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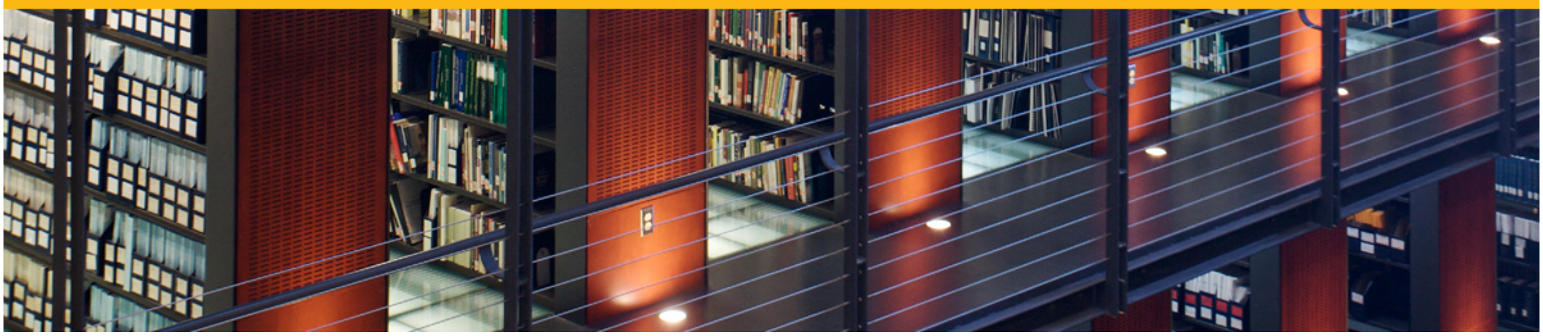

Automated and Connected Vehicles: Status of the Technology and Key Policy Issues for Canadian Governments

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Automated and Connected Vehicles: Status of the Technology and Key Policy Issues for Canadian Governments
(Background Paper)

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CONTENTS

AUTOMATED AND CONNECTED VEHICLES: STATUS OF THE TECHNOLOGY AND KEY POLICY ISSUES FOR CANADIAN GOVERNMENTS

Automated (self-driving) and connected vehicles are being developed and tested around the world. In Canada, the Government of Ontario announced a pilot project in October 2015 that would allow the testing of automated vehicles in the province.[1] Connected technology and low levels of automation are already available in vehicles sold in Canada.

This document provides background information on automated and connected vehicles (AVs and CVs), and highlights some of the key policy issues related to their deployment. The first section defines AVs and CVs. The second section explains when these vehicles are expected to be deployed. The third section provides an overview of the potential benefits of this technology. Finally, the paper explains the federal government's jurisdiction related to AVs and CVs and outlines some of the key policy challenges raised by the deployment of these vehicles.

1 WHAT ARE AUTOMATED AND CONNECTED VEHICLES?

While AVs and CVs share some of the same technologies, which can be combined, (i.e., a vehicle can be both automated and connected), the two terms are not synonymous. The Ontario Centres of Excellence Connected Vehicle/Automated Vehicle Program offers the following explanation of these technologies:

> Connected vehicles use wireless technology to connect with other vehicles [vehicle to vehicle, or V2V], transportation infrastructure [vehicle to infrastructure, or V2I] and mobile devices [e.g., smart phones] to give motorists the information they need to drive more safely. Automated vehicles, also known as self-driving vehicles, rely on sensors [such as radar and cameras] and computer analytics to sense their environments and navigate without human input.[2]

Figures 1 and 2 illustrate this explanation of the two technologies.

Figure 1 – Automated Vehicles

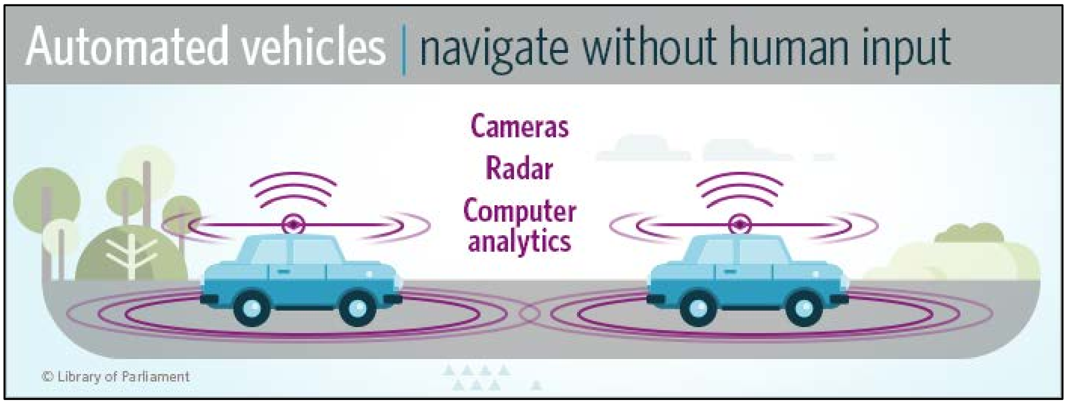
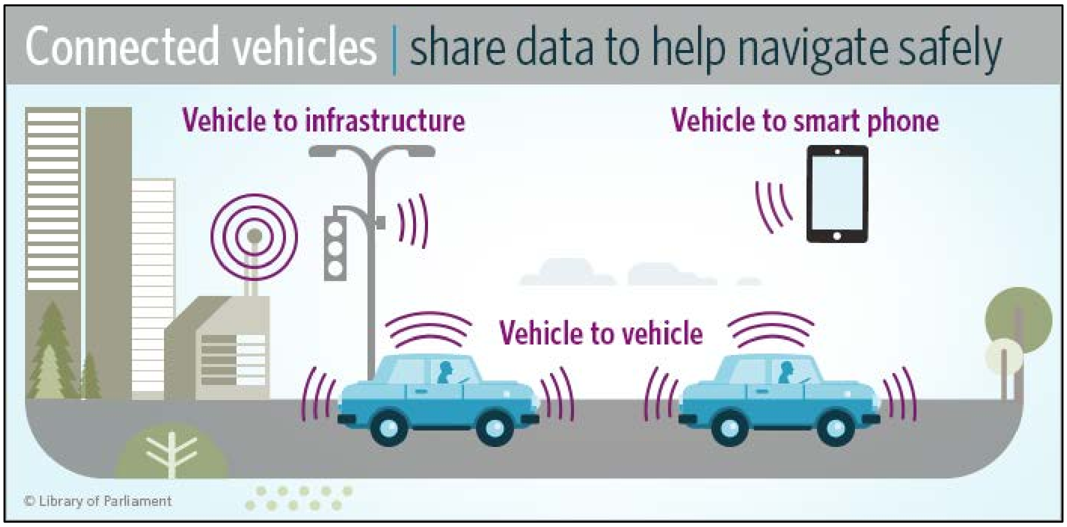


Figure 2 – Connected Vehicles



In the case of CVs, V2V connectivity allows vehicles to share their location, direction, speed, brake status and other information in real time with other similarly connected vehicles.[3] V2I connectivity allows smart roadway infrastructure equipped with CV technology (e.g., traffic signals, roadway signage, border and rail grade crossings) to exchange information in real time with vehicles and smart phones. These technologies allow vehicles to know the location of other vehicles on the road and allow drivers to receive notifications and alerts of potentially dangerous situations (e.g., a vehicle that is about to run a red light or an oncoming car that has swerved to avoid an object on the road).[4]

V2V and V2I communications occur over dedicated short-range communications (DSRC) systems, 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.[5] Canada and the United States have both designated the 5850–5925 megahertz (MHz) band for DSRC.[6]

The term "connected vehicle" can also be used more generally to describe vehicles with various telecommunications capabilities, such as enhanced navigation via global positioning system (GPS) communications, mobile Internet, infotainment (e.g., hands-free communications and back-seat entertainment) and remote software updates.[7]

In the case of AVs, it is important to note that there are varying degrees of automation. Table 1 provides an overview of the six levels of automation, based on the Society of Automotive Engineers International's Standard J3016, which is used in the regulation for Ontario's pilot program.[8] In the U.S., the National Highway Traffic Safety Administration uses a slightly different classification system.[9]

Table 1 – Levels of Vehicle Automation

Level of Automation	Description
Level 0: No automation	A human driver performs all aspects of driving, even when the vehicle is enhanced by warning or intervention systems.
Level 1: Driver assistance	A driver-assistance system performs either steering or acceleration/deceleration using information about the driving environment. The human driver is expected to perform all remaining aspects of driving.
Level 2: Partial automation	One or more driver-assistance systems performs both steering and acceleration/ deceleration using information about the driving environment. The human driver is expected to perform all remaining aspects of driving.
Level 3: Conditional automation	An automated driving system performs all aspects of driving, with the expectation that the human driver will respond appropriately to a request to intervene.
Level 4: High automation	An automated driving system performs all aspects of driving, even if a human driver does not respond appropriately to a request to intervene.
Level 5: Full automation	An automated driving system performs, full time, all aspects of driving under all roadway and environmental conditions that can be managed by a human driver.

Source: Table prepared by the author using data obtained from SAE [Society of Automotive Engineers] International, *Automated Driving: Levels of Driving Automation Are Defined in New SAE International Standard J3016*, 2014.

While CV technology is not necessary for the operation of AVs from one moment to the next, CV technology is either useful or essential to AVs for some purposes (e.g., downloading the latest maps, operating systems and driving software).[10]

V2V technologies can provide an extra layer of safety to AVs, and the data collected by AV sensors can be uploaded to other networks via CV technology.[11] Indeed, the U.S. Department of Transportation (DOT) has stated, "The full benefits of vehicle automation can be achieved only through connectivity."[12]

AV and CV technology can also be used in electric vehicles, called "ACE" (Automated, Connected and Electric) vehicles.[13]

2 DEPLOYMENT OF AUTOMATED AND CONNECTED VEHICLES

Semi-autonomous vehicles – those with low levels of automation – are already available to consumers. AVs with higher levels of automation are expected to be commercially available by around 2020, with consumers expected to start adopting the vehicles by the mid to late 2020s. Some experts expect AVs to become the prevailing mode of urban transportation during the 2030s.[14]

Nevertheless, there is some uncertainty about how quickly consumers will adopt the technology: will they take it up at the relatively slow adoption rate of new automobiles or at the faster rate of new consumer technology, like smart phones?[15] If there is a long transition period, AVs with varying levels of automation will share the road with traditional vehicles.[16] Less optimistic estimates suggest that AVs may not become common and affordable until the 2040s to 2060s period.[17]

Traditional car manufacturers, as well as technology companies, are expected to have different approaches to the deployment of AV technology, with the former preferring an incremental approach (gradually adding driver-assistance features to their vehicles over time) and the latter opting for a more revolutionary approach (designing, testing and selling fully automated vehicles from the outset). For example, most major car manufacturers intend to make vehicles capable of driving themselves for some of the time available to consumers by 2020, with some car manufacturers expecting vehicles with high levels of automation to be available by 2025. In contrast, Google aims to make vehicles capable of travelling autonomously on city streets and freeways publicly available between 2017 and 2019.[18]

On 25 August 2016, the software company nuTonomy launched the world's first public trial of an automated taxi service. The trial will allow individuals who are invited to use nuTonomy's smart phone application to hail a free automated taxi to travel within Singapore's one-north business district. A company engineer will be in the vehicle to monitor its performance and assume control if necessary.[19] In the U.S., ride-sharing service Uber launched a self-driving pilot project in Pittsburgh on 14 September 2016.[20]

With respect to CVs, V2V technologies have been tested in pilot projects, and are expected to start being made available within the next two years.[21] The U.S. DOT is working on a rule to require V2V equipment to be installed in all new vehicles.[22] In the U.S., V2I technologies are expected to be deployed over a 20-year period, as existing infrastructure is replaced or upgraded. Since V2I will capitalize on V2V technology, the former is expected to lag behind the latter in deployment.[23]

Since 2011, Japan has used V2I with the deployment of the ITS (Intelligent Transportation System) Spot. This system uses roadside infrastructure to collect and share data with vehicles, in an effort to provide three services to drivers: dynamic route guidance, safe driving support and electronic toll collection. The Netherlands, Germany and Austria are also working to develop a European smart corridor that would provide motorists with information on road work and traffic, among other things.[24]

The ACTIVE-AURORA Test-bed Network, a project led by researchers at the University of Alberta and the University of British Columbia, has also tested both V2V and V2I technologies.[25]

3 POTENTIAL BENEFITS OF AUTOMATED AND CONNECTED VEHICLES

A 2015 report from the Conference Board of Canada[26] outlined a number of benefits associated with AVs:

- Safety: Removing the human driver could eliminate most of the collisions involving driver error.[27]

- Transportation-as-a-Service (TaaS): AVs will allow ride-sharing companies (such as Uber and Lyft) to provide on-demand, door-to-door automated taxi services. As a result, AVs could encourage people to rent vehicles on a short-term basis rather than to own them, a transportation model known as TaaS.
- Synergies between TaaS and electric vehicles (EVs): One of the current drawbacks of EVs is their heavy batteries. It is expected that, in the future, batteries for EVs used as automated taxis will be small and quick-charging, mitigating this drawback. Charging could be automated to occur after dropping passengers off.[28] The smaller EVs could be used as automated taxis for most urban trips, resulting in fewer vehicle emissions.
- Lower-cost, personalized mass transit: TaaS would allow users to hail an automated taxi to take them to their destination, which could reduce the need for some public transit projects.
- Reduced need for parking: TaaS may encourage fewer people to own vehicles. AVs could also relocate themselves to an area of free parking (or, in the case of an automated taxi, drop off its passenger and move on to its next ride). As a result, AVs could free up land for other uses.
- Greener municipalities: Some parking areas could be reclaimed and turned into green spaces. Also, the use of AVs may increase the adoption of EVs. Regardless of the type of fuel used, AVs tend to be more energy efficient than conventional vehicles, especially when combined with CV technology, through platooning,[29] route optimization and smoother acceleration and braking.[30]
- Accessible transportation: AVs could provide more accessible transportation for individuals who are unable to drive.[31]

The report estimated that the total economic benefit of AVs to Canada will be $65 billion per year in 2013 dollars. This estimate includes the value of collision avoidance, heightened productivity (in a fully automated vehicle, a person who would otherwise be driving can spend his or her commuting time doing other things), fuel cost savings and congestion avoidance.[32]

CVs are also expected to have a number of benefits:

- Safety: CV applications may help drivers avoid collisions. V2V technology, for example, could warn a driver about an impending collision with a vehicle travelling ahead, or warn a driver about a vehicle in his or her blind spot.
- Mobility: CV mobility applications could help drivers navigate roads more efficiently, while also helping transportation system operators improve the functioning of the overall system, which could lead to fewer congestion-related travel delays.
- Environment: CVs, particularly with V2I applications aimed at reducing congestion and improving lane management, could reduce fuel consumption and emissions.[33]

Some of the challenges associated with AV and CV technology are discussed in the next section, which addresses key policy challenges for Canadian governments.

4 KEY POLICY CHALLENGES FOR CANADIAN GOVERNMENTS

4.1 REGULATION

4.1.1 SAFETY STANDARDS

In Canada, the federal government is responsible for ensuring that emissions and safety standards are followed in the design and construction of vehicles manufactured in or imported into Canada. The federal *Motor Vehicle Safety Act*[34] includes detailed safety regulations, referred to as the *Canada Motor Vehicle Safety Standards*.[35]

According to the British Columbia Freedom of Information and Privacy Association, these standards "set out specific requirements for everything from seatbelts and child restraints to such things as location of controls and displays, tire selection and rims, and window glazing materials."[36] These safety standards are typically harmonized with those of the U.S., since the auto industry operates in an integrated North American market and automobiles are regularly driven across the border between the two countries.[37]

Given the nascent nature of technologies for AVs and CVs, no federal safety standards exist specifically for these vehicles in Canada. However, the 2016 federal budget allocated $7.3 million over two years in part to support the development of regulations for emerging technologies such as AVs.[38] In February 2016, the Minister of Transport indicated that Transport Canada is working with domestic and international organizations to harmonize regulations and standards for AVs and CVs, and he asked the Standing Senate Committee on Transport and Communications to undertake a study on the "regulatory, policy and technical issues that Canada needs to address to successfully deploy these technologies."[39]

In September 2016, the U.S. DOT announced a federal policy for AVs. Among other things, the policy includes a 15-point safety assessment for vehicle manufacturers and a model policy for state governments.[40]

A number of harmonization initiatives are already under way:

- The Canada–U.S. Regulatory Cooperation Council has a CV Work-Plan, which will allow Transport Canada and the U.S. DOT to "coordinate and collaborate" on V2V and V2I technology.[41]
- In September 2015, the G7 Ministers of Transport agreed on the need for a harmonized regulatory framework for AVs and CVs, to facilitate the deployment of these technologies.[42]
- The American Association of Motor Vehicle Administrators has an information-sharing group that includes members from provincial transportation agencies in British Columbia, Ontario, Quebec, and Newfoundland and Labrador.[43]

4.1.2 Use of Vehicles on Canadian Roads

Provincial and territorial governments are responsible for regulating the use of roads, which includes authorizing the use of roads for AV testing.[44] In January 2016, Ontario launched a 10-year pilot program to allow the testing of AVs. The program allows for the use of AVs for testing purposes only, and participants must meet certain eligibility requirements and submit an application to the province's Ministry of Transportation.[45]

To date, no other Canadian province has introduced regulations to permit the testing of AVs on its roads. In the U.S., several states have enacted legislation to allow AV testing, and the recent federal AV policy includes a model state policy on AVs.[46]

4.1.3 Spectrum Allocation

The management of wireless spectrum is a federal responsibility, as governed by the *Department of Industry Act*, the *Radiocommunication Act* and the *Radiocommunication Regulations*, with consideration given to the objectives of the *Telecommunications Act*.[47] The Spectrum Policy Framework for Canada guides the management of spectrum in the country.[48]

As previously noted, both Canada and the U.S. have designated the 5850–5925 MHz band for DSRC, which is used for CV technology.

4.2 National Security and Policing

The Canadian Automated Vehicles Centre of Excellence (CAVCOE) has raised a number of national security and policing issues related to AVs and CVs:

> AVs can be used as mules to deliver almost anything to anywhere on the road network, and possibly off the road network too. From terrorist tools to drug mules, from criminal activity to personal vendettas, AVs could very quickly become the tool of choice for criminals and terrorists.[49]

Although most of these offences are addressed under the federal *Criminal Code*,[50] the provinces are generally responsible for the police forces[51] that enforce the relevant laws.[52]

AVs could also reduce the need for police officers to enforce traffic-related offences, given that the computers driving the vehicles will be programmed to be more law-abiding than humans. However, fewer police officers on traffic patrol could result in fewer arrests for more serious crimes, since routine traffic stops can sometimes help identify and arrest people wanted for more serious offences.[53]

In the U.S., the Federal Bureau of Investigation (FBI) released a document called a "public service announcement" in March 2016 warning consumers that digital connectivity of motor vehicles makes them vulnerable to hacking. According to the FBI document, a hacker could, for example, shut down the engine, disable the brakes, gain control of steering, lock the doors and adjust the turn signal in some CVs.[54]

4.3 INFRASTRUCTURE

The construction, operation and maintenance of most public infrastructure are within the jurisdiction of provincial, territorial and municipal governments. However, since 2000, the federal government has played an increasing role in supporting public infrastructure in all jurisdictions in Canada, by providing funding for projects.[55]

The Conference Board of Canada report recommended that all new transportation infrastructure projects include a detailed AV impact assessment, since this technology is expected to be deployed within the life of infrastructure that is being designed and built today.[56]

Although AV developers are focusing on making vehicles that can function using the current infrastructure, infrastructure designed to accommodate AVs would maximize the benefits of these vehicles, and the new infrastructure, in turn, would have an impact on future infrastructure needs. Examples of such infrastructure improvements include the creation of AV-only lanes, the construction of roundabouts (which are more efficient for AVs than traffic signals) and the changing of traffic signs to transmitters that send data directly to CVs.[57]

Road use could increase with AVs, but since AVs can use roads more efficiently by travelling closer together (particularly when combined with CV technology), their use would likely increase the capacity of existing roads. Overall, AVs are expected to reduce the need to expand existing roadways and/or build new ones.[58]

4.4 PUBLIC TRANSIT

The construction, operation and maintenance of public transit infrastructure are within the jurisdiction of provincial, territorial and municipal governments, but the federal government currently provides funding for public transit infrastructure.

The need for traditional public transit will likely remain in dense travel corridors, as AVs will have a limited impact on high-volume routes in peak periods. Conventional public transit is considered an efficient way to move large numbers of people quickly.[59]

Nevertheless, AVs could be used in providing the "last mile," which is the trip from home to the transit station and from the destination transit station to the final destination.[60] Outside periods of peak traffic, on-demand AV services may also be able to provide door-to-door transport at a cost that is lower than or comparable to mass transit. AVs may also reduce the need for buses on low-volume routes in suburban and rural areas, particularly outside peak periods.[61] For small and medium-sized cities, a fleet of AVs could even eliminate the need for traditional public transit.[62]

Automated taxis may also compete with traditional public transit, though there could be an opportunity for automated buses on bus rapid transit routes. Automated and platooned buses, operating on busways or high-occupancy vehicle lanes, could be competitive with rail.[63] These trends could affect the need to invest in public transit–related infrastructure.

Overall, this competition between on-demand AV services and traditional public transit could result in reduced ridership, lower revenues and a need for increased subsidies for publicly operated transit systems.[64]

4.5 PRIVACY CONCERNS

The federal government has some responsibility for privacy issues related to the personal information collected by car manufacturers through the *Personal Information Protection and Electronic Documents Act*, except in British Columbia, Alberta and Quebec, where similar provincial legislation exists.[65]

A paper published in 2015 by the University of Toronto's Munk School of Global Affairs argued that there is a need for a federal or provincial policy framework for the ownership, use and protection of data collected by AVs. It asserted that such a framework could address a number of issues:

- the development of policies regarding the need for governments and other stakeholders to use this data, while also protecting the privacy and security of that user data;
- access to the maps generated by AV companies for local government use (e.g., for urban design, engineering, traffic management or regulatory purposes);
- ownership and control of AV user data, and the potential role of Privacy by Design[66] and other frameworks;
- transparency of vehicle technology; and
- alignment with international best practices regarding management of this data.[67]

A number of concerns have also been raised regarding existing CV (also called "Connected Car") technologies. For example:

> Our review of several Connected Car privacy policies and terms of service indicates that the industry is violating Canadian data protection laws. In addition to lack of consent and forced agreement to unnecessary and arguably inappropriate uses such as marketing, Connected Car service providers are failing to meet the standards of Canadian law in respect of openness, accountability, individual access and limiting collection, retention, use and disclosure of customer data.[68]

Existing CVs can generate data on driver behaviour, biometrics, health, location, personal communications, web browsing, personal contacts and schedules. This information can be tracked, combined or linked with other data. A 2015 report from the British Columbia Freedom of Information and Privacy Association recommended that data protection regulations be created for CVs.[69]

4.6 URBAN PLANNING

Urban planning is typically a responsibility of municipal and provincial or territorial governments. According to a 2016 report by the law firm Borden Ladner Gervais, "Transportation and urban planning change substantially when we alter our assumptions about cars."[70] For example, AV and CV use may bring about an increase in urban sprawl if the ability to be more productive in vehicles leads to a greater willingness to make longer commutes, especially if housing prices are lower farther from the city centre.[71] In short, changes in the use of land, vehicles and public transportation are all expected to affect local governments' urban design and transportation planning.[72]

4.7 LABOUR

Generally, responsibility for labour relations falls within provincial jurisdiction, pursuant to the provincial authority over "property and civil rights in the province" under section 92(13) of the *Constitution Act, 1867*. The federal government, however, may have jurisdiction over labour relations by way of exception. For example, parliamentary legislative jurisdiction is triggered by a federal work, undertaking or business. Federally regulated sectors covered under the *Canada Labour Code* include interprovincial and international services (such as railways, road transport, canals, ferries, tunnels, bridges and shipping services), radio and television broadcasting, air transport, banks and most federal Crown corporations.[73]

The use of AVs is expected to both create and eliminate jobs; however, in sectors that work on AVs, CVs and related infrastructure, businesses may create jobs if they are able to seize the opportunity.[74] For example, companies that develop the technology used in AVs and CVs are expected to see job gains, as will construction companies that create infrastructure for these vehicles.[75] Sectors that are transportation intensive may also realize productivity gains and business model innovations.[76]

In contrast, sectors that depend heavily on existing transportation models could see job losses. For example, with fewer accidents occurring as a result of the adoption of AVs, automobile repair and maintenance firms could experience reduced business. It is also expected that the taxi and limousine industry will undergo further disruptions when ride-sharing services, such as those offered by Uber and Lyft, start using AVs.[77]

Other industries may see both business opportunities and job losses. For example, while the freight transportation industry is expected to reduce costs[78] and improve productivity with the use of AVs, truck drivers could lose their jobs.[79]

A trend towards on-demand AV-enabled transportation services could disrupt the current motor vehicle manufacturing business model, especially if more people opt not to own a vehicle. Manufacturers may choose to focus their business on AVs built specifically for ride-sharing services.[80] While a single automated taxi could replace 10 vehicles, automated taxis would have a short lifespan (two to three years) as a result of intensive use and would need to be replaced more often than individually owned cars.[81]

For its part, CAVCOE recommends that the federal government help mitigate the impact of expected job losses caused by the introduction of these vehicles and promote workforce retraining.[82]

4.8 INSURANCE

In Canada, automobile insurance is mandatory under provincial and territorial law. Provincial and territorial regulators may also oversee how insurance companies assess risk, determine their prices and handle claims. In addition, provincial and territorial governments determine what factors insurers may use when setting auto insurance rates. Under the *Insurance Companies Act*,[83] the federal government regulates the financial solvency and stability of federally incorporated general insurance companies (such as automobile insurance companies), as well as Canadian branch operations of insurance companies incorporated outside Canada; this is done through the Office of the Superintendent of Financial Institutions.[84]

In British Columbia, Saskatchewan and Manitoba, provincial governments provide the required minimum automobile insurance (coverage for injuries), and private firms and government insurers sell supplementary coverage to those policies. A similar regime exists in Quebec, but bodily injury claims resulting from accidents outside the province are covered by private insurers. In all other provinces and in all three territories, private companies provide all motor vehicle insurance.[85]

The deployment of AVs and CVs is expected to have a significant impact on the insurance industry. Accident rates are projected to drop dramatically once AVs are pervasive, which would dramatically reduce insurance costs. In addition, it will be possible to equip vehicles with connected technology to track and disable vehicles remotely, cutting the insurance costs of auto theft.[86]

Since humans will not be behind the wheel of AVs, some or all liability for accidents could shift to the automobile manufacturers, meaning that manufacturers and suppliers may have a greater need for product liability insurance.[87] For semi-autonomous vehicles, risk could be divided between drivers and manufacturers.[88]

CV technology can provide substantial data on the risk of each trip, including the duration, speed and use (or lack thereof) of driver-assistance features. This technology, which already exists in some vehicles, may allow insurance companies to offer policies where premiums change based on the operational habits of the driver.[89]

4.9 RESEARCH AND DEVELOPMENT

The federal, provincial and territorial governments can all play a role in funding research and development in the area of CVs and AVs. In October 2014, Transport Canada announced that it was contributing $1.3 million from the Asia-Pacific Gateway and Corridor Transportation Infrastructure Fund to the University of Alberta's ACTIVE-AURORA project, which conducts research into CV technology.[90] The Government of Ontario has also contributed $2.95 million to the Ontario Centres of Excellence Connected Vehicle/Automated Vehicle Program, which brings academic institutions together with businesses to promote and encourage innovative transportation technology.[91]

However, CAVCOE suggests that more funds should be invested in the development of these technologies, recommending that the federal government "[m]ake a significant investment in AV development, testing, and related activities in the auto and technology industries, universities and the National Research Council."[92]

In the U.S., the DOT is engaged in numerous research activities related to AVs and CVs.[93] In January 2016, the President proposed a 10-year investment of almost US$4 billion (about C$5.1 billion) to accelerate the development and adoption of safe vehicle automation through real-world pilot projects.[94] Elsewhere, the United Kingdom's Centre for Connected and Autonomous Vehicles is delivering a research, development, demonstration and deployment program worth up to £200 million (about C$335 million).[95]

5 CONCLUSION

Vehicles with low levels of automation and connectivity are already available to consumers, with higher levels of automation and connectivity expected to be available in the not-so-distant future. The deployment of these AVs and CVs raises a number of issues of relevance to Canadian policy-makers, including:

- **Regulation:** In Canada, there are very few regulations and standards regarding the safety and use of AVs and CVs.
- **National security and policing:** AVs and CVs could have an impact on existing police practices and could be used for criminal purposes.
- **Infrastructure:** Maximizing the benefits of AVs and CVs could involve changes to public infrastructure, and governments may wish to take this idea into account when planning new infrastructure.
- **Public transit:** The need for conventional public transit will likely remain in dense travel corridors, but automated taxis may compete with (or replace) existing public transit on low-volume routes and in small and medium-sized municipalities.
- **Privacy:** AVs and CVs can collect vast amounts of data about an individual, but no policy framework currently exists specifically for these vehicles to address the ownership, use and protection of this data.
- **Urban planning:** These vehicles are expected to have an impact on urban sprawl, vehicle usage, parking space and public transit, which will likely have an impact on urban design and transportation planning.
- **Labour:** The arrival of AVs and CVs is expected to both create and eliminate jobs, depending on the sector. The net impact on employment cannot be predicted at present.
- **Insurance:** Insurance costs could be reduced dramatically as a result of fewer accidents and the ability to remotely track and disable stolen vehicles. This technology could also enable usage-based insurance premiums.
- **Research and development:** It has been suggested that governments have a role to play in the research and development of AVs and CVs. While some investments have already been made in Canada and in other jurisdictions, a

number of stakeholders have called on Canadian governments to increase their funding in this area.

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24. Ibid., p. 2.

25. Based on a site visit to the University of Alberta by the Standing Senate Committee on Transport and Communications on 20 September 2016. See also Transport Canada, "ACTIVE-AURORA project: wireless connected vehicle technology now testing a variety of applications," Backgrounder, September 2016.

26. Gill et al. (2015).

27. In the U.S., 93% of collisions involve human error (a similar statistic is not available for Canada).

28. Ticoll (2015), p. 27.

29. Platooning decreases aerodynamic drag by grouping vehicles together and reducing the distance between them using electronic coupling, which can allow multiple vehicles to accelerate or brake at the same time. This technology is being tested in trucks in the United States and in the Netherlands. See U.S. Department of Energy, National Renewable Energy Laboratory, "Truck Platooning Testing," *Transportation Research*; and Government of the Netherlands, "Truck Platooning," *Mobility, public transport and road safety*.

30. Ticoll (2015), p. 27.

31. List compiled by the author, based on information summarized from Gill et al. (2015), pp. 16–19.

32. Gill et al. (2015), pp. 29–30.

33. List compiled by the author, based on information summarized from U.S. DOT, ITS Joint Program Office, *Connected Vehicle Benefits*, Fact sheet; and U.S. DOT, NHTSA, *Vehicle-to-Vehicle Communication Technology*, Fact sheet.

34 *Motor Vehicle Safety Act*, S.C. 1993, c.16.

35. Lawson, McPhail and Lawson (2015); and Transport Canada, *Motor Vehicle Safety*.

36. Lawson, McPhail and Lawson (2015), p. 10.

37. Ibid., p. 11.

38. Government of Canada, "Chapter 5 – An Inclusive and Fair Canada," *Budget 2016*.

39. Senate, Standing Committee on Transport and Communications, *Evidence*, 1st Session, 42nd Parliament, 17 February 2016.

40 U.S. DOT, "U.S. DOT Issues Federal Policy for Safe Testing and Deployment of Automated Vehicles," Press release, 20 September 2016.

41. Transport Canada, *Canada–U.S. Regulatory Cooperation Council (RCC) Connected Vehicles Work-Plan*.

42. Germany, Federal Ministry of Transport and Digital Infrastructure, "G7: Prosperity through modern infrastructure and Mobility 4.0," News release, 17 September 2015.

43. American Association of Motor Vehicle Administrators, *Autonomous Vehicles Information Sharing Group Roster*.

44. Lawson, McPhail and Lawson (2015).

45. Ontario Ministry of Transportation, *Automated Vehicles – Driving Innovation in Ontario*.

46. Eight states plus Washington, D.C., have introduced legislation related to AVs, and Arizona's governor has issued an executive order. Other states are also in the process of introducing AV-related laws. See National Conference of State Legislatures, *Autonomous/Self-Driving Vehicles Legislation*; and U.S. DOT, "Secretary Foxx Unveils President Obama's FY17 Budget Proposal of Nearly $4 Billion for Automated Vehicles and Announces DOT Initiatives to Accelerate Vehicle Safety Innovations," News release, 14 January 2016.

47. *Department of Industry Act*, S.C. 1995, c. 1; *Radiocommunication Act*, R.S.C. 1985, c. R-2; *Radiocommunication Regulations*, SOR/96-484; *Telecommunications Act*, S.C. 1993, c. 38.

48. Innovation, Science and Economic Development Canada, *SPFC – Spectrum Policy Framework for Canada*, June 2007.

49. CAVCOE (2015), p. 16.

50. *Criminal Code*, R.S.C. 1985, c. C-46.

51. Ontario and Quebec have established their own police forces, with municipal police forces (established under provincial law) providing policing in some larger municipalities. In the other eight provinces, the Royal Canadian Mounted Police has contracts with the provincial governments to provide police services.

52. For more information, see Peter W. Hogg, *Constitutional Law of Canada*, 5th ed. Vol. 1, 2015, Release 1, Thomson-Reuters Canada Limited, 2007, pp. 18-1,18-2, 18-10, 19-9, 19-10 and 19-12; Royal Canadian Mounted Police, *National Security Criminal Investigations Program*; and Canadian Security Intelligence Service, *Role of CSIS*.

53. CAVCOE (2015), p. 16.

54. United States, Federal Bureau of Investigation, "Motor Vehicles Increasingly Vulnerable to Remote Exploits," *Public Service Announcement*, 17 March 2016.

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

56. Gill et al. (2015), p. 46.

57. Ibid., pp. 38–41.

58. Ibid., p. 41.

59. Ibid., p. 42.

60. Ibid., p. 43.

61. Ibid.

62. CAVCOE (2015), p. 11.

63. Ticoll (2015), p. 38.

64. CAVCOE (2015), p. 10.

65. Lawson, McPhail and Lawson (2015), p. 11.

66. Privacy by design "seeks to proactively embed privacy into the design specifications of information technologies, organizational practices, and networked system architectures." See Information and Privacy Commissioner of Ontario, *Privacy by Design*.

67. Ticoll (2015), p. 12.

68. Lawson, McPhail and Lawson (2015), p. 6.

69. Ibid., pp. 5–6.

70. Kevin LaRoche and Robert Love, *Autonomous Vehicles: Revolutionizing Our World*, Borden Ladner Gervais LLP, 2016, p. 20.

71. Gill et al. (2015), p. 33.

72. Ticoll (2015), p. 11.

73. Brian W. Burkett et al., *Federal Labour Law and Practice*, Thomson Reuters Canada Limited, 2013, p. 50; and Government of Canada, *Federally Regulated Businesses and Industries*. See also "VI. Distribution of Legislative Powers," *Constitution Act, 1867*, s. 91; and *Canada Labour Code*, R.S.C. 1985, c. L-2.

74. Ticoll (2015), p. 46.

75. Ibid., p. 47.

76. Ibid.

77. Ibid., pp. 48–49.

78. It has been estimated that 40% of the cost of operating trucks could be saved by automating the truck. See Gill et al. (2015), p. 35.

79. Ticoll (2015), pp. 47–48.

80. For example, the Ford Motor Company has announced its intention to have high-volume, fully autonomous vehicles for ride sharing available by 2021. See Ford Motor Company, "Ford Targets Fully Autonomous Vehicle for Ride Sharing in 2021; Invests in New Tech Companies, Doubles Silicon Valley Team," News release, 16 August 2016.

81. Ticoll (2015), pp. 48–49.

82. CAVCOE (2015), p. 10.

83. *Insurance Companies Act*, S.C. 1991, c. 47.

84. Insurance Bureau of Canada, *Car Insurance Where You Live*; and The Co-Operators, *Why is auto insurance regulated by provincial governments?*.

85. Ibid.

86. Ticoll (2015), p. 30.

87. Ibid.; and LaRoche and Love (2016), p. 17.

88. LaRoche and Love (2016), p. 17.

89. Ibid.

90. Transport Canada, "ACTIVE-AURORA project launched at the University of Alberta," News release, 22 October 2014.

91. Ontario Ministry of Transportation (2015).

92. CAVCOE (2015), p. 15.

93. For example, see U.S. DOT, *USDOT Automated Vehicle (AV) Research Activities: Current and Completed Projects*; and U.S. DOT, ITS Joint Program Office, *Connected Vehicle Pilot Deployment Program*.

94. U.S. DOT (14 January 2016).

95. Government of the United Kingdom, *Driverless vehicles: connected and autonomous technologies*, 11 July 2016.