PHOTOS: UNIVERSITY OF WATERLOO

Connected and Automated Vehicle Activities in Canada

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University of Waterloo graduate student researchers at work on Autonomoose. Canada is developing policy, technology, and infrastructure to advance automated and connected vehicles.

Like other countries, Canada is preparing for the vast potential and complex challenges of connected and automated vehicles (CAVs) and the transformative changes in transportation that these vehicles are expected to enable. Although it is not an exhaustive account, this article describes the development of national policies, regulatory approaches, and standards to ensure that these vehicles can operate across jurisdictional boundaries in Canada and the United States. Also addressed are research and development to advance CAV technologies; legislative changes to allow automated vehicle (AV) testing on public roads; and collaborative partnerships between public agencies, private companies, and academic institutions to conduct CAV pilot tests.

National Activities

National activities are those led by the federal government or national-level associations (see sidebar, page 15). The main federal government activities in Canada include

- Developing a national strategy to address vehicle safety, cybersecurity, and privacy issues;
- Working with the United States to devise standards and regulations facilitating innovation, aiding in the safe deployment of automated features, and ensuring the interoperable deployment of connected vehicles (CVs);
- Developing policy and guidance for testing CAVs in Canada;
- Conducting research and development; and

◆ Establishing funding programs to support CAV testing and deployment.

National-level organizations dealing with CAVs include the Transportation Association of Canada (TAC), Intelligent Transportation Systems (ITS) Canada, the Canadian Council of Motor Transport Administrators (CCMTA), and the Policy and Planning Support Committee under the Council of Deputy Ministers Responsible for Transportation and Highway Safety, among others. Each organization administers a committee dedicated to CAVs.

National Strategy Development

The Standing Senate Committee on Transport and Communications, part of the Senate of Canada, conducted a recent study on CAVs to understand how this technology will affect Canada and to identify the regulatory and technical issues associated with its deployment. In January 2018, the committee released the study report *Driving Change: Technology and the Future of the Automated Vehicle*.

Among the study's 16 recommendations were for Transport Canada and for Innovation, Science, and Economic Development (ISED) Canada to establish a joint policy unit that would coordinate federal efforts and implement a national strategy on CAVs, addressing issues of vehicle safety, cybersecurity, and privacy.

Working with international governments through the United Nations Economic Commission for Europe Working Party on Automated/Autonomous and Connected Vehicles, Transport Canada is developing guidelines and regulatory requirements that facilitate innovation and to aid in the safe deployment of automated features.

Regulatory Development

In 2011, Transport Canada and the U.S. Department of Transportation (DOT) established the Canada–U.S. Regulatory Cooperation Council to enable collaboration between governments and stakeholders and increase regulatory cooperation and alignment. The council's Connected Vehicles Working Group focuses on interoperable deployment of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure communications technology through collaborative standards development, research and testing, information sharing, and implementation activities such as development of security certificate management systems, equipment certification, and cybersecurity.

The working group has developed a four-part work plan to address security, spectrum allocation policy, standards, and information sharing.

PHOTO: PIXABAY

In Canada, the federal government and stakeholders collaborate to address security, standards, and policy; share information; and test the performance of CAVs.

◆ **Initiative 1: CV Cybersecurity, Equipment Certification, and V2V Communications Security** collaborates on policy and technical requirements to develop a cross-border CV security certificate management system proof of concept and to establish certification requirements for CV system components.

◆ **Initiative 2: Spectrum Policy Analysis** identifies opportunities for collaboration and exchange on ITS communications platforms, spectrum allocation, and spectrum policy for CV applications.

◆ **Initiative 3: Standards and Architecture** identifies new or revised standards required to support

Acronyms

ADS	automated driving systems
AV	automated vehicle
AVIN	Autonomous Vehicle Innovation Network
CAV	connected and automated vehicle
CCMTA	Canadian Council of Motor Transport Administrators
CV	connected vehicle
HTA	Highway Traffic Act
ISED	Innovation, Science, and Economic Development Canada
ITS	intelligent transportation system
MACAVO	Municipal Alliance for Connected and Autonomous Vehicles in Ontario
OGRA	Ontario Good Roads Association
TAC	Transportation Association of Canada
V2V	vehicle-to-vehicle

PHOTO: VIRGINIA DOT

Truck platooning uses cooperative adaptive cruise control technology that enables trucks to travel in close formation, relieving congestion and saving fuel.

large-scale CV technology deployment and to integrate detailed Connected Vehicle Reference Implementation Architecture into overall Canada–U.S. national ITS Architecture updates.

◆ **Initiative 4: Information Dissemination and Sharing** engages stakeholders on binational and related international CV issues, such as hosting open public meetings including both Canadian and U.S. stakeholders.

Standards Development

Transport Canada is working with the Standards Council of Canada and CSA Group to survey the standards landscape, engage with stakeholders, and develop a CAV standards roadmap for Canada and, with ITS Canada, is updating the ITS Architecture for Canada to include new tools and CV requirements. Transport Canada also will consult with stakeholders and analyze requirements to advance a security credential management system in Canada to ensure that CVs and infrastructure are tested to performance and security standards.

Policy and Guidance for CAV Testing

Transport Canada and ISED Canada are working with other federal departments and provincial and territorial governments to develop a coherent national approach that facilitates the safe introduction of these technologies on Canadian roads. This includes an aligned approach for the testing and deployment of CAVs on public roads in Canada in the near term—and safe, sustained deployment over the long term.

Guidelines for Trial Organizations

Published by Transport Canada in June, these guidelines are directed at trial organizations and only apply to temporary trials of automated driving systems (ADS) in Canada—not to vehicles permanently deployed in the market.

Trial organizations are companies or organizations that seek to test ADS in Canada. They include original manufacturers of AVs; technology companies; academic or research institutions; and manufacturers of parts, systems, equipment, or components for ADS.

The guidelines promote Canada as a destination for CAV trials; clarify the various roles and responsibilities of federal, provincial, and territorial levels of government involved in facilitating these tests; and establish a set of voluntary minimum safety requirements that trial organizations must follow when operating in Canada. The guidelines take a safety-first approach, but also support innovation by compelling trial organizations to assess a comprehensive range of safety considerations and to declare that they have accounted for these risks when they submit an application for a trial to a province or territory.

Jurisdictional Guidelines for Safe Testing and Deployment of Highly Automated Vehicles

These guidelines, developed by CCMTA with support from Transport Canada—and to be published in 2018—address the administration, regulation, and control of AVs. Created for motor vehicle administrators and law enforcement, these guidelines offer a common approach to the safe testing and deployment of highly automated vehicles, providing strategies for vehicle registration, driver training, testing, and licensing programs; enforcement of traffic laws; and first response to traffic-related incidents.

Specifically, this document contains a set of voluntary guidelines and recommendations for the Canadian jurisdictions that choose to regulate ADS testing and deployment.

Safety Assessment for ADS in Canada

Transport Canada is also developing a safety assessment that focuses on vehicle safety issues not addressed in existing regulations. This assessment will be aligned with similar policy measures in the United States, such as the National Highway Traffic Safety Administration's *Automated Driving Systems 2.0: A Vision for Safety*.

The safety assessment will outline performance outcomes for industry members to consider as they review the safety and security of CAVs to be deployed that are SAE International Level 3 (environment detection) to Level 5 (human driving completely eliminated). The safety assessment offers a flexible tool for manufacturers to manage the safety

of emerging technologies, particularly for aspects that are still too early in development for regulations to be considered.

Research and Development
Researchers from Transport Canada and the University of California, Berkeley's Partners for Advanced Transportation Technology are developing and testing three-truck platooning technology using cooperative adaptive cruise control and CV technology. This joint project, conducted at Transport Canada's Motor Vehicle Test Centre in Blainville, Quebec, specifically involves fuel-economy testing based on SAE International's J1321 Type II procedure to evaluate the fuel-saving benefits of platooning for various aerodynamic tractor trailer configurations.

Program to Advance Connectivity and Automation in the Transportation System
Launched in September 2017 by Transport Canada, this program assists Canada's infrastructure owner–operators—provinces, territories, and municipalities—to prepare for the wider use of CAVs on roads. The program supports research, studies, and technology evaluations; the development of infrastructure codes, standards, and guidance materials; and capacity-building and knowledge-sharing activities through funding and leading studies, research, development, and demonstration projects.

Canadian Associations

Transportation Association of Canada CV/AV Working Group
This working group was created in 2015 to gather and share information with TAC members about CAVs and their impact on traffic operations and management, road safety, infrastructure design and maintenance, and transportation planning. Activities have included organizing webinars, workshops, and conference events; developing CAV project ideas for TAC; and creating a library of technical material.

ITS Canada CV/AV Technical Committee
This committee manages an international Google Group on CAVs and collaborates with other ITS Canada technical committees to ensure that the potential changes caused by these vehicles are considered appropriately within the organization.

CCMTA AV Working Group
This working group was created in 2014 as a forum for Canadian motor transport administrators to collaborate in monitoring emerging AV technology and issues, including regulatory developments in other jurisdictions, ongoing technological changes in the vehicle intelligence industry, the progression of the vehicle manufacturing industry, and the testing phases of the early-adopter jurisdictions.

The group also is developing vehicle policy regarding the administration, regulation, and control of AVs, including both noncommercial and commercial vehicles.

Provincial Activities

Provincial activities are those led by provincial governments or organizations. The main provincial-level activities are introducing legislation to allow testing on public roads; assessing readiness for CAVs; and coordinating research, development, deployment, and testing of CAVs.

PHOTO COURTESY GARRETH REMPEL

The Transportation Association of Canada's CV/AV Working Group shares information on CAV initiatives via workshops, a technical library, webinars, and more.

Assessing Readiness

In January, the Council of Ministers Responsible for Transportation and Highway Safety released a report titled *The Future of Automated Vehicles in Canada,* which addresses the short-, medium-, and long-term policy implications of the introduction of CAVs on public roads. Written for Canada's Transportation and Road Safety Ministries, the report identifies gaps, opportunities, and ways to encourage cooperation across Canada and internationally.

Additionally, the report finds that the testing, evaluation, deployment, and regulation of AVs in Canada has been loosely coordinated and that, although some research and deployment activities are taking place across the country, many jurisdictions are not prepared to integrate AVs into their transportation systems.

The report offers two recommendations: 1) collaborating with jurisdictions and international partners to align testing and regulatory frameworks and 2) promoting and investing in industry and academia to test and evaluate AV technology on public roads.

Legislative Changes

Provinces are responsible for regulating roadways, and several have proposed or passed legislation to allow AVs. Examples include the provinces of Ontario, Manitoba, and Quebec.

Province of Ontario On January 1, 2016, Ontario became the first province to allow AV testing on public roads by launching a 10-year pilot project under the Highway Traffic Act (HTA). This allows the testing of AVs on all of Ontario's roads by eligible participants under certain conditions. The pilot framework ensures that roads remain safe but also supports economic growth and innovation. The framework also allows the province to establish rules, monitor industry and technology developments, and evaluate the safety of AVs before the vehicles become widely available to the public.

The Ministry of Transportation of Ontario will assess data and information from on-road AV testing, engage stakeholders, and make amendments to the pilot framework as required throughout the project.

Province of Manitoba In 2018, the Manitoba government will bring forward legislative amendments to allow the testing and use of AVs on provincial highways. Like other traffic safety statutes across the country, Manitoba's HTA was based on a human driver in physical control of a vehicle.

As a result, proposed amendments to the HTA would authorize projects for research and testing of vehicles and technologies on Manitoba highways. The long-term goal is to develop regulations that allow the public use of high-level AVs.

PHOTO: MATTHEW HENRY, UNSPLASH

Leaside Bridge in Toronto. In 2016 Ontario became the first province to permit on-road testing of AVs.

Province of Quebec In 2018, the Province of Quebec amended its legislation to authorize pilot projects for testing AVs on Quebec roads. The Minister of Quebec sets the rules and conditions for implementation of any pilot project, which may last up to 5 years. The Minister also may offer an exemption from the insurance contribution associated with the authorization to operate a vehicle and set the minimum required amount of liability insurance that guarantees compensation for property damage caused by an automobile.

Research, Development, Deployment, and Testing

Municipal Alliance for Connected and Autonomous Vehicles in Ontario In 2016, the Ontario Good Roads Association (OGRA), through its Municipal Alliance for Connected and Autonomous Vehicles in Ontario (MACAVO), created an initiative for controlled AV testing. Under this initiative, OGRA is establishing a seamless, coordinated Preferred AV Test Corridor between Windsor and Ottawa and is working with several Ontario municipalities to identify preferred roads for AV testing—with an emphasis on municipal roadways.

To date, more than 2,000 centerline km of preferred roadways have been identified. MACAVO will help Ontario municipalities develop a synchronized set of logistics, policies, and communication channels to help advance the CAV industry in Ontario.

Autonomous Vehicle Innovation Network In 2017, the Province of Ontario launched the 5-year, $80 million Autonomous Vehicle Innovation Network (AVIN), which includes a demonstration zone in Stratford; a partnership fund to foster stakeholder collaboration in developing and commercializing CAV technologies; a talent development program to support internships and fellowships for students and recent graduates; and a central hub, or an online destination and specialized team focused on conducting research, sharing information, building connections, and raising awareness among industry, research institutions, and other stakeholders.

AVIN recently announced the creation of six regional technology development sites across the province. Each site will support the development of new technologies and will have a unique focus area: human–machine interface, multimodal and integrated mobility, vehicular networks and communications, vehicle cybersecurity and cross-border technologies, artificial intelligence, and high-definition mapping.

Municipal Activities

Municipal activities are those led by municipal governments or local organizations. Main activities at the municipal level include conducting pilot tests and developing initial plans to prepare for CAVs.

City of Ottawa, Ontario

In 2017, Ottawa became the first Canadian city to test an on-street AV that could communicate with live city infrastructure. Before this test, other AV tests in Canada took place in closed, segregated areas. The city partnered with BlackBerry QNX and its Autonomous Vehicle Innovation Centre to test CAVs in the Kanata North Technology Park, which is home to more than 70 companies in Ottawa's AV ecosystem.

The project involved equipping the test area infrastructure with technology to communicate with AVs via dedicated short-range communication transmitters at traffic signals, repainting street lines, and installing controllable LED street lights. Nokia also is expected to add LTE and 5G capability to the route.

In 2017, the City of Ottawa received funding from Transport Canada and the Ministry of Transportation of Ontario to deliver the Assisted Commercial Vehicle Eco-Driving Pilot Project. This initiative

Canadian Transportation Organizations

Transport Canada
This department, part of Canadian government, is responsible for developing transportation regulations, policies, and services.

Transportation Association of Canada
A not-for-profit, national technical association that focuses on road and highway infrastructure and urban transportation.

ITS Canada
National thought leader on advanced technologies and their application to the Canadian transport system.

Canadian Council of Motor Transport Administrators
Coordinates all matters dealing with the administration, regulation, and control of motor vehicle transportation and highway safety.

Council of Ministers Responsible for Transportation and Highway Safety
This council is one of Transport Canada's consultative mechanisms, not established by legislation, with the provinces and territories.

Innovation, Science, and Economic Development Canada
This organization is responsible for managing Canada's airwaves and overseeing its bankruptcy, incorporation, intellectual property, and measurement systems; providing financing and industry research tools to help businesses develop, import, and export; encouraging scientific research; and protecting and promoting the interests of Canadian consumers.

A meeting of MACAVO.

PHOTO COURTESY GARRETH REMPEL

uses technology to connect 12 traffic signals with test vehicles along a 6-km stretch of Hunt Club Road between Cleopatra Drive and Uplands Drive. The technology notifies drivers about upcoming traffic signal changes and helps drivers determine optimum speeds to reduce fuel consumption and avoid hard braking.

Commercial vehicles involved in the test received in-vehicle tablets that relayed traffic signal information to drivers. Software and hardware was added to Audi vehicles, with information displayed directly on the dashboard. Testing and data collection has been completed and researchers at Carleton University in Ottawa are analyzing the data to measure fuel consumption reduction.

In Ottawa, a partnership between private and public organizations allowed the city to connect AVs to city infrastructure.

PHOTO: PIXABAY

Cities of Vancouver and Surrey, British Columbia

In 2018, the cities of Vancouver and Surrey were shortlisted for a $50 million award through Infrastructure Canada's Smart City Challenge. Their joint proposal features Canada's first two collision-free, multimodal transportation corridors that link the two cities: the 3.4-km Surrey corridor connects Surrey Memorial Hospital and other key services to a major transit hub and the 2-km Vancouver corridor extends from Granville Island to Science World.

The proposal includes autonomous shuttles along the corridors; sensors in traffic signals, lighting, and other roadway infrastructure to generate data for real-time traffic signal adjustment and communication with AV shuttles; advanced data analytics integrating data from disparate sources to support corridor and AV operations; and enhanced user experiences through shared mobility options and optimizing trip planning.

City of Stratford, Ontario

The AVIN Technology Demonstration Zone in Stratford, Ontario, is operated by the Automotive Parts Manufacturer's Association. At the site, Ontario-based companies with CAV technologies can test, validate, and showcase innovative products to potential customers and partners—automotive suppliers, manufacturers, and original equipment manufacturers.

Performed in a controlled environment in accordance with applicable laws and regulations, the tests use city vehicle fleets and Stratford's connected infrastructure—ubiquitous high-speed Wi-Fi that covers the entire 12-km^2 city.

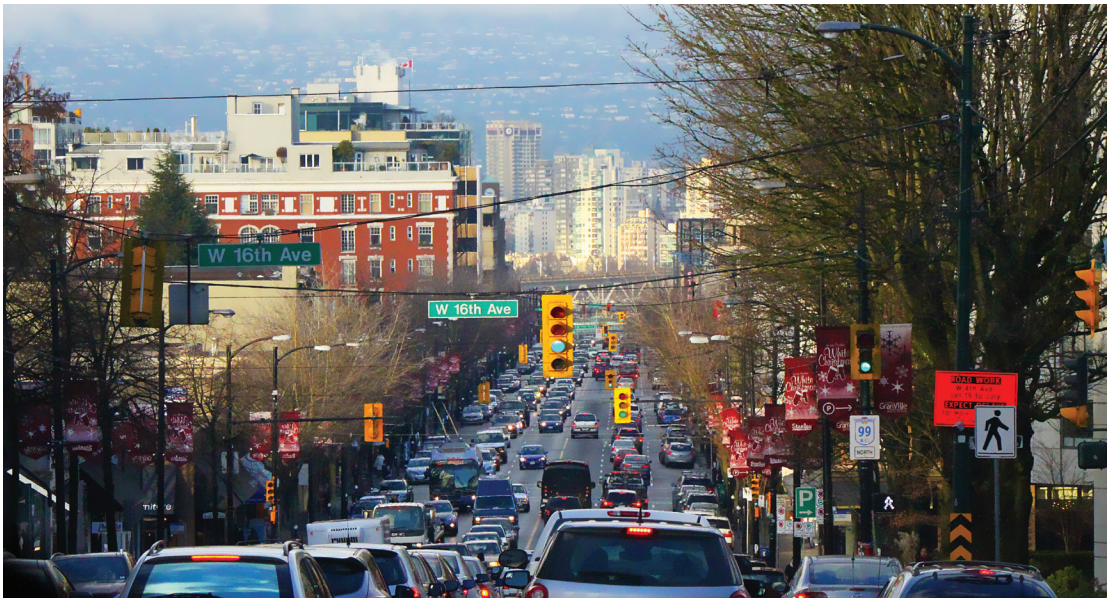

Photo: Valentina, Flickr

A proposed multimodal transportation corridor through Vancouver includes traffic signal sensors to communicate with vehicles.

City of Edmonton, Alberta

In fall 2018, the City of Edmonton will launch an all-electric AV pilot project that also is open for public testing. The shuttles' driverless technology includes collision-avoidance systems that detect vehicles, cyclists, pedestrians, and obstacles; the vehicles also are equipped with multiple safety features for vehicle braking, entry, and exit.

Each shuttle will have a trained operator onboard who is able to stop the vehicle at any point. The vehicles will operate at a maximum speed of 12 km/h, will include access ramps for mobility-challenged passengers, and will have capacity for 12 passengers.

The city also published a report in 2016, *Planning for Automated Vehicles in Edmonton*, to examine the potential impacts of AVs on passenger travel and land use. The report recommends actions for the city to prepare for AVs.

City of Calgary, Alberta

The City of Calgary is conducting a four-week, low-speed autonomous shuttle pilot to provide a last-mile connection between the Zoo light rail transit station and TELUS Spark Science Centre. Funded through Transport Canada's Program to Advance Connectivity and Automation in the Transportation System, the pilot is a collaboration with the City of Edmonton's project.

The 2017 report *Future of Transportation in Calgary* provides a high-level overview of the key trends occurring in transportation and gives information on what local governments are responsible for, the benefits and risks of each technology, and the best way for the City of Calgary to move forward.

University Activities

ACTIVE–AURORA Project

In 2014, the University of Alberta and the University of British Columbia launched the ACTIVE–AURORA project. The ACTIVE test bed in Edmonton is 60 km of public roads—highways, freeways, and arterials—equipped with 42 roadside units. Various applications tested so far include advisory driving speed, pedestrian warnings, high-collision location warnings, and emergency signal preemptions. The AURORA test bed, located in Vancouver, facilitates the testing of various CV technologies under controlled conditions.

Photo courtesy Garreth Rempel

A driverless shuttle, nicknamed "Ela," debuts in Calgary this fall.

Photo: Kurt Bauschardt, Flickr

Whitemud Drive in Alberta is one of three test beds chosen for the ACTIVE–AURORA project. Technology being tested includes pedestrian warning, advisory driving speed, and signaling.

University of Waterloo Centre for Automotive Research

The University of Waterloo Centre for Automotive Research, or WatCAR, focuses on collaborative research in automotive and transportation systems by facilitating relations between automotive industry members and University of Waterloo faculty researchers. An important component of their research is the Autonomoose: a Lincoln MKZ hybrid equipped with a full suite of radar, sonar, lidar, inertial, and vision sensors. The Autonomoose operates at SAE Level 3, with Level 4 capabilities expected in late 2018.

Researchers are working on custom autonomy software that focuses on improving self-driving capabilities in the weather conditions specific to Canada; optimizing self-driving for fuel efficiency and reduced emissions; and providing methods to design safe, robust, computer-based controls for self-driving vehicles.

Photo: University of Waterloo

Autonomoose, Canada's first autonomous vehicle.

iCity-CATTS

In 2017, the University of Toronto funded a 3-year program to study how smart transportation technologies such as AVs would affect people's transportation choices, how businesses provide transportation as a service, and how cities should plan for those changes. The iCity Centre for Automated and Transformative Transportation Systems, or iCity-CATTS, deploys a multidisciplinary team to create analysis tools, methods, models, and decision support systems to quantify the impacts of transformative transportation technologies on transportation demand, system performance, health, the environment, and society at large.

Carleton University

Carleton University's School of Information Technology received a $974,000 grant in 2017 from the federal Canadian Safety and Security Program to research cybersecurity issues with AVs. The university is partnering with Transport Canada and BlackBerry QNX for the 3-year project to identify AV security vulnerabilities, analyze the risk of attack, and develop advanced security solutions.

Conclusion

Canadian governments, universities, private industries, and citizens recognize the transformational impact of CAVs on transportation. Led by Transport Canada, the federal government is developing national strategies, policies, regulations, and standards and is launching initiatives to fund and support the research, development, deployment, and testing of CAV technologies. The Canadian government also is working closely with international jurisdictions and the United States to address technology interoperability, cybersecurity, and spectrum issues.

Canada already is heavily involved in many CAV-related activities and is preparing for increased future involvement. The country's major transportation associations are establishing dedicated committees to address the policy and technical issues of CAVs; provinces and municipalities are assessing their readiness for CAVs, changing legislation to allow AV testing on public roads, and conducting CAV pilot tests; and Canadian universities are conducting research and development and producing critical technologies required for CAVs.

Canada's research and development funding programs, access to a rich talent pool, and proximity to major automakers are attracting many of the largest telecom, technology, automaker, and Tier-1 supplier companies and establishing Canada's reputation as an important player in CAVs.