



# Driving Ontario Forward

The Car of the Future

June 2018



Ontario Centres of  
Excellence  
Where Next Happens



## **Thank you to all of the key players who contributed to the report.**

The report was informed through numerous interviews with private and public sector organizations including academia, accelerators, incubators, industry associations, multinational enterprises, municipal and provincial government, and start-ups. The key players represented several industries including automotive, logistics, manufacturing, and information and communication technology.

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# Foreword

Here in Ontario, we are proud of our leadership in the automotive industry. The ingenuity that drove the evolution from the very first horse-drawn carriage companies to today's technology-driven industry is as vibrant as it has ever been.

Our world-class research and development facilities lead the way in identifying critical solutions to the most challenging problems. Our entrepreneurs, start-ups and small- and medium-sized enterprises (SMEs) rapidly translate new ideas into cutting-edge technologies and solutions. Our automotive parts manufacturers are continually taking local innovations into global markets.

The Autonomous Vehicle Innovation Network (AVIN) takes great pride in playing a central role in reinforcing Ontario's position as a global leader in automotive technologies. The Government of Ontario is helping local companies lead the way and develop solutions facing the global automotive and mobility markets by supporting research and development, encouraging talent development, facilitating technology acceleration, providing business and technical support, and enabling testing and demonstration of new technologies.

This report highlights the immense activity underway across the province – from cutting-edge connected and autonomous vehicle (C/AV) technology testing, research and development to local manufacturing. It also describes Ontario's unique advantage – its world-class talent. These talented individuals are truly the foundation of our strength and include software developers, automotive workers, engineers, civil servants, scientists, STEM graduates and many more. Our workforce is driving the innovation that is leading the global automotive sector. This report presents emerging global trends and illustrative case studies to inspire continued development and new opportunities to propel economic growth and job creation.

Ontario has a dynamic and vibrant C/AV industry and is uniquely positioned to be a global leader. Our technology and manufacturing sectors enjoy access to world-class talent, cutting-edge research facilities, and are in close proximity to the American market. The automotive and transportation industry in Ontario also benefits from the ongoing and consistent support of the federal, provincial, and municipal governments. As we enter the next generation of automotive and manufacturing technology, Ontario has unlimited potential to lead the design, development and production of connected and autonomous vehicles.

We hope this report provides a launch pad for continued discussion and, more importantly, fresh ideas for what's next in this exciting journey.



**Raed Kadri** MSc. (Eng.), MSc. (BMR), P.Eng

Director, Automotive Technology and Mobility Innovation

# Ontario Centres of Excellence



Ontario Centres of Excellence (OCE), which was established in 1987, is a program delivery platform that focuses on job creation in Ontario.

OCE drives economic growth by:

- ✓ Supporting collaborative R&D;
- ✓ Accelerating the commercialization of leading-edge technologies from lab to market;
- ✓ Fostering youth entrepreneurship; and
- ✓ Attracting capital investment in Ontario

OCE delivers the **Autonomous Vehicle Innovation Network (AVIN)** Program on behalf of the Province of Ontario. AVIN supports the development and demonstration of connected and autonomous vehicle (C/AV) technologies including infrastructure technologies, commercially-ready technologies for application in light- and heavy-duty vehicles (including cars, commercial vehicles, trucks, buses, and recreational vehicles), intelligent transportation systems (ITS), and transit-supportive technologies. AVIN has four main programs:

## 1. The AV Research and Development (R&D)

**Partnership Fund:** the Fund supports SMEs in Ontario working with potential customers such as large firms, municipalities, indigenous communities, etc. to validate and demonstrate leading-edge automotive and transportation system technologies.

**2. Talent Development:** internships and fellowships in C/AV technology development areas such as software and hardware development, artificial intelligence, and data analytics.

**3. Demonstration Zone:** the Demonstration Zone, located in Stratford, is where technologies may be tested, validated and showcased in live scenarios in accordance with applicable laws and regulations. The Demonstration Zone promotes a customer-centered approach to the commercialization of new technologies in Ontario and, as a result, provides Ontario-based companies with a competitive advantage.

## 4. Regional Technology Development Sites:

Regional Technology Development sites provide entrepreneurs, start-ups, and SMEs with an opportunity to develop, prototype, and validate new products and technologies; use specialized equipment, hardware, and software; and access business advisory services. The Regional Technology Development sites are:

- i. Durham Region — human machine interface (HMI) and user experience.
- ii. Hamilton Region — multimodal and integrated mobility.
- iii. Ottawa Region — vehicular networks and communications.
- iv. Southwestern Ontario Region (London and Windsor) — vehicle cybersecurity and cross-border technologies.
- v. Toronto Region — artificial intelligence for connected and autonomous vehicles
- vi. Waterloo Region — high-definition (HD) mapping and localization.

AVIN is funded and supported by the Government of Ontario.

“Ontario is a **global leader in both innovation and the auto sector**, so it is fitting that as we look to the future, we continue to drive growth and opportunity in both of these areas by launching the Autonomous Vehicle Innovation Network.”

- Dr. Tom Corr, President and CEO,  
Ontario Centres of Excellence

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# Introduction and Methodology

## Introduction

Ontario has a large automotive manufacturing sector, a substantial start-up and technology-based business presence, a highly-skilled and educated workforce, and a supportive regulatory environment for research and development activities. These are several factors that distinguish Ontario as a leader in the development of connected and autonomous vehicle technology and as a hub for deploying and testing these technologies. OCE engaged KPMG LLP (“KPMG”) to provide an overview of the C/AV industry in Ontario, the results of which are contained within this report.

The overview is intended to be indicative of the C/AV industry and not a detailed assessment of the key players, partnerships or programs. KPMG completed a comprehensive jurisdictional scan to identify global best practices and C/AV related activities occurring around the world.

## Methodology

KPMG consolidated data-driven evidence gathered and developed through a carefully planned engagement with industry and market leaders. Insights gained through market consultations and supported by secondary research served as the foundation for our research.

OCE and KPMG worked closely together to identify key players to engage for market insights. KPMG conducted interviews with 20 active market players to gain an understanding of the industry. The key players can be summarized in the following four main categories:

### 1. Industry & Multinationals

- Automotive and parts manufacturers
- Telecommunications and networking
- Software developers
- Industry associations
- Infrastructure owners

### 2. Post-Secondary Institutions & Entrepreneurs

- Incubators and accelerators
- Universities and institutes

### 3. Start-ups

- Logistics technology
- Transportation technology

### 4. Government

- Provincial
- Municipal

The goal of the interviews was to assess and evaluate:

- The frequencies of interactions and partnerships between various key and supporting players;
- The activities that are occurring along the economic development pipeline in Ontario related to new automotive technologies;
- The drivers behind investment decisions; and
- The distinguishing strengths and opportunities in Ontario related to the development and deployment of new automotive technologies.

KPMG also developed an online survey that could be completed in lieu of an interview.

Secondary research was conducted in order to supplement market insights and inform the jurisdictional review of global best practices and emerging trends. The jurisdictional review in this report builds and draws from KPMG’s recently published Autonomous Vehicle Readiness Index.

Global trends identified in the jurisdictional scan were used to inform future areas of focus in Ontario.



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# Connected and Autonomous Vehicles

# Ontario's Opportunity: Connected and Autonomous Vehicles

## The Context

Ontario has the opportunity to be a global leader in C/AV technologies. The province's diverse economic base uniquely allows it to bring together expertise in manufacturing, technology, software development, and telecommunications under a single roof to create a dynamic local industry that can drive innovation around the world.

The province's traditional manufacturing base includes the top five global automakers: Fiat-Chrysler Automobiles, Ford Motor Company, General Motors, Honda Motor Company, and Toyota Motor Company, who manufacture more than 2.3 million vehicles a year from their Ontario plants.<sup>1</sup>

Ontario is home to more than 20,000 information and technology ('IT') companies employing more than 280,000 workers, making it the second largest region in North America – second only to Silicon Valley.<sup>1</sup>

This combination of global automotive corporations, IT companies, and a highly-skilled workforce results in a dynamic local C/AV industry for researchers, developers, policy makers and entrepreneurs who are pioneering new products and approaches.

Each day, companies across Ontario – from established auto manufacturers to cutting-edge start-ups – are investing in new ways to connect and automate the vehicles we drive. These innovations present significant growth opportunities for the manufacturing and transportation industries.

The continued investments by large automakers in Ontario are a positive indication of Ontario's competitive advantage. As an example, GM is expanding its Ontario engineering capacity to reach 1,000 positions and Ford announced a commitment to open a \$500 million Research and Engineering Centre in Ottawa.<sup>1</sup> This investment highlights the growing importance of C/AV technology for the future of Ontario's economy.

## Future Trends

Emerging technologies are changing the way we travel. C/AV technology is rapidly evolving and creating new opportunities. These changes will revolutionize how we get to work, ship freight, and access services. The scale and opportunity of C/AVs has the potential to change the way we design our cities and communities.

One example is 'mobility as a service' ('MaaS'). MaaS technologies and software allow the user to benefit from on-demand access without needing to own a personal vehicle.<sup>2</sup> In addition, vehicles are now able to communicate with other vehicles and surrounding infrastructure in order to modify routing, navigation and other functions that have traditionally been guided by a person.<sup>3</sup> C/AV technologies and MaaS will create new opportunities for Ontario to bring together businesses, manufacturers, and entrepreneurs to collaborate and provide new services to consumers and create new jobs.

Ford's \$1.2 billion investment to expand its Ontario operations is expected to create 800 jobs.<sup>4</sup>

Ontario's Magna will supply solid state LiDAR to BMW.<sup>5</sup>



Economic benefit of C/AV in Canada may be over \$65B per year.<sup>6</sup>

Driverless trains can operate 10% faster than human-operated trains.<sup>7</sup>

Industry executives believe that up to **50% of consumers will not want to own a car**, as new mobility services begin to meet consumer needs

- KPMG Research

# The Car of the Future

The advent of the C/AV is creating a unique opportunity to re-invent the traditional car or truck. Integration of connected technologies is transforming the traditional commute into countless opportunities ranging from being a mobile office to an opportunity to order groceries, all while avoiding traffic and congestion based on instantaneous information sharing between vehicles, infrastructure and the environment.

The scale of change is anticipated to be substantial and to have a rippling effect across the economy, the work force, and how individuals participate in their communities and workplaces. Ontario's historic advantage as an automotive and parts manufacturer underscores the need for the industry to evolve with the emerging technologies.

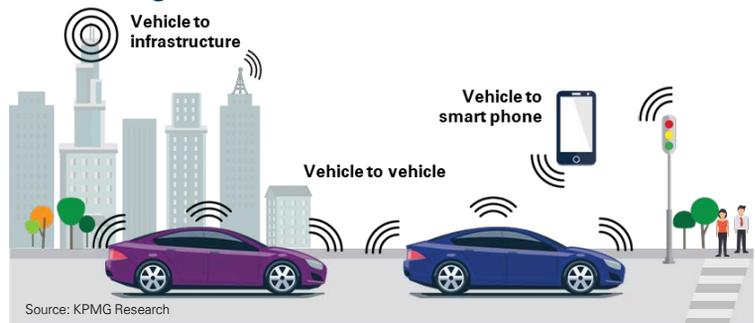
The traditional car is evolving into a complex integration of technologies such as radar and Light Detection and Ranging (LiDAR) sensors, global positioning systems, climatic sensors, artificial intelligence systems, data synthesis through machine learning and many more. The opportunities are boundless and Ontario has the key elements to become a global leader in C/AV technologies.

## Connected Vehicles

Connected vehicles have been in existence for over 20 years – dating back to legislation requiring On-Board Diagnostic Systems in 1996.<sup>8</sup> The driver in a connected vehicle can receive real time information such as road hazards and traffic conditions through wireless technologies that communicate with other vehicles and transportation infrastructure.<sup>1</sup> The constant evolution of 'intelligent' systems are creating new opportunities for connected technologies.

Modern car connectivity technologies permit communication on multiple fronts: pedestrians (V2P), infrastructure (V2I), other vehicles (V2V), cloud service (V2C), and all vehicles and transportation infrastructure (V2X).<sup>10</sup> Most modern vehicles are connected on one of these fronts through features such as lane adjustments, car condition alerts, and Geographic Positioning Systems.

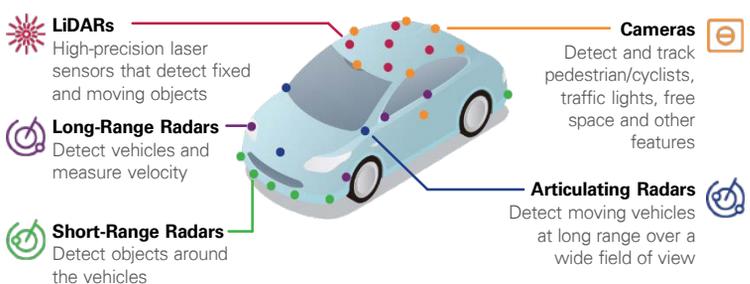
### Connecting the vehicle



## Autonomous Vehicles

Autonomous vehicles rely on sensors (radar, LiDAR and cameras) and data analytics to detect the environment around them in order to operate without the presence of a human driver.<sup>9</sup> Automotive and technology companies are actively researching new ways to provide and synthesize information to enhance the level of automation of the vehicle. The future outcome could be a fully autonomous vehicle that delivers the user to their destination without human intervention.

### Key elements of the autonomous car



Autonomous vehicles will shift the way Ontarians move around urban centres and open new opportunities for the future planning of our towns and cities. They are being considered as replacements for a variety of traditional mobility options ranging from private vehicles to freight shipping to public mass transit.

# Levels of Automation

Autonomous vehicle technology differs by the amount of driver intervention and attentiveness that is required during operation. The Society of Automotive Engineers defines six levels of automation.<sup>10</sup>

**Level 0. No Automation:** A human driver is required to execute all facets of driving. Vehicles may have an automated system that provides warnings or intervention but lacks the ability to sustain vehicle control.

**Level 1. Driver Assistance (“hands on”):** A human driver shares control of the vehicle with an automated system. However, the majority of the operation is performed by the driver. Modern examples have been in existence since the early 2000s and include Adaptive Cruise Control technology where the driver maintains steering while the automated system moderates acceleration or deceleration.

**Level 2. Partial Driving Automation (“hands off”):** An automated system is in full control of vehicular acceleration, braking, and steering but the driver must be prepared to intervene in the event of a system failure. Contrary to the “hands off” label, the driver must maintain full attention and perform all other operational tasks. Application of the technology has been ongoing since 2015.

## Level 3. Conditional Driving Automation (“eyes off”):

At the third level and higher, vehicles are considered to be automated driving systems. The vehicle is able to scan and react to the environment as well as make decisions. Conditional automation still requires driver attention in exceptional circumstances like emergency braking but generally drivers can safely divert their attention away from driving. Many new vehicles are now equipped with conditional automation features, such as parking assistance.

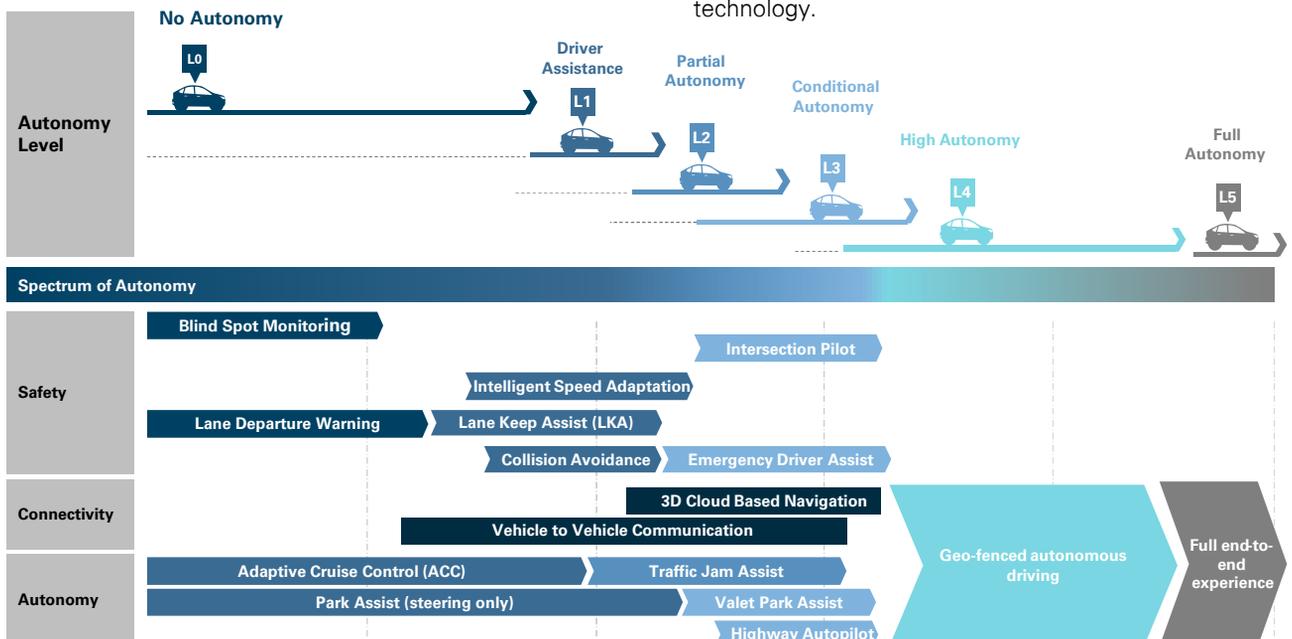
## Level 4. High Driving Automation (“mind off”):

Drivers can safely divert their attention for a more sustained period. Under specific conditions such as a geofenced city centre (i.e. a virtual geographic boundary), the vehicle is capable of operating without human intervention. Outside of these conditions the vehicle is still capable of bringing itself to a safe stop if the driver does not retake control. Testing is underway for the use and deployment of these technologies.

## Level 5. Full Driving Automation (“steering wheel optional”):

The vehicle can operate independent of a human driver regardless of the conditions. The automated driving system is capable of aborting a trip and bringing vehicles to a safe stop. At this level, the vehicle is a truly self-driving entity. Anticipated for consumer use after 2030, however, continued innovation may accelerate deployment of the technology.

## Roll out of the ‘levels of automation’



Source: KPMG analysis based on publicly available industry information and interviews with key participants in the C/AV industry



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# A Growing Industry

# The Next Generation

In this section, we explore in more detail the industry and key players that are actively contributing to the creation of a C/AV industry in Ontario. The next generation of the automobile will be created by a unique set of key players that includes automakers, parts manufacturers as well as technology innovators, software designers, machine learning researchers and many more.

The next generation of the automotive industry will be more diverse and globally integrated. Ontario's strong network of leading universities and colleges and an innovative technology sector provide a strong advantage to build on historic strengths, such as a vibrant manufacturing industry, advanced research and development capabilities and geographic proximity to the U.S. market.

In the past year, there was growing momentum and activity in the research and development, commercialization, investment, and scaling and expansion of C/AV technology in the province. Ontario has several unique advantages including a strong manufacturing sector, deep pool of researchers, entrepreneurs, a skilled workforce, and a rapidly growing technology and software sector.

## Growth opportunities

### City planning

Up to 30% of land in major urban centres is used for parking. The reduced need for permanent physical parking infrastructure presents an opportunity to redefine urban spaces.<sup>11</sup>

### Technology

is expected to comprise 40-60% of the automobile, an increase from the current 4-5% as C/AVs gain prominence over the next decade.<sup>11</sup>

### 5G wireless

adoption in Canada is expected to contribute 250,000 jobs by 2026.<sup>12</sup>

### Investment

in automation technology is helping companies remain competitive and retain and grow their workforce.<sup>13</sup>

### Safety

Autonomous vehicles are expected to reduce automobile fatality by almost 80% because of new vehicle technologies.<sup>11</sup>

### Machine learning

will enable vehicles to learn to drive without a human being from inputted data.<sup>14</sup>

### Productivity

Canadians spend 5 billion hours annually operating motor vehicles. Autonomous vehicles will reduce the current \$20 billion loss in productivity.<sup>15</sup>

# Key Players



## Government

Governments play a critical role in enabling an environment for new technologies to flourish by encouraging development, accelerating growth, and building consumer confidence through regulation. Each level of government is responsible for a unique aspect of the C/AV.

The federal government has a core responsibility for data management and security, vehicle and parts safety standards, and has a role in telecommunication infrastructure.

The provincial government is responsible for encouraging growth in Ontario through skills and talent development, supporting research and development, entrepreneurship, commercialization and growth in the scale of the production, in particular through the support provided by AVIN. It is also responsible for local road safety and delivering key infrastructure that will enable the adoption of C/AVs (e.g. smart or connected highways).

Municipal governments are focused on the local infrastructure, traffic management, public transit and mobility of residents. Local tools include bylaws focused on ridesharing services or development of multi-modal transit that include C/AVs. Additionally, the municipality in coordination with the province is responsible for land use and community planning in order to respond to the anticipated changes resulting from the introduction of C/AVs.

## Technology & Innovation

New and emerging technologies play a central role in the development of transportation solutions. Entrepreneurs, start-ups, and multi-national companies are actively contributing to and leading the development of automotive technologies.

Telecommunication companies are developing the requisite wireless and wired technologies to fuel the data and information needs of C/AVs.

Incubators and accelerators are providing tailored supports and spaces for entrepreneurs and start-ups to experiment, develop and commercialize new technologies. There is also increasing attention by investors to fund and finance technologies in order to provide a foundation for future scale and expansion or acquisition.

## Manufacturing & Industry

Automobile and parts manufacturers have traditionally had a large footprint in the Ontario economy. They are leading the research and development in new automotive and transportation technologies. Key players are partnering across industries or acquiring companies in order to rapidly increase their scale and ability in C/AV technologies.

Testing sites are a way to understand the interconnectivity and implications of new technologies. AVIN's Regional Technology Development Sites and the Demonstration Zone are providing unique environments to test products in real-world settings.<sup>16</sup>

Due to the advent of rideshare programs, demographic shifts and an anticipated large scale, coordinated use of C/AVs for public transit, fleet owners and operators will play a central role in the deployment of new and advanced technologies to provide these services.

## Academia

Ontario's colleges and universities are training the next generation of skilled workers for the automotive and manufacturing sectors. The integration of the manufacturing and technology sectors is increasing the demand for STEM graduates with applied knowledge. Employers are also in need of professional development opportunities for their current employees in order to create a workforce that is able to respond to the changing technological needs of the C/AV industry.

Automotive and parts manufacturers are expanding their presence in funding and collaborating with post-secondary institutions to conduct industry-relevant research. Through strategic initiatives with industry or dedicated institutes, colleges and universities are leading research across the C/AV technology spectrum, including machine learning, big data analytics, quantum and supercomputing.



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# Growing the Industry and Creating Jobs in Ontario



## Research & Development



## Commercialization



## Investment



## Scaling & Expanding



### Research and Development (R&D) in Ontario

The technology and transportation sectors in Ontario are diverse and have a range of strengths that make the province an optimal place for any company to establish and grow their business. Ontario has world-class research facilities, supportive programs, top tier talent and a diverse network of professionals who are focused on automotive and manufacturing technologies. In this section, we highlight the successes in Ontario and future opportunities for growth.

### Technology Focus Areas

Advancements in C/AV technology have the potential to redefine mobility, leading to more accessible cities and safer roads. As a result, Ontario has made it a priority to provide incentives to help catalyze R&D-related activities in order to create jobs and drive economic growth. The current focus for R&D in Ontario is listed in the graphic below and based on data collected through interviews and surveys with companies and key players.

### Technology research areas for Ontario

#### HD mapping and localization

High precision maps of roads and infrastructure. Modules that position C/AVs with relevant externalities.

#### Safe driving in inclement weather

The ability to operate in a safe and controlled state under all weather conditions and extremes.

#### Multisensor data fusion

The process of collecting data from externalities and analyzing the data collected with existing perceptual information, in order to reduce uncertainties.

#### Human-machine interface

The link between a human operator and technology.

#### Driver assistance systems

Systems to help the driver in the driving process.



Source: KPMG Analysis



Google's Sidewalk Labs has committed **\$50M** for installation and testing of the company's **smart city technology** for the **Quayside Project** in Toronto.<sup>19</sup>



University of Ontario Institute of Technology hosts one of **the most sophisticated climatic wind tunnels in the world** to test automotive technologies. Test winds reach speeds of 300 km/h, temperatures range from -40 to +60°C and relative humidity ranges from 5-95%.<sup>20</sup>

### There are national and provincial government supports for R&D activities

Ontario, as well as Canada, offers incentives to spur R&D activities. The National Research Council of Canada's Industrial Research Assistance Program offers financial assistance to technology R&D.<sup>17</sup> Ontario's tax credits for R&D are globally competitive and help to position Ontario as a hotbed of R&D activity.<sup>18</sup>



## Research & Development



## Commercialization



## Investment



## Scaling & Expanding



### Testing and Development

On January 1, 2016, Ontario launched a pilot program under the *Highway Traffic Act* that permits testing of automated vehicles on public roads on public roads by eligible participants under certain conditions. Ontario became the first province to permit automated vehicle testing on provincial roads in order to accelerate the development and testing of C/AV technology. However, Ontario is prioritizing safety and this pilot allows the province to evaluate the effectiveness of the automated vehicles included in the pilot and, if required, make adjustments before permanently allowing those vehicles on our roads.<sup>21</sup>

Testing sites and opportunities are helping R&D activities to develop, prototype, and validate new technologies. Ontario-based SMEs are growing in their ownership of specialized equipment (hardware and software), and knowledge of C/AV specific business and technical insights.

### Demonstration Zones and Test Tracks

The Demonstration Zone, located in Stratford, is a site where Ontario-based companies with C/AV technologies can test, validate, and showcase innovative products to potential customers and partners such as automotive suppliers, manufacturers and original equipment manufacturers in a controlled environment.<sup>22</sup>

The Ontario-Michigan cross-border drive in 2017 was North America's first publicized national, cross-border AV test drive, and Canada's first on-road AV test drive. Later in 2017, the City of Ottawa launched testing of an on-street autonomous vehicle, and was the first in Canada to connect to live city infrastructure. C/AVs communicate with the infrastructure through Dedicated Short Range Communication transmitters at the traffic lights. The site is equipped with the latest technology from BlackBerry QNX, Cohda Wireless, Luxcom and NovAtel.<sup>23</sup>

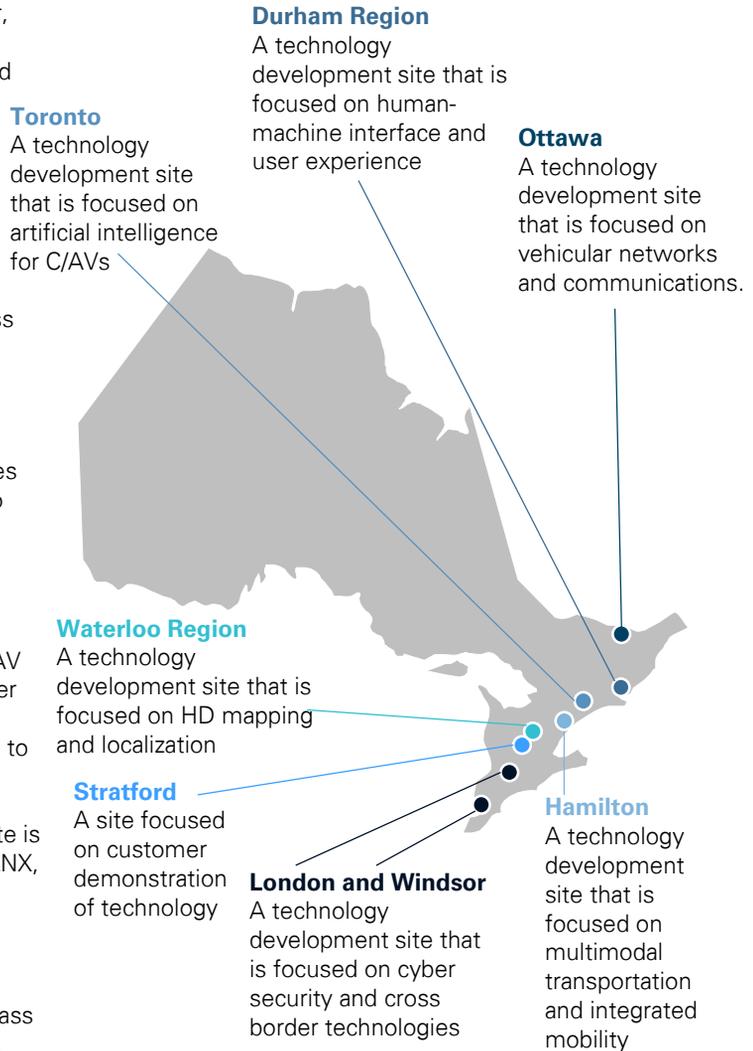
### Ontario's educated workforce

The numerous technology-focused incubators and accelerators, automotive research centres and world-class talent make Ontario a global hotspot for C/AV research.

Ontario has globally recognized artificial intelligence ('AI') research organizations and more than 200 AI-enabled firms that generated more than \$2.84 billion in sales in 2016.<sup>24</sup>

As connected infrastructure and C/AV saturation increases, demand for talent will also increase. Ontario is home to nine leading universities with 24+ auto-focused research programs and has a large talent pool of educated and skilled workers.<sup>25</sup> The availability of talent is closely linked with market growth rates.

### Ontario R&D Activities for Automotive and Transportation Technologies



Ontario's more than **200 AI enabled firms** that generated more than \$2.84 billion in sales in 2016.<sup>24</sup>





**Research & Development**



**Commercialization**



**Investment**



**Scaling & Expanding**



## Commercialization

Ontario has the opportunity to be a global hub for the commercialization and deployment of C/AV technology. Ontario's strong incubator and accelerator presence has fostered a unique environment that provides start-ups and entrepreneurs with the right tools to convert their innovations into market-ready products.

Efficient commercialization is a universal challenge. In Ontario, we are overcoming this challenge by facilitating collaboration between Ontario-based start-ups, SMEs, and multi-national companies to foster information sharing within the market and create partnership opportunities.

Targeted programs for entrepreneurs and start-ups support the development of new technologies and ideas that demonstrate commercial potential. OCE provides support and funding to early-stage projects, where the probability of commercial success and job creation are high.

Supports are also available to mitigate the financial risk for SMEs in order to encourage entry into the commercialization phase. Key supports are summarized below.

The Toronto–Waterloo Innovation Corridor has 5,200 technology start-ups and 15,000 technology companies.<sup>27</sup>



## Ontario's SMEs drive the economic growth and job creation

Incubators and accelerators play an important role in supporting Ontario's network of entrepreneurs. The growing number of automotive and technology start-up clusters in Ontario is fostering a globally competitive environment. The Kanata North Technology Park is home to over 500 companies and 21,000 employees contributing \$7.8 billion to Canada's GDP in 2015.<sup>26</sup> Similarly, the Toronto-Waterloo Innovation Corridor is home to over 5,200 technology start-ups.<sup>27</sup>

Research and technology parks help to drive new innovations into the market and provide the support needed to existing businesses to enable export-ready products.

## Strategic Innovation Fund

Allocates repayable and non-repayable contributions to expand existing and retain large investments in Canada's industrial and technology sectors.<sup>29</sup>

## Ontario Network of Entrepreneurs (ONE)

Directs entrepreneurs towards grants that help entrepreneurs commercialize their ideas.<sup>28</sup>

## AV R&D Partnership Fund

Supports industry-led projects with Ontario SMEs and larger partners focused on the development of transportation technology.<sup>30</sup>

## Voucher for Commercialization Program

Provides support to early-stage opportunities in the commercialization process.<sup>31</sup>

## Funding programs to support commercialization in Ontario



## Research & Development



## Commercialization



## Investment



## Scaling & Expanding



## Infrastructure

Smart infrastructure is anticipated to support the deployment of Level 4 and Level 5 autonomous technologies. The evolution of current infrastructure may be gradual and focused on the deployment of technologies to enhance the user experience. Innovations such as connected lights and digital signs, software solutions to inform the user of adjacent business services or to provide active traffic and congestion data for route enhancement may be more near term deployments.

C/AVs are anticipated to require large amounts of data for their information and technology systems. Many of the advancements in smart infrastructure are closely linked with deployment of 5G technology and its availability for C/AVs. Deployment of 5G technology will be capital and cost intensive and require additional investments in non-urban areas. Ottawa region is home to several global brands such as Ericsson, Avaya Inc., Nokia Corp., Alcatel-Lucent S.A., Huawei and Ciena Corp, who are leading the development of 5G technologies.<sup>32</sup>

The Ottawa AVIN Regional Technology Demonstration Site Project was the first end-to-end integrated AV test environment of its kind in Canada that offered the ability to communicate between vehicles, infrastructure and the network. It also enabled testing of AV operations in inclement weather, development of systems that pinpoint the location of hidden objects, cybersecurity, interoperability.<sup>32</sup>

## Planning for the future

Ontario municipalities, notably the City of Toronto, are dedicating staff and establishing internal working groups on C/AVs. The purpose of these working groups is to understand the challenges related to autonomous travel, passenger behaviour, impact on land use, and use of public space. Additionally, the working groups help identify opportunities within Smart Cities initiatives and future-proof the municipal Official Plan.<sup>33</sup>

An example is the Waterfront Toronto's Quayside project ("Sidewalk Toronto"), which is aiming to develop 4.9 hectares of Toronto's eastern waterfront into a sustainable and smart community.<sup>34</sup> The project presents an opportunity to test the implementation of connected infrastructure and the changes C/AVs can bring for urban design.

## Ontario Advanced Technology Platforms

Part of Ontario's innovation value proposition is the cross-collaboration and co-development of technologies happening across sectors. Ontario's advanced technology platforms are summarized below.



### Access to 5G Technology

ENCQOR (Evolution of Networked Services through a Corridor in Quebec and Ontario for Research and Innovation) is a Canada-Quebec-Ontario partnership that will build the first Canadian pre-commercial 5G wireless testbed.<sup>35</sup>

### Access to ultra-high-speed digital infrastructure

NGNP (Ontario's Next Generation Network Program) supports the development of digital infrastructure. It connects digital innovation hubs within Ontario and supports SMEs through development activities.<sup>36</sup>



### Overcoming cybersecurity challenges

CFIPP (Cybersecurity Fintech Innovation Pilot Program) is a \$7.8M program that accelerates the growth of cybersecurity start-ups in Ontario by partnering with financial institutions (FIs) seeking innovative solutions to cybersecurity challenges.<sup>37</sup>



### Commercialization support for SMEs

The IBM Innovation Incubator (i3) Project allows Ontario SME's to leverage programs and infrastructure that will lower the cost of introducing emerging and enabling technologies to the global marketplace.<sup>38</sup>





Research & Development



Commercialization



Investment



Scaling & Expanding



**Ontario ranks first** in Canada and third in North America in **Foreign Direct Investment**.<sup>39</sup>



### Supportive Business Environment

In recent years, the Ontario government has prioritized corporate tax rate reductions, R&D tax credits and other economic development programs, like AVIN to incentivize investment. Canadian immigration policies are also well-known for being conducive to the recruitment and relocation of international talent to Ontario.

### Responsive Regulation

Municipalities in Ontario are proactively planning and engaging in order to respond to C/AV technologies. Two examples include, the City of Toronto, which has established an AV working group for Transportation Services and the Regional Municipality of York which has initiated a coordinated action plan to prepare for C/AV impacts.<sup>33,40</sup>

### Large Automotive Manufacturing Footprint

Ontario has a geographic advantage in due to its shared border with Michigan and a competitive advantage because of its large industrial footprint of automotive and parts manufacturing. Ontario is the only province or state in North America that is home to five automotive manufacturers: Fiat-Chrysler, Ford Motor Company, General Motors, Honda Canada and Toyota Canada. Collectively, they operate 12 manufacturing plants. There are over 700 automotive parts manufacturers and more than 500 tool, die and mould makers in the province.<sup>25</sup> Ontario hosts the Canadian headquarters of the three largest automakers in North America as well as many global automakers. To continue to help build the industry, the Government of Canada launched the Automotive Investment Attraction Hub to assist investors in accessing up-to-date information about automotive markets in Ontario and across Canada.<sup>41</sup>

### Attracting Investment

There is a strong business case for investing in Ontario and in locally-based C/AV technology companies. Ontario has access to large markets, including the states of Michigan and New York. The value proposition for Ontario is based on several factors that distinguish it from other jurisdictions, including:

1. A strong talent pool that will help knowledge-based businesses grow and innovate new services and products.
2. A rapidly growing cluster of C/AV technology companies and start-ups that are supported by cutting-edge incubators and accelerators.
3. A suite of funding programs and supports offered by governments to encourage the development of technology and entrepreneurship.

Ontario has a global advantage in attracting investment and driving the development of the C/AV industry.

### Strong Industry Clusters

Ontario continues to develop industry clusters, such as the Toronto-Waterloo Innovation Corridor and the Advanced Manufacturing Supercluster. Innovation clusters are helping drive the industry forward by incorporating technologies developed by local start-ups and SMEs into the larger industry. Ontario has the opportunity to differentiate itself from international competitors by continuing to build super-clusters with high concentrations of technology and software-focused start-ups.

Ontario is home to 5 automakers operating 12 manufacturing plants, over **700 automotive parts manufacturers** and more than 500 tool, die and mould makers.<sup>25</sup>





Research & Development



Commercialization



Investment



Scaling & Expanding



### Scaling and expanding

The Greater Toronto and Hamilton Area is forecast to be one of the fastest growing jurisdictions in North America.<sup>42</sup> This population growth will increase transit and transportation needs. There is a strong business case for the continued production of automobiles and parts manufacturing in Ontario based on the rapidly expanding local markets.

### Infrastructure to support C/AV market saturation

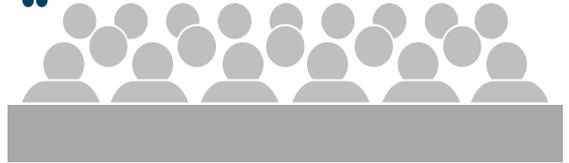
Cities across Ontario are preparing for the growth of C/AVs by considering opportunities for new smart infrastructure. Technologies such as 5G wireless will accelerate the deployment of higher levels of automation and help support C/AV market saturation and a more connected transportation network.

Ontario is also home to global leaders in the development of traffic management technology. Ontario-based start-ups have started to integrate AI with smart city technology. As Ontario's roads transition to using more connected infrastructure technology, there are emerging opportunities to leverage and extract greater value from the data analytics. Big data analytics can be used to drive social improvements and improve mobility solutions.

"Today more than **170 companies** in Ontario are teaching cars to think."<sup>25</sup>



Ontario's workforce can help support a growing C/AV industry. **68% of Ontario adults possess a post-secondary education**, more than any OECD country.<sup>20</sup>



### Growing Ontario's talent pool

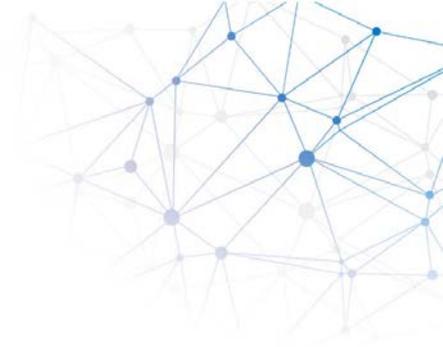
Ontario's workforce is competitive on a global scale. Ontario has committed to increasing the number of STEM graduates by 25% in 5 years, positioning the province as a North American leader for STEM graduates per capita.<sup>39</sup> Of Ontario's 104,000 autoworkers, 43% have a post-secondary education.<sup>25</sup>

Ontario is continuing to grow its high-skilled and knowledge-based workforce to respond to labor market needs. Programs such as AVIN's Talent Development program provide recent graduates with industry-based training in the C/AV market. Ontario has also implemented programs to help retain local talent as well as to attract international talent to help grow the C/AV industry.<sup>43</sup>

Ontario's 5-year goal is to graduate **1,000 applied masters students** in AI-related fields per year, and increase STEM graduates by 25%.<sup>39</sup>



# What's next?



Ontario's world-class research and development facilities, geographic advantage, depth of research and technology, and rich talent pool give it a great opportunity to maintain its predominant position in the global automotive market. AVIN provides a pivotal facilitation point where key players from the private and public sectors, and academia can efficiently form meaningful business relationships and quickly address roadblocks in the economic development pipeline. The graphic below denotes how AVIN is working with its partners to ensure that Ontario's C/AV sector players can efficiently commercialize their technology and maintain their in-house talent as they compete and grow. Open data and the standardization process represent the emerging priorities in order to ensure that Ontario companies have the advantage to lead on a global and national stage.

## Open Data

Data sharing is critical to fostering an innovative environment for C/AV research and development. Jurisdictions from across the world are working to find the balance between data sharing and personal privacy.

## Standardization Process

The development of unified standards may allow for technical interoperability and allow better vehicle operations and an ability to C/AVs and human-operated cars on the road.



## Efficient Commercialization

The rapid innovation cycle in the C/AV industry necessitates a heightened pace of acquisitions and partnerships for national and multi-national enterprises in order to adapt to new technologies. AVIN's R&D Partnership Fund is critical in bringing together large and small enterprises in order to efficiently realize their growth potential.

## Developing and Retaining Talent

AVIN's Talent Development program is central to the continued development of a highly skilled workforce and in helping retain talent in Ontario. Financial incentives and subsidies allow companies to pursue cutting-edge innovations.



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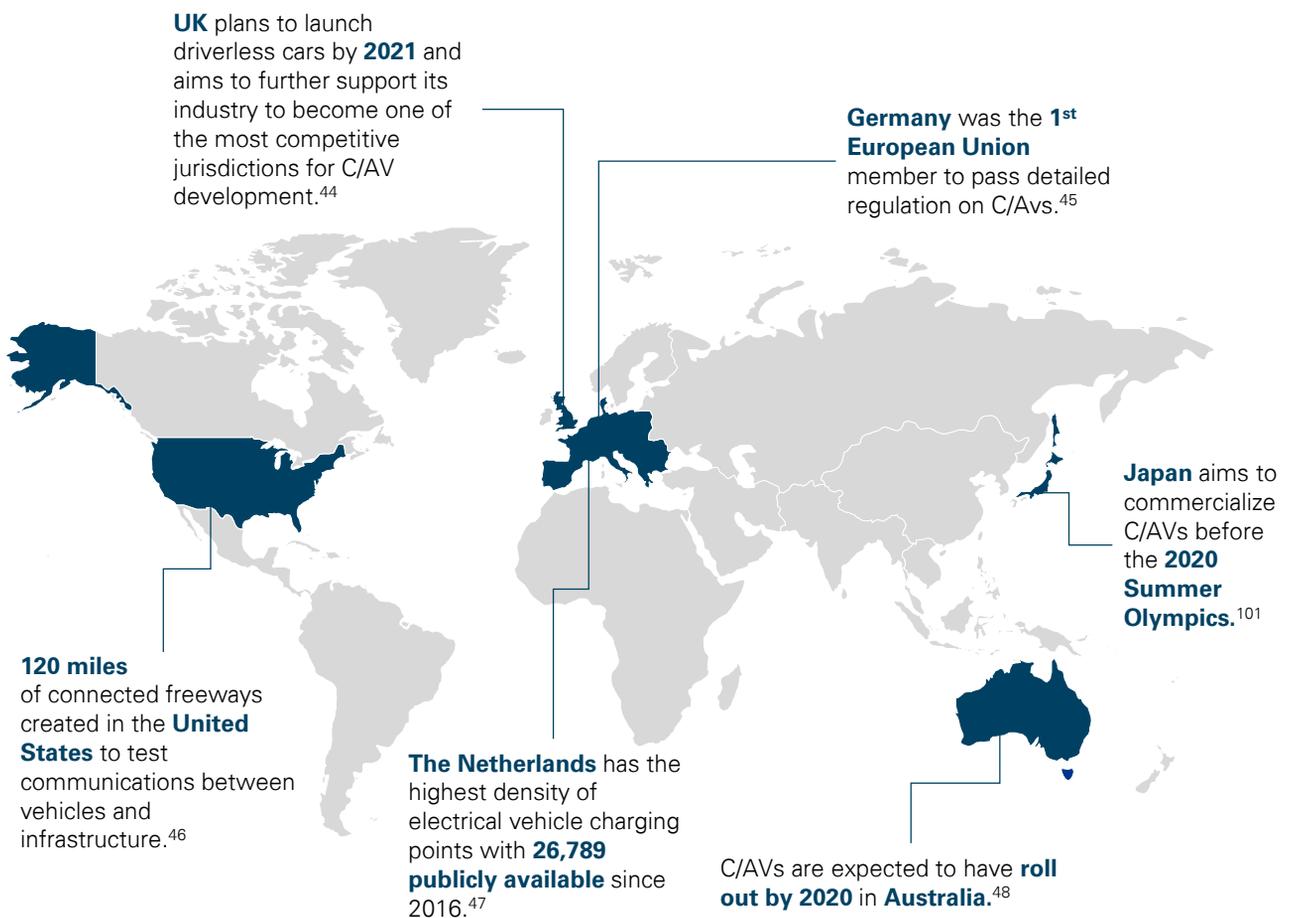
# Global Trends

# Global Overview

Countries around the world will be transformed by the advent of connected and autonomous vehicles. Governments are actively working to understand the best environment to grow the industry, how to develop smart regulation and provide strategic support to attract more investment. For Ontario, AVIN plays a critical role in enabling local businesses and researchers to prosper and pursue local and global opportunities.

Many jurisdictions are creating an environment to increase the early adoption of C/AV technologies. However, jurisdictions have varying levels of maturity in their C/AV readiness.

Leading C/AV jurisdictions are profiled in this section by describing their key initiatives, approach and programs to accelerate the development of the C/AV industry. Similar to the previous section, leading jurisdictions are profiled based on the economic development lifecycle of research and development, commercialization, investment, scaling and escalation. Ontario's role among global jurisdictions concludes the section. This multi-national overview demonstrates the opportunities for growth within a new industry that will create jobs and grow the economy.





## Research & Development



## Commercialization



## Investment



## Scaling & Expanding



### Germany

The German government is aiming to become a global player in the C/AV industry. In 2017, Germany became the first European Union member to pass a detailed regulation surrounding C/AVs.<sup>68</sup> The laws allow C/AV firms with special permits to road-test vehicles in which drivers are allowed to release control of the steering wheel. The law is anticipated to be revised in 2019 in order to adapt to technology changes and data protection concerns.<sup>45</sup>



Germany has a rich history of automotive research and development. Since 2010, almost 1 in 4 new jobs in the C/AV industry were within research and development.<sup>78</sup>

In addition, automotive manufacturers continue to invest in C/AV research and development. According to the Cologne Institute for Economic Research, Bosch and Audi have the highest number of worldwide patents related to autonomous driving with 958 and 516 respectively, followed by Continental with 439.<sup>49</sup>

In 2018, BMW opened a facility in Germany with hopes that it will “help with the systematic development of highly and fully automated driving”. The facility will pilot the use of simulations to train autonomous driving programs in addition to real-world testing.<sup>50</sup>



### Japan

In 2014, Japan launched the Cross-Ministerial Strategic Innovation Promotion Program to facilitate partnerships across academia, government and industry. Six major Japanese automakers and the Ministry of Economy, Trade and Industry signed an agreement to collaborate on C/AV development in 2016.<sup>51</sup>



The intention of the partnership was to lead large-scale operational field testing of autonomous systems between October 2017 and March 2019.<sup>51</sup> Visionary statements such as Society 5.0 are helping transform Japan into a smart society.<sup>52</sup>

Japan is also researching C/AV technologies in a variety of traffic environments including central Tokyo’s Metropolitan Expressway and Shin-Tomei Expressway.<sup>51</sup> The Government of Japan amended its Road and Transport Act concerning vehicle safety standards to allow use of driverless automated vehicles on public roads.<sup>53</sup> The government is also developing legislation regarding C/AVs with a hope to pass it by 2019.<sup>54</sup> A compendium of regulatory rules involving civil responsibility is under development. They will outline how much a vehicle owner may pay in damages through their mandatory car insurance and how much the government will pay if there is a system failure, such as a hacking.<sup>55</sup>



Germany became the first European Union member to pass detailed regulation relating to C/AVs.<sup>68</sup>



In Japan, an agreement was signed between six major Japanese automakers and the Japanese Ministry of Economy, Trade and Industry to collaborate on C/AV development.<sup>51</sup>



## Research & Development



## Commercialization



## Investment



## Scaling & Expanding



## United States

### Michigan

Since 2014, the Michigan Department of Transportation, General Motors, Ford Motor Company and the University of Michigan created 120 miles of connected freeways to test how vehicles can communicate with nearby infrastructure and vehicles using V2I and V2V technology.<sup>56</sup>



Michigan is also developing a C/AV hub called MCity – a public-private partnership being overseen by the University of Michigan’s Office of Research. Within MCity’s Test Facility is a simulated urban and suburban environment that collects data between an AV and nearby cars. It is considered one of the world’s largest operational, real-world deployments of connected vehicles and infrastructure.<sup>57</sup>

Additionally, the American Center for Mobility is one of ten dedicated test sites that encourages testing, information sharing and data analysis around AV technologies. Michigan has introduced new regulations to remove limitations on testing autonomous vehicles. C/AVs are authorized to operate on a street or highway in the state with no driver present.<sup>58</sup>

Recently, the Governor of Michigan and the UK Minister of Business have signed a partnership to collaborate on developing the rules for self-driving cars and the rollout of other emerging technologies. This is the first partnership between a US state and an international government on autonomous cars.<sup>59</sup>

### California

California started enacting C/AV legislation as early as 2012 with safety and performance requirements to ensure safe operation of the testing and later allowed transportation authorities to deploy pilot projects for testing of C/AVs at specified locations within specified speeds. The Department of Motor Vehicles (DMV) developed more advanced regulations to allow testing of C/AVs on public roads with fully self-driving cars. To test vehicles, the DMV must issue one of the following permits: testing with a driver, driverless testing, and deployment.<sup>60</sup>

California is home to significant research and development operations for C/AVs. Several car manufacturers, automakers, start-ups and technology companies have set up test facilities. According to the DMV, as of May 2018, there were 54 autonomous vehicle testing permit holders.<sup>61</sup> As part of research and development on public roads, California requires that an annual compilation of miles traveled in autonomous mode and the number of disengagements to be collected.<sup>97</sup>



Within California, United States, fully self-driving cars are permitted for testing on public roads with an appropriate permit.<sup>60</sup>



## Australia

Australian has several research and development centers for C/AV technologies such as the Flinders University’s Future Mobility Lab that is focused on public transport and driverless shuttle services.<sup>105</sup>



Australia is collaborating with New Zealand to undertake testing, minimize duplication and to increase knowledge exchange.<sup>76</sup>

In 2017, the National Transport Commission released the national enforcement guidelines for automated vehicles to clarify regulatory concepts for proper control at different levels of driving automation.<sup>106</sup>

The Australian government is developing a national regulatory framework for C/AVs that includes phased approach for regulation development in order to be responsive to the evolution of technology and market developments.<sup>106</sup>



## Research & Development



## Commercialization



## Investment



## Scaling & Expanding



## United Kingdom

The Centre for Connected and Autonomous Vehicles was established to help the United Kingdom remain at the forefront of C/AV technology development and to coordinate activities and encourage collaboration. Investment in research and development of C/AVs supports over 70 projects with around 200 partners including manufacturers, universities, insurers, tech entrepreneurs, researchers.<sup>62</sup>



Venturer is a project funded by both government and industry to focus on public acceptance, legal and insurance implications of C/AVs as well as develop an independent test site. Three trials have been completed in the project with the third trial interacting with other road users.<sup>63</sup>

The UK government expects to release legislation in early 2021 to promote safe use of driverless cars and AV technology. Recognizing potential benefits of C/AVs, the Department of Transport released a report, *The Pathway to Driverless Cars: A Code of Practice for Testing*, which provides guidance to those conducting testing of highly or fully autonomous technologies on public roads.<sup>64</sup>

As the world's third largest innovation hub (for transactions), the United Kingdom is also focusing on cybersecurity as it relates to C/AVs.



## Netherlands

The Netherlands aims to be a frontrunner in C/AVs by providing test areas and helping to bring the vehicles to market.



In 2015, the Netherlands Council of Ministers approved testing of C/AVs and in 2017 approved more advanced legislation allowing C/AV testing without a driver.<sup>65</sup>

In 2016, the Netherlands took on a leadership role by establishing the Declaration of Amsterdam in which all European Union member states agreed to work together to accelerate the development of self-driving vehicles throughout Europe. The goal is to create a coordinated approach across governments and stakeholders to enable efficient development of C/AV technologies.<sup>66</sup>

The Netherlands has benefited from cooperation between industry, research institutes and the government, as well as European Union countries.

The Dutch Automated Vehicle Initiative is a public private partnership with the goal to stimulate demonstrations of C/AVs on public roads and focus on human factors in automated driving and proofing safety.<sup>67</sup>

Venturer, a UK based project funded by both government and industry, aims to develop independent C/AV test sites. One site is testing interaction between C/AVs and road users.<sup>63</sup>



The Netherlands established the Declaration of Amsterdam to accelerate the development of C/AVs within the European Union.<sup>66</sup>



## Research & Development



## Commercialization



## Investment



## Scaling & Expanding



### Germany

German Data Protection Laws and the EU consider data collected by C/AVs to be personal data,<sup>68</sup> and recommend that this data be anonymized as it is only required for driving operations.<sup>69</sup> With commercialization of C/AVs nearing, the German government recognizes the need to collect and process large amounts of data in order to connect vehicles and infrastructure.



As such, the government is actively facilitating the implementation of 5G infrastructure with a clear focus on connected driving functions. A roll-out of 5G is expected by 2020.<sup>69</sup>



### Japan

In 2016, Japan announced its aim to commercialize C/AVs before the 2020 Summer Olympics.<sup>101</sup> This commitment led the government to begin investing in infrastructure, frameworks, and human capital to perform final testing. 3D mapping of the country's roadways is also being developed and is expected to be 20 times as precise as current maps.<sup>70</sup> To support commercialization, the Government initiated the development and operation of the Quasi-Zenith Satellite System to operate in conjunction with 3D maps to provide improvement on a vehicles location, and reduce error from 3 metres to 6 centimetres.<sup>51</sup>



Japan revised its Privacy Protection Law in 2017. These laws require organizations to obtain individual consent before using or sharing personal data with third parties and to notify the public of the data sharing. Japan also requires that no identifying information is captured and that the information remains anonymous.<sup>71</sup>



### United States

#### Michigan

The Michigan Department of Transportation ('MDOT') is the primary repository of data and responsible for the initial data management for C/AV deployments through their investment in a Data Use and Analysis Program system.<sup>98</sup> The American Center for Mobility is planning to partner with Microsoft to design a cloud-based Data Management and Analytics Platform solution to collect, store and analyze data.<sup>72</sup>



The MDOT requires that before commencing on C/AV projects, companies disclose the data handling practices in connection with the vehicle and fleet.<sup>73</sup>

#### California

New legislation released in 2018 allows fully self-driving cars to operate on public roads without an engineer and test driver. Reports indicate that Tesla and Waymo are preparing to commercialize their self-driving program in California.<sup>74</sup>



Germany expects to see a 5G infrastructure roll-out by 2020.<sup>69</sup>

Japan is investing in 3D mapping of its roadways – which are 20 times more precise than traditional maps.<sup>70</sup>



The American Centre of Mobility is planning to partner with Microsoft to design a cloud-based Data Management and Analytics Plan.<sup>72</sup>



Research & Development



Commercialization



Investment



Scaling & Expanding



## United Kingdom

The AutoAir project aims to bring 5G technologies to the automotive and technology industry to accelerate the validation and development of C/AVs. The test bed will enable the validation of Level 3 to 5 C/AVs which require high-speed, real-time connectivity to be commercialized.<sup>75</sup>



## Australia

Navya, an Australian autonomous vehicle mobility company, has been operating autonomous, driverless, and electric shuttle services globally and is establishing a driverless vehicle headquarters in Australia to introduce a 1km shuttle service.<sup>77</sup> The Australian government is in the process of developing legislation to clarify the application of current driver and driving laws to C/AVs. It is expected to be in place by 2020.



## Netherlands

To help catalyze the deployment of self-driving cars, Netherlands has the highest density of electrical vehicle charging points. 26,789 charging points have been publicly available since 2016 and it is converting 1,000 traffic lights across the smart mobility system in order to communicate with connected vehicles.<sup>76</sup> Additionally, the Netherlands government is adopting technologies such as 5G to ensure that vehicles can communicate with each other and infrastructure.<sup>76</sup> The government believes that current telecom networks are a solution in the short-term but further investment will be required in the long-term.



With regards to data sharing, the Declaration of Amsterdam plans to initiate a public-private task force to set initial steps for deployment of data sharing for traffic safety.<sup>100</sup>

UK based project, AutoAir, plans to bring 5G technologies to C/AVs.<sup>75</sup>

As part of Declaration of Amsterdam, the Netherlands plans to set up a task force to assess data sharing.<sup>100</sup>

Navya is establishing a headquarters in Australia to bring driverless shuttle services.<sup>77</sup>



Research & Development



Commercialization



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Scaling & Expanding



## Germany

In 2016, according to the European Commission, global spending on research and development increased to €40.2 billion with 50% of the spending being invested within Germany. Two-thirds of this investment came from vehicle manufacturers and one-third from suppliers.<sup>78</sup>



The government also plans to invest an additional €80 million in autonomous vehicles before 2020.<sup>79</sup>



## Japan

The Japanese government is investing in the C/AV market and is encouraging private sector investment in advance of the 2020 Olympic games.<sup>101</sup> As part of investing in C/AVs to meet the Olympic games deadlines, Toyota announced in March 2018 that it invested \$2.8 billion in a new Tokyo-based company aimed at developing production-quality software for automated driving.<sup>80</sup> Japanese automakers invested \$25.6 million in 2017/2018 in research and development, an increase of 6.8% from the previous year. Automakers are also investing in C/AVs through partnerships.<sup>99</sup> For example, Renault SA, Nissan, and Mitsubishi are investing as much as \$1 billion in a partnership to fund mobility startups that focus on electrification, autonomy, connectivity and artificial intelligence.<sup>81</sup>



## United States

The federal government committed to allocating \$4 billion over 10 years to support and encourage development and adoption of fully autonomous cars.<sup>82</sup> In Michigan, more than \$135 million was invested in MCity.<sup>83</sup> Michigan received \$253 million and California received \$38 billion in venture capital investment. Similarly, GM invested more than \$100 million in Michigan to upgrade its facilities in order to support its Plan to commercialize the Cruise C/AV.<sup>84</sup> In California and in Silicon Valley specifically, start-ups are raising millions of dollars in capital to advance self-driving technology. Companies such as Nauto and Drive.AI have raised \$174 million and \$65 million, respectively, in funding.<sup>85</sup>



Globally R&D increased to **€40.2 billion**.  
**50%** of this was in Germany.<sup>78</sup>

Japanese automakers invested **\$25.6 million** in 2017/2018.<sup>99</sup>

The United States has committed **\$4 billion** over 10 years for C/AVs.<sup>82</sup>



Research & Development



Commercialization



Investment



Scaling & Expanding



### United Kingdom

In 2014, a driverless car competition encouraged collaboration between UK cities, industry players and researchers for local vehicle trials. Four cities were awarded up to £10 million in funding.<sup>102</sup> In 2015, the Centre for Connected and Autonomous Vehicles (CCAV) committed to providing over £250 million in funding, matched by industry, to support C/AV research and development.<sup>86</sup> In 2016, the UK announced a £390 million of funding to boost the development of low-emission vehicles and C/AVs.<sup>87</sup> It also committed £740 million to fund the extension of the telecom network and the establishment of 5G trials. It offered a further £400 million to be matched by private finance to stimulate private investments.<sup>88</sup>



### Australia

The South Australian Government plans to invest AUD\$10 million in AV technology in order to boost testing, research and development.<sup>89</sup> In addition, the State of Victoria has invested AUD\$1.2 million along with the Transport Accident Commission and VicRoads to develop the first Australian C/AV.<sup>90</sup>



The UK committed GBP **£390 million** in **2016** to fund low-emission vehicles and C/AVs.<sup>87</sup>

**€90 million** were invested by the Netherlands to improve infrastructure for C/AVs.<sup>76</sup>

The Australian government and its state agencies have invested AUD **\$1.2 million** to develop the first Australian C/AV.<sup>90</sup>



### Netherlands

The Netherlands invested early in legislation relating to the C/AV industry in order to attract research and development. The government has also invested in its infrastructure through electric vehicle charging stations, and €90 million investment to replace 1,000 traffic lights with connectivity capabilities.<sup>76</sup>





## Research & Development



## Commercialization



## Investment



## Scaling & Expanding



### Germany

German auto manufacturers are planning to introduce autonomous vehicles to the market starting in 2021. BMW's partnership with Daimler could result in C/AVs being released as ride-hailing services rather than being sold to private consumers.<sup>91</sup>



### United States

In 2016, the Safe Autonomous Vehicles Act created conditions for eligible motor vehicle manufacturers to create automated vehicle fleets to run autonomous ride-hailing services within a defined geographical boundary and deploy cars on public roads without human safety drivers.



This Act is building a road to self-driving cars to consumers.<sup>59</sup> The Department of Transportation has also released the "C/AV Technology Strategic Plan" and "Connected Vehicle Infrastructure Plan." These plans will incorporate C/AVs into state-wide plans to institutionalize C/AV initiatives within strategic plans.<sup>56</sup> The goal of the plans is to facilitate the implementation C/AVs for customers. GM, the Michigan-based automaker, has indicated its plans to scale production of its autonomous vehicle unit Cruise with \$2.25 billion investment from SoftBank. The fully autonomous cars are expected to be released in 2019 as a commercial ride-hailing service.<sup>94</sup>



### Japan

Japan is aiming to scale up its production of C/AVs in time for the 2020 Olympics.<sup>101</sup> The Prime Minister of Japan anticipates that there will be fleets of self-driving taxis, buses, trucks and private vehicles on Tokyo's roads to transport athletes and visitors during the Olympics.<sup>54</sup> The ambitious timelines set by the Japanese government is encouraging private sector players to scale and expand the technology for the public use. The anticipated level of automation will require minimal driver input, and the government expects that Level 4 automation will be readily available by 2025.<sup>54</sup>



### Netherlands

A company called Amber expects to release Level 4 self-driving vehicles operating as suburban taxis in 2018. The company currently has six all-electric BMWs and plans to expand to 500.<sup>95</sup>



### United Kingdom

The UK plans to launch driverless cars by 2021 and aims to be the "World Number One" in driverless cars by streamlining its efforts.<sup>92</sup> The UK production of autonomous cars is expected to grow significantly by 2030 with all vehicles produced having at least Level 3 technologies embedded by 2027 and a 25% penetration of fully autonomous vehicles by 2030.<sup>93</sup>



### Australia

The Australian government has identified C/AVs as a strategic priority in order to prepare for the deployment of automated vehicles and other innovative transport.<sup>96</sup> C/AVs are expected to have commercial roll-out in Australia by 2020.



# Ontario and the Global Industry



## Research & Development

**Globally**, governments are building partnerships across academia and industry, while also amending traffic laws to allow driverless vehicles on public roads. Leading jurisdictions are enabling R&D by creating test centres for C/AV technology that are creating new jobs in the emerging industry. In Germany, 1 in 4 new jobs in the C/AV industry are related to R&D.<sup>78</sup>

**Ontario**-based SMEs are growing in their ownership of specialized equipment (hardware and software), and knowledge of C/AV specific business and technical insights. AVIN's Regional Technology Development Sites is facilitating small- and medium-sized companies to develop and prototype C/AV technologies.

In particular, AVIN's role in forging cross-collaborations and connecting academia with industry was recognized by stakeholders as critical in helping Ontario grow the local C/AV industry.

On January 1, 2016, Ontario also launched a pilot program under the *Highway Traffic Act* that permitted testing of automated vehicles on public roads by eligible participants under certain conditions.

**Globally**, R&D spending in the automotive industry increased by 7% in 2016 to €40.2 billion.<sup>78</sup> Jurisdictions across the world are demonstrating their commitment to C/AVs by investing in technology and infrastructure, and strategically supporting and funding industry initiatives.

**Ontario's** supportive regulatory environment has paved a well-established pathway for investments. As a result, Ontario is ranked third in North America for foreign direct investments.<sup>103</sup>

The province has a large automotive manufacturing footprint. Ontario is the only province or state in North America that is home to five automotive manufacturers, which collectively operate 12 manufacturing plants.

Companies that invest in Ontario will capitalize on this advantage and be actively supported through programs such as AVIN's R&D Partnership Fund, which enables SMEs working with potential customers to validate and demonstrate leading edge automotive and transportation system technologies.



## Commercialization

**Globally**, infrastructure developments are drawing greater interest and jurisdictions are considering the deployment of 5G technologies and 3D mapping. These developments will be critical for catalyzing C/AV deployment by providing enhanced data and information. In Germany, 5G deployment is anticipated for 2020 and its application to infrastructure for connected driving functions.<sup>69</sup>

**Ontario** is helping to accelerate the commercialization of next generation communications solutions and the development and implementation of ultra-high-speed digital infrastructure through strategic programs such as the Next Generation Network Program.

ENCQOR, a partnership between Canada, Ontario and Quebec will build a commercial 5G test site, which will enable connected and autonomous technology development.

Ontario municipalities, notably the City of Toronto, are dedicating staff and establishing working groups on C/AVs to understand the challenges and opportunities.

**Globally**, jurisdictions are making public commitments or setting targets and developing strategies based on their goals or strengths. Japan is aiming to scale up its production of C/AVs in time for the 2020 Olympics.<sup>102</sup> In the United States of America, state- and country-wide strategic plans are being developed for the use and coordination of C/AVs with other initiatives, such as infrastructure planning.

**Ontario** is sharply focused on the continued development of its skilled workforce to drive the growth of its technology and manufacturing footprint. The province has committed to increasing the number of STEM graduates by 25% – making it the highest number of STEM graduates per capita in North America.

Cities across Ontario are preparing for the growth of C/AVs by considering opportunities for new smart infrastructure and how to create more connected transportation networks, along with how to help accelerate the deployment of higher levels of automation.



## Investment

## Scaling & Expanding



## Artificial Intelligence

An intelligence demonstrated by machines whereby it can perceive its environment and react in a way that maximizes its chance of achieving success

## Automation

A technological process that allows a machine to perform tasks without human input.

## Autonomous Vehicle

A vehicle that employs sensors to detect the environment around them and operates without the need for human input.

## Autonomous Vehicle Innovation Network (AVIN)

A collaboration between government, academia, and private industry that seeks to catalyze and support Ontario-based C/AV companies as they work to solidify Ontario's position as a C/AV leader

## Commercialization

The process of introducing a new product or service to market once the research and development phase is complete.

## Connected Vehicle

A vehicle that utilizes wireless technology to communicate with other vehicles and transportation infrastructure to aid the driver in responding to hazards..

## Electric Vehicle

A vehicle that is equipped with a battery that, when charged, enables it to operate on electric power without producing any tailpipe emissions.

## The Internet of Things (IoT)

An interconnected network between physical devices fostered through equipping everyday objects with computing-capability and thereby enabling them to send and receive data

## Key Player

An individual, group, or organization that has an interest in, affected, or affects a process, outcome, or activity.

## LiDAR (Light Detection and Ranging)

A surveying method that uses a pulsed laser light to measure distances by illuminating a target with the laser and then measuring the reflected pulses with a sensor.

## Open Data

When digital data is made publically available for general use by the data proprietor. Through an Open Data License this data can be used for commercial and non-commercial use royalty-free.

## Original Equipment Manufacturers (OEMs)

A company that manufactures parts or equipment that is marketed by another company. For example, Ford using fuel injectors in their vehicles that are produced by Bosch.

## Stakeholder

An individual, group, or organization that has an interest in, affected, or affects a process, outcome, or activity.

## Standardization

A process of setting an agreed upon benchmark which industry must conform all production to. For example, safety standards.

## STEM

The term used to denote professions that fall under the disciplines of science, technology, engineering and mathematics.

## Traffic Management

A branch of logistics concerned with the planning and control of transportation infrastructure to reduce congestion.

## 5G (5<sup>th</sup>-Generation Wireless Systems)

The newest generation in wireless mobility system technology that boasts the ability to process a high amount of information with minimal data transfer delay time. 5G is a pivotal piece of wireless infrastructure for enabling roadworthy C/AV's.

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- 2 ITS Canada, Mobility as a Service: Can it be even better than owning a car?, Retrieved from <https://www.itscanada.ca/files/MaaS%20Canada%20by%20Sampo%20Hietanen%20and%20Sami%20Sahala.pdf>
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