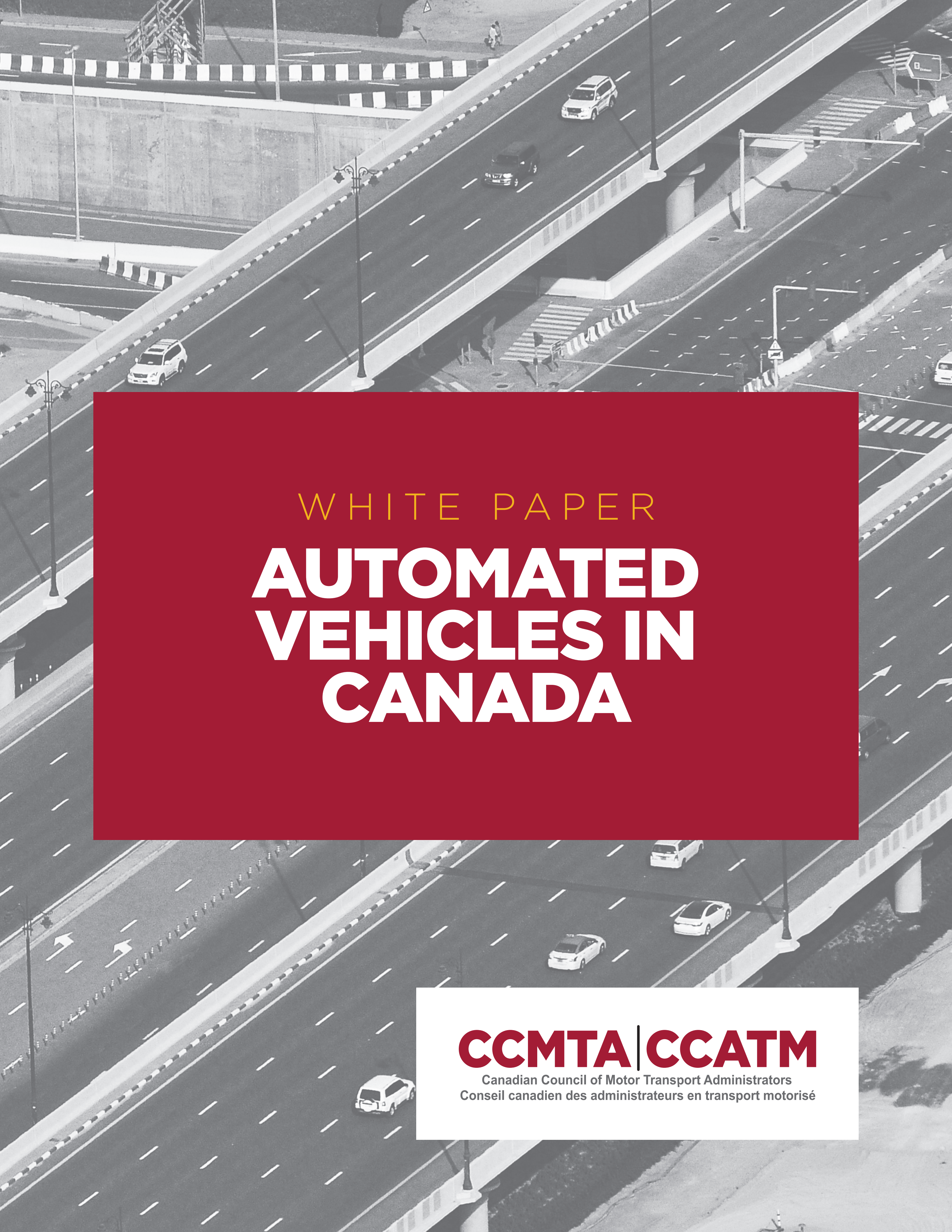

WHITE PAPER

AUTOMATED VEHICLES IN CANADA

CCMTA | CCATM

Canadian Council of Motor Transport Administrators

Conseil canadien des administrateurs en transport motorisé

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INTRODUCTION

This document represents a high level overview of the complex, rapidly evolving nature of Automated Vehicles (AVs) at this point in time. It focuses on priority areas, risks and opportunities. It also looks at the magnitude of the work taking place nationally and internationally and what it will mean for those involved in motor vehicle transportation administration in Canada. The paper includes current information from all jurisdictions, as well as from other organizations who are actively involved in this area. Due to the highly fluid nature of the AV area, new initiatives are occurring constantly, and there is recognition that there may be gaps in information.

In Canada, jurisdictions, organizations and federal departments are actively monitoring and studying this emerging technology. The federal government's interdepartmental activities include several projects focused on safety performance of non-commercial vehicles and advanced vehicle technologies for commercial vehicles. The Senate Standing Committee on Transportation and Communications is studying regulatory and technical issues related to the deployment of commercial vehicles and automated vehicles; the Transportation Association of Canada (TAC) has created a working group to review the impact of commercial vehicles on road infrastructure, maintenance, traffic control, management and safety; and the Council of Ministers Responsible for Transportation and Highway Safety has tasked the Policy and Planning Support Committee (PPSC) to monitor AV/CV with a view to sharing best practices while identifying connections of the work being done by various Canadian, provincial/territorial and private sector groups. CCMTA is a member of the PPSC AV/CV group.

Road safety is reflected in the mission and vision of the CCMTA. It is the lens through which the organization addresses its work and evaluates its outcomes. Advancements in automotive technology and current research on AVs have created new possibilities for improving highway safety, increasing environmental benefits, and expanding mobility. Being ready for the change and knowing how and in what specific ways jurisdictions will need to adapt, is a priority for CCMTA's AV work. CCMTA can learn much from other countries, and from experiences gleaned from each other, as it navigates the road forward on this issue.

As a priority of the Board, CCMTA has been monitoring the development of AV technology through its Drivers and Vehicles and Road Safety Research and Policies Program Committees for a number of years. Established by the Board, the CCMTA Program Committees provide expertise and advice to key files, initiatives or operational concerns.

CCMTA members are appointed by the Board on the basis of demonstrated expertise and interest in the particular subject matter. (For additional details on the CCMTA organizational structure, please refer to Appendix A).

The AV issue is one that will affect Canadian motor vehicle administrators in many ways, and CCMTA is committed to working with its members to support their understanding of its implications for their jurisdictions.

In 2014, the CCMTA Board approved an AV Working Group as a forum for Canadian motor transport administrators to collaboratively monitor emerging autonomous vehicle technology and issues, including the monitoring and reviewing of:

- Associated regulatory developments in other jurisdictions
- Ongoing technological changes in the vehicle intelligence industry

- The progression of the vehicle manufacturing industry
- The testing phases of the early adopter jurisdictions

The group is also developing vehicle policy with respect to the administration, regulation and control of automated vehicles, including both non-commercial and commercial vehicles.

The AV Working Group has developed communications products featuring a Frequently Asked Questions document, key messages and suggested website content to ensure consistency for the jurisdictions. The Working Group has also surveyed Canadian provinces and territories on their AV activities, and developed a checklist to assist them in foundational planning and future policy considerations. These materials can be found in the Appendix section of this paper.

In early 2015, the CCMTA AV Working Group Co-Chairs participated in the American Association of Motor Vehicles Administrators (AAMVA) Autonomous Vehicle Best Practices Working Group. The AAMVA group's collective input supported the development of the U.S. Department of Transportation's National Highway Transportation Safety Administration's (NHTSA) *Federal Policy for Safe Testing and Deployment of Automated Vehicles*. Released in September 2016, the document is intended to assist jurisdictions in regulating automated vehicles and testing the drivers who operate them. In early 2017, the AAMVA Guidelines for the Regulation of Autonomous Vehicles will be submitted to NHTSA. The CCMTA AV Working Group will review the AAMVA guidelines and develop a 'Canadianized' version to ensure reciprocity with the U.S.

In Canada, the following levels of government have a responsibility regarding the introduction of AVs:

Federal

- Establish national policy and regulatory framework for AVs
- Ensure vehicle manufacturers comply with appropriate safety standards
- Facilitate international and national collaboration to ensure harmonization of the technologies and adoption of similar standards
- Oversee emission requirements
- Raise public awareness

Provincial/Territorial

- Create a regulatory framework that allows for effective and appropriate testing and deployment
- Comply with federal provincial regulatory documents to the provincial/territorial responsibility
- Oversee vehicle safety requirements
- Oversee vehicle registration and driver licensing (and vehicle insurance, where appropriate)
- Plan, develop and budget for AV infrastructure needs to support safe deployment
- Raise public awareness

Municipal

- Vehicle movement and enforcement
- Public transportation

PURPOSE OF THE WHITE PAPER

This paper provides an overview of current activities, issues, and concerns surrounding AVs. It also highlights considerations related to regulation, legislation, enforcement, public awareness, education, public safety and issues for consideration for Canadian jurisdictions. It reflects the magnitude and complexity of the topic, and is intended to assist in CCMTA members' discussions.

DEFINITIONS AND CLASSIFICATIONS

While the terms automated and autonomous have been used interchangeably, there is a distinction.

An **automated vehicle** is a vehicle that can be operated either conventionally by a person or be controlled without human intervention under certain conditions. Systems in cars today, such as adaptive cruise control, lane centering, automatic parallel parking, self-parking, lane departure warning, forward collision warning, and collision avoidance breaking, are examples of partially automated vehicles, or automated driver assistance systems.

An **autonomous vehicle** is a driverless vehicle; it is a vehicle that does not require human monitoring or interaction. It is also referred to as a fully automated system, fully autonomous vehicle, self-driving vehicle, or driverless vehicle. These vehicles use technologies to replace the human as the driver, such as sensors to detect obstacles, software algorithms to make driving decisions, and electronic equipment to brake, accelerate, and steer the vehicle without any human participation in the driving task.

Connected vehicles are vehicles that use any number of different communication technologies to communicate with the driver, other cars on the road and the connected infrastructure. Vehicle to Vehicle (V2V) (truck platooning), Vehicle to Infrastructure (V2I), and Vehicle to Everything (V2X) are examples of the practical application of connected vehicle technology.

CLASSIFICATION OF LEVELS OF AUTOMATION

Two classification systems were created by two distinct organizations to describe the various levels of vehicle automation. The National Highway Traffic Safety Administration (NHTSA) system bases its hierarchy on five levels of automation; the Society of Automotive Engineers (SAE) uses six levels.

In order to bring clarity and consistency for manufacturers, regulators and the public, NHTSA announced it will adopt the SAE's six level classification framework.

The SAE classification divides vehicle automation into six levels that focus on the human driver who is monitoring the driving environment versus the "automated driving system" that monitors the driving environment. NHTSA expects manufacturers and entities to classify their automated vehicles using the SAE classification. (NHTSA, September 2016).

As a result, many jurisdictions in North America which previously referenced the NHTSA levels of automation are being encouraged to adjust their guidelines to the SAE levels of automation.

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE) CLASSIFICATION

SAE's classification system is based on six different levels, ranging from driver assistance to a fully automated system, and reflects the amount of driver intervention and attentiveness required, rather than the vehicle capabilities, although these are very closely related.

Today, most new vehicles on the road operate at level 0 and 1; level 2 is in development, and these vehicles are equipped with partially automated features. By the years 2025-30, many vehicles will be operating at level 3-5 (Laroche & Love, 2016).

SAE Level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
Human driver monitors the driving environment						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	N/A
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* will perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the human driver will perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
Automated driving system ("system") monitors the driving environment						
3	Conditional Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a request to intervene	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environment conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

TIMING, TESTING AND REGULATORY CONSIDERATIONS

Debate regarding the new technology's broad scale availability is ongoing. While prototype vehicles are being tested in some places, experts are still discussing how much time it will take for manufacturers to develop automated vehicles, and when government agencies will allow their deployment on public roads.

Separately, there will be a need for specific infrastructure to enable the safe testing and deployment of autonomous or connected vehicles.

AV technology is moving swiftly, yet we know legislation takes time and can be a highly consultative process. Being nimble enough to adapt to the technology without unnecessarily delaying testing and deployment is essential.

Ontario was the first jurisdiction in Canada to pilot automated vehicle testing on its public roads. The Ontario Ministry of Transport published regulatory rules in early 2016. The province plans to consider other regulatory issues once it has gained experience with its AV pilot (Ticoll, 2015).

In Canada, a national policy on automated or connected vehicles has not yet been developed. However, the 2016 federal budget provided $7.3-million over two years to increase inspection capacity and develop a regulatory framework for emerging technology such as autonomous vehicles (Federal Budget, 2016). In February 2016, Transport Minister Marc Garneau asked the Senate's Transportation and Communications Committee to launch a study of the regulatory, policy and technical issues that need to be addressed so that Canada can safely and smoothly make the transition to self-driving vehicles (Senate of Canada, 2016).

Among other things, Minister Garneau requested the Committee examine the potential for Canada to set standards for the development of automated cars that can operate safely on icy winter roads. The committee is expected to present its findings in spring of 2017 (Senate of Canada, 2016).

In some municipalities throughout the world, the automated vehicle is already a reality. Uber allowed customers in downtown Pittsburgh, Pennsylvania to summon self-driving cars from their phones, crossing an important milestone that no automotive or technology company has yet achieved (Chafkin, 2016). Uber's Pittsburgh fleet, which will be supervised by humans in the driver's seat for the time being, consists of specially modified Volvo XC90 sport-utility vehicles outfitted with dozens of sensors that use cameras, lasers, radar, and GPS receivers.

Further afield, self-driving taxis began picking up passengers in Singapore in August 2016. In Singapore, select members of the public can hail a free ride through their smart phones in taxis operated by nuTonomy, an autonomous vehicle software startup that operates in that country. While multiple companies, including Google and Volvo, have been testing self-driving cars on public roads for several years, nuTonomy is the first to offer rides to the public.

The majority of experts are of the view that AV adoption will accelerate quickly through the 2020s. Lengthier forecasts seem to presume an eight to nine year consumer vehicle replacement rate that will impact AVs introduction into the marketplace (Ticoll, 2015).

In North America, in order to assist jurisdictional Departments of Transportation, AAMVA convened an Automated Vehicles Working Group comprised of U.S. and Canadian experts (in which CCMTA participated) to develop guidelines that will inform the regulation of AVs. Their work focused on helping manufacturers and other entities in the safe design, development, testing, and deployment of highly automated vehicles (HAVs). The result of their work includes a 15-point safety assessment guide, as detailed in the *NHTSA Federal Automated Vehicles Policy*, released September 2016.

AAMVA will produce another report for NHTSA, anticipated in early 2017, that speaks to regulation of AVs for motor vehicle administrators. Once published, it will be reviewed and repurposed for Canadian jurisdictions by the CCMTA AV group. The 2017 AAMVA Report is expected to address the following areas:

- Administration
- Testing vehicles by manufacturers on public roads
- Jurisdictional permission to test (permitting process)
- Driver training and examination considerations for deployed vehicles
- Registration and title considerations for deployed vehicles
- First responder and law enforcement considerations for deployed vehicles

Canadian jurisdictions are looking to this work to inform and guide AV policy decisions domestically.

RESEARCH AND INNOVATION

In Canada, various public, private and academic partnership initiatives to test and develop the new technology are underway. Given the rapidly changing landscape, this is a snapshot of activities and is not an exhaustive list.

Transport Canada is involved in AV related projects dealing with security, privacy and automated truck platooning. The federal government has also provided financial support for several projects within the jurisdictions.

On the international front, Transport Canada takes an active role in the work of the United Nations World Forum for the Harmonization of Vehicle Regulations (UNECE WP.29) and the department continues to be an active partner in the development of global technical regulations. WP.29 has a group looking at ITS and AVs.

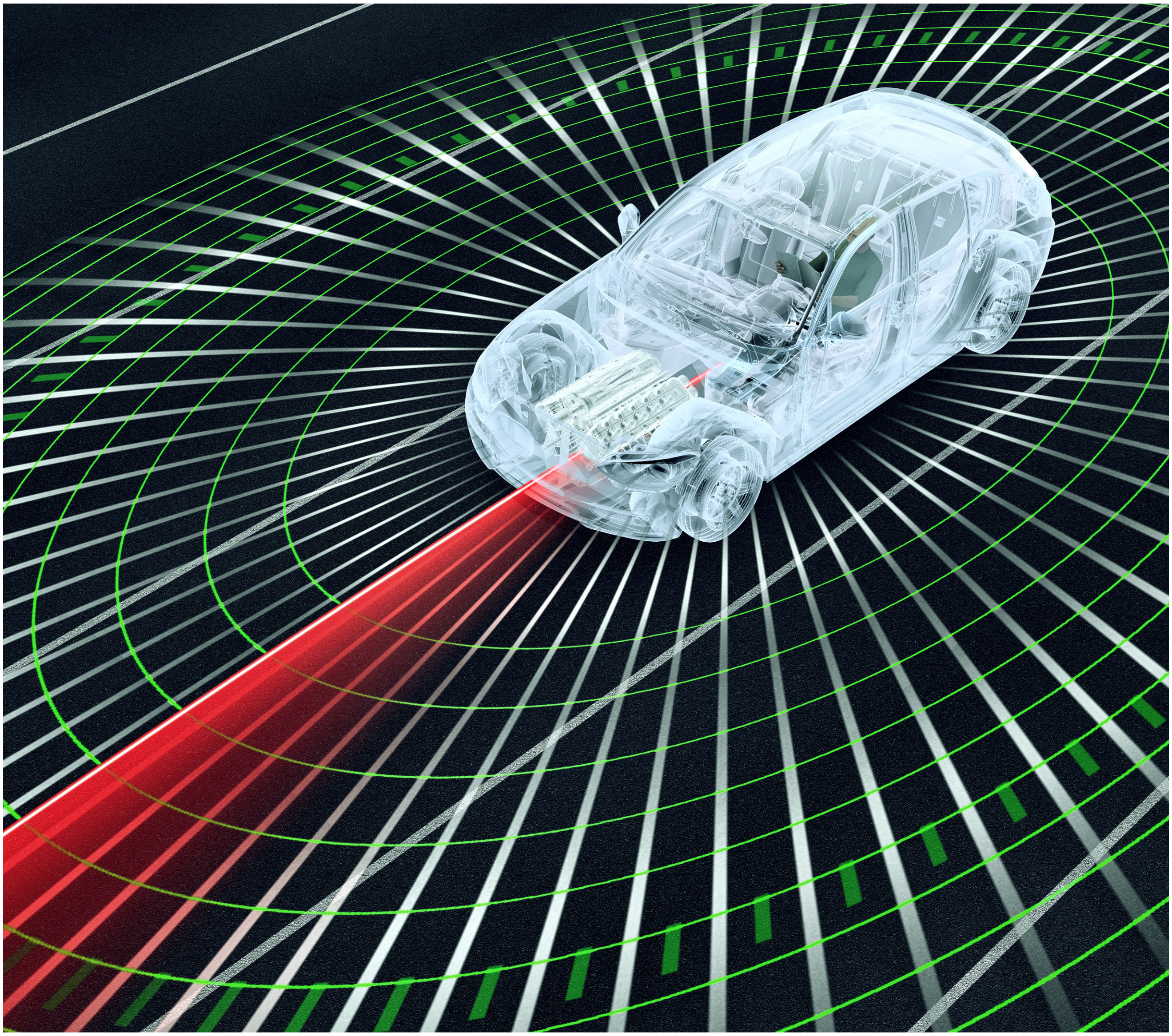
As part of the Regulatory Cooperation Council (RCC), Transport Canada, under its joint work plan published in May of 2015 with the U.S. Department of Transportation, has committed to coordinating and collaborating on V2V and V2I communications technology and applications development and implementation for light- and heavy-duty vehicles. A primary objective under the RCC work plan is to help ensure the interoperability of connected vehicles between Canada and the U.S. moving forward (Belluz, 2015).

In Alberta, the Government of Canada contributed $3.66 million which includes $1.3 million from the Asia-Pacific Gateway and Corridor Transportation Infrastructure Fund for the ACTIVE AURORA project. Launched at the University of Alberta, and led by the University of Alberta and the University of British Columbia, ACTIVE AURORA provides real-world test zones, combined with laboratory settings, where conditions can be customized to simulate various situations. Particular emphasis is on wireless communications for freight security and efficiency. A number of public and private partners are also providing funding and in-kind support totaling $2.36 million. These include the Province of Alberta, the City of Edmonton, the University of Alberta, the University of British Columbia, and the Canada Foundation for Innovation.

In Ontario, the federal government provided $300,000 to the Intelligent Transportation System Project - launched in the Regional Municipality of Waterloo (Moshi, 2016). In addition, the Ontario Centres of Excellence, which delivers innovative programs on behalf of the province, has provided $2.95 million in funding to various connected car/autonomous car demonstrations projects, and there are plans for other matching contributions from industry partners.

In November 2016, the University of Waterloo, Erwin-Hymer and QNX became the first applicants to test their automated vehicles on Ontario's roads. Specifically:

- The WATCar Project at the University of Waterloo's Centre for Automotive Research will monitor a Lincoln MKZ for performance and test it on-road at different levels of automation;
- The Erwin Hymer Group, an international auto manufacturer active in the Kitchener-Waterloo tech and innovation corridor will test and monitor a Roadtrek E-trek at different levels of automation; and
- BlackBerry QNX, a Canadian global software development leader will test a 2017 Lincoln with automated features (Government of Ontario, 2016).



In addition, several Canadian cities are studying how automated vehicles will impact their long term transportation plans. Toronto's City Council has committed to review the potential of automated public transit within its municipal transit system. Calgary and Vancouver have similarly committed to studying the impact AVs can have on their transportation plans.

Internationally, there are now 30 companies involved in the development of autonomous vehicles, according to research from CB Insights (Shead, 2016). Several manufacturers have indicated that they expect to have fully automated vehicles available by the year 2020–2025. Ford intends to start selling driverless cars to the public by about 2025. BMW plans to make semi-autonomous features standard in all their cars by 2020, but is not rushing to create a fully automated car. Toyota and Volvo are planning to have self-driving cars ready by 2020. In addition, Apple reportedly aims to release an electric car in 2019; its automation level is undefined. Uber's CEO has said he wants the company's fleet to be driverless in 2030.

BENEFITS OF AUTOMATED VEHICLES

Multiple benefits are associated with the development and deployment of automated vehicles for citizens, industry, government, and the environment.

In addition to improving road safety by eliminating or reducing the severity of traffic collisions, economists and researchers predict that the arrival of the new technology will positively impact the economy (i.e. transportation intensive sectors such as trucking and manufacturing that innovate for and facilitate emerging AV capabilities), the environment, as well as accessibility for those who cannot drive.

SAFETY

Increased road safety is one of the most often cited benefits associated with the deployment of automated vehicles. "Ninety-four percent of crashes on U.S. roadways are caused by a human choice or error. We are moving forward on the safe deployment of automated technologies because of the enormous promise they hold to address the overwhelming majority of crashes and save lives," said Dr. Mark Rosekind, NHTSA Administrator.

U.S. President Barack Obama reinforced Dr. Rosekind's message in an article which appeared in the September 2016 Pittsburgh Post Gazette, "...too many people die on our roads - automated vehicles have the potential to save tens of thousands of lives each year. And right now, for too many senior citizens and Americans with disabilities, driving isn't an option. Automated vehicles could change their lives." (U.S. Department of Transportation, 2016).

In Canada in 2014, there were 1,834 fatalities, 9,647 serious injuries, and 149,900 total traffic injuries. The primary factors in collision related deaths include speeding, driver age, alcohol and/or drug impairment, fatigue, and distraction. (Transport Canada, 2016).

Deployment of AVs may lead to a potential reduction in traffic collisions, related fatalities, injuries and their correlating financial costs.

Additionally, automated features have the potential to reduce human errors such as delayed reaction time, tailgating, rubbernecking, and other forms of distracted driving. Generally, the literature predicts a 50-90 percent safety improvement from AVs rising with the level of adoption. One such study projects that 10 percent market penetration of fully automated vehicles will provide a 50 percent reduction in crashes and injuries. A 90 percent market penetration would result in a 90 percent reduction (Fagnant, 2015).

In the U.S., the Insurance Institute for Highway Safety (IIHS) estimates that if all vehicles had forward collision and lane departure warning systems, side view (blind spot) assist, and adaptive headlights, nearly a third of crashes and fatalities could be prevented. IIHS goes on to state that the automatic braking feature is an additional safety prevention (car brakes when it detects an obstacle) that would likely reduce a significant number of rear-end collisions (Insurance Institute for Highway Safety, 2010).

Deployment of the new technology has the potential to save lives and reduce the number of traffic related injuries. However recent collisions involving automated vehicles while on a routine test drive show we are still in the learning phase. More testing is required.

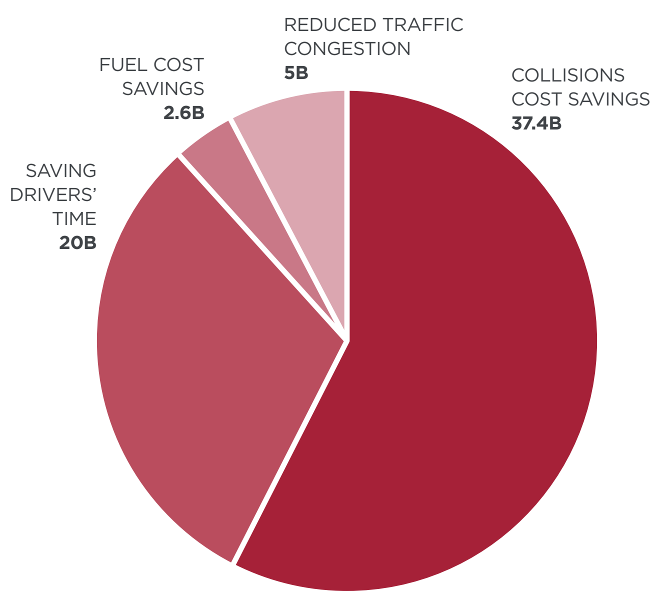
ECONOMIC EFFICIENCY

While safe testing, deployment, regulation and legislation are the primary focus for CCMTA members, there are other areas that stand to benefit from the new technology.

A number of recent studies and articles suggest that automated vehicles may create a platform for economic growth (Godsmark, Kirk, Gill, & Flemming, 2015). The introduction of AVs may trigger more jobs within specific technology related sectors, new markets for investment, infrastructure, innovation, and new customers.

In the 2015 study *Automated Vehicles: The Coming of the Next Disruptive Technology*, the Conference Board of Canada in collaboration with the Van Horne Institute and Canadian Automated Vehicles Centre of Excellence project the combined economic benefit for Canada could total over $65 billion per year.

The cumulative potential benefits are summarized as follows:



At this stage it is still too early to accurately assess the associated potential benefits and impacts that may occur in other sectors of the Canadian economy.

IMPROVED FREIGHT TRANSPORTATION

It is anticipated the deployment of automated commercial trucks will change freight transportation as we know it today. The automated truck of the future will have the capacity to function with or without a driver behind the wheel.

With their wide scale adoption, the automated truck will impact everything from the commercial driver's 'job description,' to how warehouses, receiving docks, and logistics parks are designed and operated.

The following advantages are associated with the deployment of automated heavy trucks:

- **Improved safety and precision:** automated controls and automated vehicles equipped with safety software would help drivers manage blind spots, monitor vehicle activity around the truck, make decisions about when to turn brakes on and keep drivers in lanes if they begin to drift. Automated controls can also help protect the driver who is distracted. The vehicle and equipped automotive technology will allow for precision in delivery and safety enabling faster speeds while maintaining a short distance between vehicles.
- **Solving fatigue management issue:** as a leading factor in large truck crashes, it is anticipated that self-driving vehicles will give drivers rest time during long hauls and this could significantly reduce driver fatigue. The most grueling long-haul shifts stretch as long as 11 hours (federally), and fatigue is a leading factor in the 4,000 annual deaths (U.S.) that result from large truck collisions. The self-driving truck can reduce driver fatigue and limit driver error and distractions.
- **Reduced road collisions:** automated technology, driver assists and other features will greatly reduce driver error which will in turn reduce road incidents and crashes.

- **Reduced driver shortage/driver retention:** driver shortages in North America and Europe are a pervasive problem for the industry. Shifting to automated commercial trucks could resolve this, and cut costs related to training and recruitment. There is no shortage of positions within the industry, but recruitment is difficult and turnover is high, since the occupation demands tedious hours behind the wheel and often weeks spent away from family. The introduction of the automated truck may make driving a truck more attractive for some, and minimize driver health and safety concerns.
- **Economic:** Improved aerodynamics means less fuel consumption. Software-operated trucks can drive faster and much closer to other trucks (platooning) by shielding each other from wind resistance and allowing trips to be completed in less time.
- **Environmental impact:** The technology could be more fuel efficient resulting in aerodynamics which would result in less carbon emissions. (Onwutalobi, 2015).

TRUCK PLATOONING (AUTOMATED TRUCKS)

The ability to use technology to platoon trucks is currently at the forefront of research and innovation in the commercial arena. Truck platooning or a Co-operative Truck Platooning System (CTPS) employs wireless communication and automation to create a convoy or "platoon" of two or more trucks which follow closely behind one another. Each truck uses information from its own in-vehicle sensors, plus data received via wireless link from the lead truck, to "co-operatively" measure and adjusts its position, based on the speed, direction and acceleration of the preceding truck. This enables inter-vehicle spacing to be greatly reduced, which improves aerodynamics and reduces fuel use.

More and more countries in Europe, as well as the U.S. and Canada, are offering industry the opportunity to test their latest vehicles and technologies, and the results are encouraging (Transport Canada, 2016).

CTPS technology is being developed in Europe, Asia and the United States, and has the potential to enhance road safety, reduce driver fatigue, smooth out traffic flow and improve vehicle efficiency by reducing aerodynamic drag and improving fuel economy.

On October 23, 2016, Minister of Transport, Marc Garneau participated in a demonstration of prototype platooning being tested at the PMG Test and Research Centre in Blainville, Quebec. The event was part of Transport Canada's *Eco Technology for Vehicles* program, in collaboration with the National Research Council Canada, the University of California at Berkeley's Partners for Advanced Transportation Technology, the U.S. Federal Highway Administration, Volvo and the FPInnovations' PIT Group.

Following the demonstration, Minister Garneau sent a tweet via **@MarcGarneau**

"Rode in 3rd truck of 3-truck platoon on Friday. Driver only steered. Speed and distance from 2nd truck automatically controlled. Impressive."

Some automated platooning has shown significant fuel economy benefits. In 2014, the U.S. Department of Energy National Renewable Energy Laboratory (NREL) conducted tests of platooning systems implemented by Peloton Technology. Their tests revealed up to 5.3 percent fuel savings for the lead truck and up to 9.7 percent fuel savings for the trailing truck.

In April 2016, the Netherlands initiated a European Truck Platooning Challenge.

Six brands of automated trucks (DAF Trucks, Daimler Trucks, Iveco, MAN Truck & Bus, Scania and Volvo Group) participated. The automated trucks drove in columns (platooning) on public roads from several European cities to the Netherlands. The aim of the challenge was to bring platooning one step closer to implementation. As a result of the initiative, several businesses, including Unilever and a major Dutch supermarket, have expressed interest in platooning for their fleets (European Manufacturers Automobile Association, 2016).

Platooning demonstrations and research pilots to date show the potential for making road transport safer and more efficient in the future. These along with the many potential economic benefits stand to make commercial transport some of the early adopters of the technology.

ENVIRONMENTAL IMPACT

In Canada, transportation related activities account for 23 percent of the country's total greenhouse gas emissions. Automated Vehicle technology may bring significant benefits to the environment through greater efficiency and fuel savings.

The release of greenhouse gas and their increasing concentration in the atmosphere are having an adverse impact on the environment, human health and the economy.

These impacts are expected to become more severe unless concerted efforts to reduce emissions are undertaken (U.S. Department of Transportation). In one simulation study based on a mid-sized U.S. city, researchers modeled savings for AVs that are identical to current mid-size sedans in every respect (including size). The researchers projected 12 percent less total energy use and a 19 percent drop in sulphur dioxide emissions from more efficient road performance as well as the reduction of cold and warm starts.

Another benefit could be realized when coupling electric powered vehicles with AV technology. In a study modeling savings for electrically powered AV trucks, the researchers found decreased greenhouse gas emissions of 87-94 percent compared with a 2015 conventional vehicle, and a decrease of 63-82 percent compared with a 2030 projected hybrid vehicle (Greenblatt & Saxena, 2015).

Although AVs have the potential to reduce the negative environmental impacts of transportation, it is still too early to assess the true environmental impact until the technology and consumer use is more clearly defined.

REDUCED TRAFFIC CONGESTION

Traffic congestion is a growing concern in Canada, with more than 70 percent of work commute travel by car occurring in the largest metropolitan areas of Toronto, Montreal, Vancouver, Calgary, Ottawa-Gatineau and Edmonton. Traffic congestion imposes substantial costs to the Canadian economy.

A 2006 report by Transport Canada found that congestion costs were nearly $4.5 billion annually in the six largest metropolitan areas. These costs also extend to the efficient movement of goods, due to traffic, impact delivery time, loading and related costs. In Toronto, the city's Board of Trade suggests the slower travel times is a competitive disadvantage and that traffic congestion can weigh into corporate decisions about locations for new facilities.

In more congested travel conditions, AVs could help to avoid the inefficient start-and-stop traffic conditions—a result of exaggerated braking and acceleration responses of human drivers—that negatively impact traffic flow. Traffic incidents account for about 25 percent of all congestion delays and vehicle crashes constitute a major share of this total. If successful, AVs should be able to prevent the vast majority of these incidents, in turn eliminating an appreciable share of all traffic delays (Anderson et al, 2016).

Beyond the economic benefit, the stress of not having to endure unnecessary time in traffic is something most commuters would welcome. Experts say prolonged, soul-sapping time in the driver's seat raises one's risk of obesity, diabetes, stress and fractured relationships (Eastwood, 2014).

ENHANCED ACCESSIBILITY AND MOBILITY

AVs have the potential to improve mobility of Canadians that do not drive a vehicle – either by choice or because of economic, physical or cognitive limitation (Moshi, 2016).

Mobility in Canada is an issue for a growing aging demographic and improving access to transportation may enhance the 'quality of life' for the 11 percent of Canadians that have a disability. Some additional benefits for these individuals include personal independence, reduction in social isolation and access to essential services (Transport Canada 2016).

It is projected that by the year 2031, Toronto will have 75,000 senior residents with severe or very severe disabilities who experience challenges in using public transit.

Appropriately designed and managed AVs can improve urban-rural commute and transform access to mobility for seniors, low income groups and people with disabilities living in rural and remote communities. AVs can resolve the issue of providing accessible and affordable transportation to many vulnerable categories of citizens traveling to urban centers that have limited access to public transportation (Ticoll, 2015).

To enhance accessibility and accelerate the planning and adoption of innovative urban infrastructure including clean, digitally connected technology, the federal government proposes to launch a Smart Cities Challenge in 2017. Modelled on a similar competition in the U.S., cities across Canada would be invited to develop Smart Cities Plans together with local government, citizens, businesses and civil society (Department of Finance, 2016).

The potential positive impact of AVs on mobility is an important consideration in the discussion as it has the ability to enhance road safety. Government administrators and community organizations will benefit by continuing to assess how AV's can provide better mobility options for its citizens.

BARRIERS AND RISKS

ADAPTING TO THE TECHNOLOGY

A pressing challenge for governments and regulators is how best to maintain road safety while allowing for the safe testing and deployment of AVs on public roads. For regulators, questions concern how safely the AV will operate alongside conventional or partially automated vehicles. Currently, there is uncertainty regarding AV performance in poor weather, cold, snow or other less than ideal driving conditions.

In its report *Automated Vehicles: Driver Knowledge, Attitudes, and Practices* (September 2016), the Traffic Injury Research Foundation states that despite their potential benefits, AVs currently possess a number of limitations that technology has yet been able to overcome. Most notably, AVs are not able to be driven in more complex or challenging road conditions or environments, nor are they able to make ethical decisions. They must rely on capable drivers to take control. Based on its survey of Canadians, the report suggests there is a need to educate citizens about misperceptions surrounding the technology's capabilities and limitations.

The introduction of automation in vehicles poses a host of 'human factors' concerns and guidelines are needed. Experts warn that vehicle automation may compromise performance and safety, resulting in:

- driver complacency (driver being overconfident)
- reduced situation awareness
- distraction
- driver overload and confusion
- loss of skill and interactions with other road users who assume a person is driving and not a machine.

Several international standard bodies have looked at this (SAE, ISO) and Transport Canada is involved in this work. Automation should provide users with safe mobility. The status of automation should be clearly visible to drivers at all times, and the driver should be educated on how the automated functions work and how they can interact with them. Proper instructions, supporting materials and accurate marketing are essential so that drivers have a clear understanding of system capabilities and limitations (Belluz, 2015).

Several reported crashes of automated vehicles during their testing on public roads have reinforced the need to be attentive to road safety. The first known death caused by a self-driving car was disclosed by Tesla Motors in June 2016. The incident occurred in Williston, Florida, after the driver put his Model S into autopilot mode, which is able to control the car during highway driving. According to Tesla, against a bright spring sky, the car's sensors system failed to distinguish a large white 18-wheel truck and trailer crossing the highway.

On January 17, 2017, the National Highway Traffic Safety Administration ended a six-month review of Tesla's Autopilot system spurred by the fatal Florida crash and other incidents involving the semi-autonomous driving feature, finding no specific flaw in the technology and taking no action against the carmaker led by Elon Musk. "Our investigation was thorough, evaluating every aspect of the Tesla Autopilot system including the automatic emergency braking system. Our investigators have concluded that a safety-related defect trend has not been identified and further examination is not necessary at this time," stated Bryan Thomas, NHTSA's communications director. Thomas went on to say "automakers must take extensive action to ensure consumers understand how safety systems on their vehicles work as well as their limitations. Drivers do have a responsibility to read the owner's manual, but "manufacturers have to design with inattentive drivers in mind." In the wake of the 2016 accidents, Tesla modified the programming for Autopilot, which it describes as a semi-autonomous system, to ensure drivers don't take their hands off the wheel for extended periods and reminding them of the need to remain aware of road conditions. (Ohnsman, 2017)

The Tesla example points to the need for clearly defined safety requirements. NHTSA's *Federal Automated Vehicles Policy* provides a proactive safety approach.

Their 15-point safety assessment is a guide for manufacturers, developers and other organizations to enable the safe design, development, testing and deployment of automated vehicles.

In Canada, safety is at the forefront of decisions regarding AV testing and deployment. Ensuring a harmonized regulatory framework is in place to address public safety concerns is critical for all levels of government. Prior to the broad scale deployment of AVs in Canada, regulators will need to understand and agree on:

- How manufacturers should demonstrate vehicle safety
- How licensing of vehicles and drivers should be done
- What type of regulatory framework will ensure safe operations of AVs on public roads
- How government/enforcement/police will address issues of liability, data privacy and cybersecurity
- How enforcement regulations (commercial and non-commercial) will be applied to AVs

Not only is Canada working domestically on this issue, internationally, Canada is taking a lead position in its collaboration with other G7 members in order to harmonize AV related policies and regulations in the area of vehicle safety.

During the first ever meeting of G7 Transportation Ministers in September 2015, the Ministers' issued a declaration on automated and connected driving. The declaration is focused on coordinating research and promotes international standardization within the international regulatory framework (Belluz, 2015).

PRIVACY AND DATA SHARING

Automated vehicles will radically transform the way data is shared and protected as these tech-filled vehicles will generate large amounts of data. The challenge will be in determining who owns the data, how to use it, and how to protect it. Ensuring data protection and cybersecurity is one of the key priorities outlined at the G7 declaration on automated and connected driving.

In Canada, there are a number of laws that relate to privacy rights, and there are various government organizations and agencies responsible for overseeing compliance with these laws. The Personal Information Protection and Electronic Documents Act (PIPEDA) sets out the ground rules for how private-sector organizations collect, use or disclose personal information in the course of commercial activities across Canada.

GPS systems already collect data, and with the growth of AVs, we could see the expansion of related data, including passenger identities, personal profiles, origins and destinations, travel dynamics, media use, and so on. PIPEDA may provide direction regarding which government departments and private companies can access this type of data.

Several countries have developed codes of practice regarding data protection for AVs. The UK Department of Transportation's 2015 code of practice for testing driverless cars specifies the recommended actions and practices for AV firms related to data collection, data protection, cybersecurity and software management.

Data privacy is a sensitive area which will benefit greatly from more work and discussion among government, industry and stakeholders. Along with managing public concerns related to data privacy protection, government needs to determine who will have access to data and on what conditions data will be shared.

CYBERSECURITY

In our digital era, the concept of cybersecurity is increasingly familiar. Over the last few decades our lives have been revolutionized by the rapid connectivity made possible by computers, the internet, satellites and other technologies.

According to NHTSA, cybersecurity, within the context of road vehicles, refers to the protection of automotive electronic systems, communication networks, control algorithms, software, users, and underlying data from malicious attacks, damage, unauthorized access, or manipulation.

Today, cybersecurity is a legitimate concern, both for government, and for private sector companies working on AV technology. As recently as 2015, the world's second largest reinsurer Munich RE found that 55 percent of corporate risk managers surveyed named cybersecurity as their top concern about self-driving cars. It included the potential hacking of an automated car's data systems as well as the failure of smart road infrastructure.

Software upgrades highlight a broader concern with AVs' system security. Vehicles that are connected to each other, to infrastructure, or to the Internet are increasingly open to cyberattack.

Experts believe that even primarily unconnected vehicles may be at risk. Software upgrades will likely require connection to the Internet, which creates the possibility of vehicles being attacked by computer viruses that corrupt the system. For example, a virus could enter the system by masquerading as a legitimate software upgrade. Prevention will require extremely secure connections to upgrade servers—and will need to ensure the upgrades themselves are legitimate and uncorrupted. Without safeguards in place, hackers might be able to commandeer a single vehicle (or a fleet of vehicles) to commit crimes, or even acts of terrorism.

To combat the problem, in Canada, the federal government is overseeing a cybersecurity strategy. It has requested the Ministry of National Defence, Infrastructure and Communities, Public Services and Procurement, Innovation, Science and Economic Development, and the President of the Treasury Board, to lead the review of the Canadian cybersecurity landscape, including current gaps and opportunities. Additionally, a joint Canada-U.S. Cybersecurity test program is underway that will help to identify principal cybersecurity threat factors; vulnerability and create mitigation strategies (Moshi, 2016).

The Organization for Economic Cooperation and Development (OECD) points out that connected mobility services pose "increased cybersecurity risks, especially when network-based systems interact directly or indirectly with primary control systems of vehicles."

Automotive technologies provide "back door" surveillance and tampering opportunities for AV technology firms, car manufacturers, computer hackers, government agencies, and cyber warriors." (Ticoll, 2015).

The RAND Corporation researchers believe that security threats could also be caused by the vehicle owners. Many technology enthusiasts may seek access to their own systems to gain control over elements that are otherwise locked down by the manufacturer. Case in point, in 2015, Chrysler announced a recall for 1.4 million vehicles after a pair of hackers demonstrated to mass media that they could remotely hijack a Jeep's digital systems over the Internet. At the Black Hat security conference in August 2016, automotive cybersecurity researchers Charlie Miller and Chris Valasek presented an arsenal of attacks against the same 2014 Jeep Cherokee they hacked in 2015. They remotely hacked into the car and paralyzed it on a highway, while it was driving in traffic. They were able to disable the car's brakes at low speeds. By sending carefully crafted messages to the vehicle's internal network known as a CAN bus, they were able to manipulate acceleration, cause the car to brake at any speed, and turn the steering wheel at any speed.

In 2016 NHTSA took a proactive safety approach to protect vehicles from malicious cyberattacks and unauthorized access by releasing proposed guidance to government and industry for improving motor vehicle cybersecurity.

Its proposed cybersecurity guidance focuses on layered solutions to ensure vehicle systems are designed to take appropriate and safe actions, even when an attack is successful (NHTSA, 2016).

The NHTSA cybersecurity guidance recommends manufacturers and industries ensure the following:

- prioritize identification and protection of critical vehicle controls and personal data
- include the full life-cycle of a vehicle
- conduct periodic self-audits
- consider vulnerabilities that may impact the entire supply chain of operations
- train employees on new cybersecurity practices and share lessons learned with others

Cybersecurity is a complex area, and safeguarding the public requires a multifaceted solution, engaging both private and public sector organizations.

LABOUR MARKET DISRUPTIONS

Economists and researchers predict that the arrival of the new technology will disrupt the labour market. Long term impacts on sectors that depend on current transportation models including vehicle manufacturing, taxi services and auto insurance, are anticipated. There are estimates that automated vehicles could displace more than 500,000 Canadians who currently earn their living driving a vehicle. Potentially displaced categories of workers include: transport, truck and courier service drivers, taxi/bus and tow truck drivers, traffic police, auto insurance agents, driving instructors and parking attendants, etc. (Godsmark, Kirk, Gill, & Flemming, 2015).

In the automotive manufacturing plant, everything from the automotive manufacturing equipment required to build the AV equipped vehicles, to the skills and knowledge necessary to operate the machinery will be impacted. In the auto insurance industry, there may be fewer workers required to process accident claims, given fewer collisions anticipated on the roads. As job categories become obsolete, there will be a need for an entirely new set of skills and resources to support the automated technology.

INSURANCE INDUSTRY AND LIABILITY

In the not too distant future, AVs will account for most of the cars and trucks on our roads, and the insurance industry is preparing for the changes ahead. In 2016, the Insurance Institute of Canada surveyed its members, inviting them to share their views on the state of preparedness of the Canadian insurance industry for the introduction of automated vehicles.

More than 3,000 members of the insurance community responded, which likely represents the largest survey ever conducted in Canada addressing the insurance implications related to introduction of AVs.

Results of the Insurance Institute of Canada's survey:

- More than 73 percent of respondents believe that the introduction of self-driving vehicles will be difficult for the insurance industry.
- Almost half (46 percent) of respondents believe that the industry is not prepared for the expected change in the frequency and severity of collisions over the next 10 years.
- Almost 70 percent believe that the insurance industry is prepared to participate in discussions about the introduction of self-driving vehicles (Kovacs, 2016).

As partially-automated vehicles and fully automated vehicles begin to share the road with conventional vehicles, liability for most collisions will begin to shift to include a mix of personal and product liability (Kovacs, 2016). Volvo, Ford and other companies have already said they will accept 'full liability' in the future when a car crashes in autonomous mode. They believe the technology will be that good. (Chittley, 2016)

Self-driving cars have the potential to save consumers money in premiums, and experts say the industry must change drastically and develop new products to meet the requirements imposed by AVs. As the insurance industry begins to prepare for the extensive changes vehicle automation will bring, the primary challenge over the next decade will involve determining who is responsible for collisions.

The law firm Borden Ladner Gervais issued a report in August 2016 stating even if a car is in semi-autonomous mode, the driver is liable. So, while a driver can let go of the wheel for short periods of highway driving, the driver is still liable if an incident occurs."-For fully autonomous vehicles," the report says, "it would seem that legislative amendments would be required to clarify whether the owner would be vicariously liable and under what circumstances." (Laroche & Love, 2016). As the insurance industry prepares for the massive changes, the primary challenge will involve determining where and with whom, responsibility lies.

Areas and questions being discussed by insurers and manufacturers include:

- Should vehicles have on-board devices to ascertain if the technology was engaged at the time of a collision?
- Should insurers have access to driver/manufacturer data?
- How should insurers recover costs when automakers are found to be at fault?
- How should costs be shared when driver errors and vehicle automation systems both contribute to a collision?

The rapid changes to technology and the various players involved, will require a willingness on the part of manufacturers and the insurance industry to maintain open channels of dialogue.

ETHICAL CONSIDERATIONS

While AVs have the ability to detect instances that would lead to a collision, they do not yet have the cognitive ability to think like humans.

Artificial intelligence does not have the same cognitive capabilities that humans have, instead, autonomous vehicles make decisions based on speed, weather, road conditions, distance and other data gathered by a variety of sensors, including cameras, LIDARS (Light Detection and Ranging), and radars. Ragunathan Rajkumar, a professor of electrical and computer engineering in Carnegie Mellon University's CyLab and a veteran of the university's efforts to develop automated vehicles, stated "A driverless car will calculate a course of action based on how fast it is traveling as well as the speed of an object in its path, for example. The main challenge is in gathering and processing the necessary data quickly enough to avoid dangerous circumstances in the first place." Rajkumar acknowledges that this will not always be possible but he is skeptical that in such cases it will come down to the vehicle essentially deciding who lives and who dies. (Greenemeier, 2016).

For instance, an automated car might place more value on its occupants' safety than those of other road users; or it might be programmed to value human safety over property damage; or it might give a wider berth to a truck or bicyclist, even if it means edging closer to other vehicles, increasing risk to them. These can all be a source of ethical liability if not carefully considered, resulting in both legal and policy implications (Automotive Vehicle Symposium, 2016).

The culture in which the AV is deployed may also influence how industry develops and deploys the technology. Rules of the road differ in different countries, and where one lives may influence their views on ethical issues. For instance, if an action by an AV is not dangerous, or illegal, it may still elicit negative reactions if the broader public believes that it is unethical or handled poorly.

ENFORCEMENT BY POLICING

Driver assist technologies such as blind spot detection, lane departure warning systems, and other built in safety interventions meant to avoid driver error, are likely to reduce road collisions. This may alleviate some pressure for police and traffic enforcement officers, but there are still challenges for the road safety enforcement community with the introduction of the technology.

Along with distracted driving, alcohol and drug impaired driving, there will be a new tier of issues related to liability, cybersecurity and data protection. Specifically, when dealing with collisions, determining whether the responsibility lies with the driver or the vehicle. Other considerations include when and under what circumstances should police be permitted to take control of an automated vehicle remotely.

Additionally, the deployment of AVs will impact how police officers track crashes and incidents, allowing better surveillance and reporting.

Enforcement agencies will need to collaborate with manufacturers and government to understand how the new technology works, their role with respect to data security, and ultimately, how best to ensure public safety.

INFRASTRUCTURE

The widespread adoption of AVs will eventually impact the shape of our cities and public infrastructure. The decisions that we make today in infrastructure, planning and policy, will influence how well this technology serves our citizens and our communities in the future.

Several organizations in Canada are taking a leadership role in planning and studying AV related infrastructure. These include the Transportation Association of Canada and the Policy Planning and Support Committee. Their work will inform the jurisdictions, which have a primary responsibility in maintaining and operating highway infrastructure. Provinces and territories would be accountable for any investments in intelligent infrastructure such as the creation and operation of dedicated lanes for AVs.

In the long term, Canadian jurisdictions will need to make appropriate infrastructure adjustments for the new technology. In the short-term, there is the potential to implement lower-cost modifications to infrastructure, such as changes in signage, while other elements could be part of long-term planning. As this is an evolving area, the degree to which infrastructure will be impacted remains unclear.

WEATHER: CAPACITY TO OPERATE IN ALL CONDITIONS

Weather in Canada can be harsh during winter months, and knowing how AVs operate on snowy, icy road conditions or in inclement weather is a public concern. Just how environmental factors will impact the safety of AVs or their supporting infrastructure is still unclear.

To date, AV tests have encountered fog, rain and snow. For Canada, it is essential to test AVs on icy and snowy winter road conditions to ensure their safe operations.

To address this, Federal Transport Minister Marc Garneau asked the Senate's Transportation and Communications Committee to examine the potential for Canada to set standards for the development of AVs so that they can operate safely on icy winter roads.

The automated cars now in development use a variety of sensors to read the world around them. Radar and LIDAR do most of the work looking for other cars, pedestrians, and other obstacles, while cameras typically read street signs and lane markers. And that's a problem come winter, if snow is covering a sign or lane marker, there's no way for the car to see it unless it is connected through technology.

These conditions present unique challenges for an AV as snow can bury sensing devices and render them useless, vehicle systems can interpret a squall as an obstacle and stop driving or try to route around, and the infinite variety of snowy streetscapes can confuse vehicle navigation systems.

Finally, sensors, like many human drivers, may not identify or see black ice. Snow may absorb sensor rays rather than reflect them back. Some researchers believe it will take decades to solve this problem; and the automotive manufacturing sector is working diligently to find a solution. It is an area that will benefit greatly from additional testing and evaluation.

Several manufacturers, including Ford and Volvo have begun testing automated vehicles in winter conditions.

CONCLUSION

We are just beginning to get a sense of how AVs will change our day to day lives and transform our world. For professionals in the automotive transportation industry, the advent of AVs represents the potential to provide solutions for road safety, traffic congestion, pollution, energy consumption and mobility.

The inherent benefits will be far reaching, and the way forward will require the collaborative spirit that has long characterized the work of CCMTA.

CCMTA wants to provide its members with practical and applicable information to help them plan for the inevitable changes. This general paper has covered an enormous area, but briefly, and we recognize there is much more that will be relevant to jurisdictions in the months and years ahead. As such, this white paper is a living document. As applicable information for our members becomes available, we will update this paper accordingly.

The CCMTA AV Working Group will also continue its work on this topic, identifying and supporting activities related to AVs for its jurisdictions. Going forward, the CCMTA Knowledge Management Platform will provide an integral space for AV related information, including the sharing of jurisdictional initiatives and news to increase knowledge and collaboration.

For now, we trust this is a sufficient starting point to educate, inform and begin discussions.

APPENDIX A

CCMTA ACTIVITY ON AUTOMATED VEHICLES

- Evolving impact of disruptive technology on transportation is a priority of the Board.

- CCMTA has been monitoring the development of AV technologies through its Drivers and Vehicles and Road Safety Research, Policies Program Committees.

- The Board approved a designated AV Working Group in 2014 with provincial/territorial and federal representation. Purpose is to examine challenges related to AV technology and encourage consistency across jurisdictions.

- Work to date has featured carrying out scoping / environmental scans, including:
  - o Survey of jurisdictional activities on AVs
  - o Survey of Canadian public opinion on AVs

- In November 2015, **CCMTA hosted an AV Workshop** aimed at increasing knowledge and educating its government members. More than 80 participants attended the two day event, including representatives from PPSC, TAC and vehicle manufacturers. Members had an opportunity to hear from a variety of industry and government stakeholders from Canada and the U.S., including U.S. National Highway Transportation Safety Administration (NHTSA), the California Department of Motor Vehicles and the Nevada Department of Motor Vehicles, all of which have experienced testing and deploying in their jurisdictions.
  - o CCMTA shared an "as was said" report on the workshop with Chair of PPSC.

- The **CCMTA AV Working Group made up of jurisdictional volunteers** will be providing the CCMTA Board an update/recommendations related to a work plan to support Canadian jurisdictions in working towards a consistent national regulatory framework.

- As well, CCMTA is supporting its AV Working Group Co-Chairs (Alberta and BC) in their participation in a **U.S. AV Best Practice Group led by American Association of Motor Vehicle Administrators** (AAMVA). The AAMVA led AV group is funded by NHTSA.

- The Group's overarching objectives are to work with the AAMVA jurisdictions, law enforcement, federal agencies and other stakeholders to gather, organize and share information with the AAMVA community related to the development, design, testing, use and regulation of automated vehicles and other emerging vehicle technology. Based on the group's research, they will develop a best practices guide to assist member jurisdictions (including Canadian jurisdictions) in regulating automated vehicles and testing. The guide is slated for release in 2016.

- The AV Working Group of CCMTA has created communication material for Board review and approval, including information for jurisdictions:
  - o FAQ
  - o Key Messages
  - o Content for website

- Automated Vehicles was a primary focus at the CCMTA 2016 Annual Meeting held in Halifax June 2016. Keynote speaker Karlyn Stanley, an adjunct senior researcher and lawyer with RAND Corporation oversees legal and policy issues (including privacy and cybersecurity) concerning automated and connected vehicles. Karlyn's presentation addressed what policymakers need to think about when planning in the current quickly evolving environment of AVs.

- Yvonne Rene De Contret from Deloitte Consulting spoke to the CCMTA Board on the Age of Disruption in Transportation and Impacts to Administrators. Her presentation addressed:
  - o Five disruptive trends to transportation
  - o Impact of emerging vehicle technology
  - o Timelines and how administrators should respond and plan in the current environment

- CCMTA commitment is to continue to monitor the information on this issue and provide members with the most current and relevant AV information available.

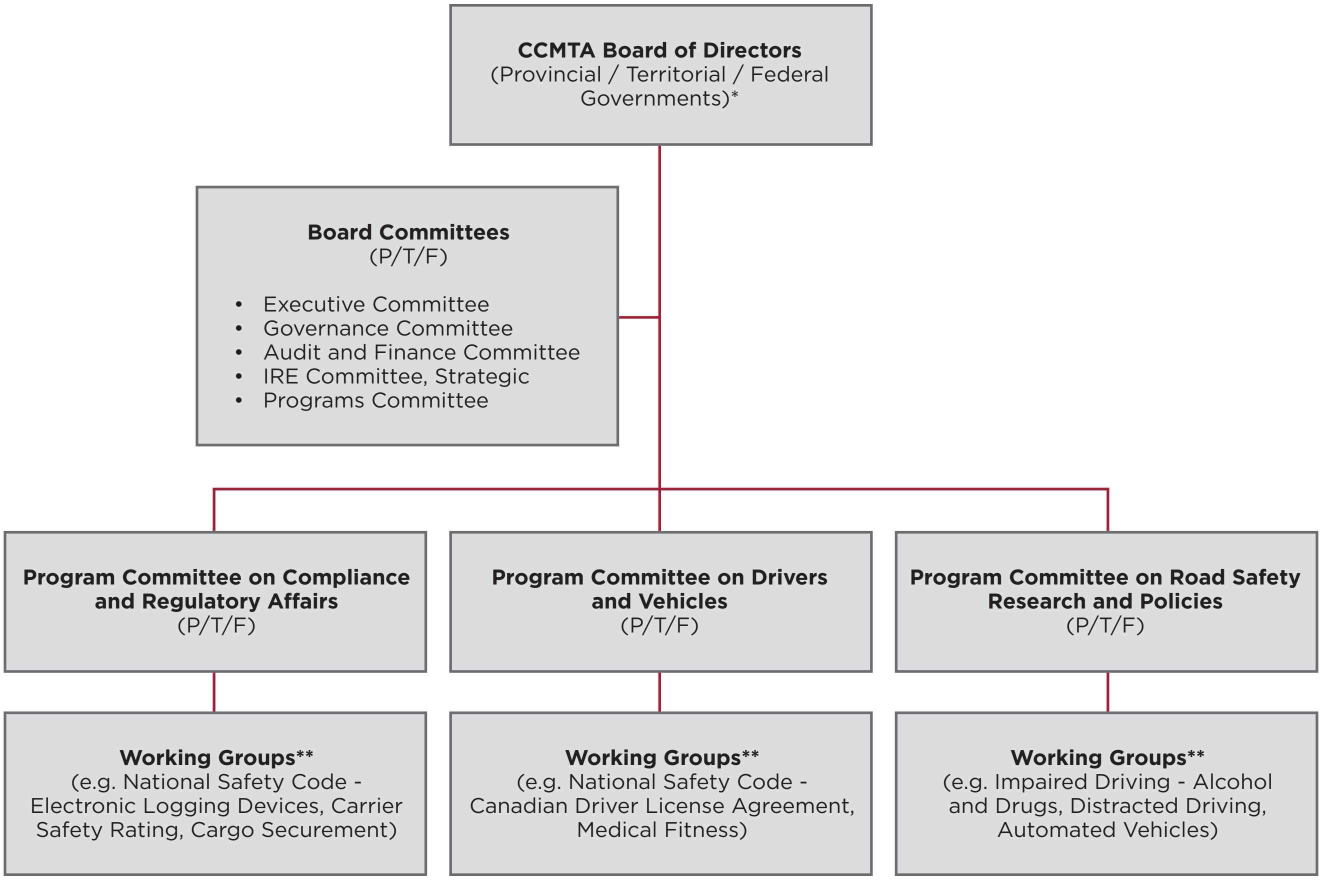
- CCMTA Board of Directors approved the CCMTA Automated Vehicles Work plan. Considering that the transition to fully automated vehicles (NHTSA level- 4 or SAE level-5) is some years away a long-term work plan is being recommended where work will be implemented in the short term to address the testing of these vehicles versus the actual deployment of vehicles which would be long-term.

- The work plan will deal exclusively with issues that CCMTA can address in terms supporting the jurisdictions. Automated commercial vehicles will be addressed when appropriate.

- Connected vehicles are not in the scope of work however the group will monitor connected vehicle (V2I, V2V and V2P) safety applications, and the activities of the G7 AV Committee via Transport Canada's participation on the group.

CCMTA ORGANIZATIONAL STRUCTURE

Established by the CCMTA Board, CCMTA's three Program Committees provide expertise and advice to key files, initiatives or operational concerns. Program Committee members are appointed by the Board on the basis of demonstrated expertise and interest in the particular subject matter. Each of the program committees consists of a total of 14 individuals from provincial and territorial governments, as well as the federal government, represented by Transport Canada.



*Membership is restricted to Canada's fourteen (14) Provincial, Federal and Territorial Governments.
**Working Groups are created on an as needed basis in order to address key priority items and/or emerging issues. This is a snapshot of some of CCMTA's working groups, it is not an exhaustive list of all working groups.
***Terms of references for all groups above are available upon request.

APPENDIX B

JURISDICTIONAL CHECKLIST FOR PILOTING AUTOMATED VEHICLES (AV'S)

The questions below are intended to aid Canadian jurisdictions in identifying issues that they should consider before they start the process of allowing pilot testing of AV's in their jurisdiction.

A. Foundational Planning

1. Do you have any policies in place to allow or disallow the testing of AVs in your jurisdiction?

2. Does your current regulatory framework allow for AVs through permit or exemption?

3. Does your 'governing' Act allow for the creation of regulations for the testing of AVs?

4. If your minister does not possess the authority to make regulations for the testing of AVs, what will you have to do to create this authority?
   a. Private Members Bill,
   b. Order in Council,
   c. Ministerial Order
   d. Other?

5. Does your governing act allow your jurisdiction to create pilots? (i.e. small scale project to prove the viability and use of AVs versus an evaluation by the manufacturer of the AVs performance.)

6. Have you considered adopting specific terminology and key definitions that are in line with other jurisdictions?

7. Are you able to draw linkages between an AV project and other government strategies?

8. Do you need to consult with appropriate stakeholders?

9. Are there opportunities to leverage partnerships with stakeholders? (i.e.: Firms from the technology and automotive industries?)

10. Do insurance companies in your jurisdiction provide coverage for AVs?

11. Have you reviewed and understood the current state of AV technology and automotive trends?

12. Does your jurisdiction have a requirement for a person to sit in the driver's seat of an AV vehicle?

13. Are there any infrastructure requirements needed to pilot AVs in your jurisdictions?

14. Will there be limits placed on time of operation (i.e. day versus night), location (i.e. school zones, construction zones, etc.) or weather conditions for piloting an AV?

15. Have you given any thought to media and public messaging for piloting AVs?

B. Future Policy Considerations for a Pilot[1]

16. Will your policies include detailed expectations for testing companies to comply with?
    a. Definitions, data retention requirement's, steering and braking requirement's, identifiers on AV's, requirement for driver's to be in driver seat, etc.

17. Will your policies outline collision and disengagement reporting mechanisms, roles and duties of testing company (manufacturer)? Will this include near-misses, or just reportable collisions? Who is responsible for post-incident inspections/re-certifications to ensure the vehicle meets CMVSS?

18. Will the manufacturer have to transmit recorder data to the jurisdiction for reportable incidents? How will you handle the storage and transmittal of this data?

19. Will your policies outline liability post-serious incidents? (i.e.: who is responsible for software malfunctions?)

20. Will your policies outline who will make the decision about revoking the testing permit?

21. How long do you intend the pilot project last?

22. Who will you allow to apply to participate in the pilot testing project?

23. What type of licence class will you require for the vehicle type being operated?

24. What minimum insurance requirements will you set for eligible participants?

25. Have you thought about the limiting the areas for the pilot testing (e.g. on all every roads, certain area of the cities, highways etc.?)

26. Can a lead organization be identified to act as a facilitator/coordinator for AV technology?

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[1] Vehicles in testing programs should meet all safety standards CMVSS

27. Will cyber security, data capture and storage be taken into consideration?

28. Will your jurisdiction be required to evaluate the pilot testing phase? If so, how will you measure the success?

C. Key Stakeholders

- Canadian Vehicle Manufacturers' Association
- Global Automakers of Canada
- Transit Associations
- Enforcement (RCMP/OPP/SAQ/Municipal Police Agencies)
- Driver Training Schools
- Transportation Association of Canada
- Insurance Bureau of Canada
- Intelligent Transportation Systems Society of Canada (ITS)
- Automotive Parts Manufacturers Association
- Provincial Police Association
- Provincial Police/RCMP
- Canadian Automobile Association (CAA)
- Canadian Association of Municipalities

APPENDIX C

AV WORKING GROUP – COMMUNICATION PRODUCT FOR CCMTA MEMBERS

Autonomous Vehicles: Frequently Asked Questions

What is an autonomous vehicle?

An autonomous vehicle (driverless vehicle) is a vehicle that does not require human monitoring or interaction. It is also referred to as a fully automated system, fully autonomous vehicle, self-driving vehicle, driverless vehicle, or fully automated vehicle. These vehicles use technologies to replace the human as the driver, such as sensors to detect obstacles, software algorithms to make driving decisions, and electronic equipment to brake, accelerate, and steer the vehicle without any human participation in the driving task.

Systems in cars today, such as adaptive cruise control, lane centering, and self-parking vehicles, are considered automated driver assistance systems.

More information and definitions concerning autonomous vehicles can be found at www.ccmta.ca

How will road safety be impacted by the use of autonomous vehicles?

(Jurisdiction) does not expect any negative impact on road safety. Testing in other jurisdictions suggests that road safety is maintained or enhanced. Driver error accounts for approximately 90 - 95% of all collisions so anecdotally there should be a reduction in collisions over time.

When will AVs be available in the market?

There are conflicting views among industry leaders as to when AVs will be widely available to the public. Some industry leaders predict that AVs will be market-ready anywhere from 2017 to 2040. Vehicle manufacturers and software developers are working very aggressively to make this technology available to the public, with a number of manufacturers committed to achieving a 2020 deadline.

As AV technology continues to improve, how is (Jurisdiction) preparing for the arrival of more vehicles with more automated driving features?

(Jurisdiction) recognizes the importance of new vehicle technology and is aware that many companies are developing technologies that automate the operation of motor vehicles. (Jurisdiction), along with Transport Canada, CCMTA and other Canadian jurisdictions are monitoring practices, developments and the latest research.

We are also learning from jurisdictions such as Ontario and California which have taken steps to regulate the testing of autonomous vehicles on their public roads and highways.

Are there any long-term environmental (e.g. climate change) benefits to AVs?

AVs have the potential to reduce emissions if they result in more efficient movement, and reduced congestion, leading to an overall reduction in fossil fuel consumption. Passenger cars and light-duty trucks are the largest sources of carbon monoxide emissions. This largely depends on whether or not the driving public chooses not to own personal vehicles, rather, to use a pooled or shared vehicle with this technology.

What are the potential benefits of AVs?

AV technology is well underway but the testing is not yet complete. As such, the true benefits of the technology are difficult to identify. Some studies have suggested that AV technology could result in:

- Fewer traffic collisions through improved collision avoidance and reduced driver error
- Reduction in traffic congestion/increase in highway capacity
- Improved fuel efficiency
- Reduced vehicle emissions
- Convenience, time savings and lower stress for drivers and commuters
- Enhanced mobility and mobility equity (i.e.: for the handicapped)
- Improved efficiency of infrastructure use (roads and parking)
- Emergence of new transportation service models
- Applications to public transit

Other benefits could be related to economic development, advancement of innovation, improved infrastructure, enhanced environment and land-use planning.

When will (Jurisdiction) permit AVs to operate on its public roads/highways?

(Note for reader: Jurisdictions to adjust their response to this question as appropriate)

Autonomous vehicles are not currently allowed on public roads in (Jurisdiction). Current legislation requires motor vehicles be operated by a person. Jurisdiction is reviewing opportunities for the testing of AVs. We are also learning from jurisdictions such as Ontario and California which have taken steps in this direction.

Other Canadian jurisdictions have established pilot programs for testing of AVs. Will (Jurisdiction) be doing the same?

(Note for reader: Jurisdictions to adjust their response to this question as appropriate.)

(Jurisdiction) recognizes the importance of new vehicle technology and is aware that many companies are developing technologies that automate the operation of motor vehicles. (Jurisdiction), along with Transport Canada, CCMTA and other Canadian jurisdictions are monitoring practices, developments and the latest research.

We are also learning from jurisdictions such as Ontario and California which have taken steps to regulate the testing of autonomous vehicles on their public roads and highways.

Autonomous vehicles are not currently allowed on public roads in (Jurisdiction). Current legislation requires motor vehicles be operated by a person.

APPENDIX D

AV WORKING GROUP – COMMUNICATION PRODUCT FOR CCMTA MEMBERS

Autonomous Vehicles: Key Messages for Jurisdictions

General

- (Jurisdiction) is a member of the Canadian Council of Motor Transport Administrators' autonomous vehicle working group and continues to monitor emerging autonomous vehicle technologies; we are participating with other stakeholder groups such as the American Association of Motor Vehicle Administrators (AAMVA) and the National Highway Traffic Safety Administration (NHTSA) to share information.
- (Jurisdiction) is involved in industry discussions surrounding best practices for autonomous vehicles (fully automated or driverless vehicles), with other jurisdictions, including learning from jurisdictions such as Ontario, which have taken steps in this direction.
- (Jurisdiction) supports the safe deployment of automated driver assistance features such as adaptive cruise control, lane centering, and self-parking vehicles, are because of the potential road safety benefits of fewer crashes, injuries and fatalities.

Legislation/Regulation

- Regulation concerning operation of autonomous vehicles (driverless vehicles) is the responsibility of the provincial or territorial ministry of transportation.
- Changes to (Jurisdiction) legislation including vehicle registration and licensing may be necessary for driverless vehicles/autonomous vehicles to operate on public roads and highways.
- Transport Canada is responsible for establishing and enforcing new motor vehicle safety standards. While current motor vehicle safety standards do not restrict the introduction of automated technology in vehicles in Canada, new federal safety requirements may be needed as vehicles become more automated.

APPENDIX E

AV WORKING GROUP – COMMUNICATION PRODUCT FOR CCMTA MEMBERS

Autonomous Vehicles in Canada – Website Information

Role of the Canadian Council of Motor Transport Administrators (CCMTA)

- CCMTA provides a forum for its members to collaboratively monitor emerging autonomous vehicle (driverless vehicle) technology and related issues. It also supports the development of a best practices vehicle policy for jurisdictional use. This includes:
- AV regulatory developments in other jurisdictions
- Ongoing technological changes in the vehicle intelligence industry
- The progression of the vehicle manufacturing industry
- The testing phases of the early adopter jurisdictions

Key Definitions

Autonomous technology: Technology that has the capability to drive a vehicle without the active physical control or monitoring by a human operator. Because automated systems perform some (but not all) driving task(s), these technologies affect the engagement of a licensed human driver with the vehicle and human monitoring of the roadway environment.

Autonomous vehicle (driverless vehicle) is a vehicle that does not require human monitoring or interaction. It is also referred to as a fully automated system, fully autonomous vehicle, self-driving vehicle, driverless vehicle, or automated vehicle. These vehicles use technologies such as computers and algorithms to replace the human as the driver, by, among other things, using sensors to detect obstacles, software algorithms to make driving decisions, and electronic equipment to brake, accelerate, and steer the vehicle without any human participation in the driving task.

An "operator" of an autonomous vehicle is the person who is seated in the driver's seat, or if there is no person in the driver's seat, causes the autonomous technology to engage.

A "manufacturer" of autonomous technology is the manufacturer that originally manufactures a vehicle and equips autonomous technology on an originally completed vehicle or, in the case of a vehicle not originally equipped with autonomous technology by the manufacturer, the company that modifies the vehicle by installing autonomous technology to convert it to an autonomous vehicle after the vehicle was originally manufactured.

Partially automated systems involve motor vehicles equipped with automation systems that are less than fully automated (ranging from no automation to partial automation). Such advanced driver assistance technologies and other automated systems include crash imminent braking, lane-keeping assist, and adaptive cruise control. These are described below.

- **Crash imminent braking** (such as automatic emergency braking) uses sensors to identify obstacles and then uses electronic equipment to apply partial or full braking to mitigate or avoid a crash.
- **Lane-keeping assist** monitors the road lane markings and uses electronic equipment to control the steering wheel to keep the vehicle within a particular lane of the road.
- **Adaptive cruise control** works like traditional cruise control, with added sensors to vary vehicle speed to the extent necessary to maintain a set distance behind the vehicle traveling directly ahead of the equipped vehicle.

Legislation/ Regulations Development

Transport Canada is responsible for vehicle importations and establishing and enforcing new motor vehicle safety standards.

While current motor vehicle safety standards do not restrict the introduction of partially automated vehicles in Canada, (i.e. equipped with one or more collision avoidance systems, such as electronic blind spot assistance, automated emergency braking systems, park assist, adaptive cruise control, lane keep assist, lane departure warning, and traffic jam and queuing assist) new federal safety (Transport Canada) requirements may be needed as vehicles become more automated.

All regulation regarding operating an autonomous vehicle is the responsibility of the provincial/territorial jurisdiction. Jurisdictions will adopt regulations that establish the requirements for the:

- Submission of the evidence of insurance, or self-insurance required for manufacturers' testing of autonomous vehicles.
- Submission and approval of the application to operate an autonomous vehicle beyond testing, including any testing, equipment, performance standards, or safety standards.

Testing of Autonomous Vehicles

Regulations for Testing of Autonomous Vehicles by Manufacturers

The testing of autonomous vehicles on public roads by manufacturers is regulated through provincial and territorial jurisdictions.

For information regarding regulation for testing of autonomous vehicles, please visit the provincial/territorial transportation website.

Deployment of Autonomous Vehicles for Public Operation

The rules surrounding testing and deployment of autonomous vehicles are regulated through provincial and territorial jurisdictions.

The regulations will establish the requirements that manufacturers must meet to certify that their autonomous vehicle has been successfully tested, meets certain safety requirements, and is ready for deployment.

Related Information for jurisdictions

Additional information related to autonomous vehicles regulations that may be of interest to jurisdictions include:

- www.tc.gc.ca
- www.mycardoeswhat.org

For web based content, jurisdictions may also wish to include relevant sections with web links to the following:

- General vehicle manufacturing associations Industry/technology
- Manufacturing
- Road Safety
- Insurance
- Enforcement
- P/T Ministries of Transportation
- Research/innovation
- Economic development

APPENDIX F

ENVIRONMENTAL SCAN

During the past several years, government organizations in a number of countries have begun planning for the regulatory and policy changes to enable the safe testing and deployment of automated vehicles.

The following case studies represent high level activities underway in countries leading automated vehicle testing and deployment.

CANADA

In Canada, a national policy on automated or connected vehicles has not yet been developed, however multiple government organizations are involved in monitoring AV initiatives. Transport Canada is participating in the development of several international AV standards (ISO TC 22 SC39 and TC 204). They are also participating in the United Nations World Forum for Harmonization of Vehicle Regulations and the International Standards Organization.

In February 2016 Transport Minister Marc Garneau asked the Senate's Transportation and Communications Committee to launch a study of the regulatory, policy and technical issues that need to be addressed for the safe and smooth transition to self-driving vehicles. Minister Garneau also asked the Senate committee examine the potential for Canada to set standards for automated cars so they can operate safely on icy winter roads.

In Alberta, the Government of Canada contributed $3.66 million which includes $1.3 million from the Asia-Pacific Gateway and Corridor Transportation Infrastructure Fund for the ACTIVE AURORA project. Launched at the University of Alberta, and led by the University of Alberta and the University of British Columbia, ACTIVE AURORA provides real-world test zones, combined with laboratory settings, where conditions can be customized to simulate various situations. Particular emphasis is on wireless communications for freight security and efficiency. A number of public and private partners are also providing funding and in-kind support totaling $2.36 million. These include: the Province of Alberta, the City of Edmonton, the University of Alberta, the University of British Columbia, and the Canada Foundation for Innovation.

In Ontario, the federal government provided $300,000 to the Intelligent Transportation System Project - launched in the Regional Municipality of Waterloo (Moshi, 2016).

In addition, the Ontario Centres of Excellence, which delivers innovative programs on behalf of the province, has provided $2.95 million in funding to various connected car/autonomous car demonstrations projects, and there are plans for other matching contributions from industry partners. In November 2016, the University of Waterloo, Erwin-Hymer and QNX became the first applicants to test their automated vehicles on Ontario's roads. Elements of the project include:

- The WATCar Project at the University of Waterloo's Centre for Automotive Research which will monitor a Lincoln MKZ for performance and test it on-road at different levels of automation;
- The Erwin Hymer Group, an international auto manufacturer active in the Kitchener-Waterloo tech and innovation corridor which will test and monitor a Roadtrek E-trek at different levels of automation; and
- BlackBerry QNX, a Canadian global software development leader which will test a 2017 Lincoln with automated features. (Government of Ontario, 2016).

Other Canadian cities are studying how automated vehicles will impact their long term transportation plans. Toronto's City Council has committed to review the potential of automated public transit within its municipal transit system. Calgary and Vancouver have similarly committed to studying the impact AVs can have on their transportation plans.

Canadian provincial and territorial governments with the support from the CCMTA Board of Directors and staff have taken a proactive approach regarding automated vehicles. The Board approved the development of a CCMTA Automated Vehicles Working Group which has provided a forum for Canadian motor transport administrators to collaboratively monitor AV technology and evaluate its implications for public safety, the economy, the environment, and infrastructure. In November 2015, CCMTA convened an Automated Vehicles Workshop for its members. CCMTA is also continuing to curate information/research on the topic for the CCMTA Knowledge Management intranet platform for its members. A key deliverable for the AV Working Group is the development of a framework of best practices concerning regulation, testing and other key issues, for jurisdictions. The AV Working Group Co-Chairs represented CCMTA at the AAMVA's AV Best Practice Work Group, liaising regularly with CCMTA Board and CCMTA program committees - Compliance and Regulatory Affairs, Drivers and Vehicles and Road Safety Research and Policies- to update members and share deliverables.

Ontario was the first jurisdiction in Canada to allow AV testing on public roads. Ontario Ministry of Transport published regulation rules for AV pilots in early 2016. The Ontario Ministry of Transportation plans to consider other regulatory issues once it has gained experience with intended AV pilots. In addition, its Centers of Excellence Connected Vehicle/Automated Vehicle Program has offered a cumulative total of $2.95 million in matching funding grants to support research, development and commercialization.

Other activities include; the Transportation Association of Canada (TAC) created a working group to review the impact of commercial vehicles on road infrastructure, maintenance, traffic control, management and safety; and the Council of Ministers Responsible for Transportation and Highway Safety tasked the Policy and Planning Support Committee (PPSC) to monitor AV/CV with a view to sharing best practices while identifying connections of the work being done by various Canadian, provincial/territorial and private sector groups. CCMTA is a member of the PPSC AV/CV group.

The Canadian government is continuing to monitor the development of policies and technology to ensure best practices are included in Canadian regulatory framework related to AVs.

UNITED STATES

The U.S. Government took a proactive approach in order to create a national framework to ensure AVs safe testing and deployment on public roads through development of national policies, research and program initiatives.

The U.S. Department of Transportation (DOT), through the National Highway Traffic Safety Administration (NHTSA), has delivered on its mission of saving lives and improving safety on U.S. roadways by consistently embracing new technologies that make driving, riding, biking, and walking safer. Twentieth century automobile technologies (such as seat belts, air bags, child seats, and antilock brakes)—developed in the private sector and brought to the U.S. public through NHTSA's safety programs and regulatory authority—are responsible for saving hundreds of thousands of lives.

In September 2016, U.S. DOT issued Federal Policy for safe testing and deployment of automated vehicles. The policy sets a proactive approach to providing safety assurance and facilitating innovation through four key components:

- Vehicle Performance Guidance for Automated Vehicles: The guidance for manufacturers, developers and other organizations outlines a 15 point "Safety Assessment" for the safe design, development, testing and deployment of automated vehicles.
- Model State Policy: This section presents a clear distinction between Federal and State responsibilities for regulation of HAVs, and suggests recommended policy areas for states to consider with a goal of generating a consistent national framework for the testing and deployment of highly automated vehicles.
- Current Regulatory Tools: This discussion outlines DOT's current regulatory tools that can be used to accelerate the safe development of HAVs, such as interpreting current rules to allow for greater flexibility in design and providing limited exemptions to allow for testing of nontraditional vehicle designs in a more timely fashion.
- Modern Regulatory Tools: This discussion identifies potential new regulatory tools and statutory authorities that may aid the safe and efficient deployment of new lifesaving technologies (U.S. Department of Transportation, n.d.).

The policy outlines options for the further use of current federal authorities to expedite the safe introduction of highly automated vehicles into the marketplace, as well as discusses new tools and authorities the federal government may need as the technology evolves and is deployed more widely. The primary focus of the policy is on highly automated vehicles, or those in which the vehicle can take full control of the driving task in at least some circumstances. Portions of the policy also apply to lower levels of automation, including some of the driver-assistance systems already being deployed by automakers today.

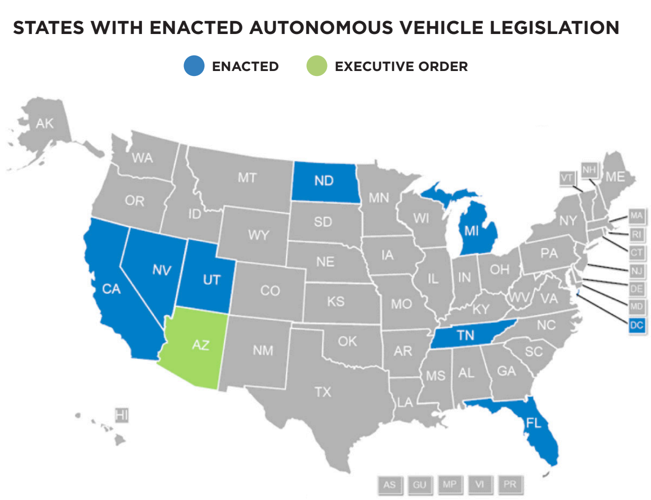
NHTSA's published Federal Automated Vehicles Policy considers vehicle cybersecurity as one of the important safety areas in the Vehicle Performance Guidance for automated vehicles. In October 2016, NHTSA released its

"Cybersecurity Best practices for Modern Vehicles". The document is anticipated to cover cybersecurity issues for all motor vehicles and therefore applicable to all individuals and organizations manufacturing and designing vehicle systems and software.

NHTSA believes that it important for the automotive industry to make vehicle cybersecurity an organizational priority. This includes proactively adopting and using available guidance and existing standards and best practices. Prioritizing vehicle cybersecurity also means establishing other internal processes and strategies to ensure that systems will be reasonably safe under expected real world conditions, including those that may arise due to potential vehicle cybersecurity vulnerabilities.

The U.S. DOT announced a national program on vehicle automation, with an ambitious goal to "position industry and public agencies for the wide scale deployment of partially automated vehicle systems that improve safety, mobility and reduce environmental impacts by the end of the decade". (U.S. Department of Transportation, 2013).

Nevada was the first state to allow AV testing on public roads in 2011. Eight U.S. states (California, Florida, Michigan, Nevada, North Dakota, Washington D.C., and Tennessee) and the District of Columbia have legalized AV use under various conditions. About 20 other state legislatures are reviewing proposed AV legislation.



The regulatory framework in the U.S. allows foreign vehicle manufacturers to test automated driving solutions. Recently, several European vehicle manufacturers and Tier 1 suppliers (Bosch, Delphi Automotive) obtained an official approval for testing automated vehicles on public roads in California.

In his last State of the Union address, President Obama signaled his intent to invest in a 21st century transportation system. The President's FY17 budget proposal would provide nearly $4 billion over 10 years for pilot programs to test connected vehicle systems in designated corridors throughout the country, and work with industry leaders to ensure a common multistate framework for connected and automated vehicles.

In 2016 the Secretary of Transportation, Anthony Foxx announced that the U.S. Department of Transportation plans to remove potential roadblocks to the integration of innovative, transformational automotive technology that can significantly improve safety, mobility, and sustainability.

Secretary Foxx also unveiled policy guidance that updates the National Highway Traffic Safety Administration's (NHTSA) 2013 preliminary policy statement on automated vehicles. The new guidance, released early in 2016, reflects the reality that the widespread deployment of fully automated vehicles is now feasible. The U.S. DOT committed to the following in 2016:

- NHTSA will work with industry and other stakeholders to develop guidance on the safe deployment and operation of autonomous vehicles, providing a common understanding of the performance characteristics necessary for fully autonomous vehicles and the testing and analysis methods needed to assess them.
- NHTSA will work with state partners, the American Association of Motor Vehicle Administrators, and other stakeholders to develop a model state policy on automated vehicles that offers a path to consistent national policy.
- The U.S. DOT and NHTSA will develop the new tools necessary for this new era of vehicle safety and mobility, and will consider seeking new authorities when they are necessary to ensure that fully autonomous vehicles, including those designed without a human driver in mind, are deployable in large numbers when they are demonstrated to provide an equivalent or higher level of safety than is now available.

In addition, Secretary Foxx encouraged manufacturers to submit rule interpretation requests where appropriate to help enable technology innovation. For example, NHTSA responded to an interpretation request from BMW confirming that the company's remote self-parking system meets federal safety standards. As well, when interpretation authority is not sufficient, Secretary Foxx further encouraged manufacturers to submit requests for use of the agency's exemption authority to allow the deployment of fully autonomous vehicles. Exemption authority allows NHTSA to enable the deployment of up to 2,500 vehicles for up to two years if the agency determines that an exemption would ease development of new safety features.

AV testing is ongoing on multiple testing facilitates across the United States. Silicon Valley is the center of AV research and development in the U.S.

In addition to technology-oriented firms (Google, Apple), many car manufacturers (BMW, Ford, General Motors, Honda, Mercedes-Benz, Tesla, Toyota, etc.), and leading Tier 1 automotive suppliers (Bosch, Delphi Automotive) conduct AV development in the area.

Other U.S. sites of AV technology development include Detroit (Delphi, Ford, and GM), Pittsburgh (Uber), and Tucson (Uber). AV testing typically occurs initially on the manufacturer's private property.

In California (GoMentum Station) and Michigan (Mcity), test sites that simulate urban streets are on offer. However, most AV developers seek to conduct tests of sufficiently reliable prototypes on public roads.

Multiple organizations are involved in AV testing and development. American Association of Motor Vehicles Administrators (AAMVA) is one of the active players in the area of AV initiatives. AAMVA has established an Autonomous Vehicle Best Practices Group to gather, organize and share information with the AAMVA community related to the development, design, testing, use and regulation of autonomous vehicles and other emerging vehicle technology. The AV Best Practice Group (AAMVA, 2016) is tasked to raise awareness of autonomous vehicle technology as it emerges including the impacts on driver's licenses and vehicle programs, legal aspects and law enforcement, environmental factors, insurance coverage and more. The group will also assist jurisdictions in determining what regulations should be in place to promote uniform regulations for autonomous vehicle technology as it relates to appropriate vehicle safety, ensuring the safety of vehicle occupants, pedestrians and other road users. The AV Best Practices Working Group will develop a best practice guide for jurisdictions to regulate the testing of autonomous vehicles. The group consists of 16 jurisdictional members and two Canadian representatives (BC and AB), AAMVA and NHTSA representatives. The Best Practices Guide is to be released at the end of 2016 or beginning of 2017.

National Cooperative Highway Research Program (NCHRP)

Another project being launched by the NCHRP in January 2017 aims to understand and address the impact of automated driving systems on motor vehicle codes and other related domains. The objective of the research is to provide state departments of transportation (DOTs) and motor vehicle departments with guidance and resources to assist with the legal changes that will result from the roll out of connected and automated vehicles. Key areas will include:

- Review applicable existing laws and regulations that may need reconsideration as connected vehicles (CV) and connected and automated vehicles (AV) become more widely used with a focus on how these codes need to be revised (and how soon).
- Address how changes to motor vehicle laws, regulations, and statutes related to CV and AV may affect current driving practices and continuous responsibility for managing traffic safety hazards.
- Identify barriers to implementation of new Rules of the Road resulting from the roll out of CV and AV and develop strategies to overcome them.
- Address processes and stages for modifying relevant motor vehicle code, laws, regulations, and statutes.

This work is being coordinated with related efforts underway by the American Association of Motor Vehicle Administrators (AAMVA).

In undertaking the work, project leaders note existing motor vehicle codes have been developed based on implicit assumptions about drivers maintaining continuous involvement in the driving task and continuous responsibility for managing traffic safety hazards. Automated driving systems significantly reduce the role of the driver, which means that some of these codes will need to be reconsidered. The incorporation of driving behavior into in-vehicle software also generates pressure to harmonize the rules of the road across jurisdictions.

New Data Element for Automated Vehicles

In January 2017, the U.S. announced its plans to introduce a new data element into its Model Minimum Uniform Crash Criteria (MMUCC) to monitor automated vehicles on its roads.

The U.S. Governors Highway Safety Association (GHSA) along with the National Highway Traffic Safety Administration (NHTSA) will add this element into their database now, in recognition that it will take an average of ten or more years for states to adopt these changes. This work represents a transition to MMUCC's 5th edition, and will provide flexibility for data collectors and managers alike as vehicles and driving environment continue to evolve.

Feedback from a broad spectrum of MMUCC users was analyzed by the federal safety agencies to develop a suite of proposed changes that would improve the quality and utility of crash data by addressing emerging safety issues, technological changes in the vehicle fleet, and how states collect, manage and analyze their crash data.

AUSTRALIA

Australian government on both national and provincial levels have been working on development national regulatory framework to allow testing of the self-driving cars.

In November 2015, the Transport and Infrastructure Council asked National Transport Commission (NTC) to identify whether there are any regulatory barriers associated with the introduction of more automated road and rail vehicles in Australia.

The release of the NTC's policy paper "***Regulatory reforms for automated road vehicles***" concluded a one year project to research the regulatory barriers and develop recommendations to support future reform.
While the launch of the discussion paper, National guidelines for automated vehicle trials, signifies the start of Phase one of the Australian reform to allow AVs on Australian roads.

The National Transport Commission's work is complementing other research and project activities undertaken by Austroads, road agencies and other organisations. These include Austroads' projects related to assessing the safety benefits of automated vehicles, any impacts on registration and licensing processes and any impacts of automated vehicle on network infrastructure.

Australian organizations are working together to ensure a coordinated approach and knowledge sharing.
In November 2016, Australian transports ministers agreed to a phased reform program so that conditionally

automated vehicles can operate safely and legally on Australian roads before 2020, and highly and fully automated vehicles from 2020.

To provide certainty on the use of existing technology, transport ministers reaffirmed the existing policy position that the human driver remains in full legal control of a vehicle that is partially or conditionally automated, unless or until a new position is developed and agreed. These recommendations and policy positions are set out in the NTC policy paper.

NTC will implement a roadmap of reform to prepare Australia for automated road vehicles. To do this, the following initiatives will commence as part of the national phased approach to facilitate the testing and trialling of automated vehicles in the short term, and prepare for the safe deployment of automated vehicles on public roads in the medium to long term:

- develop national guidelines to support automated vehicle trials
- clarify who is in control of a vehicle with different levels of driving automation
- develop a comprehensive performance-based safety assurance regime for increasingly automated vehicles
- remove regulatory barriers in Australian Road Rules and other transport laws that assume a human driver

Phase one of the described reform (above) was completed by releasing a discussion paper to seek feedback on the development of National guidelines for automated vehicle trials.

The discussion paper proposed key criteria for inclusion in the guidelines and identified key issues for supporting trials based on other Australian and international frameworks (National Transport Commission (AU), (n.d.)).

FRANCE

France began studying the issue of automation in road transport in 1996. In September 2013 the French government announced a strategic review to define its industrial policy priorities. One of its 34 industrial renewal initiatives includes "driverless vehicles". The aim of this initiative is to make the French automotive sector a pioneer in vehicle automation, notably by removing regulatory barriers to growth. (RT Question More, 2016).

In 2014 the government announced that testing of AVs on its public roads would be allowed in 2015. In 2015 it released an action plan featuring proposed standards and regulations for experimentation with plans to establish in the longer term, a French label for "Safe Autonomous Vehicle". It assigned 2000 km of road for testing AVs, with the majority located in Bordeaux, in Isère, Île-de-France and Strasbourg. The government authorized the operation of partially or totally automated passenger or freight vehicles for experimental purposes by providing, if necessary, an appropriate liability regime. The Council of Ministers called the adopted legislative initiative "*an indispensable step towards peaceful mobility, regulated and secure traffic, and transport that is both more efficient and more environmentally friendly.*"

At the October 2015 Intelligent Transport Systems (ITS) World Congress, the very first demonstration of AVs on open road in France was carried out in Bordeaux. Also in 2015, the Citroen C4 driverless car completed a test run from Paris to Bordeaux, using a special permit (The Local, 2015). (Automakers Renault and Peugeot plan to launch production models of autonomous cars by 2019).

For 2018, France's AV action plan recommends the establishment of an insurance scheme in the form of an 'Autonomous vehicle special insurance fund' and that a series of standards on the process and test rules for automated vehicles be established in 2019.

GERMANY

Germany has been a leading innovator in automotive engineering for the past 130 years and is one of the leading countries in the development of AVs technologies.

In September 2015, the German Federal Transport Ministry released its comprehensive strategy for automated and connected driving. The strategy focuses on the following areas:

Infrastructure: The expansion of a nationwide mobile broadband network which enables connectivity between vehicles and the infrastructure.

Law: A new legal framework, in the future automated vehicles will be allowed to take over driving tasks autonomously, without constant monitoring of the driver.

Innovation: Trial of innovations in real conditions, the federal ministry, the transport industry and the digital economy cooperate for the creation of a "Digital Test field highway" on the A9 in Bavaria.

IT security: In cooperation with the industry and the research, IT security standards for vehicles will be developed, to prevent hacker attacks. The standards are to be converted into binding rules.

Privacy: The operator of automated and connected vehicles must be informed about collection and use of data - and give their consent.

The strategy was, at least in part, developed by a private-public sector industry roundtable. It aims to bring highly automated (Level 4) cars to the market by 2020, particularly for structured, less complex environments like the Autobahn and for low speed areas like parking lots. It provides regulations that legalize automated driving and address liability and safety. It includes a dedicated test track on the Autobahn, focused on automation Levels 4 & 5, V2V and V2I communication, and advanced mapping and sensing.

In a study commissioned by the German Federal Ministry of Economics, it estimates that the German market for driver assistance systems and automated vehicles will be worth 8.8 billion EUR and create nearly 130,000 jobs by 2025.

Germany's leading automotive firms are engaged in AV development and the government has funded R&D on a variety of Advance Driver Assistance Systems (ADAS) and cooperative vehicle assistance technologies. It plans to fund additional research on full automation and electric vehicles. (Ticoll, 2015).

IRELAND

Automated vehicles technology is advancing at a rapid rate in Ireland; however the Irish government does not believe that it has yet reached a stage where legislation is appropriate. Any testing of driverless cars in this jurisdiction would therefore have to be on private land rather than on public roads. The Department will consider legislating as and when the technology reaches such a point that legislation is appropriate.

JAPAN

The first public road test of an automated vehicle on a Japanese highway was conducted in November 2013. As well as lane keeping and adaptive cruise control it was fitted with systems to allow automatic exit, automatic lane change, automatic overtaking of slower or stopped vehicles, and automatic stopping at red lights.

In March 2014 the Japanese Ministry of Economy, Trade and Industry published an information journal setting out the current situation for automated driving. This included a four-step definition of levels of autonomy together with short articles from leading companies in the field.

In 2016, the Japanese National Police Agency (NPA) released the first guidelines on public road tests of self-driving vehicles. The Guidelines state self-driving vehicles cannot be tested on public roads without the presence of a human driver. According to the NPA, this move has been taken to ensure road safety.

The release of the guidelines is expected to bolster the process of testing self-driving cars. The NPA also urged for the use of black boxes on autonomous vehicles being tested. These vehicle drive recorders can help in ascertaining causes of the accidents, which in turn helps in taking preventive measures. The agency looked into issues such as who should be legally responsible if there is a collision, how to adapt the driver's license to the new driverless vehicle future and what kind of measures are needed to prevent cyberattacks. The Japanese government also has come up with its own classification system. (Road Traffic Technology, 2016).

Level 4 – self-driving vehicle, it can carry out all safety-critical driving functions autonomously.
Level 3 – limited self-driving vehicle, a driver ought to have control of the vehicle when it is necessary though maneuvering can be autonomous
Level 2 – the vehicle has several automated functions such as control, acceleration and steering
Level 1 – the vehicle has some automated functions

The Japanese government is also focusing on how to establish smart-road infrastructure standards, such as systems that can relay traffic and accident data in real time. This technology could be used to change the speed limits on electronic signs to calm traffic, or to relay road construction warnings directly to smart car dashboards.

The government is already committed to working with automakers in Japan to invest 10 billion yen ($83.4 million) to build test roads. Japan has established a cross-ministerial AV innovation program to pursue research and innovation with the objective of full deployment between 2020 and 2030. Advanced next generation traffic systems are planned for the 2020 Olympic/Paralympic Games in Tokyo. All Japanese car companies are engaged in AV development.

NETHERLANDS

The Netherlands has been involved in demonstrating and testing automated driving since 1998. In January 2015, the Netherlands allowed testing of autonomous vehicles (AVs) on public roads. The country's Council of Ministers has approved an amendment of the regulations to enable large-scale tests of self-driving cars and trucks on public roads.

The government aims to have the Netherlands play a leading role in the development of AVs and systems enabling 'connected' vehicles to communicate with one another (V2V) and with traffic control centers (V2I). The country's national road traffic agency has provided permission for large-scale test drives on public roads and various parties have already expressed their interest.

The Netherlands is also working on an internationally coordinated approach. Dutch, German and Austrian governments have taken a joint initiative to enable a pan-European deployment of the roadside cooperative ITS infrastructure.

Aside from its AVs trial engagements, the country is active in the area of truck automation. It initiated a European Truck Platooning Challenge to bring platooning one step closer to implementation.

The Challenge took place on April 6, 2016, with platoons of trucks arriving in Rotterdam from Sweden, Denmark, Germany, Belgium and the Netherlands.

NORWAY

The Norwegian government has partnered with EU member states to work on AV initiatives for its country. On the highway between Norway and Finland, a platooning project involving testing of driverless trucks began in 2016. The Kongsberg municipality established itself as a pilot city for testing of AVs. The first test of a self-driving truck took place in September 2016.

The preliminary version of Norway's National Transport Plan 2018-2029 recommends following Sweden's approach for AV's in its country. The plan states that autonomous driving can provide gains in efficiency, and mentions ground vehicles in airports as a point of departure for using self-driving cars.

SOUTH KOREA

In August 2016 the South Korean government held a meeting with President Park Geun-hye to publicly discuss its plans for the future development of fully autonomous cars and indicated its intent to allow the testing of AVs anywhere in the country before 2017.

The government indicated its plans to establish a research park in 2017 located in Daegu City that would be large enough to allow for the test driving of more than 100 autonomous vehicles simultaneously. Firms such as Toyota, Honda, Nissan, Kia, and Hyundai are investing major resources to support their introduction (West, 2016). By the year 2019, manufacturers aim to have eight key AV components developed including cameras for environment recognition, and modules for driving data recording and vehicle position measurements.

In addition, manufacturers are looking at artificial intelligence (AI) capable of understanding images and human languages, and aim to have this in place by the year 2019. Further advancements in AI should allow self-driving cars to be capable of decision-making by 2022, with the goal of having the technology ready for expressways beginning in the year 2024. By the year 2026, it is anticipated that the number of companies and professional engineers researching AI in South Korea could increase to 1,000 and 3,600 respectively (Matei, 2016).

SWEDEN

The Swedish government has developed a national regulatory framework to support the implementation of automated vehicles in its country. While multiple government organizations have been involved in the consultation process, the Swedish Transport Agency (STA) is responsible for authorizing permits to carry out AV trials. When applying to the STA, the test organization would indicate how it plans to ensure road safety during its trial. This may, for example, include reports and results from tests performed in simulators or on test tracks.

In addition, the test organization is required to explain how it has resolved issues relating to cyber security and how it would ensure that those affected receive the information necessary for the trial to be carried out securely.

Should there be a need to investigate collisions, anyone granted a trial permit is responsible for submitting, on request, to the Swedish Police or to the Swedish Prosecution Authority, the data available from the vehicle's sensors. In addition, anyone granted a permit would also report any collisions involving the vehicle during the trials and submit an annual report on the performance of the trials to the STA. The STA can request the test organization take certain measures or revoke the permit if needed.

Liability:

- An automated driving system is to be regarded as the vehicle driver when the automated driving system handles all driving functions.
- When the vehicle is in self-driving mode, criminal liability falls to whoever applied for the permit.
- On those occasions on when a highly automated vehicle is driven manually, it is the physical driver who bears the criminal liability, as is the case with vehicles at lower levels of automation.

The current national regulatory framework relating to compensation for traffic collisions can be applied to all levels of self-driving vehicles. No constitutional amendment is therefore required. Data from the vehicle can facilitate the investigation of traffic incidents.

Whoever has been granted a permit for trials is responsible for submitting information available from the vehicle's sensors to the policyholder of the self-driving vehicle. Insurance companies can obtain access to data through a civil law agreement with the insured.

To ensure more accountability of all parties responsible for testing, the Swedish government plans to incorporate new regulations on camera surveillance into the trial legislation. Self-driving vehicles will have cameras on the outside of the vehicle. The Swedish Data Protection Authority supervises the camera surveillance. Visual data obtained from the outside of the vehicle shall be permanently and irrevocably anonymized before storage. The proposed laws and legal amendments are likely to be enacted by May 1, 2017.

Drive Me is an important AV initiative currently underway in Sweden. Volvo has, together with other companies, governments and research groups, initiated the project which aims to create mobility in a sustainable society. The level of automation in the project can be compared to level 3. (Driver does not monitor the vehicle at all times but is required to cede control if needed on short notice.) The system enables the vehicle, without a person driving it, to find a parking space and park itself. A test fleet of cars at this level will be on the roads of Gothenburg in 2017. Drive me has addressed all relevant considerations regarding autonomous driving: legislation, transport authorities, city environment, vehicle manufacturer and real customers. The test fleet will act in everyday driving conditions on 50 kilometres of selected roads typical for commuting, including both freeway conditions and frequent queues. Volvo highlights that these everyday driving conditions will provide insight into the societal benefits that are central for the company to be able to offer sustainable personal mobility in the future (Bohm & Hagër, 2015).

Cars in the test fleet are equipped with adaptive cruise control and steering assistance, allowing them to automatically keep pace with traffic without the driver's intervention. The driver is able to decide whether he or she wants to drive manually or use automated driving (Bohm & Hagër, 2015). Volvo's efforts will also include AV trials for winter driving. In addition to the Drive Me project the Wallenberg Autonomous Systems Program, ASTA Zero and Kista Mobility Week are other trial/deployment initiatives underway in Sweden.

UNITED KINGDOM

The UK government recognizes the potential benefits of driverless and automated vehicle technologies, particularly the potential to improve road safety and reduce casualties. In May 2016, the UK Government pledged to be at the forefront of technology for transport. Autonomous and electric cars will be the focus of new legislation that seeks to get ordinary people buying and using driverless cars by 2020 (UK Department of Transport, 2016).

The UK is allowing driverless car trials to take place on public roads anywhere, without need for permission, so long as they are covered by an insurance bond.

The new legislation would mean that by 2020 they can be insured under regular car insurance policies, allowing them to be driven outside of carefully controlled test conditions.

To support UK government's AV initiatives, the Centre for Connected and Autonomous Vehicles (CCAV) was created.

CCAV is a new joint policy unit between the Departments of Business, Innovation and Science and the Department of Transport, addressing the interaction among vehicles, infrastructure, and data to achieve these technologies' significant economic and social benefits.

CCAV provides a single point of contact for industry and academia for AV technologies and is coordinating and enhancing government activity in the sector. (University of Cambridge, (n.d.)).

The government conducted a detailed review of existing legislation to establish the regulatory situation with regards to testing of these technologies and their longer term introduction to the market. The review identified a number of actions that the UK government will take including the publication of the Code of Practice to promote safety during the testing phase. It also included a timetable for clarification and necessary changes to legislation to allow these technologies to come to market. In July 2015 the UK Department of Transport published the Code of Practice for Testing.

The *Code of Practice for Testing* outlines safety, insurance, infrastructure and transport authority's requirements. The code sets requirements for a test driver / operator to oversee testing, license, test driver and operator training, and general vehicle requirements. The document defines requirements for data protection and recording, cybersecurity, process for transition between automated and manual modes. Additional UK government investments in research and development include the launch of the Department for Business, Innovation and Skills' 20 million pounds research and development competition and the establishment of a joint policy unit Centre for Connected and Autonomous Vehicles (CCAV) with an operating budget of up 200 million pounds, through Innovate UK.

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