The Future of Automated Vehicles in Canada

Report of the PPSC Working Group on
Connected and Automated Vehicles

January 29, 2018

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Report of the Policy and Planning Support Committee (PPSC) Working Group on Connected and Automated Vehicles

Participating Jurisdictions: Canada (Co-Chair), New Brunswick, Quebec, Ontario (Co-Chair), Alberta, British Columbia

Participating Organizations: Canadian Council of Motor Transport Administrators, Engineering and Research Support Committee, Transportation Association of Canada

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Executive Summary

Automated and connected vehicle (AV/CV) technology is quickly advancing and has potentially wide-ranging implications across society. This report provides an overview for Transportation and Road Safety Ministries of the short-, medium- and long-term policy implications of the introduction of AVs and CVs on public roads. The report identifies gaps, opportunities, and ways to encourage cooperation across Canada and internationally. Although the main focus of this report is on automated vehicles (AVs) and not connected vehicles (CVs), it should be recognized that connectivity and smart roadway infrastructure (SRI) are important aspects to realizing the full potential benefits of AV technology.

The key issues identified in this report are:

1. **Road safety remains paramount:** The introduction of AVs demands involvement from all levels of government to assess emerging technologies and develop standards, policies and regulations that facilitate the safe introduction of AVs on public roads.

2. **Standards and regulations cannot be developed in isolation:** Harmonization between Canadian and US jurisdictions will facilitate R&D, testing and deployment within an integrated market.

3. **Innovation must be supported:** Governments must be mindful of how AV regulation will impact innovation and economic growth.

4. **There are significant privacy issues:** As more and more vehicle data is generated, collected and shared, governments must act to protect the privacy rights and security of individuals.

5. **Education and awareness is key:** As vehicles get closer to full automation, public outreach will be important to inform people on the safety benefits of AVs and issues like distracted driving and impaired driving. Driver training may also be appropriate.

6. **Technology expertise is urgently needed:** It will be crucial for regulators to develop expertise in data science and computer science. AVs will generate large volumes of data which currently have no clear ownership rights. Governments will need to effectively address these concerns and protect the public interest.

7. **Traffic laws must be updated:** Current traffic laws are inadequate for fully-automated AVs. The regulatory framework will need to adapt to new technology to facilitate the use of fully-automated vehicles on public roads.

8. **There are gaps in liability and insurance:** Liability rules will need to be updated to accommodate AVs in auto insurance regimes. Governments have a role to play in overseeing this transition.

9. **Transitioning could be the primary challenge:** The most challenging aspect of AV adoption may be the transition period from human drivers to fully-automated vehicles.

10. **Physical infrastructure modifications can wait:** As AVs are being designed to work with the physical or "hard" infrastructure that exists today, and their integration will be incremental over time, significant infrastructure changes can be deferred until governments observe and learn from the early integration of AVs. That said, governments will need to be aware of which technologies automakers and suppliers are using, and plan to use in the future. It should also be recognized that digital infrastructure (e.g., sensor data, maps) warrants more immediate attention, as it is key to enabling AV systems and the incremental automation that is being advanced today.

To address some of the issues highlighted in the report and contribute to the safe deployment of AVs in Canada, it is recommended that federal, provincial and territorial governments:

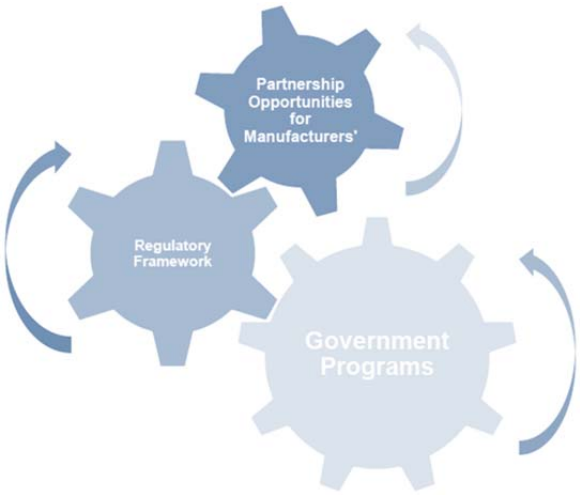
- Develop a National Policy Framework to ensure the safe deployment of AVs on public roads;

- Continue to work closely with jurisdictions and international partners to align testing and regulatory frameworks, where necessary;

- Continue to promote and invest in industry and academia to test and evaluate AV technology on public roads before they are fully deployed.

The Role of Governments

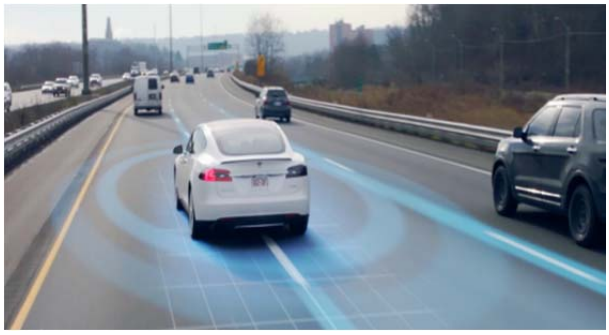
Automated Vehicles (AVs) (also described as autonomous, driverless or self-driving) are vehicles whose speed, steering, and other driving functions are controlled by computer hardware and software. The vehicles are capable of using sensors, camera systems, artificial intelligence, and global positioning systems to sense their environments and navigate without the need for human input. In lower levels of automation, control is shared with a human driver. The transition to AVs will depend on a partnership between government and industry to ensure that AV technology is safely and effectively deployed. In Canada, all levels of government have distinct jurisdictional responsibilities that will be impacted by the introduction of AVs, which means that governments must work together to bring about the most beneficial outcome. Regulations will also need to be aligned internationally to allow for safe travel across borders of both people and goods.



In Canada, the **federal government** is responsible for establishing a national AV policy and regulatory framework. Transport Canada is responsible for keeping vehicle manufacturers accountable for safety standards compliance and emissions requirements. A national framework on AVs can promote the standardization and harmonization of AV technology across the country. The federal government also acts as the facilitator for international harmonization of technology standards, particularly with the US and Mexico.

Provincial and territorial governments are responsible for creating the legislative framework for AV testing and deployment within their own jurisdictions. Provincial and territorial legislation incorporates federal vehicle safety requirements. Provincial and territorial governments are also responsible for driver licensing, vehicle registration and insurance, rules of the road and any changes to highway infrastructure that might be needed to support AV deployment.

Municipalities execute the legislative and regulatory framework created by provinces and territories, including AV safety enforcement. They also make land use decisions and operate transit systems; both could be profoundly affected by widespread availability of AVs.



Key **industry players** include automakers, auto parts manufacturers, and technology firms. As AV technology advances and AVs are deployed onto public roads, the AV industry and all levels of government will need to work together and maintain open dialogue. This will ensure that, on the one hand, governments are aware of the current challenges in AV technology, and on the other hand, ensure that the AV industry is aware of safety, accessibility, and other regulatory standards that serve the public interest. This is why it is crucial for the AV industry to work in partnership with governments on testing and deployment.

The computerization of vehicles will bring a wealth of new data that can, and should, be used by road regulators to improve the safety and performance of Canada's road transportation network. This data has the potential to significantly alter how governments plan, design and modify infrastructure, improve emissions monitoring, and enhance road safety.

All three levels of government will have an important role to play in raising public awareness as AVs are introduced to the public and disseminating important safety information about the technology.

Automated Vehicle Technology

Although automated and connected vehicles share some of the same technologies, the two terms are not synonymous. Connected vehicles use internet connectivity to extend a vehicle's awareness beyond its physical limits and enable communication between vehicles, transportation infrastructure, mobile devices, and cloud computing platforms. Connected vehicles do not necessarily control the vehicle. Automated vehicles, on the other hand, are capable of sensing their environment *independently* and navigating without human input. Automated vehicles control the actual movement of the vehicle.

Fully-automated vehicles are still being developed and not yet commercially available. However, partially-automated vehicles, with lower levels of automation, are already available. As road safety regulators, ministers are already familiar with adaptive cruise control, automatic

braking, blind spot monitoring, and lane departure warning systems.

To help describe the degree of automation in vehicles, the industry has defined a 5-point scale (see Figure 1). The highest level of automation, where human input is never required, is Level 5.

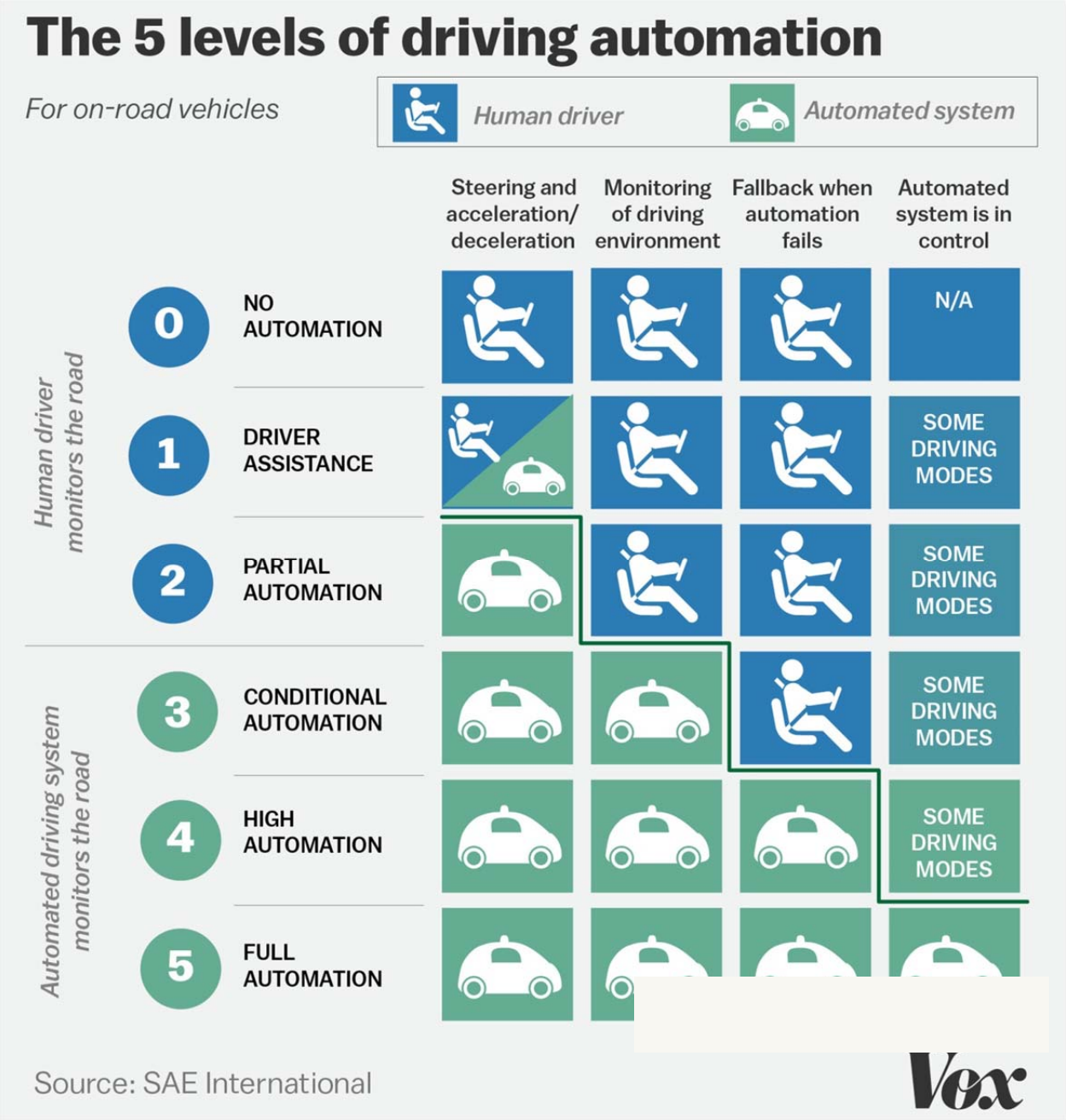


Figure 1: SAE Levels of Vehicle Automation – Vox Media (2016)

AVs work by applying machine learning and artificial intelligence to the navigation of vehicles. This means that the pace and extent at which AVs are developed is highly dependent on the pace and extent at which artificial intelligence is developed. If Level 5 automation requires what is referred to as *general* artificial intelligence, then fully-autonomous vehicles are likely decades away. If, however, Level 5 automation can be achieved through what is referred to as *narrow* artificial intelligence, fully-autonomous vehicles are likely less than a decade away.

A number of vehicle manufacturers are publicly aiming to have high levels of automation available by 2025. KPMG is forecasting Level 5 AVs will be commercially available by 2040 (Figure 2). Other estimates suggest that AVs may not be common until the 2040s to 2060s.

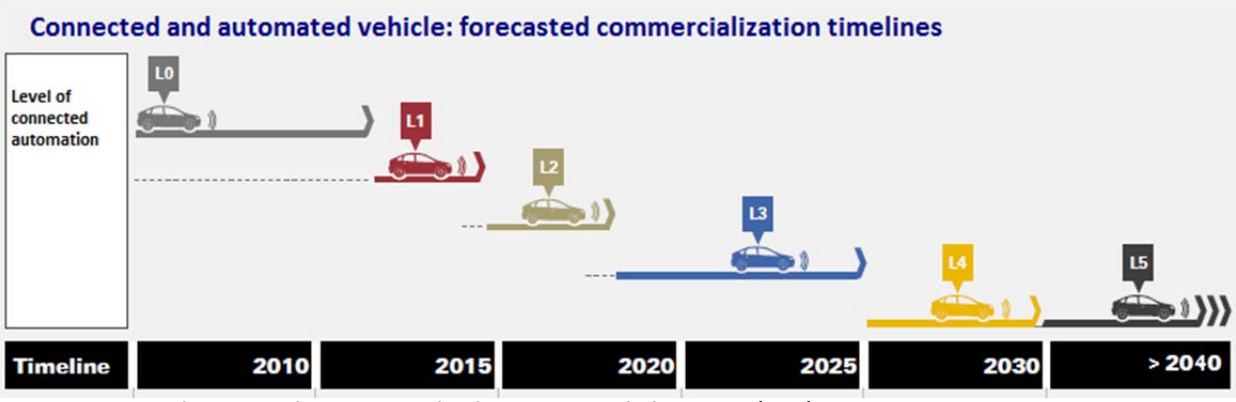


Figure 2: Commercialization Timelines: Connected and autonomous Vehicles – KPMG (2015)

The State of Automated Vehicles in Canada

While existing vehicle safety standards do not restrict the introduction of partially-automated vehicles in Canada — that is, vehicles with features such as electronic blind spot assistance, automated emergency braking systems, park assist, adaptive cruise control, lane departure warning — new federal safety requirements may be needed as vehicles become increasingly automated. Unlike these partially-automated features, fully-automated vehicles are not addressed by existing safety standards as they profoundly change the nature of the driver, vehicle, and road environment.

AV technology is rapidly developing and being tested on actual roads for entry into the market in the near future. While there is understandably pressure to adapt quickly to emerging technologies, safety remains a top priority and concern of regulators.

Automated Vehicle Industry

In the private sector, the race to bring AVs to market has accelerated, and there is both significant cooperation and competition across several industries. Cross-sector and cross-institutional partnerships are forming that leverage expertise across sectors and institutions in order to bring AVs to market.

Vehicle manufacturers, for example, have established relationships with academic institutions and research centers. They are also partnering with technology companies that develop AV technology, as in the case of Ford partnering with Google's Waymo, or buying them outright, as in the case of GM buying Cruise Automation.

The AV industry is still wide open, however, and both automotive and technology companies continue to test and refine their AV technology on public roads.

CCMTA AND TAC

The Canadian Council of Motor Transport Administrators (CCMTA) and the Transportation Association of Canada (TAC) CV/AV working groups continue to monitor developments in the United States to ensure best practices are included in the federal, provincial and territorial regulatory frameworks related to AVs. Specifically, in working towards consistent standards in the United States and Canada, CCMTA collaborates with AAMVA and FMCSA to ensure the safe deployment of AV/CVs.

ONTARIO'S HIGHWAY TRAFFIC ACT REVIEW

The Transportation Research Board has established a working group to analyze the implications of AV safety on highway traffic laws in the United States. As a member of this working group, Ontario's *Highway Traffic Act* will also be reviewed. The review is being led by the Virginia Tech Transportation Institute.

FEATURE PROJECT:

ONTARIO PILOT REGULATION ON THE TESTING OF AVS

Ontario was the first Canadian jurisdiction to allow on-road testing of AVs.

On January 1, 2016, *Ontario Regulation 306/15: Pilot Project – Automated Vehicles* took effect which allows for the testing of AVs on Ontario roads under the following conditions:

- Restricted to testing purposes only;
- The pilot will run for 10 years and include interim evaluation(s);
- Only vehicles manufactured and equipped by approved applicants are permitted;
- The driver must remain in the driver's seat of the vehicle at all times and monitor the vehicle's operation;
- The driver must hold a full class licence for the type of vehicle being operated;
- Eligible participants must have insurance of at least $5M;
- All current Highway Traffic Act rules of the road and penalties will apply to the driver/vehicle owner; and,
- Vehicles must comply with SAE Standard J3016 and any requirements of the Motor Vehicle Safety Act (Canada) that apply to automated driving systems for the vehicle's year of manufacture.

The Ontario pilot aims to strike a balance that ensures road safety without compromising innovation and the need for testing. As of December 2017, participants include Blackberry QNX, The University of Waterloo, The Erwin Hymer Group, Continental Corporation, X-Matik, Magna, and Uber.

FEATURE PROJECT:

EDMONTON/VANCOUVER: ACTIVE-AURORA

Wireless connected vehicle technology is being tested on Edmonton roads. The Government of Alberta is a partner in this innovative research project which will shape future investments in intelligent transportation systems in Alberta. The ACTIVE-AURORA project consists of four test-beds and two laboratory test environments, with ACTIVE representing the Edmonton component and AURORA representing the Vancouver component.

The three on-road Alberta Co-operative Transportation Infrastructure and Vehicular Environment (ACTIVE) test-beds will primarily evaluate how connected vehicle technology can be applied to transportation safety, traffic demand management and increase peak capacity and smooth traffic flow on busy roads. The on-road Automotive Test-bed for Reconfigurable and Optimized Radio Access (AURORA) will develop, test, demonstrate and commercialize innovations in Vancouver, with particular emphasis on wireless communications for freight security and efficiency.

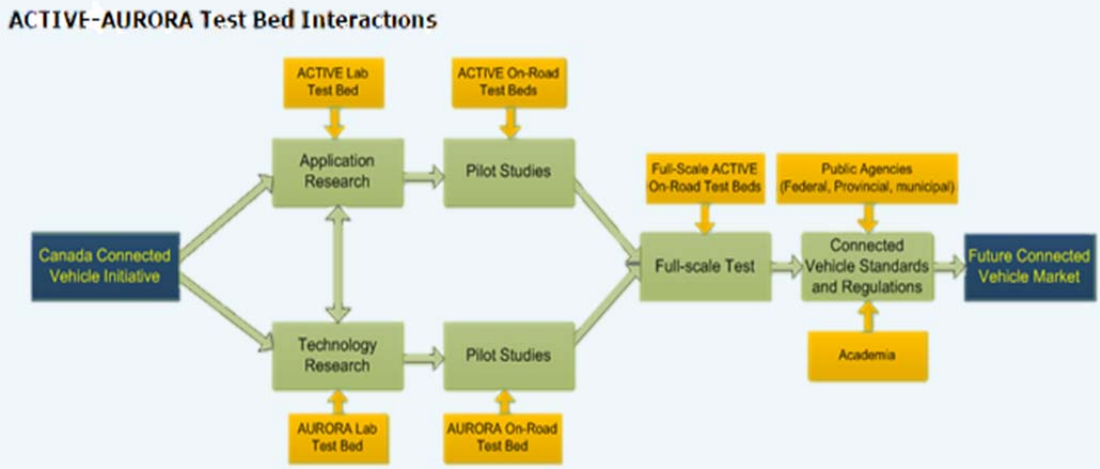


Figure 3: ACTIVE-AURORA Test Bed Project Plan - Centre for Smart Transportation September 2016

How Governments Can Prepare

In the short, medium and long-terms, governments need to consider numerous policy impacts of AVs and be prepared with regulatory frameworks. AV technology is an interdisciplinary endeavor, and a new regulatory regime, infrastructure adaptation, and data analytics will maximize the effectiveness of highway and vehicle regulation.

THE ROLE OF GOVERNMENTS

- ☑ **Regulate Vehicle Safety**
- ☑ **Harmonize Standards within Canada and the US**
- ☑ **Encourage Innovation**
- ☑ **Protect Privacy of Individual Vehicle Users**
- ☑ **Educate the Public**
- ☑ **Build Data Expertise and Capacity**
- ☑ **Develop and Enforce Traffic Laws**
- ☑ **Oversee Insurance and Liability**
- ☑ **Ensure a Safe and Smooth Transition**
- ☑ **Build and Upgrade Transportation Infrastructure**

Short-Term

These are areas where immediate actions are required by all three levels of government. These issues will need to be supported with policy, programs and regulatory initiatives in order to support the safe testing, piloting and deployment of AVs.

REGULATING VEHICLE SAFETY

Governments must maintain vehicle safety standards as AV technology evolves.

Transport Canada is responsible for determining whether vehicles can be imported or sold in Canada and the standards they must meet. Provinces and territories are responsible for determining whether a vehicle can be registered for on–road use and the rules that would apply.

The introduction of AVs will demand involvement from all levels of government to assess the technology and coordinate standards and regulations. There is an immediate need to develop policy that facilitates the safe introduction of AVs on public roads alongside human drivers and under all environmental conditions.

Governments should continue to consult with industry leaders, experts and international partners to establish safety guidelines for AV onboarding.

Timeframe for Action: 0-10 years.

REGULATORY HARMONIZATION

Governments should consider developing Canada-wide AV standards.

It would be beneficial for provinces and territories across Canada to develop common AV regulations and standards to ensure that AVs can travel across provincial and territorial boundaries without issue, and to ensure that the widest range of AVs is available on the market.

For similar reasons, Canada would benefit from aligning its AV regulatory framework with the United States and Mexico. International harmonization would also maximize export opportunities and maintain the very efficient US-Canada auto supply chain. To advance international harmonization of AV standards, jurisdictions in Canada will need to maintain and strengthen their relationships with departments of road safety in the United States and other countries.

In the United States, work is already underway to establish AV standards. In September 2016, the National Highway Traffic Safety Administration (NHTSA) published the Federal Automated Vehicle Policy which provides guidance to both the AV industry and to state highway regulators. The guidance includes a 15-point Safety Assessment that sets clear expectations for manufacturers developing and deploying AVs.

For a summary of the status of AVs in other countries, see Appendix 1.

Timeframe for Action: 1-20 years

ENCOURAGING INNOVATION

Regulation must be balanced with encouraging innovation and economic growth.

While industry is leading the development and commercialization of AV technologies, governments have a key role to play in promoting their inter-operability, updating public infrastructure, coordinating stakeholder efforts, and ensuring cybersecurity, among other things. This regulatory role is essential to ensuring public safety and promoting the public interest.

However, regulations, by their very nature, can limit innovations in technology and new economic models. As each new AV regulation is developed, governments must consider this balance between the need for regulation and permitting innovation.

Timeframe for Action: 1-20 years

PROTECTING PRIVACY AND SECURITY

Significant privacy and security issues will need to be addressed.

Once AVs are fully deployed, vehicles will be broadcasting real-time travel data, raising a number of privacy and security concerns. Institutional, legal, privacy, and cybersecurity issues will need to be considered.

For security, drivers and vehicle systems will need the assurance that incoming and outgoing data is dependable and secure. Although AV developers are, in general, very motivated to prevent hacking, in the rush to keep up in the race to bring AVs to market, some developers may try to deploy AVs which are not adequately secure. Ensuring and enforcing minimum security standards is a key job for regulators.

Even with security in place, there are significant privacy issues at play. It is presently not yet clear what the ownership rights of travel data, or privacy rights of users, will be. Even “anonymous” data can be used to gain information about private individuals. The question that regulators need to answer is: Is anonymous travel a right? And to what degree?

Regulators should be seriously thinking about privacy and security issues now. As a starting point, transportation regulators can engage with other regulatory bodies, such as those in health care, to learn best practices around privacy and address any clear gaps. In the medium-term, regulators should begin assessing shifts in the legal landscape regarding privacy rights in road travel.

Timeframe for Action: 1-10 years

PUBLIC EDUCATION AND AWARENESS

The public must be educated on distracted driving and other AV safety issues.

The introduction of AVs changes the nature of road transportation. Public outreach and education will be necessary to inform and raise awareness of limitations, regulatory changes, safety issues and privacy issues.

To start, it will be particularly important to educate the public on the need to be attentive in partially-automated vehicles. The public will also need to be educated on what they can expect from AVs on the road. Lastly, the public must also be made fully aware of the privacy implications of using AVs.

As connected vehicles (e.g. truck platoons or convoys) are deployed on public roads, regulators will need to ensure appropriate training for both CV drivers and other drivers sharing the road with these convoys.

If and as fully-automated vehicles become more common, governments will need to adapt public education to new issues and hazards on the road.

It is essential that all levels of government work closely with industry stakeholders to develop outreach and education tools that inform and raise public awareness about the potential benefits and limitations of AVs.

Timeframe for Action: 1-10 years

BUILDING DATA EXPERTISE AND CAPACITY

Regulators must start developing expertise in data science and computer science.

Because of the use of machine learning and artificial intelligence, AV technology is fundamentally dependent on data. In a world of AVs, governments will need to have the capacity to understand the data and the technology, in order to protect the safety of vehicles and roads. In other words, regulators will need to become competent in software engineering in the same way they are currently competent in civil engineering.

For example, because AVs are, in fact, computers, they will be vulnerable to hacking, potentially endangering public safety. However, without the basic knowledge of limits and capabilities of AV technology, it will be difficult for governments to engage with AV developers and address public safety concerns.

If governments wish to make effective use of the data generated by AVs, they will need to upgrade their capacity to store and process data. It is impossible to predict all the potential uses of this data, but regulators will need to have the IT systems ready when they do.

More broadly, there is the simple issue of the ownership rights over AV data. Data ownership will likely become relevant to issues on privacy rights, but also protection from unfair price discrimination and enforcement of standard pricing agreements. Governments will need a solid understanding of the technology to effectively address these concerns and protect the public interest.

Since developing AV technological expertise will take time, regulators must initiate that work now.

Timeframe for Action: 0-5 years

Medium-Term

These are areas where governments may be able to wait a few years before taking action. AV technology has not evolved to the point where immediate action in these areas are needed, however governments should keep these issues in mind as vehicles reach higher levels of automation.

DEVELOPING AND ENFORCING TRAFFIC LAWS

Traffic laws will need to be revised and overhauled to accommodate AVs on public roads.

Although deployment of AVs may lead to a reduction in traffic collisions, deployment will require appropriate traffic law revisions. For example, driver's licensing, vehicle registration, and driving offences (e.g., impaired driving, distracted driving, speeding, tailgating) may need updates to accommodate AV deployment and/or platooning.

Governments will also need to align regulatory changes across relevant laws. For example, changes made to a province's highway and traffic legislation would need to align with and reflect any amendments made to the *Criminal Code*.

Safety and traffic flow may be impacted by the integration of AVs alongside human-driven vehicles. With varying levels of automation, regulators must also assess licensing requirements that accommodate for varying automation levels and safety conditions.

Timeframe for Action: 1-5 years.

INSURANCE AND LIABILITY

The legal framework for vehicle liability and insurance will need to be amended.

Insurance companies do not presently offer vehicle liability coverage that is specifically tailored to AVs. While a number of vehicle manufacturers have demonstrated a willingness to accept full liability for vehicles that have reached full automation, that remains to be seen , and it is furthermore unclear how liability coverage would work during transition with partially-automated vehicles. Legislative amendments may be required to clarify liability laws under various automation levels, environments, and conditions.

In AV pilot programs in Canada and the US, drivers are fully liable for any damages.

As insurance premiums are based on risk pooling, and the potential magnitude of damage caused by AV collisions remains unclear, the initial formation of an AV insurance market may also be difficult. If governments wish to accelerate AV adoption, addressing these insurance gaps early on could be crucial.

Timeframe for Action: 1-5 years

TRANSITIONING

The transition period from human drivers to AVs will be the most challenging part of adoption.

It is the transition period, when human drivers must interact with computer drivers, that poses the greatest uncertainty, challenge, and risk to public safety. On the road, it is essential that CVs, AVs and human drivers are able to consistently understand and predict each other's actions.

Within the vehicle, until full automation is achieved, it is important that drivers are attentive and ready to take control of their partially-automated vehicles when necessary. This can be challenging because, not only can partially-automated vehicles give the false impression that the driver need not pay attention, but paying adequate attention can be cognitively difficult. Governments have a dual role in working with industry to develop safety systems that can mitigate these issues (such as sensors that can detect when a human driver is not paying attention) and educating the public.

As with any new technology, adoption will be rolled out at different paces. As the impacts of AV integration are still unknown, regulators should be prepared with flexible strategies that can handle unforeseen developments and smoothly manage the transition to AVs.

There are transitional challenges beyond safety. AVs are expected to generate large employment effects which are discussed on page 22. For example, AVs could change other elements of the retail supply chain.

Timeframe for Action: 1-20 years

Long-Term

These are areas that will need to be addressed by governments in order to achieve the full benefits of higher levels of automation and connectivity. Governments will need to closely monitor the development and evolution of AVs and determine the impact this technology will have on road infrastructure, our cities and communities.

IMPLICATION FOR INFRASTRUCTURE

Significant changes to physical infrastructure, such as road design and operations should wait until widespread AV adoption.

Companies and researchers are developing automated vehicle technologies that can function reliably on today's roads. As a result, AVs may not require significant infrastructure investments (i.e., physical or "hard" infrastructure) before they can be deployed on public roads.

Nevertheless, today's road and highway infrastructure has been designed to suit the needs of human drivers, and may not be optimal if vehicles are increasingly supported by AV systems and technologies.

For instance, in early deployment, AVs may have difficulty recognizing unpredictable human drivers and pedestrian behaviour; or human drivers and pedestrians may have difficulty predicting AV behaviour. Dedicated lanes or other types of user separation may be an effective first step to support AV adoption and ensure safety; therefore, the transition from human-driven to computer-driven vehicles might require changes to road markings, signage and signalization, as well as lane markings.

Significant physical infrastructure changes, however, will be highly dependent on the actual longer-term outcomes of AV deployment. As a result, road operators may want to wait and see how the technology rolls out before committing to any significant infrastructure design changes that accommodate them. For example, waiting for wide deployment could provide valuable insight on which road design features would be beneficial in rural, urban or highway environments.

Infrastructure for the AV systems that are expected in the short-to-medium term will be more dependent on digital infrastructure

than on new physical infrastructure. Such digital infrastructure mainly relates to the need for digital representation of the road infrastructure (e.g., sensor data and digital maps, accurate positioning). Similarly, it is expected that, in the long-term, digital infrastructure, such as smart roadway infrastructure (SRI), can enhance traffic flow and improve safety. SRI is technology that enables vehicles to communicate with, among other things, traffic lights, border crossings, grade crossings, and each other. However, the ultimate technology standards for SRI will not be known until CVs and AVs become more widespread.

As these applications and supporting hardware are constantly evolving, automakers and suppliers should keep governments informed of which technologies they are using and plan to use in the future.

Timeframe for Action: 10-20 years.

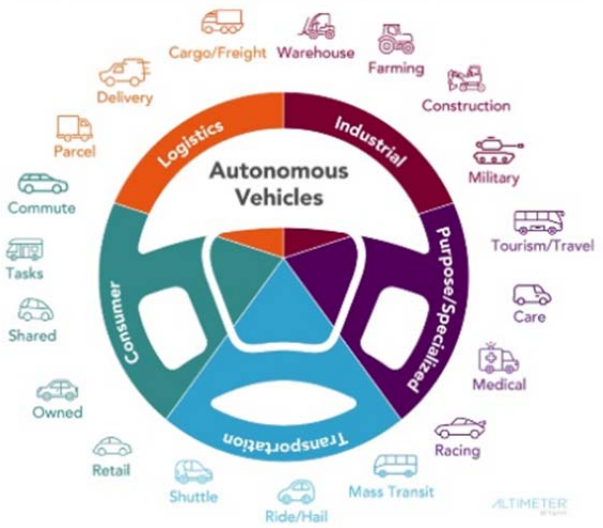


Figure 4 States of Self-Driving Cars - Venture Beat 2017

MODAL SHIFT AND PUBLIC TRANSIT

AVs may spark a shift to different modes of transit.

The introduction of AVs could ignite a modal shift in transportation networks by promoting the use of *other* forms of transportation and be an important enabling force towards a multi-modal transportation. As AVs roll out, they may present an opportunity for governments to change how they plan and prioritize transportation networks.

AVs present an opportunity to address the first and last-mile barrier to public transit use: if short AV trips feed into transit networks, there will be fewer barriers to using public transit.

AVs also have the potential to make roads safer for cyclists since AVs are more defensive and follow traffic laws more closely than human drivers. As safety is the predominant concern for future cyclists, the introduction of AVs could encourage more people to use cycling as a transportation mode.

Timeframe for Action: 5-20 years

LAND-USE PLANNING

AVs present a multi-generational opportunity to re-think how cities and communities are organized.

Land use, and encouraging transit-friendly and sustainable urban design as a result of AV technology is both a major challenge and opportunity. While the impacts are significant, it is also difficult to predict how land use will change.

It is possible that widespread access to AVs will encourage sprawl as commuting becomes easier and more pleasant. The availability of low-cost AV taxi services in urban areas could alternatively encourage further urbanization and densification.

There are other land-use issues at play as well. Municipalities could need fewer parking spacing, for example. If short AV trips are used to feed into transit networks, AVs could lead to an increased use of public transit. Also, AVs are able to drive more safely and efficiently than human drivers, potentially allowing for highers speeds and smaller leeways

There are other land-use issues at play as well. Municipalities could need fewer parking spaces, for example. If short AV trips trips are used to feed into transit networks, AVs could lead to an increased use of public transit. Also, AVs are able to drive more safely and efficiently than human drivers, potentially allowing for higher speeds and smaller leeways.

Any of these developments would improve traffic flow and have implications for urban design.

The wide-ranging and unpredictable impacts of AVs on land use present a multi-generational opportunity for governments to re-shape how communities are organized. As the timeframe will be long and the impacts will be significant, governments can take the time to thoughtfully consider their land-use priorities.

Timeframe for Action: 10-50 years

Additional Issues

ACCESSIBILITY AND INCLUSION

Government must promote, advocate, and make a commitment to accessibility.

AVs have the potential to improve access to transportation, serving those currently under-served, such as the disabled and blind. The positive impact of AVs on accessibility and social inclusion could truly be revolutionary. However, it is not guaranteed and governments have a crucial role in advocating for these groups.

On the vehicle side, governments can use regulation and their access to industry to encourage and, in some cases, enforce vehicle and service designs that are widely accessible. On the infrastructure side, as governments upgrade and redesign their roads for AV deployment, they can directly ensure that accessibility and social inclusion are components of the AV future.

Timeframe for Action: 5-20 years

Figure 5 States of Autonomous Cars - The Next Web 2017

FISCAL IMPACTS

What will be the impact on government revenues and expenses?

The fiscal impacts to government from the proliferation of AVs are yet to be seen. AVs will impact the needs of infrastructure, public transport, the use of lands, traffic, parking, the demand of automobile services, and the economy overall. All of these have implications for government expenses and revenues. As a simple example, since AVs have little need to park, especially in dense neighbourhoods, parking fees may become a thing of the past.

On one hand, AVs will impact — sometimes increase, sometimes reduce — the expenses of governments. On the other hand, AVs will also impact the tax base and, therefore, the revenues of governments. It is too early to estimate the complete fiscal impacts governments will face from the shift to AVs.

There will, of course, be opportunities to replace lost revenue sources with new ones. In lieu of parking fees, for example, penalties could be levied on empty AVs which congest the roads. Congestion pricing in general could also incent a model where most AVs are used as part of a car-sharing model. More generally, newly generated AV data will create opportunities to develop not only new sources of revenues but to also implement better initiatives for citizen and businesses to adopt more sustainable mobility behaviours.

Timeframe for Action: 10-20 years

LABOUR MARKET DISRUPTIONS

AVs have the potential to create new job markets, but they may also cause labour disruption in many sectors.

The economic impacts of AVs will be wide-ranging: increased efficiency and integration of transportation and shipping networks; new jobs in the service, retail, IT and telecommunications industries; and given the potential for enhanced worker mobility and productivity, AVs have the potential to generate significant economic growth and job creation.

Just as AVs have the potential to create new jobs, other jobs could become obsolete. The potential for growth is likely to bring significant labour disruption in industries that rely on human drivers. Taxi drivers and chauffeurs, truck and bus drivers, and operators of certain industrial vehicles could all be displaced by automated vehicles.

Governments can have a role in helping people transition from jobs negatively affected by AVs. This includes providing targeted training, re-skilling, and job matching programs; ensuring that people have access to up-to-date labour market information on anticipated in-demand jobs and skillsets, so they can make informed training and employment decisions; and helping post-secondary students develop the core competencies and skills required for the new labour market.

Despite these real impacts, it is important to keep in mind that such shifts will result in households saving money, or earning more, and thus improving their welfare. Most importantly, the reduction of accidents will save lives and improve the collective health and safety.

Timeframe for Action: 10-20 years

Next Steps

Ensuring a smooth integration of connected and automated vehicle technologies into the Canadian transportation sector will require a high degree of collaboration and investment across all orders of government, industry and other stakeholders.

To address some of the issues highlighted in the report and contribute to the safe deployment of AVs in Canada, it is recommended that federal, provincial and territorial governments:

- Develop a National Policy Framework to help government and industry ensure the safe deployment of AVs on public roads;
- Continue to work closely with jurisdictions and international partners — the U.S. in particular — to align testing and regulatory frameworks, where necessary, that will facilitate the safe introduction of these vehicles on public roads; and
- Continue to promote and invest in industry and academia to test and evaluate AV technology on public roads to identify issues and rectify them before they are fully deployed into the Canadian market.

Conclusion

This report identifies policy and regulatory issues that will need to be addressed before AVs are deployed onto public roads and estimated timelines for when these issues should be addressed. As stated previously, it should be recognized that connectivity and smart road infrastructure are important aspects to realizing the full potential benefits of fully deployed AV technology. Although AVs may be fast approaching, governments, industry and academia have been proactive in anticipating and preparing for their arrival. This work, however, will need to continue to be accelerated and deepened. See Appendix 2 for details on some of this work.

The issues identified in this report indicate that in the shorter-term, governments will need to focus on the challenges of integrating AV's with traditional vehicles. The transition period could last for several decades, but in the next few years we will be seeing most new vehicles gaining increasing levels of automation. During this time, complex issues like road safety, liability and insurance, data and information sharing, privacy and cyber security will need to be addressed.

In the medium-term, AVs present potentially significant benefits to economic growth, public mobility, and quality of life. In the longer-term, the advent of AVs presents a rare opportunity to redesign cities and communities to improve mobility and sustainability. Although the long-term effects that AVs will have on society are unclear, governments have a critical role to play in ensuring that AVs enhance existing multi-modal transportation networks instead of adding to our current congestion and infrastructure challenges.

Supporting the testing of AV's on public roads will be critical for keeping governments and industry informed of the needs and challenges related to safety, accessibility, and regulatory standards. Pilot testing will also provide an opportunity to evaluate the type of facilities and infrastructure needed to leverage the full benefits of AVs and accelerate Canada's readiness to adopt this new technology.

At present, the testing, evaluation, deployment and regulation of AVs in Canada has been loosely coordinated. While some research and deployment activities are taking place across the country, many jurisdictions are not prepared to integrate AVs into their transportation systems. It will be important for jurisdictions that are testing AVs to share best practices and lessons learned, as well as data related to testing outcomes, to assist other jurisdictions in developing pilots for testing AVs in their jurisdiction. All three levels of government will also have an important role to play in raising public awareness and disseminating important safety information about the technology.

The Working Group proposes that our next step be to work collaboratively to develop a National Policy Framework that will help governments establish shared objectives; deepen their partnerships with industry and academia; and ensure coherence amongst jurisdictions regarding the standards and regulations that will guide the safe deployment of AVs on public roads.

Appendix 1: International Scan

Effective Date: December 2017

United States
The U.S. Department of Transport's (U.S.DOT) role in vehicle automation is to facilitate development and deployment of automated transportation systems that enhance safety, mobility, and sustainability; identify benefit opportunities in automated vehicle technology; invest in research areas that further industry investments and support realization of benefit opportunities; establish Federal Motor Vehicle Safety Standards and infrastructure guidance. • As of December 3, 2017, 21 US states and Washington D.C. have passed legislation related to automated vehicles. Additionally, 5 states have issued executive orders related to autonomous vehicles. • As of December 3, 2017, the US Senate has not voted on the legislation due to a number of senators holding up the bill. • In late September 2017, the US Senate released bipartisan legislation that would provide the first overarching federal laws governing autonomous vehicles. The legislation, which is titled "The American Vision for Safer Transportation through Advancement of Revolutionary Technologies Act," gives the US DOT the authority over setting safety standards, while state and local governments would continue to govern traffic safety, registration and law enforcement. The bill, however, does not address self-driving trucks, which was also left out of the house bill passed earlier in September. On October 4, 2017, the US Senate Commerce Committee unanimously passed the Senate bill, which is still subject to a full senate vote. A number of amendments were added, such as requiring an environmental study to be done on the effects of more driverless cars on the roads, and requiring the manufacturers to educate the public on the technology. • On September 12, 2017, Transportation Secretary Elaine Chao announced a vision for automated vehicle technology, focusing on safety benefits and consumer education. These guidelines, titled "Automated Driving Systems (ADS): A Vision for Safety 2.0" call for the industry, state and local governments, and the public to lay the path for the deployment of automated vehicle technology. The voluntary guidelines focus on aspects such as guidance for levels 3-5 of automation, as well as clarifying federal and state roles going forward. • In early September 2017, the US House of Representatives passed the "Self Drive Act" on a voice vote. The bill had previously been unanimously approved by the House Energy and Commerce Committee in July 2017. The bill pre-empts states from

implementing certain laws governing the new technology. It also allows for car companies to deploy up to 100,000 self-driving cars a year that don't meet normal safety standards. States will be responsible for vehicle registration, law enforcement and local issues, while manufacturers will be required to implement cybersecurity and privacy protections.

- In July 2017, the governments of Michigan and Ontario signed an agreement that would further foster the growth of automated and connected vehicle technology testing and deployment. This agreement included a cross-border test drive of an automated vehicle from Michigan, and into Southern Ontario.
- On January 19, 2017, U.S. Transportation Secretary Anthony Foxx announced that the U.S. DOT has designated 10 proving ground pilot sites to encourage testing and information sharing around automated vehicle technologies. These proving ground designations will foster innovations that can safely transform personal and commercial mobility, expand capacity, and open new doors to disadvantaged people and communities. These designations are a logical next step in the Department's effort to advance the safe deployment of automated technology.
- On January 11, 2017, the U.S. DOT announced that it is establishing a new advisory committee that will focus on automation across a number of modes including the development and deployment of automated vehicles.
- In September 2016, the DOT National Highway Traffic Safety Administration (NHTSA) published the Federal Automated Vehicles policy, a policy that provides guidance rather than rulemaking in order to speed the delivery of an initial regulatory framework and best practices to guide manufacturers and other entities in the safe design, development, testing, and deployment of AVs.
- U.S. DOT also established along with the ITS Joint Program Office an automation program. This program will position industry and public agencies for the wide-scale deployment of partially automated vehicle systems that improve safety and mobility and reduce environmental impacts by the end of the decade.
- In December 2015, the California Department of Motor Vehicles published AV regulations that require a licensed driver behind the wheel at all times (along with other operational requirements), reflecting a regulatory approach that balances innovation with public safety, is appropriately cautious and also evidenced-based. California also has numerous data reporting requirements.

The U.S. DOT's role in vehicle automation is to:

- Facilitate development and deployment of automated transportation systems that

enhance safety, mobility, and sustainability

- Identify benefit opportunities in automated vehicle technology
- Invest in research areas that further industry investments and support realization of benefit opportunities
- Establish Federal Motor Vehicle Safety Standards and infrastructure guidance.
-

United Kingdom

The UK government is creating an open regulatory environment for innovation, testing and use. They collaborate with industry, and academia on research and development and demonstration. They are also coordinating activities through the Centre for Connected and Autonomous Vehicles.

- In November 2017, as announced in the UK budget, the government announced plans to change regulations to allow developers to test AVs on British roads. The government will invest 650 million pounds into ensuring the UK has AVs on the road by 2021. The budget also includes money to incentivize the use of electric vehicles.
- On August 6, 2017, the UK government issued new cybersecurity guidelines for connected and automated vehicles. The guidelines, titled "The key principles of vehicle cyber security for connected and automated vehicles," are designed to encourage automakers to make cybersecurity a priority, and consists of 8 principles. Organizations should ensure that security is a priority on a board level, manufacturers should assess potential risks, especially with third-party contractors, vehicle security needs to last for the lifetime of the system in question, organizations and subcontractors must work together to certify their security processes and products, security systems should be made redundant, manufactures should manage software over the expected life of the system, data storage should be secure, and the vehicle or systems should be able to withstand attacks and continue to function.
- On June 21, 2017, during the State Opening of Parliament, the Queen announced that the government will introduce a new automated and electric vehicle bill. Plans include building infrastructure that supports development and consumer uptake of electric and autonomous cars, including charging points for electric cars. The bill will also include compulsory motor insurance being extended to autonomous cars, and to require a set of common technical and operational standards.
- In April 2017, a consortium of British companies unveiled a plan to test driverless cars on UK roads in 2019. The Driven consortium is led by Oxbotica, which makes software

for driverless vehicles. The project is backed by a £8.6m government grant. In 2016, the UK government had committed £100m in total towards autonomous driving projects.

- On February 22nd, 2017, the UK Department of Transport published new measures on insurance for self-driving cars to help ensure better protection - a single insurance product for AV's that will cover both the motorist when driving, as well as the car when it is in automated mode. This will mean innocent victims involved in a collision with an AV will have quick and easy access to compensation insurance.
- There are 4 cities in the driverless car trials in the UK: Bristol, Greenwich, Milton Keynes and Coventry.
- **UK Autodrive** is a government-backed competition to support the introduction of self-driving vehicles. The project will examine general concerns such as legislation, insurance, communications and cybersecurity requirements, the future scalability of the technology, public attitudes to self-driving vehicles and potential business models for the wider rollout of the technology.
- **Milton Keynes LUTZ Program** - The project involves the development of prototype vehicles that had three main objectives: (1) seeing the technology work within the environment; (2) understanding how suitable self-driving vehicles are for urban use; (3) gauging sentiment of both the passengers and the pedestrians that will encounter the vehicle.
- **Greenwich – Gateway Program** is an 8 million dollar research project, led by Transportation Research Laboratory, to understand/ overcome the technical, legal and societal challenges of implementing AVs in an urban environment. The project analyzes different uses of AVs, including driverless shuttles and automated urban deliveries.
- **VENTURER** brings together a partnership of public, private and academic experts to establish the South West, UK as a world class test site facility for CVs. The project focuses on users and CV technology to understand the obstacles with wide-scale adoption of CVs.

France
• In February 2017, the French transport minister announced plans to test self-driving vehicles on a stretch of highways between France and Germany. The route is around 70km that is aimed at testing automated and connected driving in real cross-border traffic. • In August 2016, as part of the French government's "New industrial France" plan, the government announced that the use of autonomous vehicles on public roads was now permitted as long as there was a driver in the driver's seat. • In 2015, the French Government announced that PSA Peugeat-Citroen was to conduct trials in real conditions in the Paris area. The project was extended to other cities in France in 2016 (e.g. Bordeaux and Strasbourg). In 2014, the Government of France announced that testing of automated cars on public roads would be allowed in 2015. • In 2014 the Government of France announced that testing of automated cars on public roads would be allowed in 2015. 2000 km of road were opened in Bordeaux, Isère, Île-de-France and Strasbourg. • In 2015, PSA Peugeot-Citroen was allowed to conduct road trials in the Paris area. The projects were extended to other cities in France in 2016 (e.g. Bordeaux and Strasbourg). • At the October 2015 ITS World Congress, a conference dedicated to intelligent transport systems, the very first demonstration of AV's on an open road in France was carried out in Bordeaux. • Companies such as Thales and Valeo (1st self-parking car system providers) equip Audi and Mercedes with technology to test their own driverless car system.
Germany
• In August 2017, the German government announced that they will adopt new guidelines for self-driving cars, which will prioritize the value and equality of human life over damage to property or animals. Presented by an ethics committee on automated driving, these guidelines stress that self-driving cars must do the least amount of harm if put into a situation where hitting a human is unavoidable, and cannot discriminate based on age, gender, race, disability, or any other observable factors. These are the considered the world's first ethical guidelines for how autonomous vehicles should handle these decisions. • In May 2017, Germany's upper house approved a law setting out the conditions in which autonomous vehicles can be on German roads. The law, which was raised by Chancellor Angela Merkel in 2016, requires that a driver must be sitting behind the wheel at all times, ready to take control if prompted to.

- The legislation allows the companies to test vehicles in which drivers can take their hands off the wheel. The legislation also requires that a black box record the journey, logging if the human or computer was driving, which will be useful for dealing with accidents. The law will be revised in 2 years.

The German government wants to safeguard the market shares of companies like BMW and Volkswagen by ensuring that they have an edge with emerging technology.

- The German car industry has been working on driverless cars for years and expects the first commercially available models to be introduced by 2020.
- Audi's self-driving cars were showcased at the latest Consumer Electronics Show in Las Vegas. The producer's RS7 model set a self-driving speed record in October, 2016 by completing a lap of the Grand Prix track in Frankfurt in just over two minutes, reaching speeds of up to 240 km/h.
- In September 2015, the Federal Minister of Transport and Digital Infrastructure published a Strategy for Automated and Connected Driving.
- In January 2015, the German government converted part of the A9 Autobahn in Bavaria into a test-field for advanced car technology. The project part of the country's 'digital sovereignty,' and involves equipping roads with infrastructure to allow cars to communicate with each other and the road's own sensors to provide necessary data on traffic.
- In 2014 German carmaker Mercedes Benz presented its Future Truck 2025, a driverless vehicle which can reach speeds of up to 80kph (50mph), while the Audi prototype, the so-called RS7 which has a horsepower of 560, reached speeds of almost 240kph (150mph) when tested on Formula One's Hockenheim track.

Australia
• In May 2017, the National Transport Commission and Austroads jointly released national guidelines for trials of automated vehicles on Australian roads. The guidelines note that in Australia, vehicles cannot legally operate in highly or fully automated driving mode on public roads. Under the guidelines, a range of data from trials will need to be provided to road transport agencies, including a range of information on any crashes, near misses, and complaints from the public. The guidelines also clarify insurance details and state key criteria for developing a safety management plan. • In March 2017, the New South Wales government announced they plan to introduce legislation to test automated vehicles. • In December 2016, the Australian Road Research Board (ARRB) announced the first successful trials of partially-automated vehicles driving in live traffic. • The trial was part of an 18-month research project aimed to enable drivers to safely commute hands-free by 2018. • In November 2016, the National Transport Commission (NTC) in Australia released a discussion paper, on key elements required to support automated vehicle trials. Australia is taking a phase-in approach with partially-automated vehicles operating safely and legally on its roads before 2020, and fully automated vehicles from 2020 forward. • The National Transport Commission is preparing a roadmap of reform to prepare Australia for automated vehicles. Australia is facilitating the testing and trial of automated vehicles in the short term, and preparing for the safe deployment of automated vehicles on public roads in the medium to long term by: (1) developing national guidelines to support automated vehicle testing; (2) clarifying control of vehicle with different levels of automation; (3) developing a comprehensive performance-based safety assurance regime for increasingly automated vehicles; (4) removing regulatory barriers and other transport laws assuming a human as the driver.

Appendix 2: Automated Vehicle Research to Date

Effective Date: December 2017

Research and Work	Scope
Canadian Council of Motor Transport Administrators (CCMTA)	
Work has focused on environmental scans, including: • A survey of jurisdictional activities on AVs. • A survey of Canadian public opinion on AVs. • A scan of international initiatives on AVs, and future deployment by companies. • Workshop to educate Canadian jurisdictions on AVs. • Develop and share tools and communication materials on issues related to AVs. • Develop a jurisdictional checklist for piloting AVs. • Continue monitoring AVs for non-commercial and commercial vehicles on emerging AV issues. • Develop a vehicle policy framework for administration, regulation, and control of AVs. CCMTA has developed a white paper on automated vehicles in Canada. The paper was provided to the Canadian Council of Deputy Ministers Responsible for Transportation and Highway Safety, the Policy and Planning Support Committee (PPSC) and the Senate Committee on Transport and Communications. CCMTA has also participated in information and knowledge sharing sessions with the FMCSA on commercial vehicle CV/AV technology and regulatory implications.	Analyze challenges related to AV technology and encourage national consistency.
Transportation Association of Canada (TAC)	
Work has focused on: • Monitoring developments. • Providing tools (best practices, guidelines) for jurisdictions to help conduct pilot deployment projects. • Working collaboratively with CCMTA, Intelligent. Transportation Systems Canada, the US, etc. TAC is drafting a white paper, titled “The Impacts of Connected Vehicles and Automated Vehicles on Roadway Infrastructure and Urban Land Use in Canada.”	Review the impact of CVs on road infrastructure and maintenance, safety, traffic control and management.

Research and Work	Scope
The paper is currently an internal document for reference and has not yet been approved for broader circulation.	
The Senate Standing Committee on Transport and Communications	
The Senate Committee is conducting a study on regulatory and technical issues related to the deployment of CV/AVs. Anticipated release: December 2017.	The report will highlight regulatory, policy and technology issues, long term implications and challenges; impacts on privacy, energy, land use, transportation demand and employment.
Canada-US Regulatory Cooperation Council (Canada-US RCC)	
Transport Canada and USDOT are working towards aligning regulatory approaches for AV deployment in a four-part work plan. Timeline: 2014-2019.	The work plan aims to cover security, spectrum allocation policy, standards and information sharing.
American Association of Motor Vehicle Administrators (AAMVA)	
AAMVA is developing a report for the National Highway Traffic Safety Administration (NHTSA) on the regulation of AVs for motor vehicle administrators. Anticipated release: Late 2017.	The report is expected to address administration; testing vehicles by manufacturers on public roads; jurisdictional permission to test; driver training and examination considerations; and first responder and law enforcement considerations.
Virginia Tech Transportation Institute (VTTI)	
VTTI will be leading the review, but as Ontario is a member of the working group, the review includes *Ontario's Highway Traffic Act*. Anticipated release: Summer-Fall 2018	Analyze the implications of AV safety on highway traffic laws in the United States

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