising from automated and connected vehicle technology.
- The advantages could be astronomical — the economic benefit from automatic vehicles alone could reach an estimated $65 billion annually in collision avoidance, heightened productivity, fuel cost savings and congestion avoidance, according to one estimate.
- Automated cars could also provide greater freedom to the elderly or people with mobility issues, and they could drastically reduce collision rates.
- On the other hand, many different companies — some from outside the automotive sector — are working on these technologies. Guidelines will have to be developed so all companies share the same expectations with regard to vehicle safety.
- Hundreds of thousands of jobs could also be lost. Sectors that would be threatened by the rise of these technologies, like the taxi, transportation and parking industries, employ over 1.1 million people.
- There are also significant security and privacy concerns.
- Without strong safeguards in place, cyberterrorists could take control of Canadian cars from halfway across the world.
- Less dramatic but no less serious is the question of what corporations will do with the information automatic and connected vehicles provide.
- If you use these technologies, automakers will be able to track your routes, beam targeted advertisements directly to your car and potentially sell your data for profit.
- There is still time for Canada to put in place a robust plan that will maximize the advantages of automated and connected technology while addressing the risks.
- But the government must act now.
- To that end, the committee is making 16 recommendations that will set Canada up for success.

KEY RECOMMENDATIONS

The committee heard evidence that the government's two major players on these issues may be working at cross purposes.

One witness suggested the federal government is trying to move forward with one foot on the gas pedal and one foot on the brake pedal, with Innovation, Science and Economic Development Canada trying to stimulate research and Transport Canada focusing on vehicle safety.

The committee recommends that these organizations create a joint policy unit to co-ordinate federal efforts to implement a national strategy on automated and connected vehicles.

Harmonized policies on the use of automated and connected vehicles on public roads will be important if Canada hopes to attract developers. Robust safety guidelines will also be crucial to protect Canadians.

The committee recommends that Transport Canada work with provincial and territorial governments on a model provincial policy for the use of these vehicles on public roads.

The committee also recommends Transport Canada develop vehicle safety guidelines, including design aspects to be considered when developing, testing and deploying these vehicles on Canadian roads.

Senators believe strong cybersecurity measures are essential to maintain public safety and public confidence in this new technology.

The committee recommends that Transport Canada, the Communications Security Establishment and Public Safety Canada develop cybersecurity guidance based on best practices and recognized cybersecurity principles.

Canadians should have control over their personal information. Their vehicles should not act as spyware; rigorous oversight is required to ensure corporations treat information received from connected and automated vehicles is securely held and not exploited.

The committee recommends that the government table legislation to empower the Office of the Privacy Commissioner to proactively investigate and enforce industry compliance with privacy legislation.

NEXT STEPS

- It is not a matter of *if* but of *when* more sophisticated automated and connected vehicles will arrive on Canadian roads.
- Previous instances of disruptive technology appearing in under-prepared jurisdictions — like now-ubiquitous ride-sharing services — have shown that confusion results from a lack of planning.
- Automated and connected vehicle technology could be beneficial to Canada — but only if the government is willing to do the work to minimize the anticipated problems before they become entrenched.
- Senators will continue to press the government to act on the committee's recommendations so that Canadians can take full advantage of the next generation of transportation.

LIST OF RECOMMENDATIONS

The Committee recommends that:

RECOMMENDATION 1:

Transport Canada and Innovation, Science and Economic Development Canada expeditiously create a joint policy unit to coordinate federal efforts and implement a national strategy on automated and connected vehicles.

RECOMMENDATION 2:

Transport Canada engage with provincial and territorial governments, through the Canadian Council of Motor Transport Administrators, to develop a model provincial policy for the use of automated and connected vehicles on public roads. The department should also involve municipalities in this engagement process.

RECOMMENDATION 3:

Transport Canada strengthen its work on automated and connected vehicles with the United States through the Regulatory Cooperation Council, to ensure that these vehicles will work seamlessly in both countries.

RECOMMENDATION 4:

Transport Canada urgently develop vehicle safety guidelines for the design of automated and connected vehicles. The guidelines should identify design aspects for industry to consider when developing, testing and deploying such vehicles on Canadian roads. The guidelines should also be updated regularly to keep pace with the evolution of automated and connected vehicle technology.

RECOMMENDATION 5:

Innovation, Science and Economic Development Canada allocate the 5.9 gigahertz spectrum that it has set aside for use in dedicated short-range communications systems, while continuing to reserve this spectrum for connected vehicle uses.

RECOMMENDATION 6:

Transport Canada, in cooperation with the Communications Security Establishment and Public Safety Canada, develop cybersecurity guidance for the transportation sector based on best practices and recognized cybersecurity principles. The guidance should include advice on original equipment, replacement equipment and software updates.

RECOMMENDATION 7:

Transport Canada work with Public Safety Canada, the Communications Security Establishment and industry stakeholders to address cybersecurity issues and to establish a real-time crisis connect network, and that Transport Canada report regularly on their progress.

RECOMMENDATION 8:

The Government of Canada table legislation to empower the Office of the Privacy Commissioner to proactively investigate and enforce industry compliance with the *Personal Information Protection and Electronic Documents Act*.

RECOMMENDATION 9:

The Government of Canada continue to assess the need for privacy regulations specific to the connected car.

RECOMMENDATION 10:

Transport Canada bring together relevant stakeholders – governments, automakers, and consumers – to develop a connected car framework, with privacy protection as one of its key drivers.

RECOMMENDATION 11:

Innovation, Science and Economic Development Canada monitor the impact of automated and connected vehicle technology on competition between the various sectors of the automotive and mobility industries, in order to ensure that sectors such as the aftermarket and car rental companies continue to have access to the data they need to offer their services.

RECOMMENDATION 12:

The Government of Canada increase its investments in the research and development of automated and connected vehicles, through a new Innovative and Intelligent Mobility Research and Test Centre, to be located at the existing Motor Vehicle Test Centre. In addition to ensuring that these vehicles are tested in a mix of urban, rural and cold environments, particular consideration should also be given to projects focused on cybersecurity and privacy.

RECOMMENDATION 13:

Innovation, Science and Economic Development Canada work with Networks of Centres of Excellence of Canada (NCE) to reconsider the rule requiring that these networks close down at the end of NCE program funding.

RECOMMENDATION 14:

Transport Canada monitor the impact of AV and CV technologies on automobile insurance, infrastructure and public transit in Canada.

RECOMMENDATION 15:

Employment and Social Development Canada continue to work closely with the provinces and territories in order to strengthen retraining, skills upgrading and employment support for Canadians facing labour market disruption.

RECOMMENDATION 16:

Public Safety Canada and the Communications Security Establishment work closely with the provinces and territories to develop cybersecurity training materials and programs to improve public understanding of cybersecurity issues.

GLOSSARY

Automated vehicle (AV): Vehicles that rely on sensors and computer analytics to sense their environments and perform varying degrees of the driving task. There are six levels of driving automation, ranging from level zero (no automation) to level five (full driving automation).

Connected vehicle (CV): 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.

Dedicated short-range communications (DSRC): A wireless technology that allows rapid communications (up to 10 times per second) between elements of a connected vehicle network within a range of about 300 to 500 metres.[1]

First and last mile in public transit: The trip from home to the closest bus stop or transit station and from the final bus stop or transit station to the final destination.

LIDAR (Light Detection and Ranging): A pulsed laser that measures variable distances. In AVs, the LIDAR bounces these lasers off of objects in its surroundings (such as pedestrians and other vehicles) to map them in 3D so that the AV knows where it is positioned relative to those objects.

Platooning: The use of AV and CV technology to decrease aerodynamic drag by grouping vehicles together and reducing the distance between them, which can allow multiple vehicles to accelerate or brake at the same time.[2]

Spectrum: Airwaves along which wireless signals, from devices such as connected vehicles and smartphones, travel.[3]

1 Jed Chong, *Automated and Connected Vehicles: Status of the Technology and Key Policy Issues for Canadian Governments*, Background Paper No. 2016-98-E, Parliamentary Information and Research Service, Library of Parliament, Ottawa, 29 September 2016.

2 Ibid.

3 Government of Canada, *What is Spectrum?*.

INTRODUCTION

The automotive sector is in a period of rapid technological change, with computers, software, sensors and connected networks being increasingly used to make vehicles safer for drivers and passengers alike. Vehicles can be described as computers on wheels, a revolution akin to the move from the horse and buggy to the automobile.

Low levels of automation and connectivity are already available to Canadian consumers, often in the form of advanced driver assistance systems (ADAS), such as adaptive cruise control and automated parking. More advanced automated and connected vehicle (AV and CV) technology is expected to become available in the near future.

The Conference Board of Canada estimates[4] that the economic benefits of AVs could reach $65 billion annually in collision avoidance, heightened productivity, fuel cost savings and congestion avoidance. However, AV and CV technologies will also pose certain challenges, such as how to protect the increasing amount of data that vehicles collect about drivers, how to ensure the cybersecurity of these vehicles and how to safely manage the transitional period where AVs will share the road with traditional vehicles.

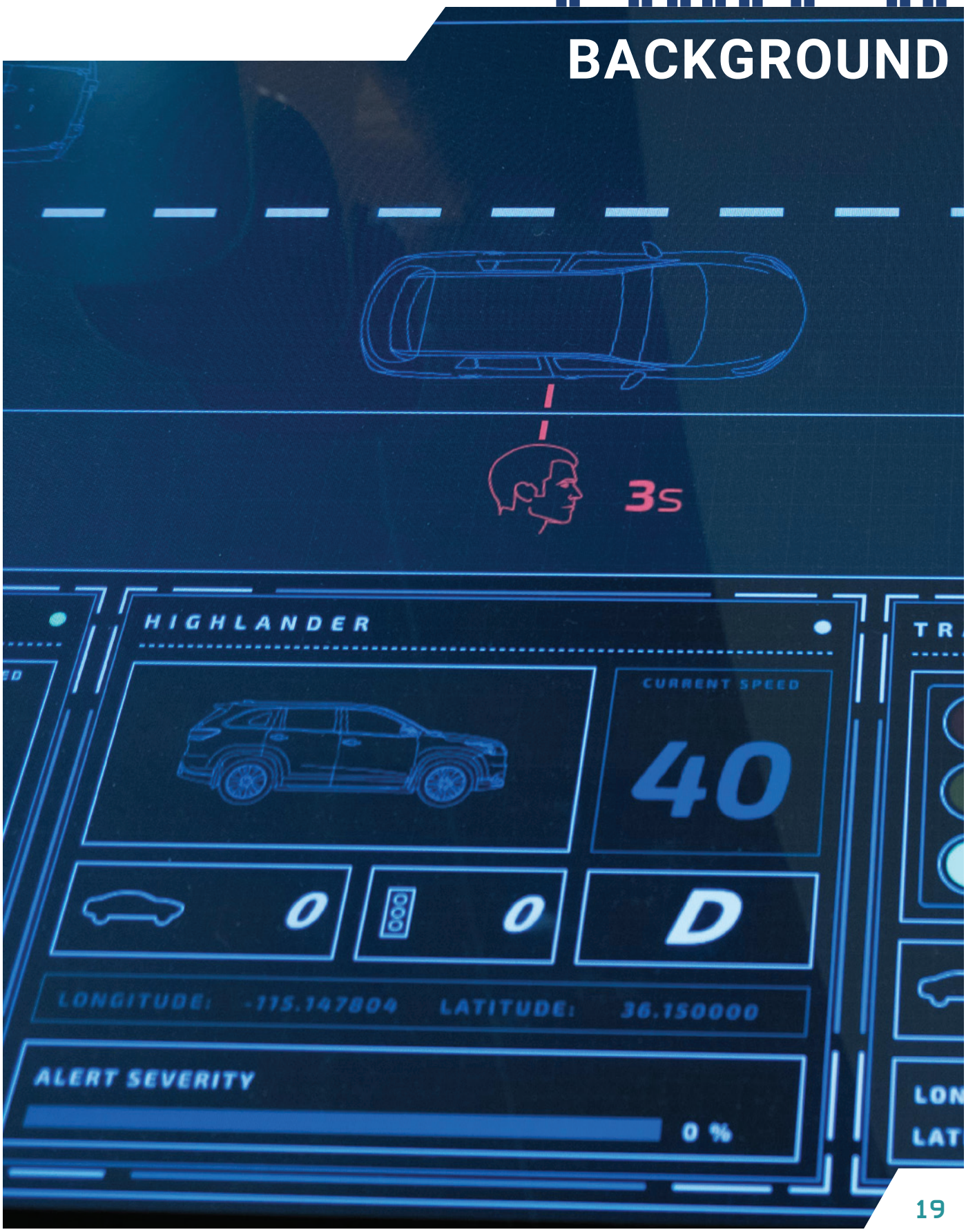
Given both the potential benefits and the challenges of this technology, the Standing Senate Committee on Transport and Communications (the Committee) decided to undertake a study, at the request of the Minister of Transport, of the regulatory and technical issues related to the deployment of AVs and CVs. Over the course of 30 meetings, the Committee heard from 78 witnesses and received numerous written briefs. Witnesses included government representatives from both Canada and the United States (U.S.), as well as representatives from industry associations, civil society and academia.

Part 1 of the report provides background information, explaining what AVs and CVs are, how they can be used, when they are expected to be deployed and their potential advantages and challenges. This background section will also discuss existing initiatives in Canada and other jurisdictions that encourage the deployment of this technology.

Part 2 of the report focuses on the Committee's recommendations regarding the federal government's role in planning for the arrival of AV and CV technologies. This part of the report will examine a number of issues, such as federal leadership on the AV and CV file, vehicle safety regulations, spectrum allocation, cybersecurity, privacy, research and development, infrastructure and public transit.

4 Throughout the report, underlined text indicates hyperlinks to further information online.

PART 1:
BACKGROUND



WHAT ARE AUTOMATED VEHICLES?

AVs – sometimes referred to as autonomous, driverless, or self-driving vehicles – rely on sensors (e.g., radar, LIDAR[5] and cameras) and computer analytics to sense their environments and perform varying degrees of the driving task.[6]

Witnesses from the automotive manufacturing sector explained that they prefer to use the specific level of automation, as established by SAE (Society of Automotive Engineers) International's J3016 Standard.[7] Table 1 provides a simplified overview of this technical standard.

TABLE 1 – LEVELS OF DRIVING AUTOMATION

LEVEL OF AUTOMATION	DESCRIPTION
Level 0: No automation	A human controls all aspects of the driving task.
Level 1: Driver assistance	An advanced driver assistance system (ADAS) helps a human driver with either steering or braking/accelerating, but not both at the same time.
Level 2: Partial driving automation	An ADAS controls both steering and braking/accelerating at the same time, under some circumstances. The human driver must still pay full attention (i.e., monitor the driving environment) at all times and perform the rest of the driving task.
Level 3: Conditional driving automation	An automated driving system (ADS) performs all aspects of driving under specific circumstances. When the ADS is engaged, the human driver is expected to respond appropriately to a request to intervene. The human driver must also perform the driving task outside the circumstances for which the ADS was designed.
Level 4: High driving automation	An ADS can perform all driving tasks and monitor the environment (i.e., the ADS does all of the driving) in specific circumstances. In those circumstances, the human does not need to pay attention.
Level 5: Full driving automation	An ADS can drive the vehicle in all circumstances. The human occupants are merely passengers and are never involved in driving.

Sources: United States Department of Transportation National Highway Traffic Safety Administration, Automated Vehicles for Safety; SAE [Society of Automotive Engineers] International, Surface Vehicle Recommended Practice J3016: Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles, September 2016; and SAE International, Automated Driving: Levels of Driving Automation Are Defined in New SAE International Standard J3016, 2014.

5 Light Detection and Ranging (LIDAR) uses a pulsed laser to measure variable distances. In AVs, the LIDAR bounces these lasers off of objects in its surroundings (such as pedestrians and other vehicles) to map them in 3D so that the AV knows where it is positioned relative to those objects. See: United States National Ocean Service, *What is LIDAR?*; and Tom Simonite, "Self-Driving Cars' Spinning-Laser Problem," *MIT Technology Review*, 20 March 2017.

6 Ontario Centres of Excellence, "How it Works," *Connected Vehicle/Automated Vehicle (CVAV) Program*, 2016. See also Michigan Department of Transportation and Center for Automotive Research, *International Survey of Best Practices in Connected and Automated Vehicle Technologies: 2015 Update*, 7 December 2015.

7 A copy of the standard can be found here: SAE [Society of Automotive Engineers] International, *Surface Vehicle Recommended Practice J3016: Taxonomy and Definitions for Terms related to Driving Automation Systems for On-Road Motor Vehicles*, September 2016.

For simplicity, the Committee uses the term "automated vehicle," or AV, when referring to such vehicles in a general sense.[8] AVs currently available to consumers mostly fall within Levels 1 and 2 of this standard.

Some witnesses, such as Robert Love, Lawyer and Partner at Borden Ladner Gervais LLP, told the Committee that manufacturers may eventually decide to skip level 3 AVs because of concerns over how quickly a human can respond to a request to take over driving. As explained by Mr. Love, such expectations could be "setting the driver up for failure."

To evaluate progress made in the development of AV technology, the Committee undertook site visits to BlackBerry QNX and the University of Waterloo; both of these organizations were part of the first cohort to receive authorization to test AVs under Ontario's regulations. As part of these visits, Committee members were able to observe and experience the technology behind the University of Waterloo's Autonomoose, a level 2 AV equipped with radar, sonar, LIDAR, inertial sensors and vision sensors. Over the course of its research, the university's researchers hope to advance the automation to level 3 and, ultimately, to level 4.

Due to rainy weather, Committee members were unable to see a demonstration of BlackBerry's test vehicle, which is perhaps an illustration of the technical challenges that this technology will have to overcome before it is ready for widespread use.

Two Committee members also joined the Minister of Transport as part of a delegation that met with stakeholders in San Francisco, California in October 2017. Notably, the Committee members participated in a tour of Tesla Motors' manufacturing facility and a demonstration of the company's AV on a public road. Committee members also met with researchers at the Stanford Center for Automotive Research, some of whom were Canadian.

8 SAE International recommends against using terms that make *vehicles*, rather than *driving*, the object of automation.

Members of the Senate Committee on Transport and Communications inspect the Autonomoose, a car outfitted with automated vehicle technology that is being developed by student engineers at the University of Waterloo's Centre for Automotive Research.

Committee members explore BlackBerry's QNX Autonomous Vehicle Innovation Centre in Kanata, Ont. during a June 2017 fact-finding mission.

WHAT ARE CONNECTED VEHICLES?

Witnesses explained to the Committee that there are two types of connected technologies in the automotive sector: (1) consumer conveniences and infotainment from vehicles connected to the Internet (typically through the same mobile network as smartphones), and (2) vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, over dedicated short-range communications (DSRC) systems. Innovation, Science and Economic Development Canada (ISED), as well as their American counterparts, have set aside the 5.9 gigahertz (GHz) wireless spectrum for DSRC systems.

Witnesses from BlackBerry explained to the Committee that there is an ongoing debate about whether DSRC or 5G cellular networks are optimum technologies to use for CV purposes. However, Sandeep Chennakeshu, President of BlackBerry Technology Solutions, suggested that there will likely be a mix of the two technologies: DSRC works well for short-range applications, whereas 5G cellular networks are ideal for applications that require a wide range of coverage.

In September 2016, members of the Committee visited the University of Alberta for a demonstration of CV technology. Members were taken around on a local bus equipped with V2V and V2I technology, which followed a test car (also equipped with V2V technology) provided by Transport Canada. The V2V technology was able to warn the driver of the bus when it was too close to the Transport Canada car. The V2I technology allowed roadside infrastructure to communicate with the bus to warn the driver when the vehicle was entering a collision-prone area. The V2I technology also showed the bus driver a countdown clock for red and green lights at intersections and provided information on weather and traffic.

CVs and AVs are different but complementary technologies. Furthermore, witnesses explained that at higher levels of automation, the distinction between the two technologies may eventually be blurred because V2V and V2I connectivity will allow an AV to have information beyond what the vehicle's sensors can perceive. In fact, some witnesses used the terms CV and AV interchangeably.

AV and CV technologies can be deployed in both individually owned automobiles and in shared vehicles, such as buses and taxis. Witnesses also noted that ride-sharing companies, such as Uber, have been investing heavily in AV and CV technologies, with the hope that people will someday be able to summon a completely driverless taxi from their smartphone.

http://bit.ly/2zGO3Ft

Witnesses from the Canadian Urban Transit Association (CUTA) and Transdev Canada demonstrated an automated minibus on Parliament Hill for Committee members. The bus was a level 3 AV, meaning that there was an operator on board who could take control of the vehicle in the event of an emergency, and the vehicle could operate without a driver only on the route that had been mapped for it in advance of the demonstration.

Certain information needed to be preprogrammed into the vehicle. For example, instead of detecting stop signs through the vehicle's sensors and cameras, the bus was preprogrammed to stop at certain locations (including those where a stop sign was present). The company noted that the bus was not (but could be) programmed to automatically back up if the vehicle in front of it unexpectedly started to do so. The bus did, however, stop when people or other vehicles passed closely in front of it.

Organizing the event proved to be challenging; given the novelty of the technology, there were no procedures in place to allow AVs on Parliament Hill grounds. The logistical challenges of ensuring the safe demonstration of this AV echo, on a smaller scale, the challenges faced by the companies working to demonstrate these vehicles on public roads.

As discussed later in the report, many of the potential benefits and challenges of these technologies will depend on the extent to which they encourage the use of shared vehicles as an alternative to individually owned automobiles.

AUTOMATED AND CONNECTED VEHICLE APPLICATIONS IN THE TRUCKING AND NATURAL RESOURCE SECTORS

In addition to their uses in automobiles and buses, witnesses discussed the use of AV and CV technologies in the trucking and natural resource sectors. Witnesses from the trucking sector highlighted the importance of using the correct terminology when referring to trucks equipped with automation and connected technology. Indeed, witnesses from the Canadian Trucking Alliance and the Atlantic Provinces Trucking Association (APTA) prefer to use the term "semi-automated vehicles" or to discuss specific ADAS technology.

These witnesses suggested that driving is only part of a truck driver's job. As explained by Marco Beghetto, Vice President of Communications and New Media with the Canadian Trucking Alliance:

> *The truck operator is required to do much more than just hold a steering wheel. Among other things, they control access to the vehicle, maintain security, balance loads, secure cargo, manage transportation of dangerous goods, communicate with first responders, conduct pre-trip inspections, perform en route mechanical tasks, communicate with customers and deal with the myriad of border crossing processes.*
>
> *(Marco Beghetto, Vice President, Communications and New Media, Canadian Trucking Alliance, 20 September 2017)*

In other words, witnesses from the trucking sector suggested that there will always be a role for a human driver in trucks, although the role of that truck driver will likely evolve as ADAS technologies are increasingly added to these vehicles.

Witnesses who testified before the Committee anticipate that AV and CV technologies will allow semiautomated trucks to drive in "platoons" (i.e., convoys), where there is a driver in the first vehicle and the subsequent vehicles automatically follow behind the first one at a predetermined distance. Truck platooning is expected to reduce the space taken up by these vehicles on the road, while also allowing the trucks to use fuel more efficiently. Jean-Marc Picard, Executive Director of the APTA, suggested that fuel savings may be as high as 20%, which would mean millions of dollars in savings each year.

Platooning technology will not be without its own unique challenges. For example, witnesses noted that platoons may not work on ice roads because having the trucks close together would likely create a concentration of weight that is too much for the ice roads. Witnesses also noted that truck platoons could make entering and exiting a highway more challenging if multiple truck platoons are in the far right lane.

In addition to demonstrations in the U.S. and Europe, truck platooning technology has been tested in Canada. Franck N'Diaye Bonny, Director General of the Motor Vehicle Test Centre (MVTC) in Blainville, Quebec, told the Committee that Transport Canada and the National Research Council (NRC) conducted a test of truck platooning technology at the MVTC in 2016 as part of a collaborative effort with U.S. stakeholders. According to a brief from the NRC, this particular test found that the combined effect of platooning and aerodynamic trailer devices was measured to be up to 14% in net fuel savings at the shortest separation distance (17.4 metres) between vehicles. The NRC's brief also notes that another round of platoon testing was conducted at the MVTC in August 2017 and that the NRC is currently in the process of analyzing the data that was collected.

The Committee heard testimony from the Central North American Trade Corridor Association

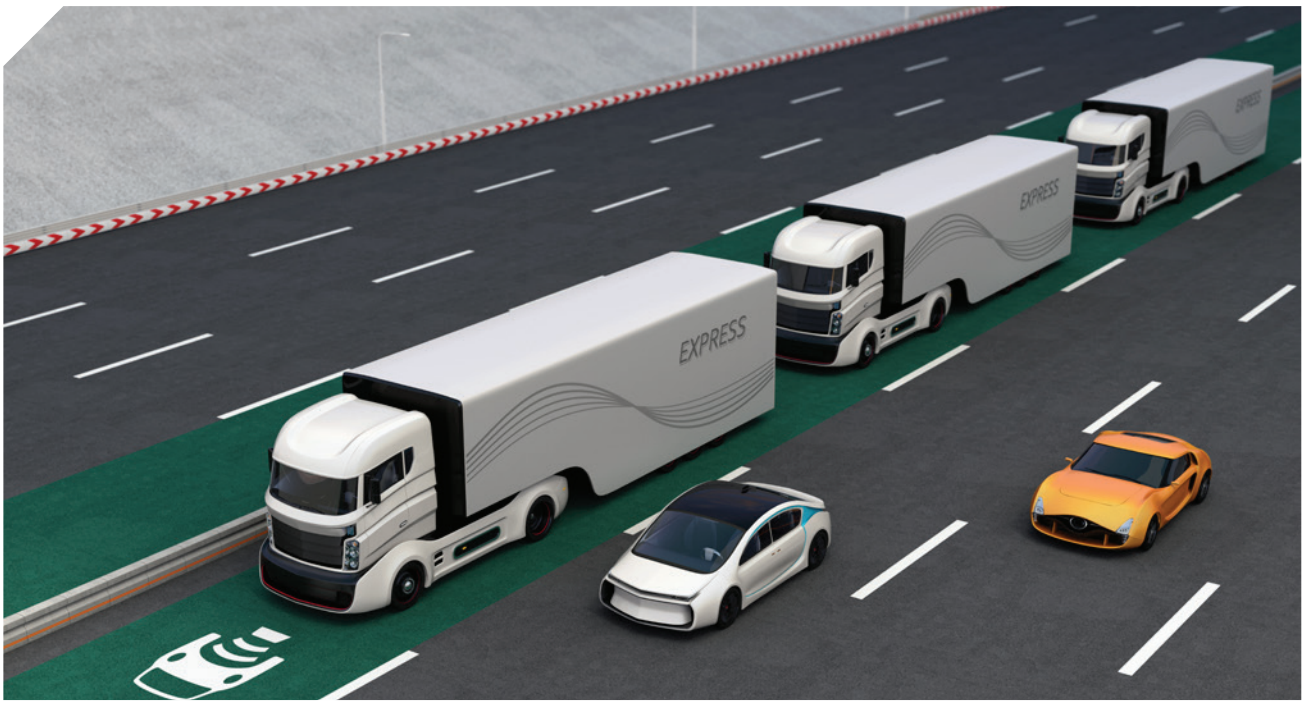
(CNATCA), which is advocating for the creation of an AV-friendly north-south trade corridor that would connect Canada to the central U.S. and Mexico. In addition to automated truck platoons, this corridor would involve autonomous drones in a reserved air corridor above the highway route. The witnesses from CNATCA told the Committee that a similar east-west corridor could also be created. CNATCA is in the process of seeking government funding to conduct a feasibility study of these concepts.

Regarding the natural resources sector, witnesses believe that some of these industries have closed environments – with few pedestrians and other vehicles – that are ideal for testing AV and CV technologies. François Adam, General Manager of the Innovative Vehicle Institute (IVI), told the Committee that his organization has been studying off-road applications for AVs in agriculture, industrial handling and the transportation of people on private land. Frederick Prigge, Research and Development Director of the IVI, added that existing farm tractors are at level 4 automation; once the route is programmed into the tractor's system, it will plow the field and then return without any further human input.

David Michelson, Co-Chair of the Intelligent Transportation Systems (ITS) Society of Canada and Professor at the University of British Columbia, identified Canada's resource roads as an untapped opportunity to test AV and CV technologies. According to Professor Michelson, there are over 620,000 km of resource roads in B.C., which is more than conventional public roads.

Professor Michelson also noted that FPInnovations, the Canadian forestry industry's national research and development organization, has started a program to develop intelligent forestry transportation system architecture that will build upon existing CV technology.

According to a brief from the Saskatchewan Ministry of Highways and Infrastructure, off-road applications in the agriculture and mining sectors could be the most promising areas for AV innovations in the province.



DEPLOYMENT OF AUTOMATED AND CONNECTED VEHICLE TECHNOLOGIES

The Committee heard a variety of predictions about when higher levels of automation and connectivity in vehicles will be available to Canadian consumers. However, the Committee believes that a lack of public acceptance and of policies to support the technology will prove to be more of a barrier to deployment than the technical challenges that AV and CV technologies will have to overcome. In other words, as mentioned by Thomas Small, Director of New Product Development for New Flyer Industries Canada, "the technology will outpace regulation."

Witnesses generally agreed that AVs may first be deployed in fleets (e.g., taxis, buses or delivery vehicles) and/or in environments where they can operate in a closed area (e.g., a university campus, a business park, or – as Committee members saw demonstrated – on Parliament Hill). Kirk Steudle, Director at the Michigan Department of Transportation (MDOT), and Bernard Soriano, Deputy Director of the California Department of Motor Vehicles, noted that automated shuttle buses could be used for the first and last mile of public transit (i.e., the trip from home to the closest bus stop or transit station and from the final bus stop or transit station to the final destination).

> ***The technology will outpace regulation.***
>
> *– Thomas Small*

One of the more optimistic predictions regarding the deployment of AVs on public roads came from Barrie Kirk, Executive Director of the Canadian Automated Vehicles Centre of Excellence (CAVCOE), who suggested that fully autonomous vehicles for use on public roads will be available by about 2020. According to Mr. Kirk, AV technology may first be deployed in taxis.

Similarly, Dominique Lemay, Chief Executive Officer of Transdev Canada, explained to the Committee that lower levels of automation have already been commercially deployed sooner than expected. For example, Mr. Lemay noted that two years ago,

his company thought it was five years away from operating a low-level AV – something that his company is already doing today. Mr. Lemay suggested that the same thing may occur with higher levels of automation, predicting that low-speed level 5 AVs could be as little as five years away.

Other witnesses discussed the technical challenges that AV technology will have to overcome. As explained by Denis Gingras, Professor at the University of Sherbrooke's Laboratory on Intelligent Vehicles:

> *Typically, the environment of a vehicle travelling at 100 kilometres per hour changes every three seconds. That is already enormous and requires real-time applications and systems that perform extremely well and have very rapid response times. There are also many other parameters including the weather, and traffic and road conditions. The result is a multitude of driving scenarios that cannot all be foreseen or anticipated. An automated vehicle cannot be programmed like a traditional system, as we know it today. To handle all these variables we will need an extremely robust system.*
>
> *(Denis Gingras, Professor, Laboratory on Intelligent Vehicles, University of Sherbrooke, 16 May 2017)*

A brief from the Government of the Northwest Territories notes that the region's roads are subject to snow and ice conditions for eight to ten months of the year, which could make it difficult for an AV's sensors to detect its surroundings. Given these various technical challenges, Stephen Beatty, Vice President, Corporate, at Toyota Canada Inc., suggested that a fully autonomous vehicle "is further out than the most optimistic people would argue for."

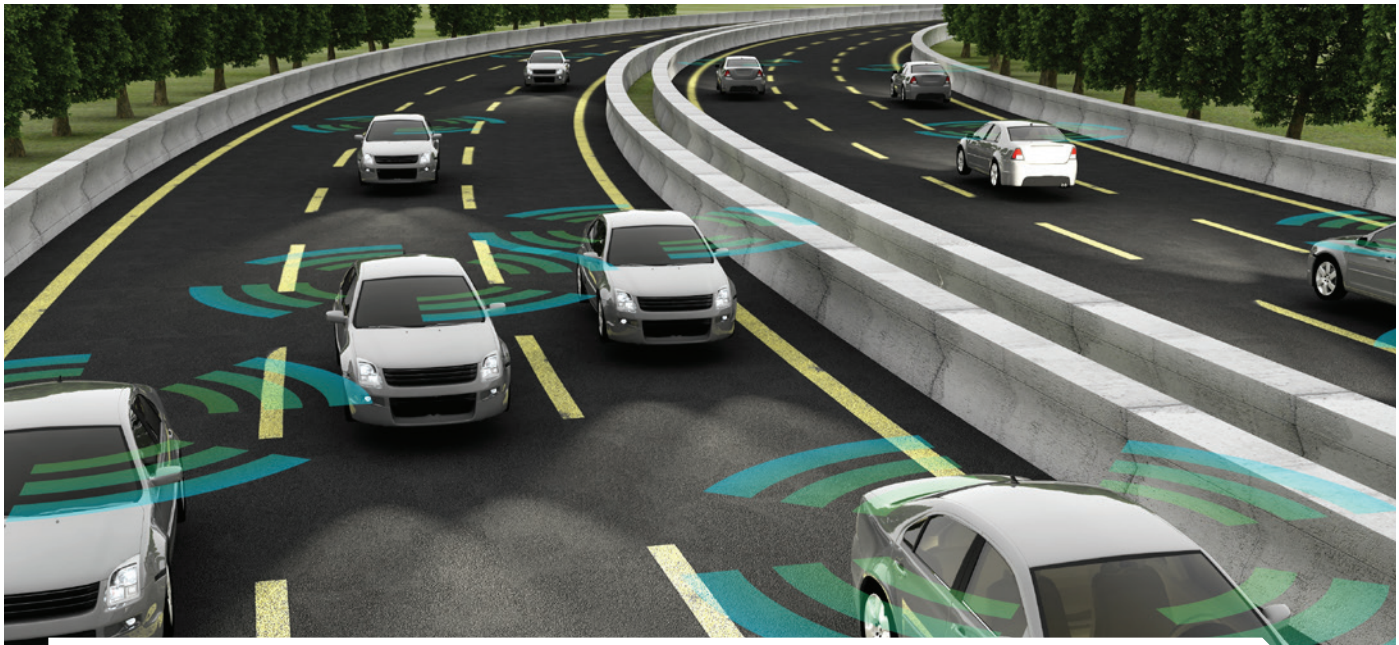
Ross McKenzie, Managing Director of the Waterloo Centre for Automotive Research at the University of Waterloo, suggested that an AV that will transport people within a city could be 10 to 15 years away, but an AV that will transport people between cities is likely 20 to 30 years away.

There is also a distinction to be made between the first availability of AVs and their deployment on a significant scale. Todd Litman, Executive Director of the Victoria Transport Policy Institute explained that it will likely be in the 2040s or 2050s when middle-income families can afford AVs that can operate in all conditions, and even longer before low-income families can afford such vehicles; though, as noted above, AVs may first be deployed as fleets, which may allow a wider range of people to access them via automated taxis or buses.

Witnesses further explained to the Committee that the turnover of the vehicle fleet is typically a slow process, which could mean that AV and CV technologies will be deployed iteratively over the coming decades. For instance, Blake Smith, Director of Sustainability, Environment and Safety Engineering at the Ford Motor Company of Canada, Limited, suggested that 8% of the vehicle fleet changes in a typical year, with the average age of a Canadian vehicle currently sitting at 10 years old. George Iny, Director at the Head Office of the Automobile Protection Association, told the Committee that other automotive technologies, such as air conditioning and automatic transmission, have taken 12 to 30 years to make their way into half of the vehicle fleet.

Given the high costs that AVs are likely to have when they are first deployed, some witnesses cautioned that deployment of this technology may start off slower in rural areas, due to the lower population density over which to spread those costs than in urban areas.

In contrast, some witnesses, such as Mr. Steudle, noted that once rural areas have been mapped for the vehicles, AVs can play a role in improving mobility in these areas. Indeed, Brenda Vrkljan, Associate Professor of Occupational Therapy at McMaster University's School of Rehabilitation Science, told the Committee that AVs and CVs could potentially "revolutionize the promotion of safe and viable mobility, particularly for our aging population living in rural areas."



POTENTIAL ADVANTAGES OF AUTOMATED AND CONNECTED VEHICLES

The Committee heard detailed evidence of the many advantages associated with AVs and CVs. Although all witnesses agreed that AV and CV technologies hold great promise, opinions differed as to how soon – and how effectively – the full potential of the technologies can be realized. Witnesses focused their attention on the key advantages described below.

Safety Benefits

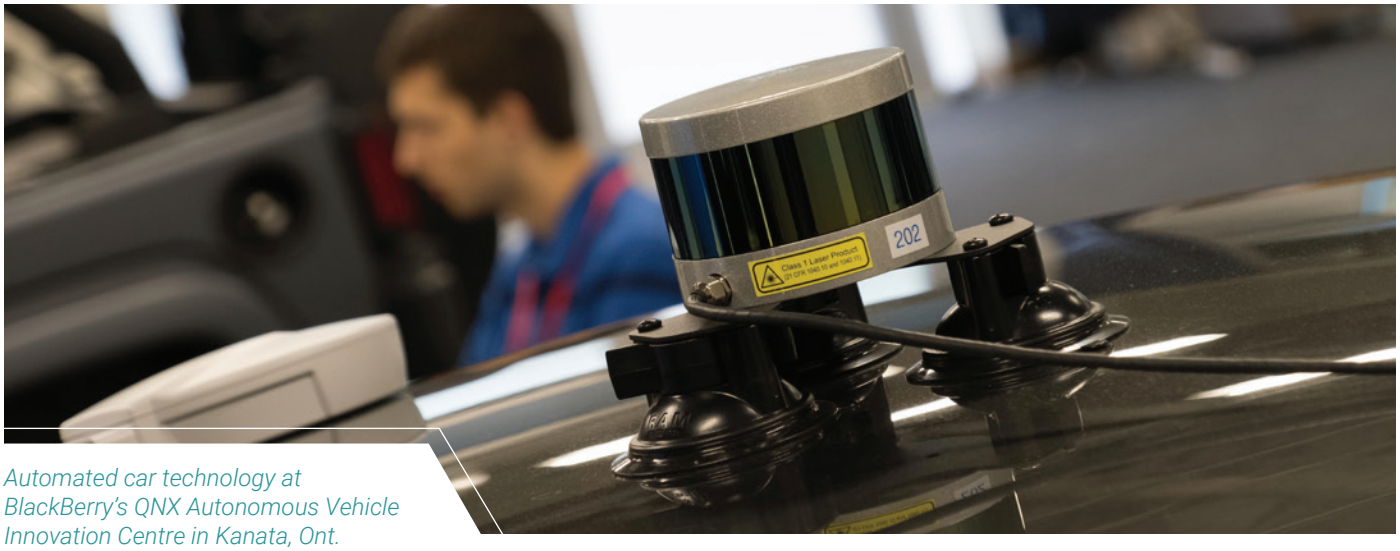
In 1984 Canadian roads bore witness to a staggering 4,120 fatalities and 237,455 injuries whereas, by 2015, these figures had fallen to 1,669 and 116,735 respectively.[9] In spite of this positive trend, much more needs to be done. Road traffic collisions remain the leading cause of preventable deaths for children and teenagers and exert a heavy financial and emotional toll on many families across the country.[10]

The sustained decline in fatalities and collisions over the past four decades can be attributed to a combination of factors, including industrial innovation (e.g., the development of airbag technology) and government action (e.g., the introduction of provincial legislation requiring all vehicle occupants to wear seat belts). The advent of AV and CV technologies provides further opportunities for industry and government to greatly advance road safety.

Today, as many as 94% of traffic collisions are caused by human error and poor decision-making; however, as AV and CV technologies assume an increasing number of driver functions, the significance of human fallibility will decline dramatically. Thus, although witnesses told the Committee that AV and CV technologies would not completely eliminate road traffic accidents, they are nonetheless expected to bring about significant reductions in the number of collisions on Canadian roads.

9 Transport Canada, *Canadian Motor Vehicle Traffic Collision Statistics: 2015* combined with earlier Transport Canada Statistics provided in Insurance Institute, *Automated Vehicles: Implications for the Insurance Industry in Canada*, p. 18.

10 Insurance Institute, *Automated Vehicles: Implications for the Insurance Industry in Canada,* p. 18.



Automated car technology at BlackBerry's QNX Autonomous Vehicle Innovation Centre in Kanata, Ont.

More concretely, a joint study conducted by CAVCOE and the Conference Board of Canada estimates that AVs could prevent up to 80% of all collisions and traffic deaths. While such significant gains will not be immediately evident, David Ticoll, a Distinguished Senior Fellow in the Innovation Policy Lab at the University of Toronto's Munk School of Global Affairs, estimates that achieving AV and CV uptake "in the range of 75% could end nearly all traffic fatalities and injuries."[11]

Manufacturers already offer elements of automated technology in today's vehicles, and many have made bold statements about safety gains that will be made over the next decade.[12] For example, Nissan has announced a "Double Zero" target of zero emissions and "virtually zero" fatalities and serious injuries from collisions involving new Nissan vehicles.

Nevertheless, witnesses also cautioned that the transition period – when roads will be shared by both conventional and automated vehicles – will likely prove very challenging. (Indeed, Ian Jack, a Managing Director at the Canadian Automobile Association (CAA), observed that it was unclear whether roads would be safer or more dangerous during this period). Increased risk during the transition period is, in part, due to the likelihood of drivers becoming over-reliant on technology and taking risks they might otherwise avoid. Moreover, some drivers may simply opt to turn off new safety features.[13]

In spite of concerns about consumer behaviour, representatives from the Insurance Institute of Canada noted that they were "incredibly impressed with the potential of the technology that exists today, let alone the exciting improvements […]that are expected in the years ahead." In the opinion of the Insurance Institute, cooperation between industry and government is key to realizing the safety benefits AV and CV technologies offer:

> *Importantly, it will also take time to educate drivers about how best to use the new technology. Driver training programs need to be redesigned and mandated. The combination of an early mandate requiring the installation of automated features in new vehicles along with driver training could largely eliminate collision fatalities within a decade.*
>
> *(Paul Kovacs, Researcher and Author, The Insurance Institute of Canada, 4 October 2017)*

11 David Ticoll, "Harnessing the mobility revolution to build the Canada that we want," Brief, 11 April 2017, p. 3.

12 Insurance Institute, *Automated Vehicles: Implications for the Insurance Industry in Canada*, p. 23.

13 Ibid., p. 24.

Environmental Benefits

Many witnesses drew attention to the potential environmental benefits AVs and CVs stand poised to offer. In particular, many witnesses explained that AVs have the potential to reduce congestion and, therefore, to reduce the fossil fuel consumption and pollution associated with idling in heavy traffic. This is because, when combined, vehicle automation and infrastructure connectivity can mitigate many of the factors that contribute to congestion, such as traffic incidents and poor signal timing.[14]

In spite of this potential benefit, witnesses noted that congestion reduction is not a foregone conclusion, but depends on the implementation of appropriate government policies. For example, Patrick Leclerc, President and Chief Executive Officer of CUTA, explained that empty AVs returning home or going to pick up other passengers would create "a new type of traffic called zero occupancy vehicles," potentially undermining environmental sustainability goals. In light of this and other concerns, Mr. Ticoll urged government to reflect upon how to control vehicle use when on-demand mobility becomes cheap and convenient. Mr. Litman expressed a similar view and argued that AVs will likely increase total vehicle travel unless efficient road and traffic pricing policies are introduced.

Mr. Litman also raised the issue of social equity. Although he felt that AVs were "very unlikely" to reduce traffic congestion on city streets in the foreseeable future, he explained that dedicated AV lanes could be used to reduce congestion on highways. Nonetheless, he cautioned that publicly funded AV lanes could raise questions of social equity, as only those who can afford to buy AVs would benefit from them (as noted earlier, AVs are initially expected to be relatively expensive).

Mr. Leclerc noted that the environmental benefits of AVs could be further undermined by their short shelf life. Citing a recently published Goldman Sachs study, he explained that autonomous taxis might only have a depreciating shelf life of three years, and zero residual value. If, as predicted by some, "transport as a service" overtakes private car ownership, it might follow that more cars would be replaced on a more regular basis.

The environmental benefits flowing from increased automation and connectivity are expected to be enhanced by a concomitant rise in the use of electric vehicles. Several witnesses, including David Paterson, Vice President of Corporate and Environmental Affairs, General Motors of Canada Company (GM), expressed the view that electric propulsion would be the future of mobility. To that effect, according to officials from Natural Resources Canada (NRCan), a trend toward greater transport electrification could play a significant role in helping Canada lower its transportation sector's greenhouse gas emissions.

Human and Social Benefits

A number of witnesses discussed the role of AVs and CVs in fostering social inclusion. A socially inclusive society is one that provides all people and communities with the opportunity to participate fully in political, cultural, civic and economic life. Research suggests that inclusive societies foster greater social cohesiveness and better standards of health, while social exclusion and lack of community interaction are associated with poorer health outcomes and earlier death.[15]

Social exclusion affects a wide range of individuals and communities, although certain groups, including seniors and persons with work-limiting disabilities, are at particular risk. While many factors contribute to social exclusion, inadequate transportation has been identified as a key contributory cause. This is because an inability to access or use personal or public transport can leave people unable to access health services, employment

14 See discussion in David Ticoll, *Driving Changes: Automated Vehicles in Toronto*, 15 October 2015, para. 5.5.

15 Healthy Spaces and Places, *Social Inclusion*.

opportunities and social activities. The problem can be particularly acute in rural areas.

The Committee heard evidence about the potential that AV and CV technologies can offer both to those who have never been able to drive and to those who are no longer able to drive. Professor Vrkljan described the "devastation" some of her patients experienced when they had to relinquish their driver's licence and noted that driving cessation has been linked with "social isolation, decreased health status, higher rates of depression and even institutionalization." She recognized that AV and CV technologies have the potential to promote "safe and viable mobility," particularly for Canada's rural seniors.

That said, witnesses also agreed that AVs and CVs do not constitute a panacea for seniors and people living with disabilities. Bob Brown, Transportation Committee Chairperson with the Council of Canadians with Disabilities, explained that not all transportation-related difficulties could be overcome by technology alone. By way of example, he pointed out that many passengers with disabilities require assistance to operate a vehicle restraint system while some experience difficulty completing a payment transaction independently. In addition, some witnesses observed that AVs would need to be affordable for the communities they are being touted to benefit.

Nevertheless, witnesses stressed that many of these difficulties could be mitigated by incorporating universal design principles into AVs and CVs. Universal design requires products to be usable by all people – to the greatest extent possible – without the need for adaptation or stigmatizing solutions. Mr. Brown told the Committee that universal design principles need to be incorporated not only in vehicle design, but also in the design of related infrastructure, such as electric vehicle charging stations.

Improved mobility is expected to flow not from privately owned AVs alone, but from the development of ride-sharing services. In evidence provided to the Committee, Uber explained that it was looking to form public-private partnerships with government to incentivize drivers to better accommodate the needs of people with disabilities. Similar projects are already under way in other jurisdictions: for example, in September 2016, the Massachusetts Department of Transportation launched a pilot program with Uber and Lyft to provide transportation services to paratransit riders.

Equally, witnesses pointed out that on-demand shared mobility services could improve mobility for communities with limited access to public transit. Rick Baker, President of the Ottawa Chapter of CARP (formerly known as the Canadian Association for Retired Persons), noted that many Canadians of all ages drive not by choice, but because "there are no reasonable alternatives." Mr. Leclerc suggested that on-demand electric AV shuttles could mitigate this problem by providing local authorities with a more affordable alternative to traditional transit. A concrete example of this type of initiative is the ride-sharing transit partnership established between Uber and the town of Innisfil, Ontario.

As will be discussed later in this report, these new technologies could be integrated into existing public transit systems while also providing new modes of transport that can be incorporated into the traditional public transit network.

Economic Benefits

The Committee heard extensive testimony about the economic benefits AV and CV technologies will potentially deliver. However, as there is considerable uncertainty as to when AVs will achieve full market penetration, and about how they will affect the economy when fully adopted, witnesses often displayed caution in providing detailed projections and estimates.

Committee deputy chair Senator Dennis Dawson, left, and committee member Senator Art Eggleton take a spin around Parliament Hill in an automated shuttle as part of a demonstration in September 2017.

Nevertheless, several witnesses cited the aforementioned Conference Board of Canada estimate that the cumulative potential benefits for Canada could stand at around $65 billion per year. A brief submitted by Brian Flemming of the Van Horne Institute (one of the co-authors of the Conference Board of Canada report) attributed these potential savings to collision avoidance, fuel cost savings, congestion avoidance and heightened productivity. This heightened productivity would be due to individuals spending less time in their cars, but also to cars being put to more productive use (according to an NRCan official, today's cars spend about 96% of their time parked).

Over and above individual productivity gains, witnesses also discussed the global productivity gains that AV and CV technologies hold for certain sectors of the economy. For example, Mr. Prigge explained that AV and CV technologies could improve productivity in the mining, farming and forestry sectors, while Mr. Ticoll predicted increased productivity and growth in the technology, automobile, retail and transportation sectors.

Noting that Canadian households currently spend $11,000 per year on transportation, Mr. Flemming's brief informed the Committee that AVs and CVs would lead to significant savings for consumers. In a similar vein, Mr. Ticoll suggested that AVs and CVs would reduce the total cost of vehicle ownership and operation by 50% or more. In contrast, several witnesses, including Mr. Litman, observed that AVs will not be affordable for middle- and low-income families for the foreseeable future.

POTENTIAL CHALLENGES OF AUTOMATED AND CONNECTED VEHICLES

The Committee also heard considerable evidence about the potential challenges associated with AVs and CVs, although many stressed that careful planning, sound decision-making and strong federal leadership could mitigate the worst effects. Witnesses focused their attention on the following key challenges:

Job Loss

Disruptive technologies such as AVs and CVs are shifting the socioeconomic landscape and generating concern about job loss and economic inequality around the world. While the effect of the AV revolution on the Canadian economy is not yet fully understood, Mr. Ticoll stated that it could "lead to job losses in sectors or occupations that employ over 1.1 million Canadians." Witnesses observed that direct employment displacement would affect industries such as:

- Truck and courier service drivers
- Taxi drivers, bus drivers and snowplow drivers
- Traffic police and traffic wardens
- Driving instructors
- Tow truck drivers and autobody repair mechanics
- Health care workers and lawyers (due to a reduction in collisions)
- Auto insurance agents and salespeople
- Parking attendants
- Gas station employees

While all witnesses agreed that jobs would be lost, some anticipated that losses would be partially offset by existing employees carrying out new tasks. For example, Chief Superintendent Eric Stubbs, Director General of National Criminal Operations in Contract and Aboriginal Policing with the Royal Canadian Mounted Police, suggested that a redistribution of resources was more likely than job losses in policing. In a similar vein, Jonathon Will, Director General of the Economic Policy Directorate in the Strategic and Service Policy Branch of Employment and Social Development Canada (ESDC), observed that new jobs could be created within an affected sector, suggesting, for example, that the haulage sector may require new workers to oversee a fleet of self-driving trucks. In addition, some witnesses believed the effects would not be felt in the immediate future. Wendy Doyle, Co-Chair of the Canadian Council of Motor Transport Administrators (CCMTA) AV Working Group, made the following observation:

> *If we look at the commercial industry, because of the complex task of moving those large loads it will take technology a long time to replace all the requirements a driver is required to do. I mentioned earlier a few of the cargo securement and maintenance requirements on commercial vehicles. If the lights go out or brake issues happen, the human gets under and fixes that. That would still be an expectation because we still want to ensure they are safe vehicles on our roads, whether or not they are highly automated. There's still a place for commercial drivers. The technology will be replacing a portion of the driving task. I believe it will be a ways before it will impact the work of commercial drivers. We also know there's a shortage in commercial drivers as well, so that's a benefit.*
>
> *(Wendy Doyle, Co-Chair, CCMTA, Automated Vehicles Working Group, Alberta Transportation, Government of Alberta, 5 April 2017)*

Furthermore, witnesses argued that in some instances the new technologies could address current labour market shortages. For example, witnesses from the trucking sector noted that there is expected to be a shortfall of between 25,000 and 30,000 drivers by 2024, a problem that may be attenuated by the advent of AVs and CVs.

In contrast, other witnesses were less optimistic. Mr. Ticoll stated that it was "hard to see how the net outcome would be positive" and others demonstrated the vulnerability of particular skill sets. For example, Tony Qiu, Professor in the Faculty of Engineering at the University of Alberta, told the Committee about a pilot project in which a holiday resort was trialling an automated guest shuttle service. Although there was no net job loss, as the company hired maintenance technicians to service the AV, the driver's job was still lost.

Finally, Phil Benson, a lobbyist for Teamsters Canada, highlighted the issue of displaced pensions and retirement benefits for individuals working as drivers. In a brief submitted to the Committee, he explained that, if the arrival of AVs results in fewer licensed drivers working and contributing to pension plans, "there is a greater possibility that those very plans could falter due to lack of funding."

> ***"There's still a place for commercial drivers. The technology will be replacing a portion of the driving task."***
>
> *– Wendy Doyle*

Privacy

Many witnesses remarked that AVs are fuelled by data. The Privacy Commissioner of Canada, Daniel Therrien, explained to the Committee that there are two main streams of data:

> *The first is "telematics" – the sensors which capture a broad expanse of information about vehicle systems. From this data, further information can be extrapolated about the vehicle's driver, including how and where they drive. The second stream comes from "infotainment systems." As the name suggests, these are conduits for information related to navigation, traffic, weather, or entertainment, such as streaming audio. These systems can be paired with a driver's phone to enable hands-free communication, giving the system access to the user's contact list, as well as incoming calls, text messages and emails.*
>
> *(Daniel Therrien, Privacy Commissioner of Canada, Office of the Privacy Commissioner of Canada, 28 March 2017)*

Carmakers can use data generated by their telematics system for product improvement and other beneficial purposes. For example, Mr. Adam explained to the Committee that manufacturers use the data to develop the "neural networks" that will drive the AVs of the future. In addition, Mr. Adam explained that data can be used to analyze accidents and better understand traffic flow. As such, some witnesses, including Mr. Adam and Mr. Smith, argued that data can be used to serve the public interest by allowing the mobility ecosystem to operate more efficiently.

However, as explained by the British Columbia Freedom of Information and Privacy Association (BC FIPA), data generated by AVs and CVs can also be used to create individual user profiles and categorize customers for targeted marketing purposes.[16] Mr. Jack told the Committee that automakers were amassing vast quantities of data "with the hopes of monetizing it" and cautioned that new entrants to the market would move even faster than traditional automakers to exploit the financial opportunities consumer data presents.

Given the potential financial opportunities associated with consumer data, witnesses raised important questions of data ownership. Mr. Jack drew the Committee's attention to a survey conducted by KPMG that found 84% of consumers wanted direct monetary benefit in exchange for their data while 45% of auto executives believed they need not offer anything in exchange for the data.[17] Several witnesses suggested that, in discussions of data ownership, it is important to distinguish between data essential to the functioning of the car and data gathered for other purposes.

Over the course of its hearings, the Committee heard repeated concerns about the adequacy of the processes used by auto manufacturers and their partners to inform consumers of how their data was being used and with whom it was being shared. Several witnesses, including the Privacy Commissioner, also expressed concern that rental car agencies were not wiping customer data from rental cars when vehicles were returned to them. Tomi Gerber, Assistant Vice President of Government and Public Affairs with Enterprise Holdings, acknowledged this problem and explained that her industry was working on the issue with manufacturers.

16 Philippa Lawson, Brenda McPhail and Eric Lawson, *The Connected Car: Who Is in the Driver's Seat? – A study on privacy and onboard vehicle telematics technology*, BC FIPA, Vancouver, 2015, p. 29.

17 KPMG, *Global Automotive Executive Survey 2017*, p. 39.

Cybersecurity

Data generated by AVs and CVs is not only useful to automakers and their partners, but can also be used for more nefarious purposes by hackers. Scott Jones, Deputy Chief of IT Security with the Communications Security Establishment (CSE), explained the cybersecurity threat in the following terms:

> *The convergence of these technologies has the potential to provide many economic and social benefits for Canada and Canadians, from improving the movement of goods and services to road safety. At the same time, it risks exposing us and making us more vulnerable to cyber threats from nation-states, criminals, terrorists and hackers seeking to exploit those same technologies. The motivations of these cyber actors vary widely, from financial gain and creating havoc to just doing it because they can.*
>
> *(Scott Jones, Deputy Chief, IT Security, CSE, 4 April 2017)*

Mr. Jones observed that Canadians often underestimate cybersecurity threats, as they do not view the consequences of security breaches as affecting their everyday lives. He noted, for example, that if a hacker steals money from an individual's bank account, the bank will usually compensate the customer for his or her loss. As the consequences of a cyber-attack on an AV or CV may be more immediate, Mr. Jones contended that the deployment of AVs might help consumers grasp the severity of the cybersecurity threat and cause them to reflect on the consequences of failing to take adequate precautions. He noted that in-depth stakeholder dialogue would be needed to strike the appropriate balance between security and consumer convenience.

While recognizing the seriousness of the cyber threat, several witnesses expressed confidence that cybersecurity was a priority for industry. Mr. Chennakeshu told the Committee that automakers and their suppliers were acutely aware that any failure to ensure the safety and security of their vehicles would negatively impact the adoption of AVs and CVs and cause harm to their reputations. Mr. Chennakeshu also informed the Committee that Blackberry has developed a framework to deliver holistic cybersecurity solutions.

Mr. McKenzie explained that cybersecurity is being "actively and aggressively pursued and investigated" by researchers. For example, the Committee heard evidence about technologies, such as blockchain and public key infrastructure (PKI), that can help ensure the

integrity of the mobility ecosystem. In addition, Mr. McKenzie noted that technologies exist to facilitate the detection of suspicious activity, although he acknowledged that no technology was foolproof. Still, Professor Qiu told the Committee that the primary challenge lies not in overcoming technical obstacles but in ensuring that appropriate policies are developed to support the measures.

In terms of industry activity, Mr. McKenzie told the Committee that GM has a cybersecurity unit that is working with "white hat" hackers[18] to better understand the mindset of would-be hackers. Mark Nantais, President of the Canadian Vehicle Manufacturers' Association, told the Committee that the automotive industry established an Automotive Information Sharing and Analysis Centre (Auto ISAC) in July 2015 to identify and share information on potential cyber threats and to safeguard electronic systems and networks. Mr. Paterson also discussed the Auto ISAC and the importance of sharing information to ensure safety. He stressed that automakers and their suppliers did not seek to gain a competitive advantage in matters relating to cybersecurity.

Urban Sprawl

The widespread deployment of AVs and CVs is also expected to change the way in which cities grow and develop. Witnesses discussed two principal trends: increased urban sprawl and increased urban densification. An urban densification model envisages land no longer required for parking lots and garages being reclaimed for housing, while the increased urban sprawl model assumes that people will tolerate longer commutes if they are able to work productively during their journey.[19] These models were not considered to be mutually exclusive. Witnesses also pointed out that land no longer required for parking could be used for purposes other than housing, such as pedestrian walkways, cycle paths and green spaces.

Overall, witnesses suggested that the exact manner in which these advantages and disadvantages occur will vary depending on how higher levels of automation and connectivity are deployed, particularly in regards to the debate about shared versus individually owned vehicles.

Infrastructure

As detailed later in the report, witnesses discussed the extent to which new infrastructure would be needed to ensure the successful deployment of AV and CV technologies. While AV manufacturers aim to build vehicles that can function with existing infrastructure, witnesses suggested that new infrastructure could maximize the potential of these vehicles in the long run. Witnesses identified decisions about who will fund this infrastructure and the integration of AV and CV considerations into infrastructure planning as key challenges.

18 "White hat hackers" is a term used to refer to computer security experts who conduct penetration testing in order to ensure the security of a company's information systems.

19 Brian Flemming (the Van Horne Institute), "*The Automated Vehicle: The Coming of the Next Disruptive Technology*," 28 January 2016, p. 8.

An automated vehicle built by French company Transdev took committee members and the federal transportation minister around the grounds of Parliament Hill during a demonstration in September 2017.

EXISTING INITIATIVES IN CANADA

In general, the federal government is responsible for regulating the safety of vehicles, whereas provincial and territorial governments are responsible for regulating the roads where those vehicles are used. As will be shown later in Part 2 of the report, the federal government can also play a role in a number of other issues related to AVs and CVs.

Witnesses told the Committee about the work that is already under way, both federally and provincially, to prepare for the arrival of AV and CV technologies.

Federal Government

The Minister of Transport suggested this study topic to the Committee, in order to help develop Transport Canada's response to AV and CV technologies. According to many witnesses, that work is already under way.

Witnesses also told the Committee that Transport Canada is working with the U.S. on the AV and CV file through the Regulatory Cooperation Council (RCC). The RCC has a CV working group and a motor vehicle safety standards working group, both of which are working on issues related to AVs and CVs.

Transport Canada's MVTC in Blainville, Quebec, performs tests to ensure that vehicles comply with Canadian safety standards.[20] MVTC also does research tests with Transport Canada to help the department develop new (or modify existing) standards. Vehicle manufacturers can also hire the MVTC to perform compliance tests to ensure that their vehicles meet Canadian safety standards. As mentioned earlier in the report, Transport Canada was part of a partnership that tested truck platooning technology at the MVTC.

20 The MVTC is owned by Transport Canada, but PMG Technologies Inc. is contracted to operate the facility.

Officials from ISED discussed the Automotive Supplier Innovation Program and the Automotive Innovation Fund, both of which support research and development in the automotive sector and could be used for AVs and CVs.

Witnesses also discussed ISED's $950 million Innovation Superclusters Initiative, a program that aims to "strengthen clusters of existing commercial strength, pulling in a range of highly innovative industries, small and medium-sized enterprises (SMEs) as well as industry-relevant research talent, to create the conditions required to develop a supercluster that reflects Canadian excellence and world-class leadership." The shortlist of applicants invited to the second phase of the application process includes an "AI-Powered Supply Chains Supercluster" in Quebec and a "Mobility Systems and Technologies for the 21st Century Supercluster" in Quebec, Ontario, B.C. and Atlantic Canada.

A brief from the NRC highlights the Fleet Forward 2020 Program, which aims to improve fleet efficiency and reduce the emissions of heavy-duty vehicles. The aforementioned tests of truck platoons at the MVTC were part of this NRC program. Under this program, the NRC has also tested CV technology that alerts local road traffic of an approaching train before they reach a rail grade crossing.

The brief also notes that the NRC plans to open a centre for automotive manufacturing collaboration at their facility in London, Ontario. Scheduled to be operational in April 2018, this collaborative workspace would help automotive manufacturers to adopt advanced manufacturing approaches and to manufacture with new materials and technologies, such as AVs and CVs.

As noted in a brief by Mr. Ticoll, Budget 2017 proposed $125 million for the Canadian Institute for Advanced Research (CIFAR) to develop a Pan-Canadian Artificial Intelligence (AI) Strategy. The CIFAR website notes that the strategy aims to increase the number of AI researchers and skilled graduates and to create centres of scientific excellence in the three parts of Canada (Edmonton, Alberta, the Toronto-to-Waterloo corridor in Ontario, and Montréal, Quebec) with existing clusters of AI expertise.

Witnesses also highlighted Infrastructure Canada's Smart Cities Challenge, through which the federal government "will work in collaboration with cities and communities that are ready to innovate and take risks – providing financial and in-kind support for their smart cities transformation." Three rounds are planned for the program, and each round will include one large prize of $50 million, two prizes of $10 million for mid-sized communities, one prize of $5 million for a small community and one prize of $5 million for an Indigenous community. Professor Qiu told the Committee that this challenge is "a good way to encourage the early adoption or early pilot test of automated vehicles or connected vehicles."

A brief from the Natural Sciences and Engineering Research Council of Canada (NSERC) suggests that Canadian researchers have also received federal funds for AV and CV research. From 2007 to 2016, NSERC awarded $40,249,696 as part of 327 individual grants to Canadian researchers working on developing and testing AV and CV technologies.

A brief from the Social Sciences and Humanities Research Council of Canada (SSHRC) states that since 2007, the council has awarded $5,201,115 in grants to five research projects with a component that investigates AVs and/or CVs and their economic, legal, social or policy implications. The SSHRC notes, though, that most of that funding ($5,054,750) went to two major initiatives – the AUTO21 network and Automotive Partnerships Canada – that included research projects on various subjects, making it unclear precisely how much of that funding was spent on research of AVs or CVs.

Committee members listen as representatives from BlackBerry's QNX autonomous vehicle centre explain their work. Senator Rosa Galvez, fourth left, deputy chair Senator Dennis Dawson, centre, and Senator Terry Mercer, third right, were among the committee members who undertook a fact-finding mission to the Kanata, Ont. facility in June 2017.

Provincial and Territorial Governments

Canadian provinces and territories have also been working on AV and CV issues through the Council of Ministers and Deputy Ministers Responsible for Transportation and Highway Safety (CoMT). The aforementioned CCMTA, a sub-committee of the CoMT, coordinates federal, provincial and territorial matters dealing with the administration, regulation and control of motor vehicle transportation and highway safety. As explained to the Committee by a representative from the CCMTA,

> *We act as a forum to bring our provinces, territories and the federal government together so we can share, coordinate and look at matters of jurisdictional and national importance and to be able to raise issues among our members to ensure that we can advance ideas and find solutions that have the best impact. As a forum, we seek to ensure national harmonization wherever possible, but also to recognize the provincial, territorial and federal autonomy that rests within each of those jurisdictions.*
>
> *(Allison Fradette, Executive Director, CCMTA, 5 April 2017)*

In June 2014, the CCMTA established a working group, co-chaired by provincial officials from Alberta and B.C., to develop guidelines and share best practices regarding the deployment of AVs on public roads. Similarly, the CoMT's Policy Planning Support Committee established a working group, co-chaired by Transport Canada and provincial officials from Ontario, to monitor CV and AV issues in order to share best practices and identify links to existing work being done on these issues.

To date, Ontario is the only province that has introduced an AV regulation. Ontario Regulation 306/15 creates a 10-year pilot program to allow the testing of AVs. This program allows for the use of AVs for testing purposes only, and program participants must meet certain eligibility requirements and submit an application to the province's Ministry of Transportation.

In terms of CVs, the Government of Alberta is one of the many partners, including the City of Edmonton and Transport Canada, involved in the aforementioned University of Alberta research centre visited by members of the Committee. An affiliated CV research network exists at the University of British Columbia (UBC), and the British Columbia Ministry of Transportation and Infrastructure participates in that UBC network.

The British Columbia Ministry of Transportation and Infrastructure also noted, in its written brief, that the ministry has an Autonomous Vehicle Working Group that is monitoring progress in the AV and CV field. The Insurance Corporation of British Columbia is also monitoring AV and CV issues.

A brief submitted by Manitoba Infrastructure suggests that the province has adopted a "wait-and-see" approach for the short term, given the unclear status and trajectory of AV and CV technologies. As a result, the province has not yet undertaken any major initiatives on this file, though officials are actively monitoring the development of this technology and analyzing best practices from other jurisdictions. For example, Manitoba Infrastructure has created a working group with Manitoba Public Insurance, the province's Crown corporation for automobile insurance, in order to examine AVs in the provincial context and share information.

Similarly, a brief submitted by the Saskatchewan Ministry of Highways and Infrastructure notes that "the Province of Saskatchewan has been monitoring the national and international development and research of AVs and CVs, and has had internal discussions about their future use and possible impact." The brief also notes that the cities of Saskatoon and Regina have started initial discussions with SaskTech, a group of Saskatchewan technology companies that hope to create a test bed for AVs and CVs operating under extreme weather conditions in rural and smaller urban environments.

According to a brief submitted by the Government of Newfoundland and Labrador, the province is an active participant in forums like the CCMTA and the CoMT, where issues related to AVs and CVs have been thoroughly discussed.

The Committee also received a brief from the Prince Edward Island Department of Transportation, Infrastructure and Energy. According to this brief, the provincial government has not implemented any initiatives related to AVs and CVs, but is "following, with interest, any initiatives that other jurisdictions are entertaining or implementing."

Finally, a brief submitted by the Government of the Northwest Territories suggests that they have not implemented any initiatives related to AVs and CVs, but are "continuing to monitor national and international trends and developments regarding AVs and CVs."

Committee deputy chair Senator Dennis Dawson speaks with federal Minister of Transport Marc Garneau at an automated vehicle demonstration on Parliament Hill in September 2017.

EXISTING INITIATIVES IN OTHER JURISDICTIONS

United States

Officials from the U.S. Department of Transportation (U.S. DOT) discussed their country's national AV policy, originally released in September 2016 and updated in September 2017 based on stakeholder feedback. According to these officials, the policy focuses on automation levels 3 to 5 and provides voluntary guidance on 12 priority safety design elements for manufacturers to consider in their AVs.

U.S. DOT officials told the Committee that their government has taken the voluntary approach – identifying key safety design elements without mandating how industry addresses those elements – in order to allow flexibility for innovation. According to these officials, it would be too soon to put forth mandatory regulations in this area, given the early stages of AV technology. In their testimony to the Committee, officials from state governments in Arizona and Michigan echoed this idea, noting that it is also important to balance safety and innovation considerations when regulating the use of AVs on public roads.

Another aspect of the U.S. DOT's national AV policy is a set of best practices for state governments to use in their AV legislation (known as the "Model State Policy" in the original version of the U.S. DOT's guidance). According to the National Conference of State Legislatures, 21 states and Washington, D.C. have passed AV legislation, and the governors of an additional four states have issued executive orders on AVs.

Witnesses also told the Committee that various AV-related bills are currently working their way through the U.S. Congress, though at the time of writing this report, none had completed the legislative process.

In terms of CVs, the U.S. DOT issued a notice of proposed rule-making in 2016 for the establishment of a new federal motor vehicle standard to mandate V2V communications for new light vehicles and to standardize the message format of those V2V transmissions. U.S. DOT officials told the Committee that there are ongoing discussions with stakeholders about the future of this proposed rule.

The U.S. DOT's National Highway Traffic Safety Administration also issued *Cybersecurity Best Practices for Modern Vehicles* in October 2016. This guidance targets vehicles that are on the road today, which have an increasing number of computers on board, but witnesses told the Committee that cybersecurity will become even more important as vehicles reach higher levels of automation and connectivity. The Committee will return to the issue of cybersecurity later in the report.

United Kingdom

In 2015, the United Kingdom (U.K.) Department for Transport (DfT) published a summary report and action plan on AVs. The report found that the existing U.K. legal and regulatory framework did not present a barrier to testing AVs on public roads. The U.K. government therefore decided to pursue "a light touch non-regulatory" approach to the testing and development of these technologies through the use of a code of practice. This code of practice was released in July 2015.

Witnesses highlighted the U.K.'s Centre for Connected and Autonomous Vehicles (CCAV), created in 2015 as a joint policy unit between the DfT and the Department for Business, Energy and Industrial Strategy (similar to ISED in Canada, this department's mandate includes innovation issues). The CCAV "works across government to support the early market for connected and automated vehicles," providing over £250 million (about C$416.1 million) in industry-matched funding to position the U.K. at the forefront of AV and CV research.

The U.K. government has also taken measures to address cybersecurity, including the development of a National Cyber Security Strategy. In addition, the non-profit organization, Cyber Security Challenge UK, has developed a working partnership with the U.K. National Crime Agency to produce free teaching resources to help parents and teachers across the U.K. to raise awareness of the issue of cybercrime amongst young people.

Other Jurisdictions

As part of the September 2013 New Industrial France initiative, the French government announced an AV project that seeks to make the country an international leader in AV testing. France introduced legislative amendments in August 2016 to allow AVs to be tested on public roads where certain requirements are met.

In May 2017, Australia's National Transport Commission (NTC) – an independent advisory body that provides advice and national land transport reform proposals through the Transport and Infrastructure Council (an organization similar to Canada's CoMT) – released Guidelines for Trials of Automated Vehicles in Australia. The purpose of the guidelines is to promote the country as a test bed for AV technology, while also helping organizations ensure the safety of AV tests on public roads.

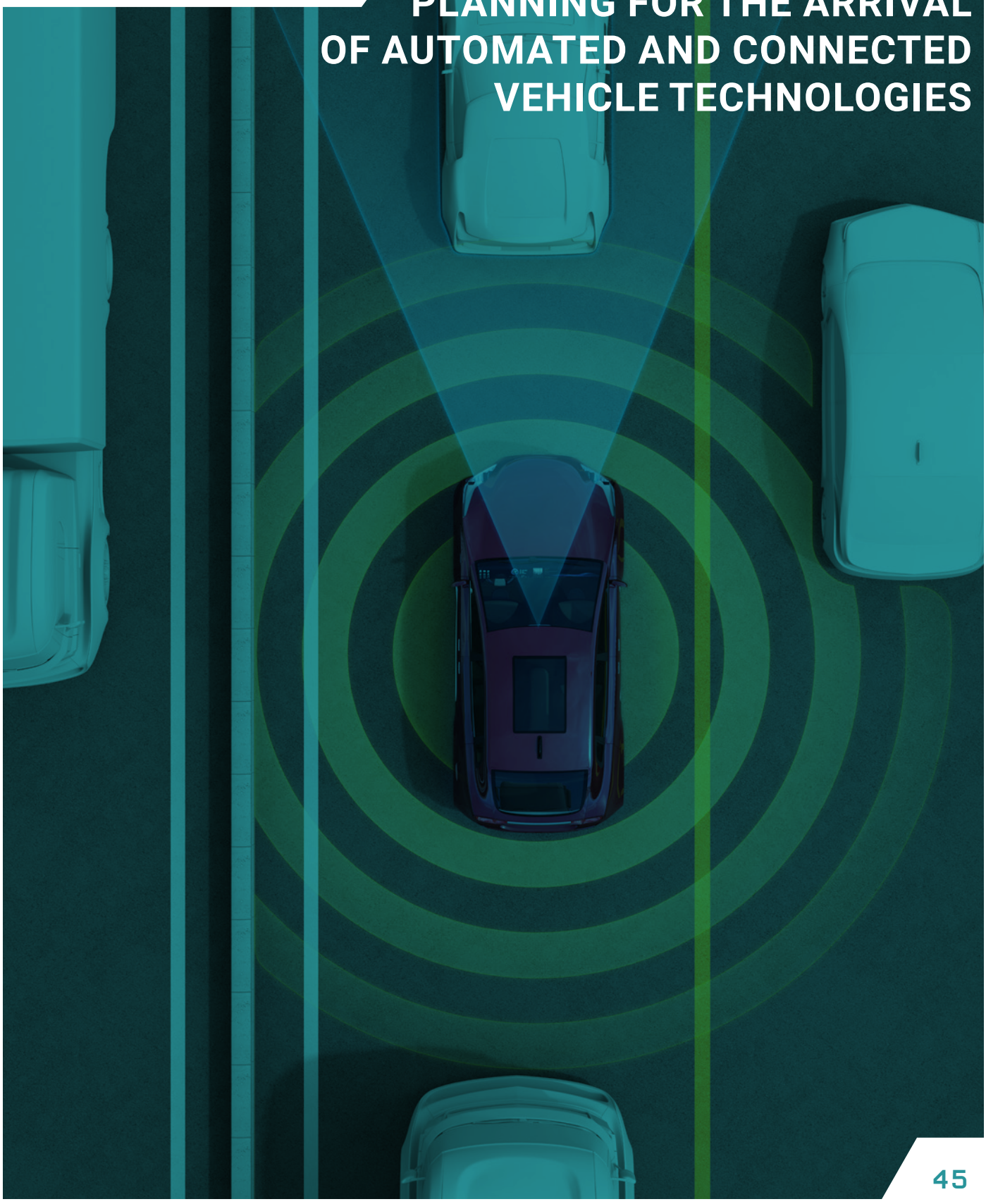
Japan has been an early adopter of CV technology, introducing V2I connectivity through the Vehicle Information and Communication System in 1996. According to a white paper published by the CCMTA, Japan's National Police Agency released guidelines for public road tests of AVs in 2016.

The European Commission proposed reforms to its data protection framework in January 2012 and, in April 2016, the European Parliament adopted its new Regulation on the processing and free movement of personal data. The Regulation is designed to "strengthen citizens' fundamental rights in the digital age and facilitate business by simplifying rules for companies in the Digital Single Market." A new Directive for the police and criminal justice sectors was adopted alongside the Regulation and aims to "protect citizens' fundamental right to data protection whenever personal data is used by criminal law enforcement." Sharon Polsky, President of the Privacy and Access Council of Canada, spoke positively of the new European Directive, noting that it sets the bar very high for consent and individual control of personal information.

According to a brief submitted by Krzysztof Czarnecki, Professor of Electrical and Computer Engineering at the University of Waterloo, Germany has updated its existing legislation to allow deployment of level 3 and 4 AVs on public roads and to require that those vehicles still have a human driver who can take over if need be (as noted above, road use is a matter of provincial jurisdiction in Canada).

PART 2:

PLANNING FOR THE ARRIVAL OF AUTOMATED AND CONNECTED VEHICLE TECHNOLOGIES



In spite of some uncertainty about the timing of its deployment, AV and CV technologies will be coming to Canadian roads. Some work is already under way at the federal and provincial/territorial level to prepare for the arrival of this technology.

However, the Committee agrees with Professor Michelson, who suggested that "the full benefits of efforts in this field will only accrue to Canada if a coordinated national strategy is developed." The subsections below discuss the Committee's recommendations regarding the key elements that should be included in such a strategy.

> ***The full benefits of efforts in this field will only accrue to Canada if a coordinated national strategy is developed.***
>
> *– David Michelson*

FEDERAL LEADERSHIP

Many witnesses discussed the importance of the federal government playing a leadership role in AV and CV issues. As explained by Mr. Love, "an unprecedented amount of coordination and collaboration is required across various industry sectors but perhaps most importantly across various levels of governmental agencies. […] This requires proactive leadership."

AV and CV technologies could have an effect on the mandates of several federal departments. In that regard, witnesses expressed concern that federal departments and agencies may be working at cross-purposes to each other as a result of organizational silos. For example, Mr. Kirk explained that:

> *I look at what the Innovation, Science and Economic Development Canada is doing to try to stimulate this, I call that the gas pedal. I see what Transport Canada is doing, and they are really trying to emphasize the safety aspects; that's the brake pedal. Unfortunately, the federal government is trying to move forward with one foot on the gas pedal and one foot on the brake pedal at the same time.*
>
> *(Barrie Kirk, Executive Director, CAVCOE, 3 May 2017)*

In addition to Transport Canada and ISED, a follow-up document submitted by Transport Canada identifies seven other federal departments and agencies with mandates that may be involved in the AV and CV file, such as ESDC, Public Safety Canada and the Communications Security Establishment.

Mr. Chennakeshu also noted that it would be helpful for the federal government to take a single-window approach so that stakeholders have a single primary contact point. Mr. Kirk and Mr. Ticoll pointed to the example of the U.K.'s CCAV, a joint policy unit between their equivalents of Transport Canada and ISED. Therefore, the Committee recommends that:

RECOMMENDATION 1

Transport Canada and Innovation, Science and Economic Development Canada expeditiously create a joint policy unit to coordinate federal efforts and implement a national strategy on automated and connected vehicles.

While the Committee envisions this joint policy unit as the body that would be responsible for implementing the recommendations that

follow in this report, it has directed those recommendations to existing federal departments to facilitate the process of requesting the government's response to this report.

Considering that the regulation of how AVs and CVs are used on public roads falls within the purview of provincial and territorial governments, witnesses expressed concern that there may eventually be a patchwork of requirements across provincial and territorial boundaries. For example, Mr. Leclerc explained that "[i]f we want to attract investors and deploy that technology, we have to ensure that we have something that is harmonized right across the board, and we are not necessarily seeing that dialogue happening."

The Committee believes that this technology will also affect municipal governments, given the impact of AVs and CVs on issues such as infrastructure and transportation planning, urban sprawl, land use and public transit.

Some witnesses, such as Mr. Kirk, Ms. Gerber, Mr. Paterson and Craig Hirota, Vice President of Government Relations and Member Services with the Associated Canadian Car Rental Operators, recommended that the federal government develop a model provincial policy in order to ensure some degree of harmonization. As mentioned above, the CCMTA already has a working group that is developing guidelines and sharing best practices regarding the deployment of AVs on public roads. Therefore, as part of a national strategy on AVs and CVs, the Committee recommends that:

RECOMMENDATION 2

Transport Canada engage with provincial and territorial governments, through the Canadian Council of Motor Transport Administrators, to develop a model provincial policy for the use of automated and connected vehicles on public roads. The department should also involve municipalities in this engagement process.

Witnesses also noted the importance of collaborating with the U.S., as AVs and CVs will need to work across the Canada–U.S. border. As noted above, Transport Canada is already working with its American counterparts through the RCC. Therefore, as part of a national strategy on AVs and CVs, the Committee recommends that:

RECOMMENDATION 3

Transport Canada strengthen its work on automated and connected vehicles with the United States through the Regulatory Cooperation Council, to ensure that these vehicles will work seamlessly in both countries.

VEHICLE SAFETY

The federal government is responsible for ensuring that safety standards are followed in the design and construction of vehicles that are manufactured in or imported to Canada. In this regard, the *Motor Vehicle Safety Regulations* (made under the *Motor Vehicle Safety Act*) contain detailed requirements for the design and construction of motor vehicles.

Witnesses noted that the status and timelines for the deployment of AV and CV technologies is still unclear and that overly prescriptive safety standards could entail a number of risks. As explained by Mr. Iny, "The perception right now is that the area is changing too quickly for regulation to be effective and that it would be out of date very quickly."

Some witnesses and organizations that submitted briefs, such as Manitoba Infrastructure, echoed that sentiment and indicated that prescriptive regulations would risk being overly restrictive and restrain industry innovation and market integration. For example, Justin Kintz, a Senior Director of Americas Policy and Communications with Uber, explained that the software that will run on his company's test vehicles is updated multiple times daily, and will likely go through numerous iterations before being ready for consumers. As a result, Mr. Kintz said that "[i]t would be very stifling to that technology if a governmental body or some sort of third party needed to approve the evolution of that technology from a software perspective along the way."

According to Professor Czarnecki's brief, SAE International and the International Organization for Standardization are developing standards for the verification and validation of AV safety, which should be available within the next two years. Professor Czarnecki notes that any detailed regulation would have to be updated when those international standards become available.

Nevertheless, the Committee believes that the federal government has a role to play in ensuring the safety of AVs and CVs. The Committee shares the concern of Ata Khan, Member of the ONE-ITS Board of Directors and Professor of Civil and Environmental Engineering at Carleton University, who noted that "sometimes technology will be ahead and regulations will try to catch up."

As noted earlier in the report, AV and CV technologies could have significant safety benefits; but as highlighted by Mr. Bonny, there needs to be a plan to ensure that these vehicles actually work and can be operated safely. Mr. Love suggested that there needs to be "a clear statement of what is expected and the standards to meet." A brief from Manitoba Infrastructure suggests that Transport Canada should "establish a policy that sets forth the expectations, practices, and procedures that manufacturers, suppliers, and others must follow in the development and deployment of AVs and CVs."

Based on the experience of other jurisdictions, the Committee believes that a set of vehicle safety guidelines would strike the right balance between the importance of vehicle safety and the risks of over regulating when the trajectory of AV and CV technologies is unclear. Therefore, as part of a national strategy on AVs and CVs, the Committee recommends that:

RECOMMENDATION 4

Transport Canada urgently develop vehicle safety guidelines for the design of automated and connected vehicles. The guidelines should identify design aspects for industry to consider when developing, testing and deploying such vehicles on Canadian roads. The guidelines should also be updated regularly to keep pace with the evolution of automated and connected vehicle technology.

SPECTRUM ALLOCATION

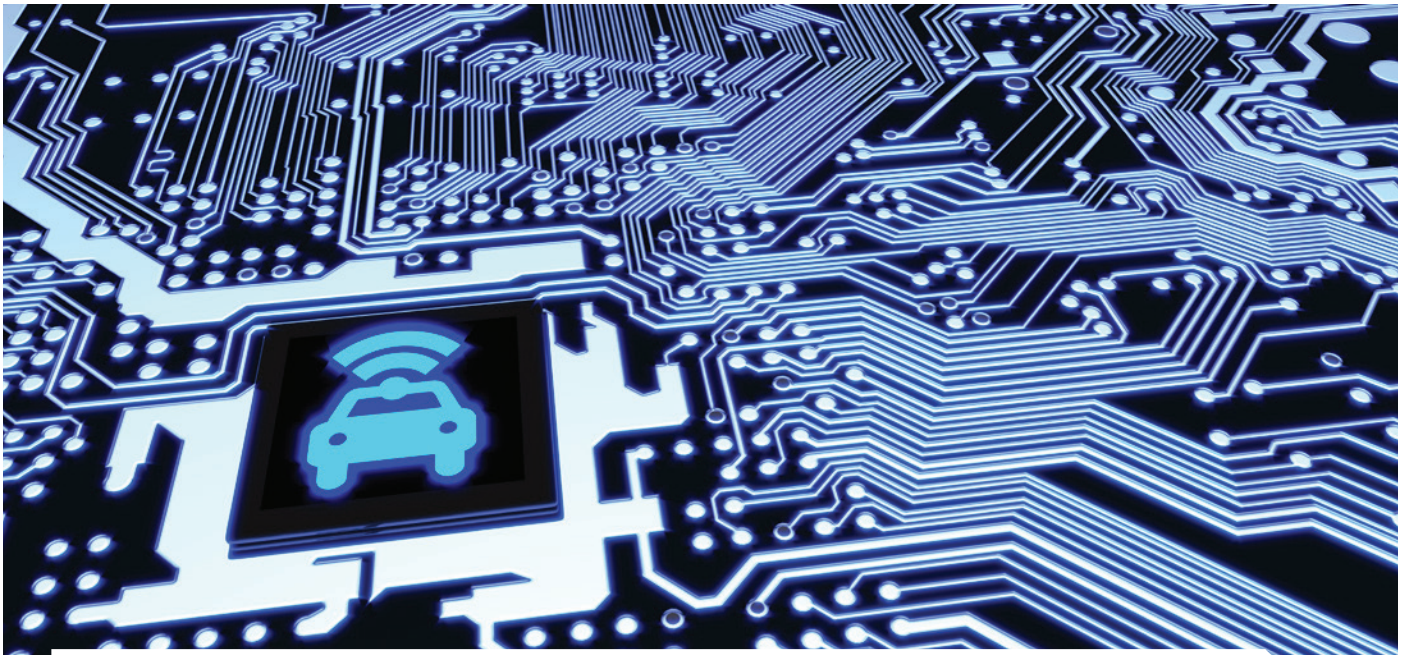
The allocation of radio frequency spectrum is also an area of federal jurisdiction. Professor Michelson told the Committee that ISED has not yet allocated the spectrum that it has set aside for DSRC in CVs:

> *Anyone who wants to experiment with connected vehicle technology has to get a developmental licence from Innovation, Science and Economic Development Canada. They can't just install the equipment and use it directly, as they would in the U.S. This is actually a bit of an impediment to development and innovation. […] It's a fairly intensive application to prepare, and it takes a long time to approve.*
>
> *(David Michelson, Co-Chair of the Intelligent Transportation Systems Society of Canada, and Professor, University of British Columbia, as an individual, 14 June 2017)*

David Adams, President of the Global Automakers of Canada, highlighted the importance of continuing to reserve the spectrum for DSRC purposes, noting that this spectrum "is currently under siege in the United States from the telecommunications companies also looking to utilize the bandwidth." Therefore, as part of a national strategy on AVs and CVs, the Committee recommends that:

RECOMMENDATION 5

Innovation, Science and Economic Development Canada allocate the 5.9 gigahertz spectrum that it has set aside for use in dedicated short range communications systems, while continuing to reserve this spectrum for connected vehicle uses.



CYBERSECURITY

Cybersecurity was a pressing concern for many witnesses who provided testimony to the Committee. Patrick Patterson, President of Carillon Information Security Inc., explained to the Committee that data integrity is of paramount importance when vehicles send and receive information digitally, as in the case of AVs and CVs. Vehicles need to know whether they can trust the message they are being sent and manufacturers need to know that the message that leaves the signalling centre gets to the correct vehicle without being tampered with in transit.

Witnesses drew attention to the potential impact of ransomware, which is malicious software that denies access to a computer (or the computer's data) and demands a sum of money to restore access. Ms. Polsky, for example, anticipated that it would have an "astounding" effect on the Canadian economy.

Other witnesses focused on the potential risks associated with "over-the-air" (OTA) software updates. OTA updates can be used, for example, to patch security vulnerabilities or to update infotainment systems. OTAs are already being used by vehicle manufacturers and their use is expected to increase as AVs and CVs become more commonplace. However, Mr. Jones noted that, at the present time, consumers cannot be certain that updates are coming from the original vehicle manufacturer. This uncertainty is problematic since, as Mr. Patterson explained, vehicles must "first and foremost […] [be] […] trusted computing environments."

In order to mitigate this uncertainty, Mr. Patterson told the Committee that steps must be taken to ensure that a piece of software not signed by an automotive manufacturer or a designated software producer is not executable by the vehicle. Both Mr. Jones and Mr. Patterson

suggested that the automotive sector follow the aviation industry's approach to assured updates.

Witnesses noted that cybersecurity challenges were not unique to the automotive industry, but also affected automated trains, airplanes and ships. As a result, Mr. Patterson suggested that Transport Canada should develop a common set of cybersecurity standards or principles for all modes of transportation. Witnesses also stressed the importance of cross-border co operation when developing standards and principles in order to ensure global interoperability. Mr. Patterson also noted that in order to be effective, federal guidance should reference specific security standards rather than simply encouraging industry to take cybersecurity considerations into account. Therefore, as part of a national strategy on AVs and CVs, the Committee recommends that:

RECOMMENDATION 6

Transport Canada, in co operation with the Communications Security Establishment and Public Safety Canada, develop cybersecurity guidance for the transportation sector based on best practices and recognized cybersecurity principles. The guidance should include advice on original equipment, replacement equipment and software updates.

A number of witnesses spoke of the importance of co operation within industry – and between industry and government – when seeking to enhance cybersecurity, although the extent to which such co operation currently exists is less obvious. For example, Mr. Jones explained that partnership with industry is important, as sector-specific expertise is not necessarily available within CSE and other cybersecurity bodies. He also told the Committee that, although CSE worked with industry experts in the aviation sector, the agency did not currently have the resources to work with auto manufacturers.

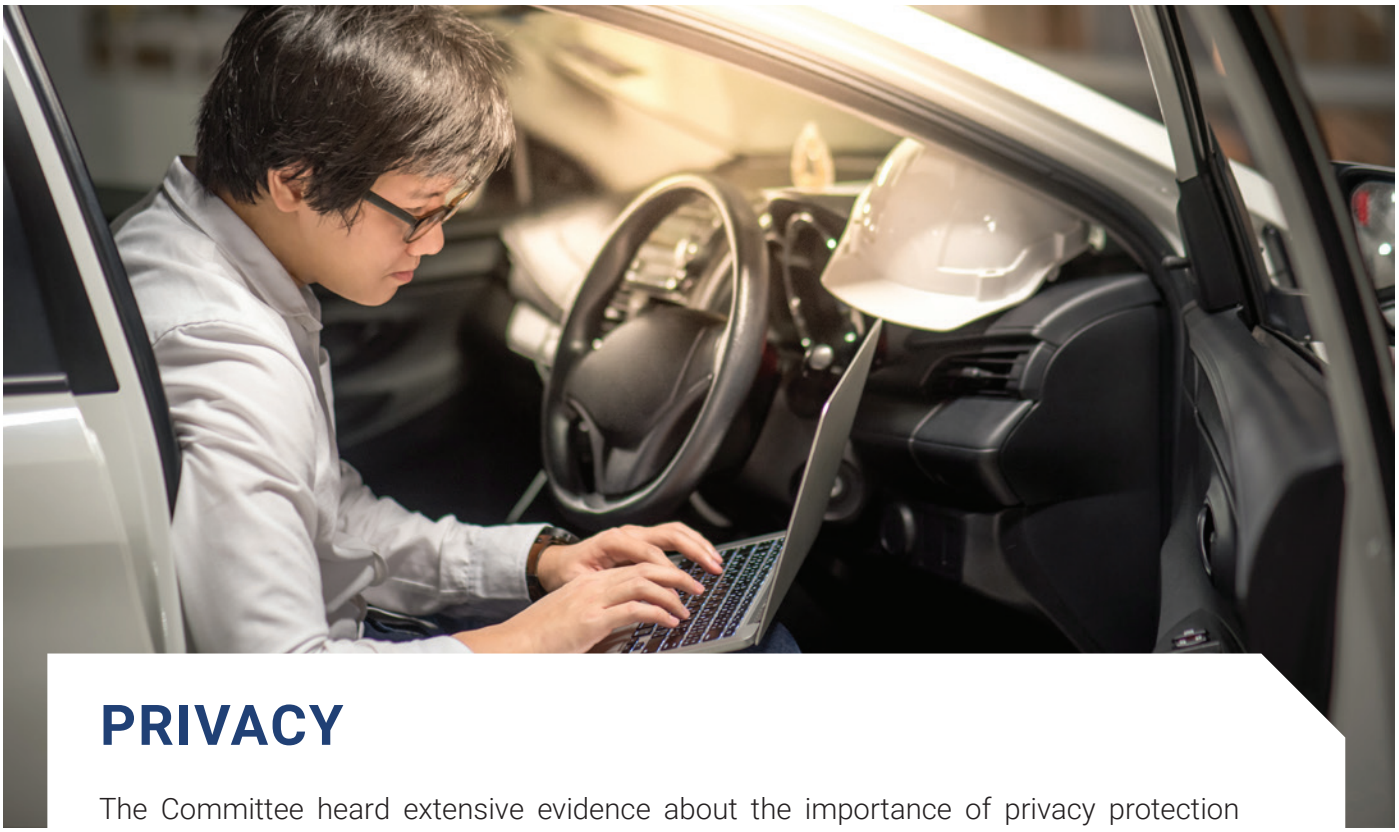
In a similar vein, Colleen Merchant, Director General of the National Cyber Security Directorate at Public Safety Canada, noted that the Canadian Cyber Incident Response Centre (CCIRC) serves as a single point of contact for owners and operators of Canadian critical infrastructure to report cyber incidents to the federal government. Nonetheless, Ms. Merchant explained that, while the CCIRC works very closely with Transport Canada, it does not have "any specific relationships" with industry. Ms. Merchant recommended "increased information sharing between government and industry regarding cybersecurity threats and vulnerabilities" and stated that mitigating cybersecurity concerns regarding AVs and CVs would require "coordinated efforts in several areas including regulation and standards development and research along with vulnerability and incident reporting."

In terms of co operation between industry stakeholders, Mr. Chennakeshu stressed the importance of manufacturers and suppliers sharing information on "common vulnerabilities and exposures" so that measures can be implemented when problems are detected. While he acknowledged the important role played by the Auto-ISAC, he noted that not all stakeholders were members of the organization and that information was not shared on a real-

time basis. Mr. Chennakeshu recommended the establishment of an industry-wide, real-time "crisis connect network" to allow subscribers to respond to cybersecurity vulnerabilities in a timely manner, and to learn from each other. Therefore, as part of a national strategy on AVs and CVs, the Committee recommends that:

RECOMMENDATION 7

Transport Canada work with Public Safety Canada, the Communications Security Establishment and industry stakeholders to address cybersecurity issues and to establish a real-time crisis connect network, and that Transport Canada report regularly on their progress.



PRIVACY

The Committee heard extensive evidence about the importance of privacy protection in an era of widespread AV and CV deployment. In spite of these many privacy challenges, witnesses did not consider increased connectivity and privacy protection to be irreconcilable. Instead, the Privacy Commissioner explained that ensuring adequate privacy safeguards could reassure Canadians and foster the uptake of AVs and CVs.

Witnesses focused their commentary on four overarching themes: privacy by design; informed consent; enforcement; and industry guidance.

Privacy by Design

Privacy by design, whereby companies consider privacy from the outset, is a concept that is gaining currency in the automotive sector. An ISED official explained the term as follows:

> *[C]ompanies need to make sure they are thinking about privacy and cybersecurity at the outset. It's not something that you just tack on at the end. Once you have the car built and the wheels on is not the time to be thinking about privacy. In addition they need to make sure that they are thinking about it at the CEO level. It [is] not just a technology issue. It is a whole issue for the board to think about and to direct the entire company to evaluate what they are doing from a privacy and digital security standpoint so that they really understand the implications.*
>
> *(Krista Campbell, Director General, Spectrum, Information Technologies and Telecommunications, Digital Policy Branch, ISED, 14 February 2017)*

The Privacy Commissioner noted that privacy by design was a "good concept," but stressed the importance of ensuring that it is applied in a concrete way. To achieve this objective, he suggested that stakeholders work together to set appropriate standards to bring certainty to both industry and consumers.

Informed Consent

The *Personal Information Protection and Electronic Documents Act* (PIPEDA) is Canada's federal private-sector privacy law. It applies to the personal information that private sector organizations, such as automobile manufacturers and their partners, collect, use or disclose in the course of commercial activities across Canada.[21] Although witnesses recognized that the legislation had considerable strengths, they drew attention to some areas of weakness in the context of AVs and CVs.

For example, Philippa Lawson, Barrister and Solicitor for BC FIPA, explained that PIPEDA "assumes that individuals can give informed consent to the collection, use and third-party disclosure of their information." However, given the multiplicity of players in the connected car ecosystem, as well as the tendency of industry to use "loose" language when describing how data will be used, Ms. Lawson argued that this assumption was unworkable. Indeed, she contended that consumers often provide little more than "fictional" consent.

> ***[C]ompanies need to make sure they are thinking about privacy and cybersecurity at the outset. It's not something that you can just tack on at the end.***
>
> *– Krista Campbell*

The Office of the Privacy Commissioner has been studying ways in which consent processes could be made more meaningful: it launched public consultations on consent under PIPEDA in May 2016, and recently published a report on its findings. The Privacy Commissioner explained that the consultations revealed consumers to be dissatisfied with the lack of clarity and accessibility of many industry privacy policies. He stressed that privacy policies should be readable so that consumers know what kind of information is being collected about them; what use the company will make of it; with whom they will share it;

21 Note that organizations operating wholly within a province that has legislation that is "substantially similar" to PIPEDA are exempt from the federal legislation.

and what risk of reputational or material harm may arise from the use or disclosure of their data.[22] He also cautioned against companies inundating consumers with so much information that they are unable to make informed choices and exercise meaningful control over their personal information.

BC FIPA shared the views expressed by the Office of the Privacy Commissioner on the importance of transparency in obtaining consent. Ms. Lawson recommended the approach adopted by the Ontario Securities Commission with regard to mutual fund disclosures. She explained that, by standardizing the language and format of the disclosure, consumers were better able to compare the different options available to them.

That being said, while recognizing the value of meaningful consent, Ms. Lawson, among other witnesses, maintained that obtaining consent could be impossible, or even inappropriate, in some instances:

> *There are also areas where you're just never going to get consent and where it may actually be inappropriate, where we may be able to decide as a society that certain information simply need not be collected and should not be collected and that the privacy and safety and security risks are too great and outweigh any benefit that might be provided. For example, by connecting the telematics to the infotainment system, you can have cars where the volume on the infotainment system automatically adjusts depending on the engine noise. Is it worth the potential hacking or security risk that that kind of connection or sharing of information requires?*
>
> *(Philippa Lawson, Barrister and Solicitor, BC Freedom of Information and Privacy Association, 2 May 2017)*

Several witnesses expressed the view that different data sharing rules should apply in different contexts. For example, Mr. Jack explained that consumers should perhaps not have any choice as to whether they share anonymized safety data, but should be able to select what other data they are willing to share. Mr. Iny framed the distinction in terms of information collected for public safety purposes versus information collected for purely economic purposes, and suggested that guidelines on information sharing be developed.

Enforcement

The Committee heard that, while existing privacy legislation contained numerous privacy protections, industry compliance was not always achieved. For example, Ms. Lawson informed the Committee that while Canadian law prohibits service providers from requiring consumers to consent to something that is not necessary to the service they have purchased, this prohibition is not always respected:

> *What we were seeing with the systems is that it was an all-or-nothing proposition, that if you don't agree to the whole whack — which was often wide open — then you can't use the service at all; you can't use the automatic navigation system.*
>
> *(Philippa Lawson, Barrister and Solicitor, BC FIPA, 2 May 2017)*

The Privacy Commissioner expressed similar concerns, characterizing PIPEDA as deficient in terms of compliance mechanisms. He explained that, at the present time, his office can investigate only if it receives a complaint and argued that allowing his Office to act preventively – rather than reactively – would improve compliance with existing legislation. To that end, he argued that a flexible framework

22 These four elements are listed as key elements that must be highlighted to consumers in the Commissioner's recently released draft update to its Guidelines for Online Consent.

was required in order to allow a regulator to act quickly to address the "limitless" number of problems that could arise in the context of AVs and CVs, artificial intelligence and big data.

This view was echoed by Ms. Polsky, who further noted that allowing companies to flout privacy legislation was detrimental to all Canadians. Ms. Polsky suggested several ways in which the Privacy Commissioner's powers could be strengthened:

> *I have been quite clear that Canada's privacy laws are toothless. […] The commissioner does not have the power necessary to enforce the privacy legislation. The privacy law itself is not adequate. […] [Privacy Commissioners] need to have order-making power. They need to be able to conduct investigations not only after the fact or after a complaint but of their own volition. When they see a problem, they need to be able to move on it. I suggest the commissioner also needs to have a budget and a mandate for education.*
>
> *(Sharon Polsky, President, Privacy and Access Council of Canada, 31 October 2017)*

Therefore, as part of a national strategy on AVs and CVs, the Committee recommends that:

RECOMMENDATION 8

The Government of Canada table legislation to empower the Office of the Privacy Commissioner to proactively investigate and enforce industry compliance with the *Personal Information Protection and Electronic Documents Act*.

Industry Guidance and Regulation

In addition to strengthening the Privacy Commissioner's powers under PIPEDA, the Committee also heard that privacy protection could be enhanced by issuing federal guidance to industry. Several witnesses, including Ms. Lawson stressed the important role the federal government could play in bringing stakeholders together to develop robust guidance. The Privacy Commissioner also highlighted the important role industry can play and urged companies to develop robust internal privacy management programs to manage the data they collect and use in the course of their commercial activities.

Witnesses debated the respective merits of voluntary industry guidelines versus a regulatory approach. For her part, Ms. Lawson argued that government regulation would be needed, although she supported the development of a technology-neutral code of practice in consultation with key stakeholders as a first step toward regulation. In turn, Ms. Polsky appeared to favour regulation, stressing the importance of "imposing" limits on car manufacturers. In explaining his preference for beginning with voluntary guidelines, the Privacy Commissioner noted that while PIPEDA sets out fundamental principles that can apply to all industries, a code of practice could provide enhanced standards tailored to connected cars. As a result, the Privacy Commissioner informed the Committee that his Office intends to fund an arms length project to develop a privacy code of practice for connected cars.

In a follow-up brief submitted to the Committee in November 2017, the Privacy Commissioner further elaborated on this topic. While reasserting the value of a code of practice for

the connected car, he noted that a broader effort would be needed to address "the many challenges and opportunities" presented by the evolution of the connected car. To that end, he strongly encouraged the government "to bring relevant stakeholders – regulators, legislators, automakers, and consumers – together in the development of a connected car framework, which has the protection of privacy as one of its key drivers." The Commissioner stressed that his Office would "intend to play a key role in any such project."

The Committee believes that it is too early in the development of the AV and CV industry to determine whether voluntary guidelines will suffice or whether privacy regulations will be required to protect Canadians' privacy in the era of AVs and CVs. Therefore, as part of a national strategy on AVs and CVs, the Committee recommends that:

RECOMMENDATION 9

The Government of Canada continue to assess the need for privacy regulations specific to the connected car ;

RECOMMENDATION 10

Transport Canada bring together relevant stakeholders – governments, automakers, and consumers – to develop a connected car framework, with privacy protection as one of its key drivers.

DATA ACCESS AND COMPETITION

According to BC FIPA, "the breadth and depth of personal data that can be culled from [...] [AVs and CVs] [...] goes significantly beyond what is already available via mobile devices, both in quality and in quantity." The available data, which could include driver behaviour data, health data, personal contacts and schedules, is potentially very valuable and many stakeholders wish to secure access to it. In particular, witnesses from the aftermarket and rental car sectors told the Committee that there are some legitimate uses for which their sectors should have access to that data.

In the aftermarket sector, the Canadian Automotive Service Information Standard (CASIS), a voluntary "right to repair" agreement, ensures that original equipment manufacturers (OEMs) share their service and repair information with the automotive aftermarket to enable them to carry out repairs. However, Jean François Champagne, President of the Automotive Industries Association of Canada (AIA Canada), told the Committee that CASIS is silent on the issue of telematics, the CV technology that collects and sends data from the vehicle in real time. Mr. Champagne explained that OEMs may use this technology to limit competition:

> *It [telematics] provides OEMs and their dealerships with unprecedented access to communicate with a car and its owner. This creates a customer monopoly through a closed-loop communication circuit. This closed-loop communication circuit will increasingly facilitate the capabilities of OEMs to, among other things, instruct an owner of a vehicle to bring their vehicle into a specific dealership for a routine checkup and to conduct remote diagnostics, repairs and software updates. The above-mentioned applications of telematic services have the potential to give OEMs a huge competitive advantage in the battle for repair dollars by driving business away from independent repair and maintenance shops.*
>
> *(Jean-François Champagne, President, AIA Canada, 17 May 2017)*

In spite of these concerns, Mr. Champagne told the Committee that AIA Canada intends to continue working within the framework of CASIS, the voluntary "right to repair" agreement between OEMs and the automotive aftermarket system. Nevertheless, he added that "it is not beyond the realm of possibility that, some day, we'll be back here with a request, telling you that, our efforts aside, it might be time for the government to get involved in the matter and establish a regulatory structure."

Witnesses also noted that this data access concern could be more acute in rural communities, where smaller, "mom-and-pop" repair shops may be the only option for people seeking vehicle repairs. Mr. Nantais told the Committee that "Mom-and-pop shops are already struggling to keep up with changes in technology, and this trend will likely continue."

Witnesses from the rental car industry expressed similar concerns about OEMs restricting access to AV and CV data. Ms. Gerber told the Committee that many vehicle manufacturers intend to both make AVs and use them to offer mobility services directly to consumers. As a result, she explained that these OEMs may have an incentive to restrict data access and limit consumer choice:

> *If […] a manufacturer is owning and operating their own automated vehicles fleet and providing transportation services to consumers at the same time they are selling cars to other fleet operators who are providing the same services to the same market of consumers, but those manufacturers have the ability to restrict access to the data that makes the fleets operate efficiently and effectively and can dictate the cost those other providers have to pay in order to operate their fleets, you can see that competitive market distortions will quickly arise.*
>
> *(Tomi Gerber, Assistant Vice President, Government and Public Affairs,Enterprise Holdings, 4 October 2017)*

In addition to its impact on the aftermarket and rental car industries, Ms. Gerber noted that these issues of data access and competition would likely have an impact on the insurance industry and fleet management companies.

A brief from Geotab Inc., an Oakville, Ontario company that works on CV technology, also expressed concerns about access to vehicle data. According to the brief, the company is concerned that vehicle manufacturers will impose licensing restrictions on the use of vehicle data, so that vehicle and fleet owners (such as rental car companies) would have to pay for access to that data.

Mr. Ticoll also explained to the Committee that if Canadians switch from car ownership to on-demand mobility, "a handful of global companies" could end up controlling most of the cars on our streets and the data that they generate.

The Committee believes that it is too early in the development of the AV and CV industry to determine definitively how, if at all, the technology being developed will affect the competitive behaviour of OEMs. However, given the risk identified by stakeholders in the aftermarket and rental car industries, the Committee believes that the government should monitor the situation. Competition issues fall within the mandate of ISED. Therefore, as part of a national strategy on AVs and CVs, the Committee recommends that:

RECOMMENDATION 11

Innovation, Science and Economic Development Canada monitor the impact of automated and connected vehicle technology on competition between the various sectors of the automotive and mobility industries, in order to ensure that sectors such as the aftermarket and car rental companies continue to have access to the data they need to offer their services.

RESEARCH AND DEVELOPMENT

The federal government has already started investing in the research and development of AV and CV technologies through existing programs, and witnesses told the Committee that Canada is home to world-renowned automotive, information technology and AI expertise. Canada is home to the largest information technology cluster in North America outside of Silicon Valley, the Windsor to Montréal corridor. For example, Mr. Kintz told the Committee that his company chose Toronto for one of its Advanced Technologies Group offices because of the city's status as a hub of AI expertise.

Other witnesses suggested that the federal government could be doing more to encourage the testing of these vehicles in Canada. These witnesses suggested that Canada lags behind other countries in AV and CV research and development.

Witnesses told the Committee that the MVTC in Blainville, Quebec is a world-class facility. Nevertheless, Mr. Bonny noted in his written brief that without further investment, the MVTC "will be lost for lack of infrastructure to evaluate the vehicles of the future." Noting that Canada does not have a testing facility that can evaluate all of the systems of an AV or CV, Mr. Bonny's brief suggests that the existing infrastructure at the MVTC makes it the ideal site for a new Innovative and Intelligent Mobility Research and Test Centre.

The Committee believes that AVs and CVs should be tested in both urban and rural areas, given the very different considerations for deploying the technology in each of those environments. A brief from the Government of the Northwest Territories also suggested that the federal government could carry out studies and analysis of the challenges of using AVs and CVs in different Canadian regions, particularly in extremely cold climates.

Given the importance of vehicle cybersecurity and privacy, the Committee also believes that these subjects would be good

candidates for further research. Therefore, as part of a national strategy on AVs and CVs, the Committee recommends that:

RECOMMENDATION 12

The Government of Canada increase its investments in the research and development of automated and connected vehicles, through a new Innovative and Intelligent Mobility Research and Test Centre, to be located at the existing Motor Vehicle Test Centre. In addition to ensuring that these vehicles are tested in a mix of urban, rural and cold environments, particular consideration should also be given to projects focused on cybersecurity and privacy.

Professor Gingras also told the Committee about AUTO21, a research network that received funding from the Networks of Centres of Excellence of Canada (NCE). Created in 1989 by ISED and the three federal research granting agencies, the NCE "funds partnerships between universities, industry, government and not-for-profit organizations to create large-scale research networks."

In particular, the AUTO21 NCE was Canada's largest research network focused on advanced automotive research and development. Professor Vrkljan observed that AUTO21 had been a useful means of bringing industry and researchers together.

As noted by Professor Gingras, AUTO21 was closed in 2016 because – as per the NCE Program Guide – these networks must have a plan to wind down their activities at the end of NCE program funding (which lasts a maximum of 15 years). Professor Gingras recommended that this rule be changed so that networks like AUTO21 that remain valuable are not forced to close down. Therefore, as part of a national strategy on AVs and CVs, the Committee recommends that:

RECOMMENDATION 13

Innovation, Science and Economic Development Canada work with Networks of Centres of Excellence of Canada (NCE) to reconsider the rule requiring that these networks close down at the end of NCE program funding.

INFRASTRUCTURE AND PUBLIC TRANSIT

The construction, operation and maintenance of most public infrastructure are within the jurisdiction of provincial, territorial and municipal governments.[23] Nonetheless, since 2000, the federal government has played an increasing role in supporting public infrastructure in all jurisdictions in Canada, by providing funding for projects.[24]

Witnesses spoke extensively about the extent to which infrastructure development would be needed in order to ensure the successful deployment of AVs and CVs. Some witnesses noted that AVs are being designed to travel on existing roads without modifications to the current infrastructure and expressed confidence in the ability of technology to overcome the challenge of guiding AVs along snow or ice covered roads in winter. In contrast, other witnesses, including an ISED official, expressed a more cautious view:

> *There is no doubt a fairly significant infrastructure investment will be required, not in any one place but right across the country. If you start looking at the testbeds for some of these early technologies, whether they're sensors in the roads or various technologies embedded in the infrastructure, there is a heavy infrastructure investment required to do that.*
>
> *(Charles Vincent, Director General, Automotive and Transportation Industries Branch, ISED, 14 February 2017)*

Nevertheless, witnesses generally agreed that infrastructure investment would be needed to maximize the potential of AVs and CVs. Mr. McKenzie explained that, although road infrastructure will not need to be changed over the next five years, changes will be required shortly thereafter in order to facilitate V2I and V2V communication. Professor Khan noted that there cannot be automation in any meaningful way without changing the intelligence of infrastructure through connectivity.

23 Vijay Gill et al., *Automated Vehicles: The Coming of the Next Disruptive Technology*, Conference Board of Canada, January 2015, p. 39.

24 Transport Canada, Canada Transportation Act Review, *Pathways: Connecting Canada's Transportation System to the World*, Vol. 1, 2015, p. 20.

Witnesses also agreed about the importance of considering the impact of AVs and CVs on future infrastructure projects. Mr. Ticoll noted that some infrastructure projects being considered today, based on pre-AV and CV assumptions, could seem overpriced or obsolete by the time they are built. In light of this concern, some witnesses, including Mr. Kirk, suggested that new transit and transportation infrastructure funding should require an AV audit to consider the impact of AVs on the project. Mr. Kirk noted, though, that the necessary mathematical modelling tools have not yet been developed for such an AV audit.

Public transit is another area of provincial jurisdiction, although the federal government provides funding for public transit infrastructure. The advent of AV and CV technologies is expected to have a significant impact on public transport. Witnesses still envisage a role for mass transit: for example, Mr. Ticoll highlighted the "huge" opportunity new technologies present for the development of automated busways and railways. However, beyond simply automating existing modes of public transit, witnesses suggested that new modes of transport would be incorporated into the public transit network. In particular, witnesses discussed the way in which the widespread deployment of AVs could lead to both the use of small automated taxis for door-to-door personal transportation and the use of automated shuttles to cover the "first and last mile".

Several witnesses noted that AVs had considerable potential to improve mobility in areas that are not well served by traditional transit. As explained by Mr. Leclerc,

> *We believe that the advent of autonomous vehicles is a great opportunity to improve and complement the public transit service offerings, most notably where mass transit is not optimal — in low-density or low-demand areas. In those cases, small autonomous vehicles would transport residents, on demand or on a fixed schedule, to a fast and efficient public transit hub. Such an approach will make the system more efficient and optimize the use of resources.*
>
> *(Patrick Leclerc, President and Chief Executive Officer, Canadian Urban Transit Association, 19 September 2017)*

In spite of the potential offered by AVs and CVs, witnesses cautioned that they would not resolve all transit issues. Mr. Litman noted that transit will likely still remain expensive for rural families:

> *My guess is that self-driving taxis will never get below about 40 cents per kilometre; it's probably going to be 40 cents to 50 cents a kilometre. If you live in a rural area where you are 50 kilometres from the nearest store, it's never going to be cheap. There is no technology that will make it truly cheap for you to commute or go shopping every day.*
>
> *(Todd Litman, Executive Director, Victoria Transport Policy Institute, 2 May 2017)*

Mr. Leclerc cautioned that, without adequate policies and forethought, AVs would not solve many of the transit issues urban communities face:

> *Turning our personal vehicles into autonomous vehicles will not address one of the major issues we are facing in cities, namely, scarce urban space. An autonomous car with one person on board doesn't take less urban space than a traditional vehicle with a driver. The issue of traffic congestion, road capacity and bottlenecks will remain the same.*
>
> *(Patrick Leclerc, President and Chief Executive Officer, Canadian Urban Transit Association, 19 September 2017)*

INSURANCE

According to witness testimony, AVs and CVs are expected to change auto insurance underwriting, pricing, sales distribution and claims management. Witnesses, including Ryan Stein, Director of Policy with the Insurance Bureau of Canada, explained to the Committee that several different factors would contribute to these changes. For example, Mr. Stein noted that the advent of AVs and CVs will likely result in fewer collisions, although the cost of these collisions will increase. Specifically, Mr. Stein cited data from consulting firm KPMG that predicts a 35% to 40% decline in the collision rate and a 25% to 30% increase in repair costs over the next decade.

Several witnesses also discussed potential shifts in accident liability. As explained by the Insurance Institute of Canada, human error has been the predominant cause of collisions since motor vehicles were first introduced. Accordingly, both legislation and insurance procedures have developed around "an expectation of driver error."[25] However, as automation increases, insurers and the legal system will also have to consider the role of software errors and equipment failure in collisions. In the long term, this raises questions about whether liability will shift entirely from drivers to manufacturers when fully automated vehicles become the predominant means of transport.[26]

Nevertheless, the Insurance Institute of Canada also pointed out that the "greatest challenge" around liability will arise not in the era of full automation, but over the next decade when conventional, semi automated and the first fully automated cars share the roads. This is, in part, because "there are no clear rules for determining responsibility, nor approved techniques for securing evidence about liability" in this new context.

25 Insurance Institute, *Automated Vehicles: Implications for the Insurance Industry* in Canada, p. 39.

26 Ibid.

Witnesses also drew attention to the importance of vehicle manufacturers sharing data with insurers to determine the cause of a collision. Mr. Stein informed the Committee that the Insurance Bureau of Canada has established a working group to examine issues relating to the deployment of AVs, such as data access and potential regulatory changes. Mario Fiorino, Director, Legal and Senior Counsel with the Insurance Bureau of Canada, expressed confidence that the insurance industry would support any guidance issued by the Privacy Commissioner regarding the use of data.

Automobile insurance, infrastructure and public transit are areas that fall mostly under provincial jurisdiction. Furthermore, the precise impact of AV and CV technologies on these policy areas, while important, remains unclear. Therefore, as part of a national strategy on AVs and CVs, the Committee recommends that:

RECOMMENDATION 14

Transport Canada monitor the impact of AV and CV technologies on automobile insurance, infrastructure and public transit in Canada.

EMPLOYMENT AND EDUCATION

It is widely anticipated that AV and CV technologies will result in job loss in some sectors of the Canadian economy. ESDC officials explained to the Committee that the federal government works closely with the provincial and territorial governments to develop programs that are flexible enough to withstand adjustments to the economy. He informed the Committee that the federal government invests nearly $3 billion annually in transfer agreements with the provinces and territories for skills training and employment support. The transfer agreements allow the provinces to develop programs and services to help both unemployed people and underemployed people receive skills development, training and

employment search assistance. The Committee is encouraged by the department's efforts but remains concerned in light of witness testimony about the potential impact of AVs and CVs on the labour market. Therefore, as part of a national strategy on AVs and CVs, the Committee recommends that:

RECOMMENDATION 15

Employment and Social Development Canada continue to work closely with the provinces and territories in order to strengthen retraining, skills upgrading and employment support for Canadians facing labour market disruption.

Many witnesses also observed that the AV and CV technologies sector had the potential to create jobs in fields such as technology, software, visualization and simulation. In particular, witnesses noted that Canada enjoys a global reputation in software development and artificial intelligence and attracts a significant number of high-technology companies.

Despite that reputation, witnesses such as Professor Khan stressed that Canada must actively pursue the economic opportunities AVs and CVs present. Professor Khan further noted that no time could be lost in the pursuit of these benefits as the window of opportunity for Canada to position itself as a global leader could close within a decade.

Witnesses also discussed current and future skills shortages in the Canadian labour market. For example, Ms. Merchant spoke about the need to increase the availability of IT security professionals while John Wall, Senior Vice-President and Head of BlackBerry QNX, spoke about the shortage of embedded software expertise. Mr. Wall also explained that there is a role for industry to play in helping universities identify what skills are needed in order to allow Canada to compete in the global market.

Officials from ESDC explained that they were rolling out a new "work integrated learning program" to provide students with more opportunities to acquire on-the-job experience during their post-secondary studies. The program focuses primarily on the STEM fields (science, technology, engineering and mathematics). While encouraged by such programs, the Committee also heard that learning opportunities had to be provided earlier in a child's education. For example, Mr. Wall stated that insufficient effort was being made at the high school level, particularly to encourage girls to enter the technology industry.

Training and education are also needed to ensure that people can use AV and CV technologies safely in their everyday lives. While recognizing that driver licensing is an area of provincial responsibility, Professor Vrkljan suggested the possibility of incorporating a new technologies education session into the licence renewal process. In a similar vein, Paul Kovaks, researcher and author with the Insurance Institute of Canada, stressed the importance of all drivers undertaking training to learn how to best use AV and CV technologies in order to fully reap its benefits.

Witnesses also discussed the role of training and education in fostering a cybersecurity literate society. In terms of efforts currently under way, Mr. Jones noted that CSE has taken steps to better educate members of the public by launching a Twitter account, posting

new content to its website and producing public videos about its cyber defence work. However, witnesses agreed that much remains to be done and stressed the importance of early intervention:

> *I realize education is a provincial matter, but as a matter of public policy, national economic policy and a cybersecurity strategy, we think that education has to incorporate mandatory learning for children starting in kindergarten. I'm not kidding […] We need kids to be taught so that they can grow to become the legislators, the car designers and the technologists who will design things — laws, products, technology — that are privacy embedded. It's a long-term strategy, but we have to start. We're already behind the curve.*
>
> *(Sharon Polsky, President, Privacy and Access Council of Canada, 31 October 2017)*

The Committee shares the concerns expressed by the witnesses who contributed their expertise to its study. Therefore, as part of a national strategy on AVs and CVs, the Committee recommends that:

RECOMMENDATION 16

Public Safety Canada and the Communications Security Establishment work closely with the provinces and territories to develop cybersecurity training materials and programs to improve public understanding of cybersecurity issues.

From left, senators Michael L. MacDonald, Betty Unger and Terry Mercer ride in a connected bus during a September 2016 fact-finding mission to the University of Alberta's Centre for Smart Transportation in Edmonton.

CONCLUSION

In undertaking its study on automated and connected vehicles, the Standing Senate Committee on Transport and Communications sought to understand how this technology will have an impact on Canada and to identify the regulatory and technical issues associated with its deployment. Low levels of automation and connectivity are already available to Canadian consumers; the Committee's study demonstrates that it is not a matter of *if,* but *when* higher levels of automation and connectivity will arrive on Canadian roads.

These more advanced AVs and CVs could have a number of benefits, notably in terms of reduced automobile accidents, lower pollution from automobiles, more mobility options for Canadians and a variety of economic benefits. Nevertheless, this technology also raises a number of concerns in terms of job losses, privacy, cybersecurity, and urban sprawl. As a result, the Committee believes that the full benefits of this technology will not be realized unless a coordinated national strategy is developed.

To build upon the initiatives already introduced by Canadian governments, the Committee has recommended that Transport Canada and ISED establish a joint policy unit that would be in charge of coordinating federal efforts and implementing a national strategy on AVs and CVs. As part of its recommendations, the Committee has also identified the key aspects of that strategy, which include, for example, addressing issues of vehicle safety, cybersecurity and privacy.

The Committee believes that this strategy will help Canada plan for the arrival of automated and connected vehicles, ensuring that the country is ready for this period of rapid technological change.

APPENDIX A:
WITNESSES

Wednesday, February 8, 2017	
Transport Canada	Kim Benjamin, Director General, Road Safety and Motor Vehicle Regulation, Safety and Security Group Catherine Higgens, Assistant Deputy Minister, Programs, Programs Group Craig Hutton, Director General, Strategic Policy, Policy Group Ryan Klomp, Acting Senior Director, Environmental and Transportation Programs, Programs Group
Tuesday, February 14, 2017	
Innovation, Science and Economic Development Canada	Krista Campbell, Director General, Spectrum, Information Technologies and Telecommunications, Digital Policy Branch Martin Proulx, Director General, Spectrum, Information Technologies and Telecommunications, Engineering, Planning and Standards Branch Charles Vincent, Director General, Automotive and Transportation Industries Branch
Wednesday, March 8, 2017	
Natural Resources Canada	Aaron Hoskin, Acting Chief, ecoENERGY for Biofuels, Senior Technical Advisor, Office of Energy Efficiency Dean Haslip, Director General, CanmetENERGY Paula Vieira, Director, Transportation and Alternative Fuels Division, Office of Energy Efficiency Marc Wickham, Director, Energy Science and Technology Programs, Office of Energy Research and Development
Tuesday, March 28, 2017	
Office of the Privacy Commissioner of Canada	Daniel Therrien, Privacy Commissioner of Canada Patricia Kosseim, Senior General Counsel and Director General, Legal Services, Policy, Research and Technology Analysis Branch

Wednesday, March 29, 2017	
Employment and Social Development Canada	Amy Mifflin-Sills, Director, Program Policy, Skills and Employment Branch Atiq Rahman, Acting Director General, Canada Student Loan Program, Learning Branch Jonathan Will, Director General, Economic Policy Directorate, Strategic and Service Policy Branch
Tuesday, April 4, 2017	
Royal Canadian Mounted Police	Chief Superintendent Eric Stubbs, Director General, National Criminal Operations, Contract and Aboriginal Policing
Communications Security Establishment	Scott Jones, Deputy Chief, IT Security Richard Pierson, Director General, Cyber Defence, IT Security
Public Safety Canada	Colleen Merchant, Director General, National Cyber Security Directorate
Wednesday, April 5, 2017	
Canadian Council of Motor Transport Administrators	Allison Fradette, Executive Director
Alberta Transportation, Government of Alberta	Wendy Doyle, Co-Chair, Canadian Council of Motor Transport Administrators, Automated Vehicles Working Group
Tuesday, April 11, 2017	
As an individual	David Ticoll, Distinguished Senior Fellow, Innovation Policy Lab, Munk School of Global Affairs, University of Toronto
Borden Ladner Gervais LLP	Kevin LaRoche, Lawyer and Partner Robert Love, Lawyer and Partner
Tuesday, May 2, 2017	
BC Freedom of Information and Privacy Association	Vincent Gogolek, Executive Director Philippa Lawson, Barrister and Solicitor
Victoria Transport Policy Institute	Todd Litman, Executive Director

Wednesday, May 3, 2017	
PMG Technologies	Franck N'Diaye Bonny, Director General, Motor Vehicle Test and Research Centre
Canadian Automated Vehicles Centre of Excellence	Barrie Kirk, Executive Director
Tuesday, May 9, 2017	
Canadian Automobile Association	Ian Jack, Managing Director, Communications and Government Relations, Public Affairs Jason Kerr, Director, Government Relations, Public Affairs
Automobile Protection Association	George Iny, Director, Head Office
Wednesday, May 10, 2017	
Innovative Vehicle Institute	François Adam, General Manager Frederick Prigge, Research and Development Director
As an individual	Ata Khan, Professor, Member of ONE-ITS Board of Directors, Civil and Environmental Engineering, Carleton University
Tuesday, May 16, 2017	
As individuals	Denis Gingras, Professor, Laboratory on Intelligent Vehicles, University of Sherbrooke
	Tony Zhijun Qiu, Professor, Faculty of Engineering, University of Alberta
Wednesday, May 17, 2017	
Automotive Parts Manufacturers' Association	Warren Ali, Director, Emerging Technologies Initiatives
Automotive Industries Association of Canada	Jean-François Champagne, President France Daviault, Senior Director, Stakeholder Relations
Tuesday, May 30, 2017	
Waterloo Centre for Automotive Research (WatCAR), University of Waterloo	Ross McKenzie, Managing Director
Wednesday, May 31, 2017	
Global Automakers of Canada	David Adams, President
Toyota Canada Inc.	Stephen Beatty, Vice President, Corporate Dave Nichols, National Manager, External Affairs

Tuesday, June 6, 2017	
BlackBerry	Sandeep Chennakeshu, President, BlackBerry Technology Solutions John Wall, Senior Vice President and Head of BlackBerry QNX
Wednesday, June 7, 2017	
General Motors of Canada Company	Harry Lightsey, Executive Director, Emerging Technologies Policy David Paterson, Vice President, Corporate and Environmental Affairs
Canadian Vehicle Manufacturers' Association	Mark A. Nantais, President
Tuesday, June 13, 2017	
CoinDesk	Nolan Bauerle, Director of Research
Carillon Information Security Inc.	Patrick Patterson, President
Ford Motor Company of Canada, Limited	Blake Smith, Director, Sustainability, Environment and Safety Engineering
Wednesday, June 14, 2017	
As an individual	David Michelson, Co-Chair of the Intelligent Transportation Systems Society of Canada and Professor, University of British Columbia
Tuesday, September 19, 2017	
Canadian Urban Transit Association	Patrick Leclerc, President and Chief Executive Officer
Transdev Canada	Dominique Lemay, Chief Executive Officer
Wednesday, September 20, 2017	
Canadian Trucking Alliance	Marco Beghetto, Vice President, Communications and New Media
Atlantic Provinces Trucking Association	Jean-Marc Picard, Executive Director

Tuesday, September 26, 2017	
CARP (formerly Canadian Association for Retired Persons)	Rick Baker, President, Ottawa Chapter of CARP, Advocacy
Council of Canadians with Disabilities	Bob Brown, Transportation Committee Chairperson
Candrive	Brenda Vrkljan, Associate Professor, Occupational Therapy, School of Rehabilitation Science, McMaster University
Wednesday, September 27, 2017	
Office of the Governor of Arizona, United States	Matthew Clark, Policy Advisor
Wednesday, October 4, 2017	
Insurance Bureau of Canada	Mario Fiorino, Director, Legal and Senior Counsel Ryan Stein, Director of Policy
Enterprise Holdings	Tomi Gerber, Assistant Vice President, Government and Public Affairs
Associated Canadian Car Rental Operators	Craig Hirota, Vice President, Government Relations and Member Services
The Insurance Institute of Canada	Peter Hohman, President and Chief Executive Officer Paul Kovacs, Researcher and Author
Tuesday, October 17, 2017	
United States Department of Transportation	Nathaniel Beuse, Associate Administrator for Vehicle Safety Research, National Highway Traffic Safety Administration Finch Fulton, Deputy Assistant Secretary for Transportation Policy
Michigan Department of Transportation	Kirk Steudle, Director
Wednesday, October 18, 2017	
Uber	Justin Kintz, Senior Director, Americas Policy and Communications
Tuesday, October 24, 2017	
Central North American Trade Corridor Association	Paul Godsmark, Chief Technology Officer at the Canadian Automated Vehicles Centre of Excellence Roy Ludwig, Mayor, City of Estevan, Saskatchewan

Wednesday, October 25, 2017	
California Department of Motor Vehicles, United States	Bernard Soriano, Deputy Director
Tuesday, October 31, 2017	
Motor Coach Industries	John-Paul Pelletier, Vice President, Engineering
Privacy and Access Council of Canada	Sharon Polsky, President
New Flyer Industries Canada	Thomas Small, Director, New Product Development

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