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AVIN ecosystem analysis and roadmap 2020

Strengths, challenges, and opportunities across Ontario's automotive and mobility ecosystem

Ontario's Autonomous Vehicle Innovation Network (AVIN) and Deloitte Canada

October 2020

OCE Where Next Happens

Executive summary

Key findings and opportunities for Ontario's automotive and mobility ecosystem

Ontario is poised to solidify its reputation as a **world leader in the automotive and mobility ecosystem**. The province is currently home to five of the largest global automotive OEMs, 700+ parts suppliers, 24 automotive skilled trade programs, and a very robust start-up community. In 2019, the province produced 1.9 million vehicles with 85 percent of Ontario's automotive production being exported, generating $70.6 billion in automotive exports. In addition, Ontario is the second largest IT region in North America, with a growing Artificial Intelligence (AI) and cybersecurity technology hub developing world-leading talent and drawing additional talent, innovation, and new business into Ontario.

The ecosystem is growing beyond the automotive sector, becoming increasingly diverse and interconnected. The combination of these factors has helped to create the current day ecosystem where legislation and policy, economic factors, research and development (R&D), and talent initiatives converge to help generate innovative solutions.

In order to ensure Ontario remains competitive in the global ecosystem, AVIN has conducted **an in-depth analysis of Ontario's automotive and mobility ecosystem**. This analysis highlights the province's strengths, challenges, and opportunities for national and global leadership.

Legislation and policy

Ontario's legislative environment has helped to create a competitive market where new test sites and pilot programs are helping to pave the way for innovation.

These opportunities serve to supplement Ontario's regulatory infrastructure and to help prepare for future changes in the industry.

Key opportunities include:

- ✓ Standardization between jurisdictions
- ✓ Developing privacy guidance
- ✓ Improving collaboration and co-developed assets
- ✓ Optimizing procurement models

Economic development

The growth in public-private partnerships coupled with high Return on Investment (ROI) in the broader automotive and mobility industry is fostering a robust start-up community and helping to generate increased scale-up and commercialization opportunities.

Key opportunities include:

- ✓ Building transit and digital infrastructure
- ✓ Expanding synergies with Venture Capital (VC) and Private Equity (PE)
- ✓ Focus on high-ROI scale-up opportunities, fueling innovation from start-up to global scale
- ✓ Restructuring and retooling existing plants

Research and development

Partnerships between academia and industry along with mature research in AI, analytics, telecommunications, and cybersecurity are accelerating automotive and mobility innovation in Ontario.

New and expanded use cases – including safety technologies, healthcare, micro-mobility, and automated and optimized goods movement – are growing market opportunities.

Key opportunities include:

- ✓ Growth in connectivity, data, energy, and physical infrastructure
- ✓ Identifying and expanding new use cases
- ✓ Expanding cross-border initiatives
- ✓ Increasing mobility-as-a-service (MaaS) capabilities research

Talent development

Ontario's unique talent programs, large talent pool, and growing connections between industry and academia provide the province with unique advantages to developing and growing the necessary skills for the future of mobility.

Key opportunities include:

- ✓ On-the-job learning
- ✓ Synergistic curriculum with industry partners
- ✓ Retaining and retraining underrepresented or aging talent

Ontario's competitive advantage lies in the capacity for the province's diverse group of stakeholders to **collaborate** in ways that promote both **strategic and technological synergies**, spurring new advancements across the ecosystem. The integration and adoption of **cross-sector emerging technologies** will be crucial for sustaining accelerated innovation. Advances across five major focus areas – facilitating ecosystems, public adoption and experience enablement, development and manufacturing, infrastructure enablement, and mobility management – will provide important foundations, catalysts, and convergence points that support the growth of Ontario's **automotive and mobility ecosystem** in the coming years.

Table of contents

AVIN ecosystem analysis and roadmap 2020

Page

Introduction & methodology

Introduction and methodology

Introduction

The expanding automotive and mobility ecosystem – Beyond the vehicle

Connected and autonomous vehicles (CAVs) are being used and tested for the transportation of both goods and people across Ontario. These vehicles use devices and sensors to communicate with their surroundings and allow the vehicle to take on or assist with various levels of driving functions.[1] CAVs strive to create a safer, more accessible and integrated mobility experience for users – across personally-owned or shared vehicles, trucks supporting delivery, urban and rural transit, and even new forms of micro-mobility (such as shared bikes or scooters).

The ecosystem that develops and supports these experiences can be described as the "**automotive and mobility ecosystem**". In Ontario, this includes a number of different components – from the development of people and tools needed to build the vehicles, to the operations and services needed to support their use, along with the education, policy, legislation, and testing needed to ensure the safety and security of those adopting advanced mobility features on Ontario roads.

This ecosystem is rapidly expanding and includes a number of diverse stakeholders who operate by collaborating across sectors and regional borders. Talent, investment, policies, and infrastructure (including **physical, digital, and energy**) continue to play foundational roles in enabling Ontario's expanded automotive and mobility sector.

2020 brought unique challenges

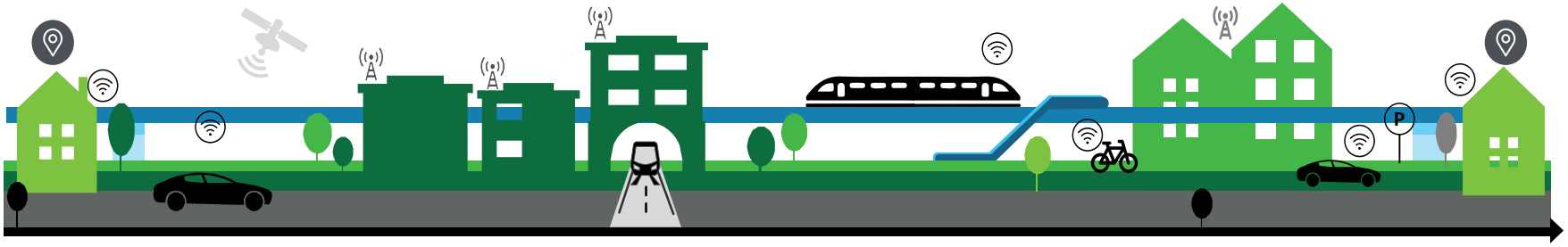
In 2020, the automotive and mobility ecosystem faced the COVID-19 pandemic, resulting in changed priorities, new business focuses, disrupted supply chain operations, and new service delivery models. The automotive and mobility ecosystem has responded by increasing long-term investments and finding new opportunities to collaborate with other stakeholders. Ontario's is well-positioned to help local and global organizations overcome this challenge.

> Ontario's favorable legislative and policy environment for R&D, pilots, testing, talent, immigration, infrastructure, and technology have put Ontario on the map as a global leader – **empowering Ontario to attract key players and grow the mobility ecosystem**, even during challenging times.

Industry-changing forces and emerging technology and service trends have led to the creation of impactful **new use cases, models, and systems for moving people and goods**. Ontario now has an opportunity to continue to build on their success as a global leader in this space.

The next five years will be a jumping off point for Ontario

Recent increases in both foundational and catalyst activities across the ecosystem show that Ontario is poised to capitalize on historical growth over the next 5 years. Operating at the convergence of physical and digital spaces, enhancing data sharing while maintaining privacy, and innovating in infrastructure and manufacturing, will both improve the public experience and foster security and trust in the future of mobility.



Introduction and methodology

Methodology

Report objective

This report was developed to provide a holistic overview of the current automotive and mobility ecosystem in Ontario and highlight key opportunities over the short, medium and long term.

Data gathering approach

To provide a window into the current and future state of the industry, this report was developed through a layered data gathering approach of both primary and secondary research, involving a number of diverse industry stakeholders.

Primary research methods included a survey developed for this report (the 2020 AVIN Mobility Analysis survey) and the 2020 Deloitte Global Automotive Consumer Survey.[2] Primary data also refers to a series of remotely-conducted interviews and validation discussions with emerging industry leaders and subject matter experts from Ontario and other global jurisdictions.

Secondary research methods included a review of thought leadership reports, proprietary consumer sentiment research, market data, academic literature, and research and reports from global organizations. Throughout this report, we layered in select insights from other leading jurisdictions – spotlighting key lessons learned from around the world that inform the Ontario analysis.

The information collected supports a view of the **automotive and mobility ecosystem**, that is best analyzed through four categories.

Analysis approach and methodology

The PESTLE Model – a model for analysis using Political, Economic, Social, Technological, Legal, and Environmental perspectives – was used to enable a holistic review of the mobility ecosystem. In order to make informed, strategic decisions about opportunities for growth and development, it is imperative to understand the key elements of the interconnected ecosystem.

The PESTEL model was considered as part of the analysis to ensure the automotive and mobility ecosystem's **strengths**, **challenges**, and **opportunities** were comprehensive and built on multiple, interrelated perspectives.

This report summarizes insights across Ontario's automotive and mobility ecosystem into **four categories** – inspired by the PESTLE highlight key opportunities for Ontario across each area

Legislation and policy

Key policies, standards, regulation, strategy and governance shaping the global advanced mobility ecosystem.

Economic development

Public and private economic activities including key organizations, investments, cross-border collaboration, insurance, commercialization, innovation hubs, start-up accelerators, VCs, and funding.

Research and development

Highlights of important R&D activities (both public and private), including notable testing or development facilities and pilots.

Talent development

Trends in supply and demand for talent as well as talent development, retention, and availability challenges and opportunities.

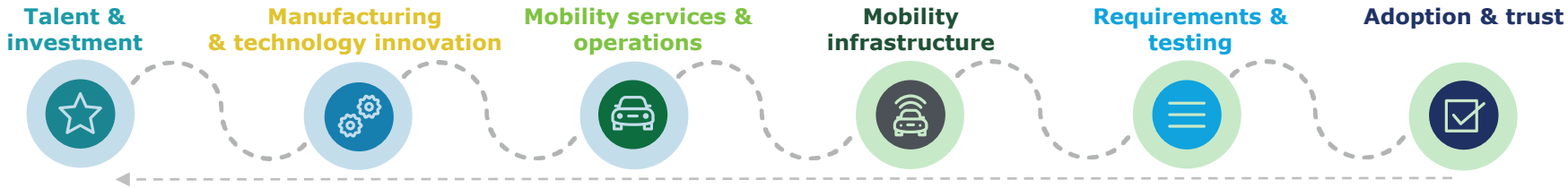
Automotive and mobility ecosystem overview

Automotive and mobility ecosystem overview

The journey from development to adoption – a convergence of stakeholders and ideas

The automotive and mobility lifecycle

Automotive and mobility innovation does not occur within a single place or domain. Rather, diverse activities are conducted throughout a complex lifecycle, involving a broad group of interconnected organizations and individuals across the supply chain, development catalysts, and user communities. Each component of the lifecycle works in an iterative fashion, building off each other's strengths and differentiators, and growing the overall ecosystem in Ontario.



Talent & investment
The talent development and investment groundwork that must be in place for mobility initiatives to be successful.

Manufacturing & technology innovation
Vehicles and mobility parts and software developed to enable the physical, digital and service components of automotive and mobility technology.

Mobility services & operations
The mobility services and operations that support the full spectrum of mobility experiences, within and outside of the vehicle, across all types of automotive, transit and truck or fleet operations.

Mobility infrastructure
The physical, digital, and energy infrastructure that is required to support automotive technology and mobility, including the use of and protection of mobility data.

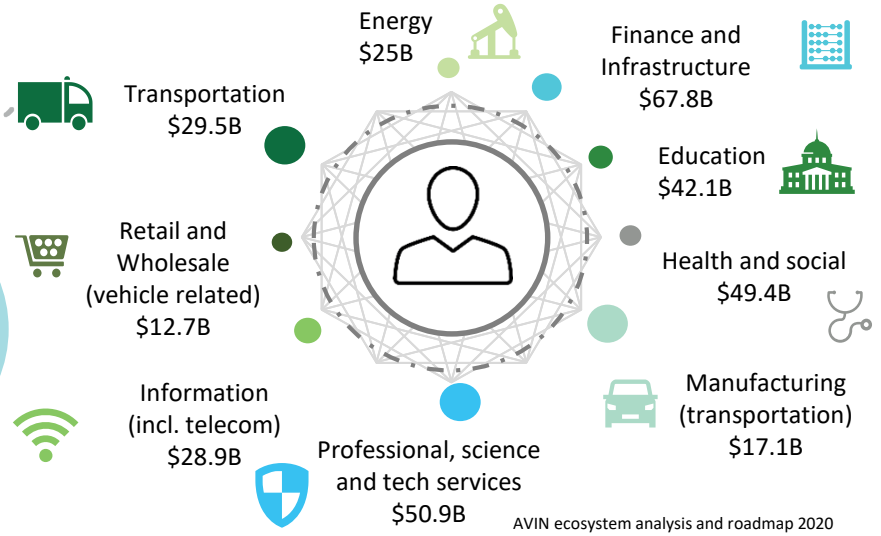
Requirements & testing
The policy and legal requirements, including safety, insurance, privacy, and security, and testing needed prior to market availability and user adoption.

Adoption & trust
Public experience and the level of interest in, trust with, and adoption of mobility vehicles, features and support.

The size of the Ontario automotive and mobility ecosystem is growing

1. Stakeholders are increasingly collaborating across sectors and industries – including automotive, insurance, telecommunications, payments, and energy, among many others – to develop new products and services.
2. Cross-provincial and cross-border relationships are growing.
3. New and sustained investments are seen across the ecosystem.

Ontario's extended automotive ecosystem GDP[3] ~$375B



Note: Additional details can be found in the Analysis and Appendix A.

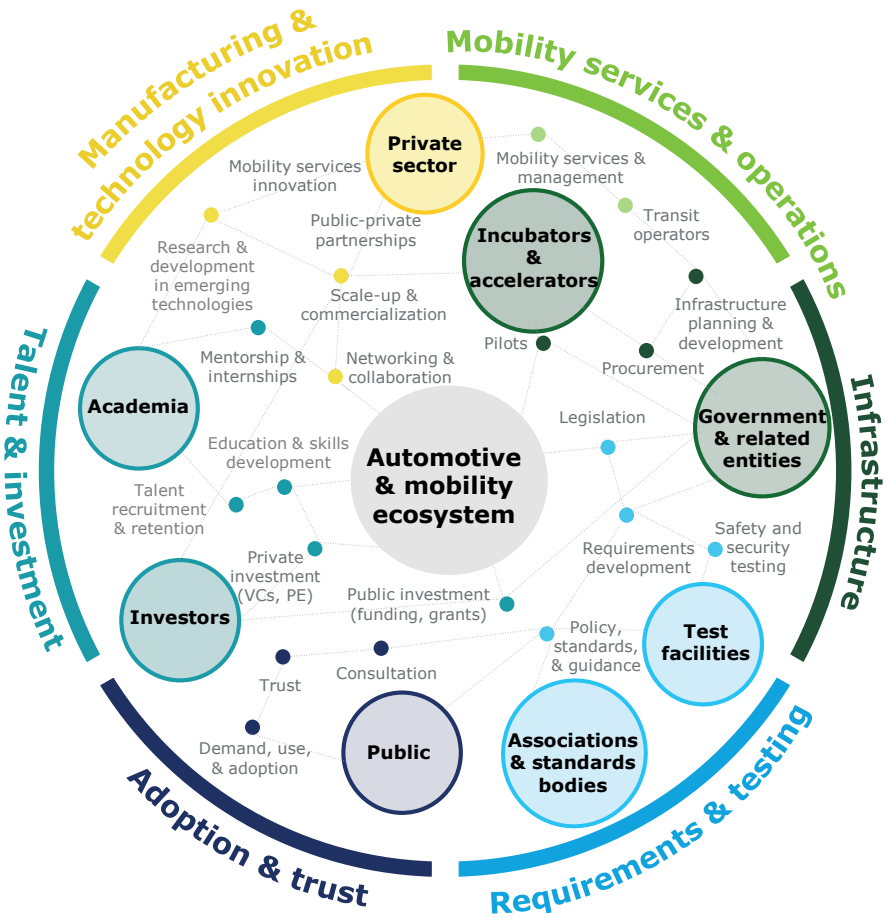
Automotive and mobility ecosystem overview

The mobility ecosystem is growing, and its stakeholders are highly interconnected

Connectivity between automotive and mobility ecosystem members

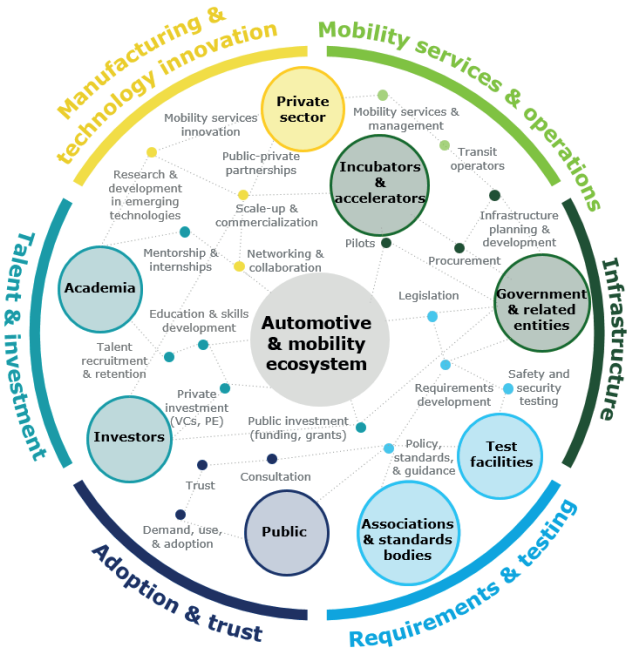
Ontario's automotive and mobility ecosystem members each play important, interconnected roles in enhancing the competitiveness and sustainability of the ecosystem. For example, the ecosystem's diverse industry players will drive a number investment and innovation initiatives, supporting infrastructure, R&D, and commercialization. The public sector plays an important role working closely with industry and the public in setting policy objectives and requirements, supporting infrastructure, and moving innovation forward through pilots and accelerators.

A description of each ecosystem group is captured on the following page.



Automotive and mobility ecosystem overview

The mobility ecosystem is growing, and its stakeholders are highly interconnected (cont.)



Key ecosystem stakeholder groups

Private sector includes automotive & transportation manufacturers (including OEMs, Tier 1-3 suppliers), technology providers (such as infotainment, sensors, software development, and vehicle cybersecurity services), finance (including payments and authentication providers), insurance, telecommunications infrastructure (5G), and service providers (supply chain & logistics, fleet management, transport/mobility as a service). Industry stakeholders involved in this ecosystem continue to expand as new collaborations are formed, innovations in manufacturing, communications, and operations emerge, and products and services grow such as COVID related health and safety technology.

Government & related entities include government at all levels, and their initiatives (e.g., Ontario's AVIN), regulatory bodies within Ontario and Canada (including police and justice, ministries, departments), municipal bodies, public sector agencies, as well as government-related entities (e.g., not-for-profit organizations primarily funded by government). Government entities play an important role in legislation and requirements development, infrastructure planning and development, piloting, accelerating, and procurement.

Incubators & accelerators support new and growing businesses to succeed, from startups, to scale-ups, to commercialization and expansion. These organizations can be industry or investor-led (including private and/or public investment) or government-led.

Investors provide funding to ecosystem stakeholders through private investments (venture capital, private equity) or public investments (government-funded investment initiatives).

Academia includes post-secondary institutions (universities and colleges), research bodies and development labs. Academia play an important, collaborative role with industry and government in research and talent & skills development.

Automotive and transportation test facilities conduct research, advanced development, testing and evaluation for surface vehicle transportation (automotive, transit, and truck), testing the safety and security of these vehicles prior to availability on the market.

Associations & standards bodies include standards organizations, industry associations, and accreditation bodies. Some of these organizations are part of, or funded by, public sector organizations, while others are industry-led and run.

Public includes citizens and organizations who use or experience advanced automotive and mobility technology. Public experience, perception, and trust – across the entire supply chain, vehicle lifecycle, and connected communities – are critical to the success and sustainability of the ecosystem.

Ontario's entire automotive and mobility ecosystem relies on supporting Legislation and Policy, Economic Development, Research and Development, and Talent Development for its success. The following section will describe Ontario's current state, including key strengths, challenges, and opportunities for achieving continued growth.

Ontario in 2020 – Ontario's automotive and mobility ecosystem analysis - *Overview*

Ontario in 2020

Overview of Ontario's automotive and mobility ecosystem analysis

Ontario's current state – An analysis to shape Ontario's future

In order to know where Ontario is going, we need to understand where Ontario is today among global leaders. This analysis – based on research and industry insights – highlights Ontario's **strengths**, **challenges**, and **opportunities** in the automotive and mobility innovation space. This report provides select highlights from Ontario to date, including key initiatives and catalysts driving change, and includes references to relevant **global initiatives** across the four domains below.

Legislation and policy

Key policies, standards, regulation, strategy and governance shaping the global advanced mobility ecosystem

Economic development

Public and private economic activities including key organizations, investments, cross-border collaboration, insurance, commercialization, innovation hubs, start-up accelerators, VCs, and funding

Research and development

Highlights of important R&D activities (both public and private), including notable testing or development facilities and pilots

Talent development

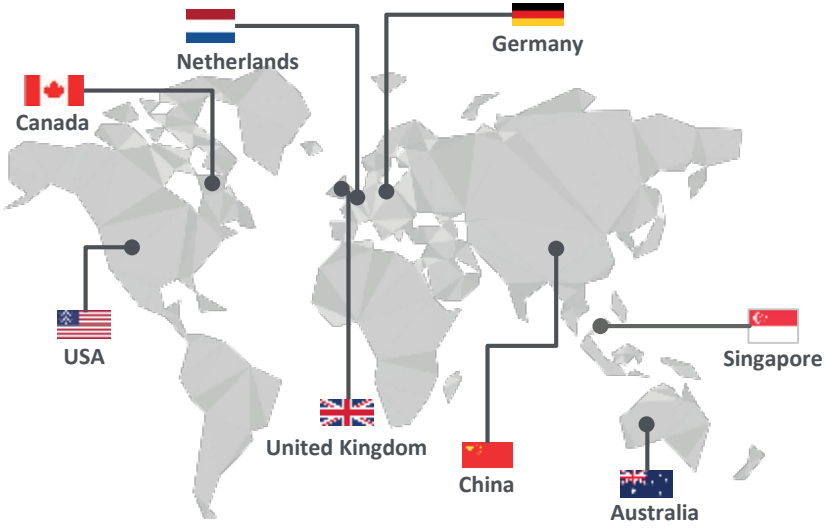
Trends in supply and demand for talent as well as talent development, retention, and availability challenges and opportunities

Key Highlights across the Automotive and Mobility Ecosystem

The analysis will highlight key initiatives, programs, and events shaping Ontario's leadership role in the global ecosystem.

Analysis Structure

Global Jurisdictions Referenced



Ontario in 2020

Overview of KPIs measuring Ontario's overall ecosystem

Ontario's current state – By the numbers

Ontario's automotive and mobility ecosystem continues to grow and evolve. To the right are select numbers and indicators reflecting the size and complexity of Ontario's ecosystem.

Effectively measuring Ontario's KPIs into the future will require collaboration with government institutions (at the federal, provincial, and municipal levels), academic institutions, as well as private sector organizations.

Continued stakeholder collaboration is necessary between government, industry and academic partners to collect data and develop models to consistently measure the broader advanced automotive and mobility innovation market and operations, including key infrastructure and facilitating ecosystem activity necessary for the sustainability and adoption of these innovations.

GDP & Exports of advanced automotive markets
2.4% of Ontario's overall GDP and **18.5%** of total manufacturing GDP[4]
85% of Ontario-made vehicles and parts are exported, represented **over 35%** of Ontario's total exported goods, the largest share of exports in Ontario[4]

Automotive tax revenues & incentives
The 2018-19 Ontario Gas Tax Program provides $364 million in gas tax funding to 107 municipalities that provide public transit service – **reaching 144 communities** – for municipal transit service improvements (e.g. expanded routes, longer hours, increased accessibility, and improved security infrastructure).[5]
$268,000 in revenues (84.8% profitability) from the automotive manufacturing industry in 2018[6]
$0.5 billion in revenues from parking fees and fines within Toronto alone[7]
$2.7 billion in gasoline tax and **$0.7 billion** in fuel tax revenues within Ontario[8]

R&D spend ($)
+$1 billion invested in Ontario by the private sector since 2016 within the automotive and mobility landscape, including funding automotive R&D centres[9] and committed **$85 million** in funding over the next five years for AV technologies[10]

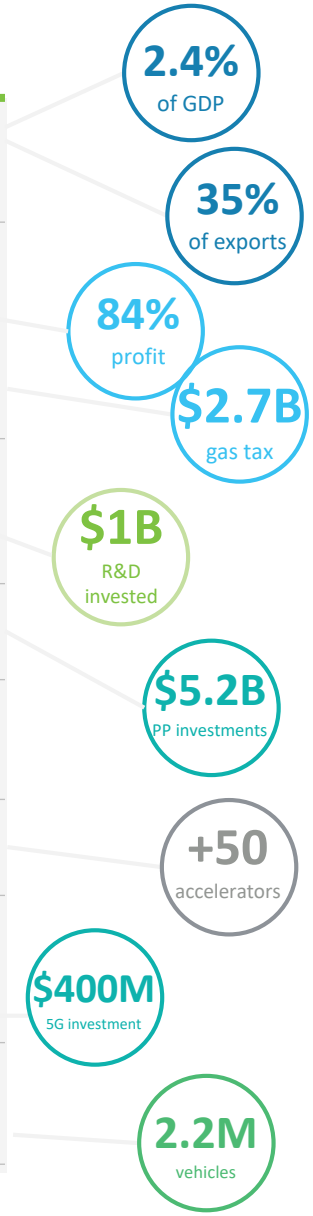
Public-Private investments & projects
$5.2 billion invested in joint public-private infrastructure projects as well as collaborative projects / partnerships led by Infrastructure Ontario[11]

Government incentives/grants
16 R&D and innovation incentives registered provincially by organizations within the automotive and mobility ecosystem, totaling **$1.2 million** in R&D funding[12]

Organizations within incubators/accelerators
+50 incubators/accelerators across Ontario with **200+ small and medium sized enterprises (SMEs)** registered across the automotive and mobility ecosystem[13, 4]

Digital and physical infrastructure readiness
48% of new project kilometers within metro lines expected to be fully automatic by 2022[7]
$400 million has been invested in **5G research and innovation**[7]
Over +1,200 of EV charging stations within Ontario[14]
Ontario has **148 Road Weather Information System** stations to provide timely road weather data[5]

Production of electric, hybrid & ICE vehicles
Ontario was North America's top auto-production region for 2017, creating **2.2 million** vehicles including electric, hybrid and internal combustion engine (ICE)[4]
1.9 million vehicles produced in 2019[7]



Ontario's automotive and mobility ecosystem analysis - *Legislation and policy*

Ontario in 2020

Legislation & policy

Ontario's policy environment

Ontario's legislative and policy environment is a global leader in terms of creating an ecosystem open to innovation and testing, and supporting the type of infrastructure needed for use and adoption by the public.

Pilot legislation – CAV piloting on Ontario public roads

The Ontario Regulation 306/15 is one of the leading autonomous vehicle (AV) testing laws globally – it permits the testing of AVs on the roads and highways of Ontario under limited, strict conditions. In 2016, the ten-year Ontario AV Pilot Program was launched to allowed eligible participants such as automobile manufacturers, technology companies and research institutions to participate in the pilot program. Pilot participants include multinational corporations such as, BlackBerry's QNX, Magna, Uber, as well as academic institutes like the University of Waterloo.[15]

In 2019, the Ontario AV Pilot Program was expanded to permit the operations of AVs with either a passenger on board or with a remote operator monitoring the vehicles operations. CAVs equipped with level 3 technology from the Society of Automotive Engineers (SAE) are eligible for public purchase in Canada and are permitted on Ontario roads. In addition, organizations are permitted to test platooning technologies that enable vehicles to follow each other in a group by means of advanced support systems.[16]

Rebuilding Ontario: An infrastructure plan for the people

Under the Rebuilding Ontario plan, the Ontario government has made a number of key commitments to enhance the movement of goods and people across the province. The Ontario government plans to:[17]

- Widen Highway 401 around the GTHA
- Support safe bypass of highway inspection stations by leveraging new pre-screening technologies, which will allow for efficient flow of goods
- Commit $11.2 billion in new subway projects which includes the Ontario Line

The Ontario government is also working with the Ontario Energy Board (OEB) to develop policies that are conducive to telecommunication infrastructure development. The OEB is responsible for regulating utility poles, which are crucial in the development of 5G networks. Regulatory reform by the Ontario government has the potential to accelerate key infrastructure projects that support the automotive and mobility ecosystem. The Ministry of Infrastructure, who is also responsible for Ontario's Broadband and Cellular Action Plan (BCAP) , will invest $150 million into telecommunication infrastructure related initiatives.[18]

Ontario in 2020

Legislation & policy

Ontario's policy environment

Ontario's provincial and municipal stakeholders have been developing key policies looking to support the long-term sustainability of mobility – including micro-mobility.

At a municipal level, key public-private partnerships and collaborations with provincial and academic institutions, are allowing cities to put innovation into practice earlier and develop cutting-edge services for the public.

Ontario-wide sustainability strategy and policy

The MTO's **Sustainability inSight** strategy provides key insights on how Ontario plans to achieve their goals relating to social, environmental and economic sustainability.[19]

Specific policies that are favorable to micro-mobility are laid out in Ontario's #CycleON Action Plan 2.0 (AP 2.0), which aims to develop a province-wide cycling network that connects rural communities with urban centers. AP 2.0 also includes plans to expand bicycle parking, year round maintenance of bicycle lanes and construction of additional bike-sharing hubs around key bus and train stations.[20] Additionally, the City of Ottawa has installed smart traffic signals that reduce vehicle emissions and improve traffic flows.

Municipal strategic plans and partnerships

The **Ontario Smart Mobility Readiness Forum** facilitates dialogue between Ontario-based municipalities and public sector agencies in order to advance the adoption of CAV and smart mobility technologies. Key areas of focus of the Forum include CAV development, pilot project program management, CAV modelling, regional mobility platform strategy, as well as data needs and management.[21]

Peel Region's Goods Movement Strategic Plan 2017-2021 has resulted in the development of key guidelines and activities that reduce congestion and improve sustainability around its $1.8 billion transportation of goods industry. The Transportation Systems Planning Team within Peel's Transportation Division is currently supporting the following initiatives:[22]

- 20 Signal timing changes on Goods Movement Corridors adjusted for improved travel time and traffic flow
- A Goods Movement Economic Impact Analysis Report
- A Peel truckers map that employs GPS and includes routes and by-law references
- Development of a Strategic Goods Movement Network (SGMN)

In **collaboration with McMaster University, University of Toronto, and York University, the Region of Peel** will contribute $240,000/annually to the Smart Freight Centre to help develop strategies that will optimize the movement of goods across the GTHA.[22]

Sustainability strategies and policies

Leading municipal plans

Public-private partnerships

Collaboration with academia

Key highlights

Ontario in 2020

Legislation & policy

Ontario's policy environment

Ontario's policy developments and legislative environment has made Ontario a prime location for testing, research, and pilot projects, putting innovation into action.

For example, regional test sites and provincial or municipal pilot initiatives have moved the Ontario automotive and mobility ecosystem forward, paving the way for a better understanding of the future policy changes needed to support such initiatives.

Municipal testing policies promoting innovation

New proposals for AV testing capabilities and pilots

Key highlights

Municipal testing policies and proposals

The **City of Hamilton** is home to one of six **AVIN Regional Technology Development Sites**. The City of Hamilton was also selected as a testing center by the Innovation Factory's Center for Integrated Transport and Energy in order to collect data related to the integration of autonomous vehicles in a real traffic environment. The Innovation Factory's Centre for Integrated Transportation and Technology helps facilitate test beds on public roads within Hamilton. Hamilton's testing ground provides a space for SMEs to test and pilot mobility solutions and interact with smart infrastructure within a real traffic environment.[23, 24]

The **Town of Belleville** has partnered with Pantonium in a **pilot project** involving transit-on-demand for three buses that are currently in rotation. This program is meant to address the challenges of low density public transit areas by allowing riders to schedule a bus pickup using a free mobile application. This will help to optimize the existing system by minimizing the amount of empty buses operating at a given time. This type of initiative is especially attractive for municipalities who wish to explore the changing transit landscape without making major changes to their existing transit infrastructure.[25, 26]

In collaboration with Ontario's AVIN, the **City of Toronto** developed the **Automated Vehicles Tactical Plan** in 2019 to outline a vision for the future based on the principles of health, environmental sustainability, privacy, security and mobility equity.[27] The city currently has 143 electric charging stations with 752 charging outlets across 15 square kilometers. In addition, the 407 has been recommended as a test highway for CAVs.[7]

The City of Toronto has also put forward a **proposal** to develop **CAV testing capabilities** at the **Exhibition Place**.[28]

Earlier this year, the **North Bay** city council approved a three-year pilot program for on-demand transit services. This three-year program will allow the transit system to operate more efficiently while being a source of convenience for riders.[29]

Ontario in 2020

Legislation & policy

Ontario's broader policy environment

Ontario's policy environment is not only driven by provincial and municipal institutions. The policy landscape includes recommendations and guidance from the Federal government and relevant industry associations. For example, Transport Canada plays a large role in regulating Ontario's automotive and mobility ecosystem. Industry associations also play an important role providing the voice of ecosystem players across the entire supply chain.

Federal Government policy development

In 2020, Transport Canada published Canada's Vehicle Cybersecurity Guidelines, in alignment with other leading jurisdictions, providing an important first step towards the standardization of cybersecurity for the automotive and mobility ecosystem.[30]

Further support for policy and standards development includes Transport Canada's Advanced Connectivity and Automation in the Transportation System (ACATS) program, which funds initiatives related to the **development of standards, codes, and guidance, as well as research and capacity-building**. Additionally at the national level, the Canadian Standards Association (CSA) led the development of a standardization roadmap for the safe deployment of CAV technologies in Canada.[31]

Private sector advocacy for business-friendly policies

The Automotive Parts Manufacturers' Association's (APMA) aims to promote the original equipment (OE) automotive supply manufacturing industry by providing strong representation at multiple levels of government, as well as actively campaigning for business-friendly policies within the automotive sector.[32]

The Toronto Region Board of Trade advocates for **policy reform that advances the competitiveness** of the GTA region. While the Board highlights key opportunities and insights within the automotive and mobility landscape through publications, they strongly advocate the efficient movement of people and goods by prioritizing the enhancement of the region's transportation infrastructure.[33]

The Canadian Urban Transit Association (CUTA) includes members from the majority of transit systems in Canada. CUTA advocates for **strong public transit and integrated urban mobility** for all members of the public.[34]

Key highlights

- Supportive federal government policies
- New federal cybersecurity guidelines
- Industry association policies
- Transit association policies

Ontario in 2020

Legislation & policy

New policy and legislation insights from leading jurisdictions

Although Ontario is currently a global leader in CAV pilot and testing legislation, other global laws and policies can provide insights and lessons learned for Ontario when considering new or amended laws and policies.

UK

The United Kingdom has focused on developing a number of high-profile connected and autonomous vehicle policy initiatives and municipally-based catalysts, spawning innovation in emerging areas including CAV cybersecurity, trailing, and claims.

For example, the Code of Practice: automated vehicle trialing, permits the trials of autonomous vehicles of any level on UK's road as long as there is an operator either inside or outside of the vehicle.[35] The Automated and Electric Vehicles Act allows individuals to submit claims relating to accidents involving automated vehicles.[36]

USA

The United States – both at the federal and state level – have initiated new laws or regulations aiming to reflect the new automotive landscape. For example:

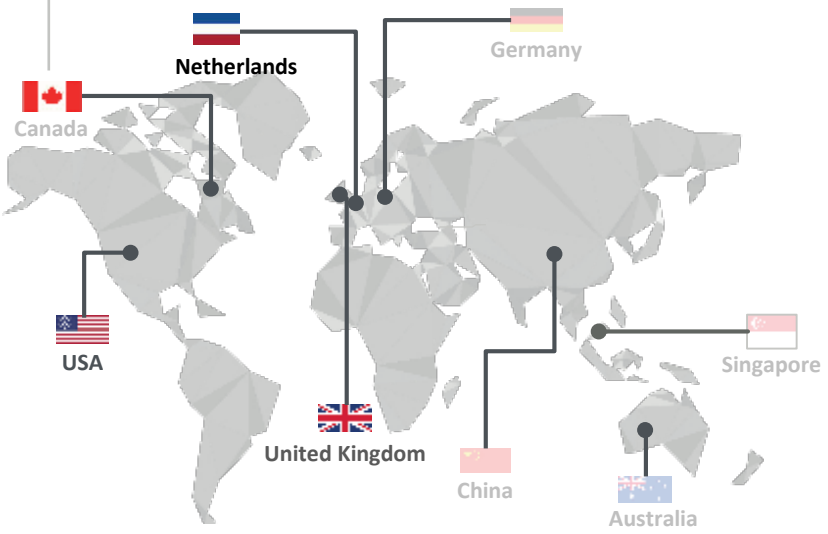
- In January 2020, the US Department of Transportation (USDOT) released the "Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0 (AV 4.0)," which comprises of key focus areas such as safety and economic development.[37] In 2017, the SELF DRIVE ACT was passed by the U.S. House of Representatives but is still pending in the U.S. Senate.[38]
- The Federal Communications Commission (FCC) published, "Facilitate America's Superiority in 5G Technology Plan (5G FAST Plan)," which will allow for V2V and V2X communication by advancing high-speed communication through new policies.[39]
- In December 2019, legislation was passed in California to allow testing of autonomous trucks on public roads.[40]

Netherlands

The Ministry of Infrastructure and the Environment (I&M) has allowed autonomous vehicle testing to be hosted on public roads. The Council of Ministers in the Netherlands authorized road testing for autonomous vehicles in 2015. This bill was updated in February 2018 enabling tests to happen without a back-up driver present in the vehicle. The Dutch Vehicle Authority is the authoritative figure in making decisions regarding autonomous vehicles on public roads.[41]

Ontario

In Ontario, Regulation 306/15 permits the testing of CAVs on provincial roads. In 2019, the Ontario AV Pilot Program was expanded to permit either remote or passenger assisted operations. Collaboration across different government entities has helped to accelerate key infrastructure projects in the province.



Ontario in 2020

Legislation & policy

Ontario's policy foundation is strong

Ontario has a strong policy and legislative foundation, which includes important collaboration and forward-thinking policies that enable innovation and the translation of these developments into practice.

KEY LEGISLATION & POLICY STRENGTHS

Collaboration across different levels of government

There has been a demonstrable willingness at the federal, provincial and municipal levels to **foster stakeholder collaboration and develop policies** that are conducive to the growth of the automotive and mobility ecosystem. Examples of forums where different levels of government collaborate include the Canadian Council of Motor Transport Administrators and the Transportation Association of Canada. These two bodies worked together to monitor emerging AV technologies and issues, including legislative changes in other jurisdictions, ongoing technological developments in vehicle intelligence, and the testing phases of early-adopter jurisdictions.

At the onset of the COVID-19 pandemic, Federal and Provincial governments began work on various cross-government solutions to better understand the implications of COVID-19 on demand and supply of personal protective equipment and critical supplies such as ventilators, including the use of centralized procurement, decision-support tools, and optimized supply chain management. While it is currently unclear if these initiatives will continue once the pandemic subsides, increased collaboration and cross-government policy development are likely to continue for shared priority initiatives.

Municipal transportation strategies focused on innovation

Various municipalities across Ontario have adopted mobility technologies (e.g., on-demand transit service in Innisfil and Niagara Region, smart traffic system in Ottawa) or have defined their transportation plans for the future (e.g., AV transit shuttle pilot in Toronto). While the mobility innovation maturity curve differs amongst municipalities, there is a general trend from municipalities towards adopting innovative tools and practices.

For example, the Halton and Peel regions of Ontario are currently piloting a web-based service known as a Municipal Reference Model, to help define and plan municipal programs and service delivery.

Additionally, there is a **strong vision for the automotive and mobility ecosystem shared across various municipal jurisdictions in Ontario**. Existing forums such as the Municipal Alliance for Connected and Autonomous Vehicles in Ontario (MACAVO), Smart Freight Centre, and municipal/regional boards of trade can be leveraged to facilitate dialogue and collaboration amongst municipalities.

Ontario in 2020

Legislation & policy

Ontario's policy foundation is strong

Ontario has engaged proactively in the policy and legislative landscape, including recently engaging with the public and industry on a "made in Ontario" approach to privacy. Policies and laws are developed to nurture innovation in Ontario while protecting Ontarians and paving the way for more sustainable solutions.

KEY LEGISLATION & POLICY STRENGTHS (CONT.)

Leading in sustainable transportation strategies and policies

The Ontario's government is committed to the safe, sustainable and the efficient movement of goods and people, as highlighted by the framework contained in the Ministry of Transportation of Ontario's (MTO's) Sustainability inSight strategy.[19]

Furthermore, strategies such as MTO's #CycleON Action Plan 2.0 – a comprehensive, cross-ministry and agency approach to advancing cycling in Ontario between 2018 and 2023 – place Ontario among the leading jurisdictions for micro-mobility related policies and infrastructure development activities.[20] These initiatives cement Ontario's position as a **global leader in sustainable mobility policies**.

Regulatory and policy leader for testing, development, and privacy

Globally, Ontario is seen as a leader in regulatory design for automotive and mobility testing, given the province's leading pilot testing legislation. The Ontario government is also actively engaging with various agencies such as the OEB to achieve regulatory excellence.[18] The Ontario government has displayed a strong commitment to enable the development of digital and physical infrastructure through policy reform and investment.

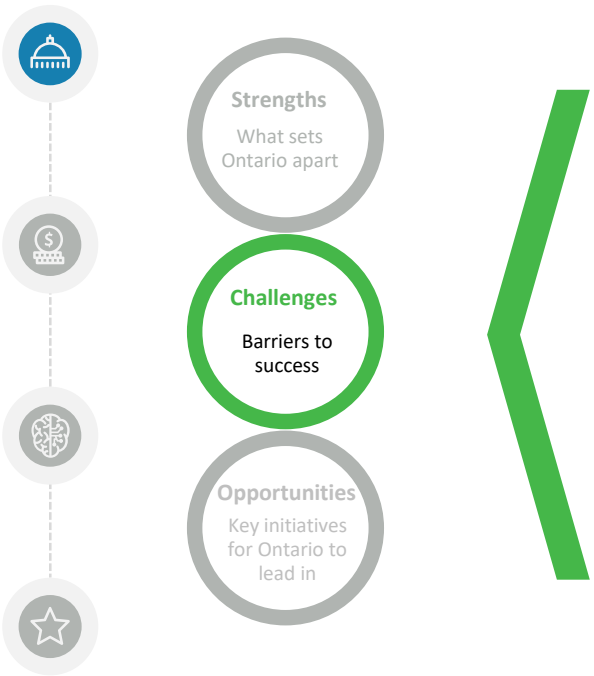
Further, Ontario's former Information and Privacy Commissioner coined the term "Privacy by Design", setting up Ontario as a leader in privacy on the world stage and informing global legislation. The Government of Ontario is committed to a **"made in Ontario" solution to privacy rights**, and is currently conducting public and industry consultations on how to address gaps in Ontario's legislative privacy framework as it relates to private businesses and organizations.[42] Organizations that wish to be part of the consultation must finalize their submission prior to October 1, 2020. Ontario continues to engage with the public and industry proactively in leading-edge privacy discussions on forward-looking legislation, guidance, and policy. These discussions will be critical for maintaining a proportional approach to privacy, and a safe, secure, and sustainable automotive and mobility ecosystem.

Ontario in 2020

Legislation & policy

Ontario is leading consultations to address harmonization challenges

Ontario will continue to face challenges ensuring collaborative efforts are also reflected into harmonized and standardized requirements – for example, across cybersecurity and insurance. These challenges pose a risk of increased costs to ecosystem players seeking clarity and aiming to maintain safety in both innovation and market activities. Ontario's government and industry stakeholders are taking a leading role in discussing and addressing these challenges.



KEY LEGISLATION & POLICY CHALLENGES

Insurance and data models for CAVs

The use of CAVs creates a challenge for the insurance industry to develop the types of **insurance models reflective of the new landscape, technology, and use** patterns. In developing these new models, data is a primary driver for new insurance and liability models, and insurers are keen to gain access to user data in order to develop insights. This also raises **privacy and data security issues** and the market will require the appropriate regulatory oversight to ensure that insurers continue to innovate in a manner that considers the imperatives of data privacy.

Maintaining alignment between regions

While many municipalities and regions in Ontario have unique and impactful transportation strategies, it is important there is also alignment and strong collaboration between regions to ensure interoperable environments between jurisdictions. **Diverging visions, strategies, and transit fragmentation** may lead to differing policies and strategies relating to CAVs, which will increase the risk of misalignment between regions.

Multiple sources for overlapping technical standards

Currently, Ontario's ecosystem operates under a **patchwork of regulatory requirements and international standards**. The standardization of liability, connectivity and interoperability, as well as the harmonization of industry standards (e.g., NIST and ISO for cybersecurity) is seen as a requirement to achieving a prosperous automotive and mobility ecosystem. Both government and industry stakeholders in Ontario are leading important national and global harmonization discussions.

Ontario's Key Opportunities – Legislation & policy

The following are key opportunities related to Legislation and policy.

Building off Ontario's Strengths

- ✓ Collaboration across different levels of government
- ✓ Innovative and sustainable transportation strategies
- ✓ Regulatory and policy leader in testing, development, and privacy

Addressing Key Challenges

- ✓ Insurance and data models for CAVs
- ✓ Maintaining alignment between regions
- ✓ Multiple technical standards

Developing Opportunities

- ✓ Standardization between jurisdictions
- ✓ Developing privacy guidance
- ✓ Improving collaboration and co-developed assets
- ✓ Optimizing procurement models

KEY LEGISLATION & POLICY OPPORTUNITIES

Streamline and standardize cross-jurisdictional requirements

As the regulatory environment surrounding CAVs continues to evolve, Ontario is well positioned to lead **cross-jurisdictional collaborative efforts to harmonize and standardize requirements** for the automotive and mobility ecosystem. This includes working with other jurisdictions to develop an interoperable legislative environment where regulations are streamlined and roadblocks are minimized across regional boundaries. The harmonization and standardization of safety requirements, testing and development requirements, cybersecurity and privacy, and data sharing requirements and data formats will support interoperability and the protection of data.

Develop and embed privacy guidance across the ecosystem

Unprecedented volumes and new types of data generated by CAVs could potentially improve safety, insurance options, environmental outcomes, and accessibility. However, **realizing these benefits is contingent on the secure transmission, storage, and use of data in compliance with privacy laws and best practices to ensure the efficient and secure sharing of data across partners.** Ontario has an opportunity to lead this discussion - together with Ontario's and Canada's privacy commissioners, and the Ontario public - and develop automotive and mobility privacy guidance that could be adopted nationally and globally.

Ontario's Key Opportunities – Legislation & policy

The following are key opportunities related to Legislation and policy.

Building off Ontario's Strengths

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- ✓ Innovative and sustainable transportation strategies
- ✓ Regulatory and policy leader in testing, development, and privacy

Addressing Key Challenges

- ✓ Insurance and data models for CAVs
- ✓ Maintaining alignment between regions
- ✓ Multiple technical standards

Developing Opportunities

- ✓ Standardization between jurisdictions
- ✓ Developing privacy guidance
- ✓ Improving collaboration and co-developed assets
- ✓ Optimizing procurement models

KEY LEGISLATION & POLICY OPPORTUNITIES (CONT.)

Improve cross-governmental collaboration to co-develop transportation assets

Opportunities exist to leverage existing government assets (including data assets) across multiple levels and areas of government, for the advancement of the automotive and mobility ecosystem. The public sector can improve government-operated fleets (e.g., postal service and military vehicles), invest in new related infrastructure (e.g., highways, parking), and spur provincial and local adoption of autonomous vehicles, shared mobility, and other new types of travel through a comprehensive operations, asset management, data management, and procurement strategy. New use cases will require **cross-governmental collaboration and shared assets to drive and delivery on strategies with shared goals**. This will create new opportunities such as developing an inventory of data assets, developing data sharing and data formatting standards and enabling collaboration across the ecosystem to promote secure, public-focused data sharing initiatives.

For example, there are opportunities for collaboration across different ministries (such as the Ministry of Transportation and the Ontario Ministry of Health and Long Term Care) to help identify the most promising areas of cross-sector innovation and shared innovation assets. **Mobility innovations supporting healthcare have the potential to both reduce healthcare spending and improve the quality and accessibility of care.**

Optimize procurement models

Centralized, tailored procurement models and optimized supply chain management tools should be designed and used to enable the broader automotive and mobility ecosystem to share information, manage vendor-related risks, and make decisions using self-service analysis and scenario modelling. Multiple levels of government need to work together to develop innovative and effective procurement models that capture the emerging landscape and meet public needs, as was demonstrated through collaborative procurement of critical supplies during COVID-19. For example, the Healthcare Supply Chain Network Innovation Procurement Toolkit includes templates for procurement, a guide to outcome-based specifications, a guide for evaluation criteria, and a guide to evaluate the total cost of ownership.

Ontario's automotive and mobility ecosystem analysis - *Economic development*

Ontario in 2020

Economic development

Ontario's growing economic development environment

Ontario's is nationally and globally-renowned for bringing people and organizations together to support innovation in the automotive and mobility space. Ontario's favourable testing environment, infrastructure and funding commitments, public-private partnership, and use of accelerators to promote scale-ups and commercial success, have attracted new industry players to the Ontario ecosystem.

AVIN's five main objectives[43]

1. Foster the commercialization of Ontario-made advanced automotive technologies and smart mobility solutions.
2. Showcase Ontario as the leader in the development, testing, piloting and adoption of the latest transportation and infrastructure technologies.
3. Drive innovation and collaboration among the growing network of stakeholders at the convergence of automotive and technology.
4. Leverage and retain Ontario's highly skilled talent.
5. Harness Ontario's regional strengths and capabilities and support its clusters of automotive and technology.

Provincial government economic development

Driving Prosperity: The Future of Ontario's Automotive Sector

As part of the Driving Prosperity plan, the Ontario government has invested in the advanced automotive and mobility technology landscape in order to develop a collaborative environment between key stakeholders (e.g., public, private sector, and academia). Their $85 million commitment (through AVIN) is connecting the province's world leading automotive and technology sectors, first-class talent and regional infrastructure to support entrepreneurship and create jobs.[4]

Ontario funding transit network with the Greater Toronto Area (GTA)

Transit networks within the GTA received a $28.5 billion expansion, including an investment of $11.2 billion to support four rapid transit projects.[4, 44] New builds will leverage the latest smart infrastructure and vehicle technology. Expanded transit network will improve access to transit and economic opportunities (e.g., construction jobs, connect community to places of employment, reduce dependence on private vehicle ownership.

Ontario funding micro-mobility

The Ontario's #CycleON Action Plan 2.0, aims to develop a province-wide cycling network by investing $15 million into cycling infrastructure. In addition, the Ontario Municipal Commuter Cycling provided $94 million in funding to 118 municipalities to support the development of cycling infrastructure. Since 2015, Bike Share Toronto has increased their number of bikes and bike-sharing stations and have enjoyed a 450% increase in their services.[45]

Ontario's Autonomous Vehicle Innovation Network (AVIN)

Led by the OCE, AVIN is a key component of Driving Prosperity where it supports industry led projects within the advanced automotive and smart mobility ecosystem, as well as preparing Ontario's transportation and infrastructure networks.[46]

Ontario in 2020

Economic development

Ontario's growing economic development environment

According to *InvestinOntario*, the province is currently home to **5 global OEMs** establishing vehicles, **700+ parts suppliers**, 500+ tool, die and mould companies, and **24 automotive skilled trade programs**.[47] In 2019, the province produced **1.9 million vehicles** with 85 percent of Ontario's auto production being exported outside the province and generating **$70.6 billion** in automotive exports in the same year.[47]

In September 2020, the union of Canadian auto workers announced a tentative agreement with Ford Motor Company, which included **$1.98 billion** towards new assembly plants in Windsor and Oakville. The deal includes five models of electric vehicles (EV) to be produced at the Ford Oakville plant with the first of the vehicles rolling off the line in 2025. The union also announced intentions to negotiate similar outcomes with Fiat Chrysler and General Motors. Unifor president Jerry Dias explained, "This is a major commitment from Ford Motor Company… **a decades long commitment**."[56]

Private sector investments

- The Ottawa Research and Engineering Center (REC) was established as part of **Ford's $1.2 billion investment in Canada**. The REC focuses on smart mobility technologies, in-vehicle internet capabilities and safety.[48]
- **GM opened their Canadian Technical Centre in Markham,** able to hold 1,000 engineers. The center focuses on developing advanced driver assistance features, their fully autonomous vehicle program and infotainment design and improvements.[4]
- **Uber dedicated US$150 million** to invest in a Toronto Advanced Technology Group to develop new engineering talent hubs to grow their autonomous research teams. These hubs will bring in 300 new employees.[49]
- **Microsoft** is increasing their automotive and SME partner ecosystem to help advance smart mobility solutions. Microsoft has partnered with TomTom and Moovit to develop a multi-mode trip planner using Azure Maps.[50] Microsoft's AI for Accessibility is a **$25 million grant program** that help start-ups advance mobility equality. MapinHood, a navigation app designed for differently-abled individuals was created by a Toronto start-up, iMerciv. iMerciv was accepted by Microsoft to further develop their technology.[51]
- The **MaRS Discovery District** connects investment capital to SMEs and has helped to raise $5 billion in total capital, which includes support for SMEs in the automotive and mobility ecosystem. There are over 1,200 companies in the MaRS ecosystem, and 25 percent of all Canadian venture capital goes through MaRS.[52]

Key highlights

- Over 200 companies producing automotive and mobility technologies
- Dedicated funding from private sector organizations for innovation
- Private sector grant programs focused on accessibility and equality
- Increase in venture capital for automotive and mobility start-ups

Ontario in 2020

Economic development

Ontario's automotive and mobility ecosystem investments and economic developments

Government & related entities

CANADA INFRASTRUCTURE BANK

$35B

Funding into infrastructure projects including public transit, transportation corridors and green infrastructure projects in 2020.[53]

Transport Canada

$2.9M

Funding for advanced automotive and smart mobility projects over four years.[54]

AVIN Ontario

$85M

Committed into talent development, R&D funding, technical support for business and testing facilities over five years.[4,55]

Large multinational corporations

Ford

$1.2B

Invested in the Canadian economy. Built the Ottawa Research and Engineering Centre, and in 2020 committed an additional $1.98B to Ontario assembly plants.[56]

GM

$550M

Invested in factories in Oshawa and St. Catharines since 2016.[57]

Uber

$150M

Invested in Toronto Advanced Technology Group talent hub in 2019, and in 2020 committed $800M globally to electrifying its drivers in US, EU, and Canadian cities.[58]

BlackBerry

$100M

While the New Innovation Centre for CAVs was made in 2019, 175M vehicles have embedded BlackBerry software in 2020.[59]

MAGNA

$400M

Joint investment in R&D into EV technologies since 2011.[60]

Sample incubators & accelerators[13]

CATALYST[137]

DMZ

RYERSON LEADERSHIP LAB>>>

UTEST UNIVERSITY OF TORONTO EARLY-STAGE TECHNOLOGY

VELOCITY

COMMUNITECH

techstars TORONTO ACCELERATOR

Spark CENTRE

NEXT

MaRS

MAGNA RocketSpace

Ontario in 2020

Economic development

Small and Medium Sized Enterprise (SME) development

There is a vibrant start-up community in Ontario's automotive and mobility ecosystem. Ontario has over 300+ SMEs registered and 40 incubators and accelerators operating within the automotive and mobility ecosystem.[13] Ontario's cluster of incubators and accelerators facilitates a collaborative working environment for SMEs and enjoys support from a diverse group of organizations within the automotive and mobility ecosystem. Below and to the right are a few examples of key developments in and success stories in Ontario:

- **Catalyst137** in Kitchener-Waterloo is among the largest urban hubs globally within the technology development space related to Internet of Things (IoT). Start-ups have the ability to collaborate with multinational corporations. They also have access to many different support services such as, mentorship, government funding, and VCs.[61]
- Queen's University has partnered with the **L-Spark Launch Acceleration Program** in order to broaden access opportunities for technology businesses run by women.[62]
- Ontario has **over 200 AI companies** who have raised a total of $2.84B since 2016. According to the Vector Institute, there is high concentration of AI start-ups located in the Toronto-Waterloo Corridor.[63]
- In 2018, the Toronto-Waterloo Corridor received funding through the **federal innovation superclusters program**, which has impacted the automotive manufacturing industry. This funding will enable Ontario to lead on the global stage by supporting industry-led projects to continue progress within the advanced automotive sector, including advanced manufacturing, IoT, AL/ML, robotics and advanced materials.[64]

Spotlight on select SMEs in Ontario

IN·VISION ARTIFICIAL INTELLIGENCE

INVISION AI has developed AI solution for real time collision warning, autonomous rail vehicles and vehicle occupancy counters.[65]

CLOUD DX

CLOUD DX use cloud based technologies in an innovative way to transfer patent data within the health care sector.[66]

MIOVISION

MIOVISION provides traffic data collection and management solutions for transportation networks in order to build smart city platform.[67]

Pantonium

PANTONIUM provides AI based route optimization software and digitized infrastructure to optimize public transit routes.[68]

SENSOR CORTEK

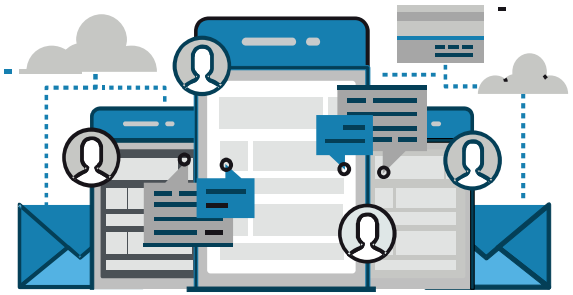
SENSOR CORTEX provides specialized automotive sensors with embedded AI to improve operational safety in self driving and advanced driver assistance systems.[69]

Gatik

GATIK offers road ready Level 4 autonomous driving capabilities for B2B good delivery, by providing efficient short-haul logistics in city environments.[70]

nuport

NUPORT is Canada's first autonomous, driverless trucking company that uses platooning and autonomous driving technology to create self driving supply chains.[71]



Ontario in 2020

Economic development

Economic development insights from leading jurisdictions

Ontario's collaborative efforts and accelerator programs have made it a destination for innovation and development in the automotive and mobility global ecosystem. Some other jurisdictions are also pushing the envelope in developing cutting-edge strategies and programs to promote larger scale change and economic development.

UK

The UK has been a leader in connecting the dots on autonomous vehicle strategy and economic development – resulting in key contributions to the economy and the addition of new jobs.

As UK's innovation agency, Innovate UK supports innovative and technology-driven companies, including those operating within the automotive and mobility landscape, supported by Innovate UK's Manufacturing, Materials & Mobility Team.[72] By fostering collaboration between public, private and academia, Zenzic is shaping UK's connected and self-driving ecosystem at the national level.[73]

USA

In the United States, state-led economic development organizations are placing their bets on the future mobility system's impact on their economies and the public, and investing in long-term programs.

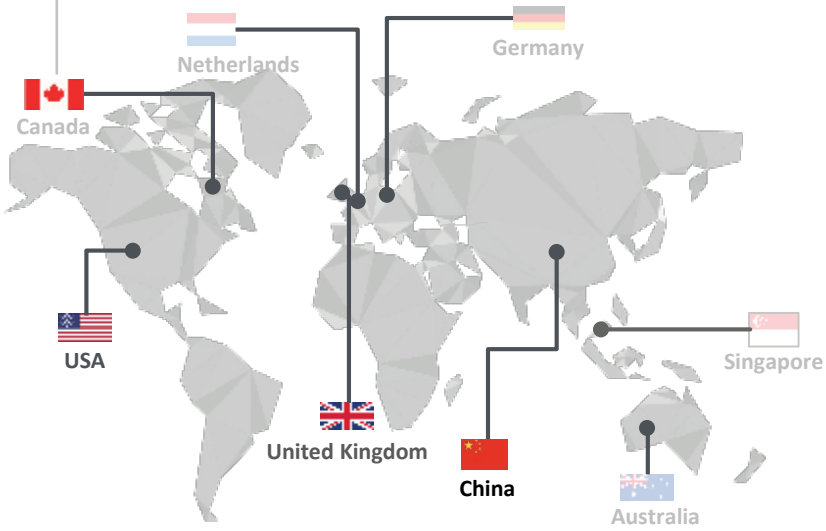
Under the Michigan Economic Development Corp., PlanetM is actively investing in stakeholder collaboration in order to increase economic activity within the future of mobility ecosystem. Since 2017, PlanetM has helped invest over $91 million into the advanced mobility ecosystem.[74]

China

Earlier this year, the Strategy for Innovation and Development of Intelligent Vehicles was published by various Chinese government departments in an attempt to advance China's role in the autonomous vehicle industry over the next 30 years. Some components of this strategy include government collaboration, research and development, intelligent infrastructure, enhanced laws / standards and adherence to cybersecurity requirements.[75]

Ontario

Ontario is home to clusters of incubators and technology development hubs, including a number of large private-sector organizations such as Microsoft, Uber, and GM, all of whom are making investments in the province for testing and research. A number of provincial and federal programs are partnering with these private sector investments and provide attractive support.



Ontario in 2020

Economic development

Strong talent, markets, and ideas, bolstered by strategic investments

Ontario's economic landscape - public and private investments in talent and innovation, with access to cross-jurisdictional markets – are placing Ontario as a leader on the world stage and attracting business and jobs. Key investments in the broader ecosystem and the future of mobility – including transit, micro-mobility, mobility-as-a-service (MaaS), and advanced manufacturing – are catalysts for long-term economic growth in Ontario.

KEY ECONOMIC DEVELOPMENT STRENGTHS

Ontario's strong talent pool and academic research community

The talent emerging from leading academic institutions in Ontario, such as University of Waterloo's dedicated Centre for Automotive Research, is fueling both R&D and innovation. Ontario Tech University in Oshawa provides the **only accredited Automotive Engineering program** of its kind in Canada to help students meet the need for advancements in the automotive industry by accelerating research and the development of electric and fuel-cell driven vehicles. Survey respondents cited **talent as the number one reason for establishing a presence in Ontario**, growing their business and employee base in Ontario.

Ontario's strong industry rooting and access to North American markets

Year-over-year, Ontario has been capitalizing on their existing assets and talent in this ecosystem. Ontario now has **over 250 companies producing autonomous vehicle technology**.[76] Ontario is well positioned to capture the ever-expanding global autonomous vehicle market which is expected reach US$1.3 trillion in value by 2035.[4] The Canada-U.S.-Mexico Agreement (CUSMA) allows Ontario to have access to the U.S. auto market[77], providing further access to the revenue and private investments needed to continue to scale in other markets globally.

A vibrant start-up community supported by incubators and accelerators

Ontario boasts a high density of incubators and accelerators supporting the commercialization of innovation across the automotive and mobility ecosystem. The province is host one of the **largest urban hubs for technology development** at Catalyst137 in Kitchener-Waterloo.

Ontario in 2020

Economic development

Strong talent, markets, and ideas, bolstered by strategic investments

Ontario's and Canada's governments are committed to fostering innovation in Ontario. All levels of government have recognized the economic return on investments in the automotive and mobility space, and are continuing to support programs, with immediate and long-term economic benefits to Ontario.

KEY ECONOMIC DEVELOPMENT STRENGTHS (CONT.)

Government and public support for retooling and R&D

The federal and provincial government have recognized the opportunity to promote collaboration across the broader ecosystem and have put forward several financial support programs to create a collaborative environment for multiple stakeholders to help foster the innovation of CAVs. This includes supporting the use and retooling of existing infrastructure and plants to develop innovative technologies like electric vehicles.[78] **The provincial government has a strong commitment to the automotive and smart mobility ecosystem, and understands the economic return on these investments**.

The federal government recognizes the same opportunity and has committed federal funding to enhance the advanced automotive and smart mobility industry in the Toronto-Waterloo corridor, including as part of the Advanced Manufacturing Supercluster Initiative as it relates to automotive manufacturing advancements. In addition, the Canadian government has provided $8.3 billion in federal funding for infrastructure across Ontario municipalities and includes investment in Metrolinx.[79]

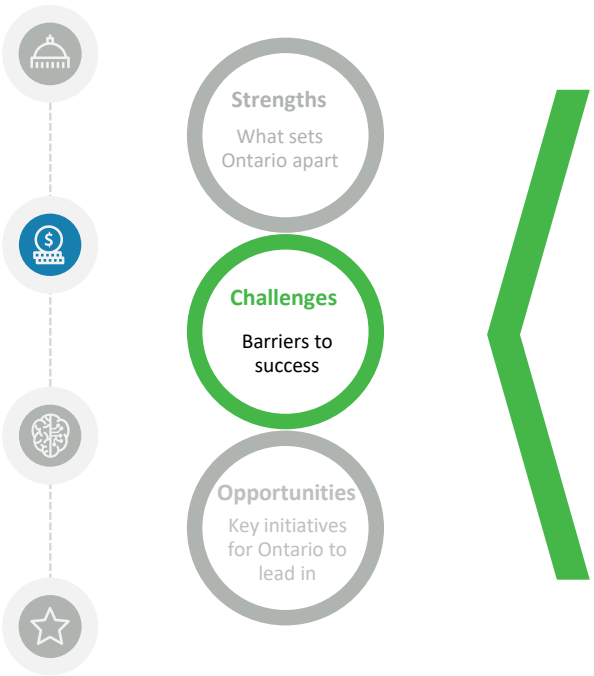
Since 2016, the Ford Motor Co. has invested over $1 billion into a growing ecosystem[4] and committed an additional $1.9 billion to Ontario assembly plants including retooling for EV production – with impacts to hundreds of billions of dollars of economic activity across the broader ecosystem.[80] The Ontario government has also committed $85 million in funding over the next five years for R&D in CAV technologies.[43] Provincially, there have also been major investments that span from mass transit projects to developing infrastructure for micro-mobility and mobility as a service (MaaS).

Ontario in 2020

Economic development

Market disruption and the COVID-19 pandemic are testing Ontario

The entire automotive sector is continuing to be disrupted by market forces and changing public demands. This year, Ontario was also faced with the global COVID-19 pandemic, resulting in new challenges to the health and safety of the public in all mobility spaces. These events have created global challenges to the continued use, adoption, and trust in the future of mobility – challenges Ontario is particularly well-suited to address.



KEY ECONOMIC DEVELOPMENT CHALLENGES

Foreign trade policies affecting automotive sector

Ontario is subject to a **number of foreign trade policies and tariffs**. To minimize the impact of US tariffs, Ontario will require close collaboration with the federal government in order to adapt to the dynamic trade environment with the United States.[4]

Competing incentives for start-ups

One of the challenges that Ontario may continue to face is **competition with other jurisdictions** who also provide incentives and private investment capital opportunities, such as the United States. However, the large number of incentives, investment opportunities, talent pool growth, and environmental benefits are drawing business to Ontario and bringing a large number of start-ups from other jurisdictions into the province. Most surveyed stakeholders indicate a more favorable environment and growing opportunities in Ontario, with **Ontario continuing to compete** in this area on the global stage.

Interoperability between cities

Ecosystem stakeholders surveyed underscored the importance of shared or interoperable digital and physical infrastructure between cities. To have effective integrated mobility and an interoperable landscape where advanced automotive and smart mobility technologies are accommodated, **the connection points between city infrastructure** – for example, from one city to a neighboring city – should be considered.

Enhancing public transit experiences, given COVID-19 challenges

Due to the pandemic, concerns about health and safety in shared settings has led to a decline in public transit ridership. Understanding the key role public transit plays in restarting the economy and ensuring the safety of the public, the Ontario government has provided $1B+ in support of public transit[81] to establish a safer future and foster public trust in shared mobility. While these specific challenges may be resolved as the pandemic subsides, growth in innovations such as intelligent scheduling automation and dynamic routing (e.g., on-demand transit service) throughout COVID-19 will continue to support operational efficiencies and **enhanced transit experiences for the public**.

Ontario's Key Opportunities – Economic development

The following are key opportunities related to Economic Development.

Building off Ontario's Strengths

- ✓ Strong talent pool and research community
- ✓ Government and public support for retooling and R&D
- ✓ Strong industry rooting, market access, and start-up community
- ✓ Key incubators and accelerators

Addressing Key Challenges

- ✓ Foreign trade policies
- ✓ Competing incentives
- ✓ Interoperability between cities
- ✓ Enhancing public transit experiences during COVID-19

Developing Opportunities

- ✓ Building transit and digital infrastructure
- ✓ Expanding synergies with VCs and PE
- ✓ Focusing on high-ROI scale-up opportunities
- ✓ Restructuring and retooling existing plants

KEY ECONOMIC DEVELOPMENT OPPORTUNITIES

Expand transit and digital infrastructure, including micro-mobility and telecommunications
Building off major investments in mass transit projects and telecommunications development, Ontario's next opportunity is to continue to track and expand on these investments and continue support for sustainable infrastructure.

For example, **governments are actively enabling micro-mobility**, as the public increases use of cycling over public transit, taxis or other ride-sharing services (e.g., Uber). As such, additional infrastructure related changes will be required to support and expand micro-mobility services (e.g., bike lanes, bike parking/lockers, e-charging, multi-modal mobility as a service (MaaS) platforms, congestion/social distancing management). The continued tracking of private and public sector telecommunications investments and initiatives will also be important, to ensure the effective and sustainable use of this growing infrastructure by the broader ecosystem.

Create and expand synergies with private sector investors, Venture Capital (VC) and Private Equity (PE)
Major automotive sector organizations such as Ford and GM have made sizeable investments in smart mobility technologies and autonomous vehicles. However, the industry is also seeing investments flow from technology companies such as Uber and Microsoft. The increasing fusion of the technology industry with automotive in the private sector will present new opportunities for organizations to optimize the value of these synergies and support.

Focus on supporting high-ROI scale-up opportunities
As technologies develop, certain focus areas have begun to reflect higher ROIs. Specifically, enhanced payment systems, driverless trucking technologies, traffic data management, and mobility as a service (MaaS), along with various authentication mechanisms have generated high rates of returns for investors. Additionally, as the Ontario market grows increasingly saturated with fledgling enterprises, there will be **promising opportunities to focus on scaling up** the best among these to improve their long-term sustainability.

Restructuring and retooling existing plants
Ontario has many manufacturing plants that can readily be **converted and retooled to fit the next opportunity**. For example, idle GM plants in Oshawa have been retooled to provide much needed masks during the pandemic[82] and Ford plants in Oakville are being retooled for EV production.[83] In the long-term, Ontario can leverage strengths in advanced manufacturing to help develop the hardware needed to support the future of mobility, including CAVs, EVs, sensors, and related communications devices.

Ontario's automotive and mobility ecosystem analysis - *Research and development*

Ontario in 2020

Research & development

Ontario's research and development ecosystem – Driving change in Ontario

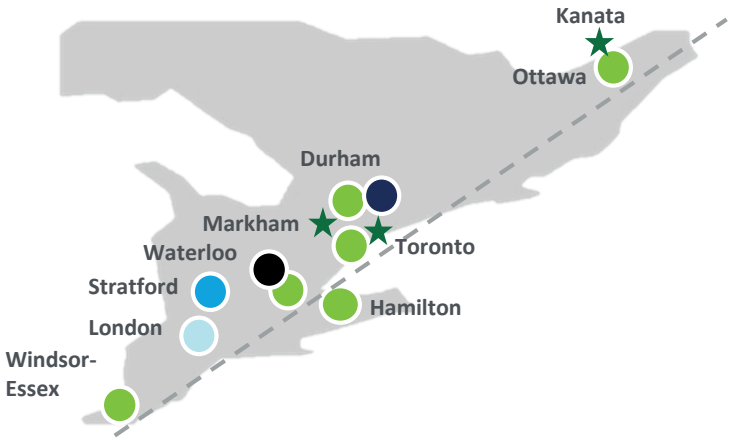
Ontario has developed a favourable environment for research and development by building key, collaborative clusters of innovation throughout the province. These clusters include both public and private sector organizations and support, and many have leading academic institutions and not-for-profit organizations guiding cutting-edge research.

CAV testing and demonstration map

Ontario's CAV innovation is located along a corridor, clustered close to academic and innovation centres and spilling into nearby jurisdictions.

Legend: Clusters of CAV testing and demonstration

- AVIN Regional Technology Development Sites (RTDSs)
- AVIN Demonstration Zone
- Automotive Centre of Excellence (ACE) at the Ontario Tech University
- National Research Council Canada space for manufacturing and automotive innovation
- Waterloo Centre for Automotive Research (WatCAR)
- Industry Research and Initiatives/Pilots: GM (Markham), Ford (Kanata), Uber (Toronto), Kanata Autonomous Vehicle Cluster led by BlackBerry QNX (Kanata)



Key highlights

Leading academic research institutions

Public, private, and not-for-profit R&D partnerships

AVIN RTDSs and Demonstration Zones

Cross-jurisdictional innovation partnerships

Ontario in 2020

Research & development

Ontario's unique automotive and mobility R&D initiative – Ontario's AVIN

Unique to Ontario, Ontario's AVIN is a key catalyst and provides critical support to the growing automotive and mobility ecosystem. No other jurisdiction globally has an initiative that is identical in nature and size to AVIN. The entire automotive and mobility research and growth ecosystem in Ontario is tied to AVIN in some way – whether through facilitated collaborations and discussions, new investment opportunities, support growing a footprint nationally and globally, or co-developing emerging technology with multiple stakeholders that will change the future of mobility.

AVIN Funds and Development Programs

AVIN offers two streams of the AV R&D Partnership Fund. These funds and strategic partnerships allow SMEs and start-ups to develop and bring to market their automotive and mobility technologies.

The ability to test winter adept automotive and mobility solutions have placed Ontario on the map as a global leader. The **WinterTech Development Program** supports SMEs to validate, test, and further develop new mobility products in extreme winter climates conditions.[84]

AVIN's Regional Technology Development Sites (RTDSs)

In supporting SMEs, AVIN's Regional Technology Development Sites (RTDSs) create an opportunity for testing automotive and mobility technologies across six different locations across Ontario. While each RTDS has a unique focus area, they each provide support for the development of new technologies. These sites bring together industry, academia and the public sector to capitalize on economic opportunities within the automotive and mobility ecosystem. The six RTDSs are located in the Waterloo Region, Ottawa Region, Hamilton Region, Durham Region, Windsor-Essex Region and Toronto Region.

AVIN Technology Demonstration Zone

Companies with automotive and mobility solutions can showcase their innovative products or services at the AVIN Technology Demonstration Zone, located in Stratford, Ontario. Stratford provides the digital and physical infrastructure needed to allow demonstration of such technologies. The Demonstration Zone's objectives include demonstrating Ontario-made and commercially ready technologies, promoting such technologies, and strengthening Ontario's position as a global leader in automotive and mobility solutions.

Key highlights

AVIN R&D Partnership Funds

AVIN's WinterTech Development Program

AVIN's Demonstration Zone

AVIN's Regional Technology Development Sites

Ontario in 2020

Research & development

Ontario's research and development – Key partnerships

Ontario's provincial R&D initiatives are supported by excellent collaboration with academic organizations and federal R&D initiatives. These collaborations open up new investment and innovation opportunities for Ontario-based organizations, and provide unique opportunities for new local testbeds, the scaling of innovation, and broader adoption nationally and globally.

Federal R&D initiatives

According to Transport Canada's 2019 annual report, **forming key policies, guidelines, and pilot programs** for CAVs and Unmanned Aircraft Systems (UAS) is central to the Transportation 2030 vision. At the national level, Transport Canada has run simulations and field trials to better understand advanced collision deterrence systems as they relate to automotive and mobility technologies.[54]

The **Program to Advance Connectivity and Automation in the Transportation System** (ACATS) is an initiative started by Transport Canada in 2017. This program work with provinces to develop guidelines and conduct research with $2.9 million in funding over four years to support automotive and mobility type projects and pilot programs such as autonomous shuttle service trials in Toronto.[54]

The Natural Sciences and Engineering Research Council of Canada provides **Collaborative Research and Development Grants (CRD)** to universities and their partners (e.g., private and/or public sector) to help advance autonomous and mobility systems R&D.[85]

The continuing adoption of existing and emerging technologies in smart cities will help build the necessary **digital and energy infrastructure** needed to accelerate the automotive and mobility ecosystem. The federal government is partnering with municipalities, regional governments, and Indigenous communities throughout the country by delivering the Smart Cities Challenge. This challenge will help encourage innovation and further develop R&D activities.[86]

By collaborating with regional and national organizations, the **National Research Council of Canada Industrial Research Assistance Program (NRC IRAP)** aims to accelerate the growth of innovative SME businesses by providing financial and advisory support. The NRC IRAP supports SMEs to develop and commercialize their technologies.[87]

Provincial and academic collaboration

In collaboration with the MTO and City of Toronto, the Intelligent Transportation Systems (ITS) Centre and Testbed at the University of Toronto is **researching ITS technologies and various applications**. This research is **multi-jurisdictional across Ontario and various regional transportation agencies**. This R&D program will help address the multifaceted considerations between technology, cognition and behaviour, and social interaction, economics, and political systems. The University of Toronto is also researching data management platforms in order to help deliver ITS by facilitating data exchange between public-private sector organizations.[88]

Key highlights

- Academic and private sector partnerships
- Federal initiatives supporting Ontario R&D
- Multi-jurisdictional collaboration
- Provincial and academic collaboration

Ontario in 2020

Research & development

Ontario's R&D focus on telecommunications and good transport innovation

Ontario is paving the way for the future of telecommunications, and how the automotive and mobility ecosystem will be able to leverage this growing network. Additionally, Ontario is continuing to innovate in the effective and sustainable movement of goods, along with people, and have proposed new, tailored test facilities to move these innovations forward in the province.

5G Networks and testbeds

Ontario's Broadband and Cellular Strategy will expand telecommunication networks throughout the province increasing high-speed communication and allowing organizations to offer advanced mobility technologies leading to new jobs, R&D, and increased economic activity. 5G networks will accelerate and enable safer CAVs, smart cities and IoT deceives. ENCQOR 5G (Evolution of Networked Services through a Corridor in Québec and Ontario for Research and Innovation) is an R&D partnership between the private sector and the federal as well as provincial governments. Offering Canada's largest 5G testbed, ENCQOR enables the testing of emerging technologies within the automotive and mobility ecosystem. The ENCQOR 5G initiative brings together multinational corporations (e.g., Ericsson, Ciena, IBM), SMEs, academia, and government in a collaborative environment that promises a strong digital economy and long-term sustained economic growth in Ontario and the larger Canadian innovation ecosystem.[89]

Goods movement

Given the current pandemic, the way consumers and business think about automotive and mobility technologies has changed. With this shift, certain trends in R&D have remained the same while others have accelerated, such as the movement of goods.

Autonomous driving capabilities for middle mile B2B logistics is gaining traction in Ontario and around the world as demand for eCommerce capabilities surges. Gatik for example, is partnering with major retailers to bring full adoption of SAE Level 4 driving for middle mile transportation on fixed and predictable routes without an operator in the vehicle. Gatik, along with similar organizations across the automotive and mobility ecosystem, are testing sensor fusion technology while solving for critical edge cases specific to Ontario's climatic environment.

Transportation innovation zones

Early in 2020, a transportation innovation zone (TIZ) within the Exhibition Place was proposed to the Toronto city council's infrastructure and environment committee. Pending final approval, city council has adopted the proposed idea. Situated close to the downtown core, the proposed test facility will provide R&D opportunities around the transportation of people and goods, smart traffic signals, and pedestrian safety.[28]

Key highlights

- Advanced mobility R&D infrastructure
- Growing 5G networks
- Plans for a new Transportation Innovation Zone
- Advancing autonomous driving capabilities

Ontario in 2020

Research & development

Ontario's research and development – Academic and private sector partnerships

Ontario has a number of leading academic institutions and programs supporting the development and commercialization of key automotive and mobility innovations. To the right are some leading research and development programs and initiatives, many started by partnerships between industry players in the automotive and mobility market, academic and research institutions, and government-driven support programs.

Private Sector and academia R&D – Key examples

- As a **successful partnership** between Fraunhofer ICT and Western University, the Fraunhofer Project Centre for Composites Research is researching advanced polymer composites in order to develop light-weight materials with desired characteristics for the automotive and mobility sector. Successfully commercializing such materials will lead to better fuel efficiency.[90]
- The **Waterloo Centre for Automotive Research (WatCAR)** has 7 research teams that focus on the automotive and mobility sector. The Waterloo Intelligent Systems Engineering Lab researches the safety of intelligent systems and CAVs.[91]
- As a key player within Ottawa's automotive and mobility landscape, **Carleton University** has over 100 researchers within their engineering faculty that are researching ICT applications and CAVs. Carleton has 7 areas of specialization within their R&D programs which includes AI, analytics and wireless communication systems and networks (e.g., DSRC, 4G LTE, 5G).[92]
- **GM's Canadian Technical Centre** in Markham holds 1,000 engineers who research and develop autonomous vehicles and related features.[4]
- Ford has committed to a total investment of $1.2 billion within Canadian market. This includes **Ford's Ottawa Research and Engineering Centre** that focuses on advance automotive and smart mobility technologies.[56]
- A global leader in mobile transportation platforms, DiDi has established their R&D lab in the Toronto-Waterloo corridor. The **DiDi R&D lab** focusses on AI and intelligent driving research and development.[93]

Key highlights

- Academic-led research teams focused on AI, analytics, wireless communications, and networks
- Cutting-edge research in autonomous vehicles and features
- University partnerships with global industry
- Intelligent driving R&D labs

Ontario in 2020

Research & development

Research and development insights from leading global jurisdictions

Globally, national and state governments, together with agencies, academia, and government-related organizations, are investing in research, development, and testing in autonomous vehicles, connected vehicles, and mobility solutions.

Germany

In Germany, CAVs have become a key focus area of research in academia, with specific courses focused on autonomous driving from universities such as the Technical University of Munich.

USA

In California, the GoMentum Station is one of many numerous testing and research facilities for CAVs with a focus on traffic safety. The testing facility has a V2X Lab, which is able to conduct tests on V2X technology interoperability.[94]

The US Federal Transit Administration (FTA) is researching innovative solutions related to the last commuter mile. The FTA's Mobility on Demand (MOD) Sandbox project is aimed at public-private partnerships to cultivate last mile mobility innovations.

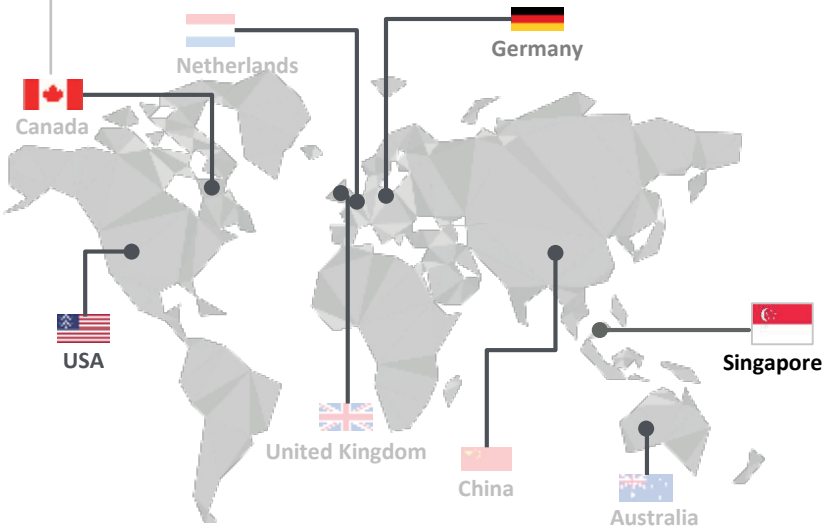
Singapore

Key research areas within Singapore's AV landscape include the development of self-driving utility vehicles that provide services such as waste collection and road sweeping, suggesting research and development in Singapore is focusing on how the AV industry can provide public service offerings.

Singapore's western side is a testing ground for autonomous vehicles. The testing areas include areas of Singapore such as Woodlands, Bukit Merah and Choa Chu Kang with more than 1,000km of public roads available for testing AVs.[95]

Ontario

In Ontario, AVIN plays a major role supporting R&D through partnership funds, regional technology development sites and the AVIN Demonstration Zone. ACATS and Collaborative Research and Development grants provide federal support to the province. Universities engage in research with multi-jurisdictional mandates such as the Intelligent Transportation System (ITS) Center and Testbed at the University of Toronto.



Ontario in 2020

Research & development

Automotive and mobility research and development growth areas

Technology is the foundational fabric driving the maturity of the automotive and mobility ecosystem. Ontario's research and development communities are shaping many areas of mobility innovation globally by focusing on some emerging technology, supporting challenges in manufacturing, communications, and authentication and trust across the supply chain. Below are key emerging technologies that are pivotal in the advancement and development of Ontario's ecosystem.

Ontario's emerging technology initiatives

Ontario is on the cusp of developing key emerging technologies that support the advancement and development of Ontario's ecosystem. Below describes a few Ontario-based organizations changing the technology landscape and contributing to the automotive and mobility ecosystem's future potential and sustainability.

ARTIFICIAL INTELLIGENCE

Artificial Intelligence (AI) is a crucial enabler for CAVs. Deep Learning systems can be trained to mimic human decision-making which could systematically ease human-machine interaction on the roads. Behavior prediction of other vehicles and pedestrians can enhance safety and operational effectiveness of transit usage.

Based in Toronto, the Vector Institute for Artificial Intelligence, an organization dedicated to research and talent development in the field of AI, is excelling in machine and deep learning. Recent examples include development of 'first of its kind' **AI-powered search engine to pre-train models**.[96]

BLOCKCHAIN

Blockchain is a digital, decentralized, ledger that enables information to be shared and processed by a network of participants. It enables exchanging value without the use of an intermediary providing near-real time, transparent and reliable information exchange across the mobility ecosystem.

Mavennet is a Toronto based start-up which provides **Blockchain-enabled and AI products with a focus on large enterprise implementations**, who recently won large governmental contracts for enabling the cross-border tracking of oil low between US and Canada.[97]

CYBERSECURITY INNOVATION

Cybersecurity innovation is needed in order to defend against the range of evolving and new cyber threats to the connected and autonomous vehicles ecosystem. Organizations operating in this sector must develop robust defense mechanisms to improve their data security, manage identities and rights, secure the cloud, and enhance incident management. Emerging technologies include **enhanced authentication techniques and the use of AI** to proactively detect threats.

Headquartered in Waterloo, Blackberry's QNX software is embedded in 175 million cars on the road (as of June 2020). Blackberry provides a broad portfolio of **security and software for CAVs**.[59]

Note: Additional details can be found in Appendix B.

Ontario in 2020

Research & development

Automotive and mobility research and development growth areas (cont.)

PRIVACY ENHANCING TECHNOLOGIES

Privacy Enhancing Technologies (PETs) are being developed and tailored to address CAV challenges. The data sharing requirements for CAVs will require engagement in innovative technology strategies to realize the value of unshared data assets. By adopting PETs, multiple parties can collaborate to gain the required insights into data assets which are currently not shared, without forfeiting any competitive insights or sensitive information.

Ontario-based organizations are making big waves globally in PETs. Cryptonumerics developed the idea for their solution during a Creative Destruction Lab, and generated **$3.5 million in seed funding and was recently acquired** by Snowflake.[98]

5G NETWORKS

5G cellular networks will provide a consistent and real time experience while allowing for ultra-low latency and increased bandwidth. Playing an important role in new communications infrastructure across the ecosystem, innovation in – and the expansion of – 5G provides an example of emerging communications technology shaping the future of mobility in Ontario.

Canada's Big 3 Telecom companies (Bell, Rogers and Telus) have all started the **introduction of 5G networks in major cities** across the country, and recently committed to further expansion. In September 2020, Rogers announced **expanding their 5G network to 50 new communities** across Canada.[99]

ADVANCED MANUFACTURING

Advanced manufacturing techniques, such as 3-D printing and the use of advanced robotics, facilitates the creation of complex parts that would otherwise be time consuming or not possible. It is more efficient than traditional means of manufacturing and useful for rapid prototyping and iterative design of parts required in CAV product development and testing.

Striving to be a global leader, University of Waterloo's Additive Manufacturing Research includes developing **methods to use new materials for production.**[100]

Note: Additional details can be found in Appendix B.

Ontario in 2020

Research & development

Ontario is a hotbed for automotive and mobility research and development

Ontario has an expansive number of leading R&D initiatives in this space, due to key investments and funding, infrastructure, academic and privacy research institutions and programs, and talent and emerging technology that attract businesses to Ontario.

KEY RESEARCH & DEVELOPMENT STRENGTHS

R&D and innovation are key focus areas for Ontario's government

One of the Government of Ontario's three key pillars for action for the automotive industry is "innovation," which includes supporting the research and development of new technology.[4] This is in addition to complementary federal government support, such as the federal government commitment to the Toronto-Waterloo Corridor as part of its Advanced Manufacturing Supercluster Initiative.

Large portion of VC and private sector budgets are dedicated to R&D initiatives

Most organizations we surveyed or interviewed reported 20-40% of their revenue is dedicated to R&D programs within the automotive and mobility ecosystem. This strengthens Ontario's position with emerging technologies and commercialization of these technologies.

Canadian **VC funding hit an all-time high in 2020**, despite the negative impacts of COVID-19 on the marketplace. A major standout was Miovision who secured $120 million in funding to pursue opportunities relating to traffic data.

Numerous high-quality academic institutions partnering with industry

Ontario houses **over 45 academic institutions**, many of which focus on innovative programs or training certifications surrounding the automotive and mobility industry. These institutions have been highly ranked both nationally and internationally and provide a critical strength to developing R&D within the ecosystem. Increasingly, these institutions are partnering with industry to co-develop curricula, test and develop innovations, and provide internship opportunities.

Ontario in 2020

Research & development

Ontario is a hotbed for automotive and mobility research and development

Ontario's R&D initiatives are developing the types of emerging technologies and capabilities that will propel automotive and mobility ecosystem forward, including advances in AI and ML, attracting additional research in both academic and private sector research settings, to remain and grow in Ontario.

KEY RESEARCH & DEVELOPMENT STRENGTHS (CONT.)

Leading innovation hubs in emerging technologies

Ontario has a number of **high-profile public and private sector innovation hubs that are at the cutting-edge of emerging technologies** relevant to the automotive and mobility ecosystem, developing a number of emerging technologies and techniques supporting the sector. AI is a crucial enabler for CAVs and is becoming a key technology for elements across the automotive value chain, including deep learning systems to systematically ease human-machine interaction on the roads and behaviour prediction of other vehicles and pedestrians to enhance the safety and operational effectiveness of transit usage.

Multiple testing facilities and Canada's diverse testing environment

Most of the survey respondents stated that Ontario's autonomous vehicle sector strengths include access to multiple facilities, software technology and R&D and advanced technology testbeds. SMEs sentiment is further supported by Ottawa's announcement of a 16km test track for CAVs in 2019 consisting of roads, bike lanes, pedestrian crossings, street lights and speed bumps. The test track is also being used to test 5G, cloud computing, sensor and signal based technologies.[101] The Automotive Centre of Excellence (ACE) in Oshawa provides cutting-edge climatic and autonomous vehicle technologies testing.

Canada also provides a **diverse testing environment and demographics** that are key to accurate and scalable testing. Canada's four seasons, urban, rural and multi-cultural settings, allow companies to test for diverse weather conditions, such as freezing rain, snow and sleet, while accounting for urban and rural traffic conditions.

Legislation supporting R&D and testing on Ontario roads

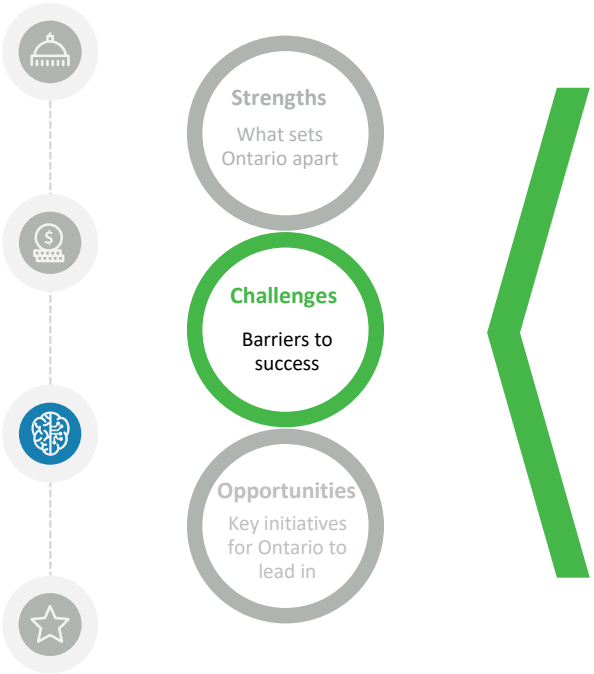
As part of the MTO's AV pilot program, autonomous vehicle of SAE Level 3 can be used on Ontario roads.[16] This policy has led to many R&D activities while attracting further private sector investments.

Ontario in 2020

Research & development

Ontario will need alignment and good data to make future support decisions

Ontario is committed to supporting the automotive and mobility ecosystem's advancement, but will always need to make tough decisions on support and investment, in light of competing demands, market trends, and events such as the COVID-19 pandemic. Ensuring alignment across the public and private sector, both within and outside of Ontario, and having access to the type of data that will help inform decision-making, will remain a key challenge and important goal for Ontario's continued success advancing innovation in this space.



KEY RESEARCH & DEVELOPMENT CHALLENGES

Impacts to private sector funding and changing market demands

While survey respondents noted that the direction of some business models have pivoted to meet market needs, and VC funding faced an all-time high in Canada in 2020, **some respondents reported facing changes or a drop in investment due to COVID-19**. However, many reported that their focus areas for R&D programs remained the same, with longer-term projects seeing fewer impacts and some new health-driven use cases being a new area of research and opportunity.

Maintaining momentum for larger-scale pilot programs and scale-ups

While Ontario's legislative and R&D ecosystem are supportive of important pilot programs to test smart mobility technology, **growing the size of pilot programs and maintaining momentum** to support start-ups who have moved into the scale-up stage, will be needed for Ontario to compete on the global stage. A key challenge for Ontario will be to prove the validity and sustainability of testing and pilots, including in the winter season and during a global pandemic. Supporting growth at these stages will help ensure these organizations and innovative initiatives have staying power.

Competing public sector needs and navigating available support

Public sector funding has been impacted by COVID-19. The automotive and mobility ecosystem has also responded to the need to help this shared challenge, but this has resulted in some **changes to priorities and funding in the short term**. However, government's COVID-19 response has included economic relief programs for small and medium sized companies. The additional challenge faced by automotive and mobility sector organizations is **understanding the complex series of available support or funding programs**, including those being deployed at a rapid pace as part of the government's recent economic relief stimulus or COVID-19 related initiatives such as transit support.

Ontario's Key Opportunities – Research & development

The following are key opportunities related to Research and development.

Building off Ontario's Strengths

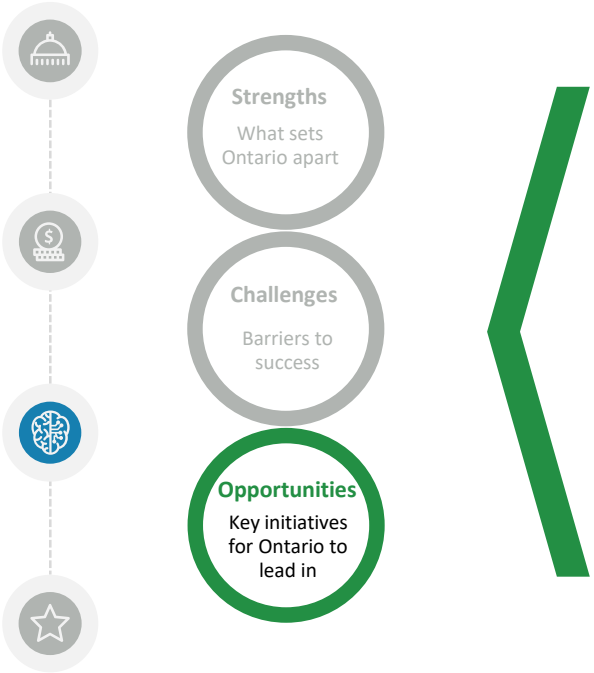
- ✓ R&D government focus
- ✓ Dedicated R&D budgets
- ✓ Supportive legislation
- ✓ Multiple testing facilities
- ✓ Leading innovation hubs in emerging technologies

Addressing Key Challenges

- ✓ Funding impacts and changing market demands
- ✓ Maintaining momentum and scalability
- ✓ Navigating changing support

Developing Opportunities

- ✓ Growth in connectivity, data, energy, and physical infrastructure
- ✓ Identifying and expanding new use cases
- ✓ Expanding cross-border initiatives
- ✓ Increasing mobility-as-a-service (MaaS) capabilities research



KEY RESEARCH & DEVELOPMENT OPPORTUNITIES

Grow innovation in critical infrastructure components – Including connectivity, data, energy, and physical infrastructure

The support and continued development of innovation around key infrastructure components are critical to the research and development of the automotive and mobility ecosystem. Ontario is well positioned to move the needle globally in the following areas:

- **Mobility connectivity and data management** infrastructure, including 5G networks to accelerate and enable safer CAVs, smart cities and IoT devices, and the infrastructure to securely share and analyze data in a reliable way. This new level of connectivity will present organizations with the opportunity to pursue novel value propositions through vertical integration across their business. Fostering trust through innovation in secure data connectivity is key to favourable public sentiment and adoption.
- **Energy and physical infrastructure**, building off Ontario's varied urban and rural settings, and variety of weather patterns, supporting leading-edge innovation that will allow more sustainable and effective technology in a variety of environments globally.

Identify and expand new use cases for development – including middle mile, last mile, and healthcare capabilities

Building off Ontario's innovation space and current retail and healthcare climate, ecosystem members are advancing new use cases that Ontario has the opportunity to further support and grow. For example:

- The current environment has increased eCommerce demand by up to 60% across Canada, and has supported the development of numerous small and medium sized enterprises spanning from driverless trucking to traffic data management. The technology and automotive industries have led to the growth of a unique ecosystem that is favorable for start-ups and new technology development in the "**middle mile**" – the distribution leg between a regional stocking location and forward stocking locations or retail stores. Connected fleets will provide new opportunities for OEMs to broaden their market offerings to customers as well as to provide a more seamless mobility service, and reduce the economic footprint of the movement of goods as well as people.
- Building on the increase in investment in **last-mile** solutions – which grew from $390 million in 2014 to $3.9 billion globally by 2018 – Ontario's current research environment is well-positioned to lead in the development of new last-mile channels, including connected courier fleets, autonomous drones, and collection-point networks.[102]
- Most organizations across Ontario's automotive and mobility ecosystem are looking into **new healthcare related use cases** in the context of COVID-19, including the transportation of PPE, driverless patient transfers, and enhancing patient safety.

Ontario's Key Opportunities – Research & development

The following are key opportunities related to Research and development.

Building off Ontario's Strengths

- ✓ R&D government focus
- ✓ Dedicated R&D budgets
- ✓ Supportive legislation
- ✓ Multiple testing facilities
- ✓ Leading innovation hubs in emerging technologies

Addressing Key Challenges

- ✓ Funding impacts and changing market demands
- ✓ Maintaining momentum and scalability
- ✓ Navigating changing support

Developing Opportunities

- ✓ Growth in connectivity, data, energy, and physical infrastructure
- ✓ Identifying and expanding new use cases
- ✓ Expanding cross-border initiatives
- ✓ Increasing mobility-as-a-service (MaaS) capabilities research

KEY RESEARCH & DEVELOPMENT OPPORTUNITIES (CONT.)

Explore and expand on federal and cross-border R&D initiatives

As availability for R&D dollars are shifting, more national and international partnerships provide opportunities to pool resources. For example, the ACATS program started by the federal government in 2017 provides support for developing guidelines and funding research to support mobility innovation. The province of Ontario and State of Michigan have already aligned to provide the first cross-border automated vehicle test drive through Southern Ontario and Michigan. Ontario has an opportunity to initiate new R&D partnerships through existing national and cross-border relationships.

Increase research in mobility-as-a-service (MaaS) and on-demand mobility capabilities

On-demand services will play an important role in Ontario's future mobility landscape and changing public demand. These services will be backed by digital infrastructure, emerging mobility technologies, route optimization, mapping functions, updates to real-time road conditions, supporting reduced road congestion and the enhanced sustainability of urban and rural travel, adapting closely to our changing travel needs.

Ontario's automotive and mobility ecosystem analysis - *Talent development*

Ontario in 2020

Talent development

Ontario's growing talent landscape

The automotive and mobility ecosystem is constantly changing and evolving. While some skills required by future trade workers and professionals will remain the same, many will evolve and require new skillsets necessary to enable the future of mobility. Key players across the automotive and mobility sector compete to hire experts in computer science, robotics engineering and artificial intelligence.

These disruptive shifts in the human capital requirements of the automotive and mobility ecosystem will result in a network of multidisciplinary skillsets. To meet these demands, Ontario's ecosystem is laying the talent and skills development groundwork for global automotive and mobility leadership.

Talent by the Numbers

- 80,000 tech workers added from 2014-2019 – **North America's fastest growing tech market**.[7]
- Automotive sector in Ontario has an **annual payroll of $8 billion**.[103]

Automotive related research initiatives and training programs[4]

Ontario colleges **24** | **12** Ontario universities

Industry is investing in Ontario's talent. For example, General Motors established its Canadian Technical Centre in Markham in 2018, which accommodates 1,000 engineers with a research focus of advanced driver assistance features and fully autonomous vehicle functions. This investment in Ontario aims to attract strong technical talent and new engineering graduates to advance R&D around CAVs.[104]

Ontario's talent are winning global automotive and transportation innovation challenges. For example, in 2018, a team of students from the University of Toronto (UofT) participated and won in the GM and SAE International sponsored Autodrive Challenge competition. As a North American wide competition, the Autodrive Challenge brought together American and Canadian universities to turn a Chevy Bolt into an autonomous vehicle.[105]

Through **AVIN's Talent Development program**, students and recent graduates from Ontario's post-secondary institution have the opportunity to contribute to tackling industry challenges related to automotive and smart mobility technologies. These opportunities are available within Ontario-based companies or post-secondary institutions where student will receive on-the-job learning in software and hardware development, among other key areas.

As part of Ontario's Driving Prosperity initiative, Ontario developed the **Career Ready Fund's Auto Stream program**, which allows students, recent graduates, and apprentices gain valuable experience and skills within the automotive and advanced manufacturing sectors. This program reinforces the public-private shared commitment – including an investment of $19M – in developing Ontario's workforce. The Career Ready Fund's Auto Stream is a key initiative which will help bring new talent into Ontario's automotive and mobility ecosystem.[106]

Key highlights

Industry investment in talent

International automotive innovation challenges

AVIN's Talent Development program

Ontario's career initiatives

Ontario in 2020

Talent development

Ontario's growing talent landscape

Ontario's talent landscape is growing and evolving. With new initiatives and programs developing local talent, and favourable legislation and policies attracting global talent, Ontario continues to be a unique location for talent in the automotive and mobility ecosystem.

Ontario's talent ecosystem contains a number of unique initiatives and programs, giving Ontario talent – and the automotive and mobility organizations hiring them – a competitive advantage.

Ontario also has one of the world's **highly ranked livable cities**. The Global Livability Index has ranked Toronto in the top 10 livable cities in the world for three years straight.[107] In 2019, Toronto tied with Tokyo as the 7th most livable city and was noted for its stability, healthcare and education, followed by its infrastructure.

Ontario is home to **leading university and colleges** that are top ranking nationally and internationally. Both University of Toronto and University of Waterloo's engineering program have been consistently ranked in Canada's top 3 engineering programs.[108] Ontario also has **the only Automotive Engineering program in Canada** at the Ontario Tech University in Oshawa. Numerous top institutions within Ontario, such as University of Toronto, University of Waterloo, McMaster University, Ryerson University, York University, Ontario Tech University, Carlton University and Durham college provide research programs focusing on AVs and technological developments in the mobility industry, providing the industry a highly educated pool of talent to choose from.

The standard tuition for an engineering degree, or similar STEM fields in Ontario (approx. $15,000 CAD) is equivalent to or lower (approx. 3 to 5 times) than STEM education in other leading jurisdictions. The relatively **competitive costs for an education in a STEM field** in Ontario is a clear competitive advantage in developing the talent required to support the future of the CAV industry.

Some **unique talent programs** in Ontario include:

- Recognized as a school of the future 2020 by the World Economic Forum, The Knowledge Society, based in Ontario, is one of the top innovation programs globally for high-school aged students with an interest in STEM.[4, 109] The development of tech talent in high schools and leading into post-secondary schools is beneficial to maintaining and improving Ontario's future tech talent.
- Raise-AI has a two-year commitment to the Vector Institute to increase the amount of STEM graduates by improving math teaching.[110]
- The Ryerson University Rogers Cybersecure Catalyst functions as a national centre for innovation and collaboration across governments and public agencies, and aims to support advancements in cybersecurity across sectors like mobility, by developing and supporting a diverse talent base.[111]
- Ontario is phasing out the Ontario College of Trades to create a modern skilled trades and apprenticeship system, improving the process for employees to hire apprentices and for the apprentices to receive training and certification faster. This will allow the automotive and mobility sector to hire trade workers who possess modern skillsets needed for the future of mobility.[4]

Key highlights

Highly livable cities

Leading universities and colleges

Unique talent programs

Competitive costs for STEM education

Ontario in 2020

Talent development

Talent development challenges in other leading global jurisdictions

Globally, the automotive and mobility ecosystem is facing a number of challenges recruiting and retaining talent for the growing sector. Even among leading jurisdictions, automotive and mobility innovation groups have identified that thousands of additional jobs will be needed.

USA

In the next decade the US smart mobility sector will require up to 115,000 people, including 45,000 mobility engineers with software skills according to research from the Michigan Mobility Institute.

Talent is currently in low supply within the automotive and mobility ecosystem in the US market. This was evidenced when Uber Technologies scooped up fifty employees from the nearby National Robotics and Engineering Center in Carnegie Mellon.[112]

Germany

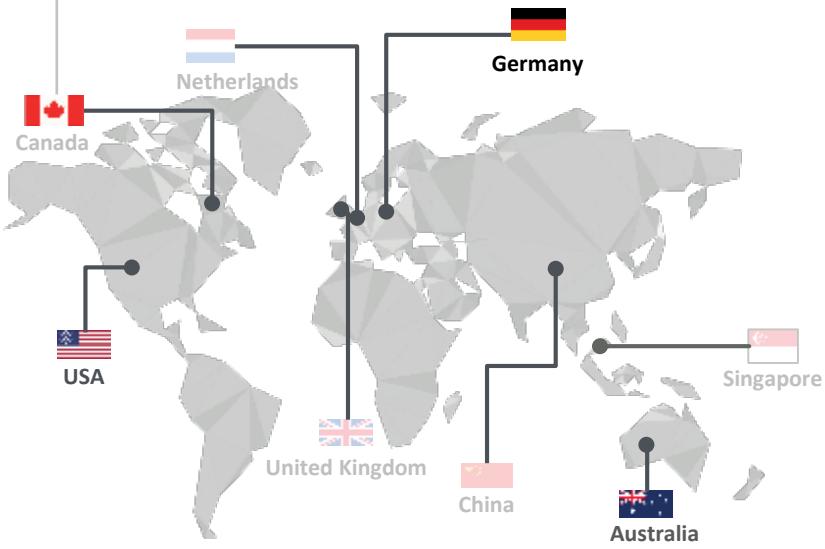
Although Germany's automotive industry is one of the most important industrial sectors in the country, they are not leaders in the AV industry. Talent acquisition is difficult due to higher salaries offered by tech companies in the US. Also, German universities are not producing enough software engineers and machine learning specialists to fulfill the needs of the AV industry. The industry acquires talent through acquisitions of companies or partnerships. Klaus Fröhlich, the Head of Development at BMW, demonstrated this lack of talent by stating his company needs the "manpower equivalent to another 15,000 to 20,000 people from partnerships with suppliers and elsewhere."[113]

Australia

Australia is also experiencing a shortage of talent, as seen in other countries. The Australian Driverless Vehicle Initiative (ADVI) estimates the autonomous vehicle industry will require approximately a new 16,000 jobs.

Ontario

Similar to other jurisdictions, in Ontario, attracting young professionals to the automotive and mobility sector remains a challenge. However, new talent and skills training programs in Ontario focused on changing demographics and collaboration with industry are impacting the talent ecosystem – and global organizations are taking notice.



Ontario in 2020

Talent development

Ontario's favourable talent environment

Ontario is a leading jurisdiction for the type of talent that is shaping the automotive and mobility ecosystem. Many of the survey respondents and stakeholders interviewed noted that skilled and professional talent availability as well as diversity of culture were among the primary reasons for choosing Ontario over other jurisdictions. The large and growing talent pool in Ontario is supported by favourable immigration and work-visa programs, and a number of high quality public educational institutions working closely with industry to advance automotive and mobility innovation.

KEY TALENT DEVELOPMENT STRENGTHS

Strong immigration and work-visas programs attracting global skilled talent to Ontario

Since 2017, highly skilled talent have been moving from the US to the Ontario market, with the number of new technology jobs in Ontario rivalling many US technology hubs. This is partially due to **better work-visa and immigration programs in Ontario** and Canada, and Ontario's support for integrating skilled and professional foreign workers and international students. Surveyed stakeholders have indicated that the time period for a skilled professional to be granted a work-visa in Ontario has been shorter and more straightforward than other similar jurisdictions, contributing to their **decision to be based in and hire in Ontario**.

For example, the province of Ontario has created two immigration programs since 2019 that are specifically tailored to attract talent with STEM skillsets. The Ontario Immigration Nominee Program (OINP) – a partnership with the federal immigration department, Immigration, Refugees and Citizenship Canada (IRCC) – has a focused initiative that is designed to attract software engineers and designers along with data analysts and professions relating to computer and information systems.[114] The OINP also has an Entrepreneur Stream designed to attract entrepreneurs looking to develop new business initiatives.[115]

High quality public educational institutions with industry connections

Ontario's quality of education within the STEM areas is strong. According to MacLean's annual rankings, Ontario's top STEM school's include University of Toronto and University of Waterloo, who are global leaders in R&D.[116] Ontario's **36 automotive related research initiatives and training programs** at leading academic institutions have **positively contributed to the automotive and mobility sector within Ontario**, and have formed strong partnerships with leaders in industry and government to provide opportunities for talent and to contribute to continuous skills development.

Ontario in 2020

Talent development

Changing talent needs, demographics, and competition pose challenges

Ontario's talent pool is large due to a favourable environment for attracting and growing talent across a broad range of innovation areas. However, there remain challenges with ensuring skilled talent is attracted early, continuously trained, and ultimately placed and retained in the automotive and mobility sector over the long term.

KEY TALENT DEVELOPMENT CHALLENGES

The ecosystem's rapidly changing talent needs

The autonomous vehicle industry is continuously changing and evolving, meaning the **skills needed to ensure Ontario remains a leader in the future are evolving**, and need to be closely followed to be ahead of the curve. This requires not only industry to stay ahead of emerging trends, but for academic institutions to continuously evolve curricula and internship programs to align with these needs.

Attracting new talent – providing industry exposure and building early education tailored to the ecosystem

One of the key challenges in developing and maintaining a strong talent pipeline to serve the automotive and mobility innovation industry, is **attracting new students and new professionals to the sector early in their education and careers**, exposing them to the variety of transformational career options across the ecosystem.

High school and post-secondary institutions are often not fully informed of career options in the advanced automotive industry and new opportunities that exist across the entire supply chain and services landscape. In some cases, this results in students not taking STEM courses rooted in automotive and mobility, or looking to other sectors like finance without understanding the potential mobility opportunities related to those areas (e.g., CAVs and payments innovation). Ontario has a large opportunity to leverage these cross-sector skills and build tailored training programs that promote retention within the automotive and mobility ecosystem.

Ontario in 2020

Talent development

Changing talent needs, demographics, and competition pose challenges

The added complexity to talent development in the automotive industry is market competitiveness – with intellectual property and trade secrets being highly important to OEMs and parts innovators. This can make it challenging for industry to easily provide opportunities to new talent moving from academia, or from another career.

KEY TALENT DEVELOPMENT CHALLENGES (CONT.)

Competitive market landscape

Industry stakeholders are at times hesitant to provide internships or R&D placement opportunities to those outside of their organizations, given a highly **competitive market that relies heavily on trade secrecy**. This poses a challenge placing important talent into cutting-edge roles and long-term positions in industry – leaving them with few options once they complete their education, and resulting in them leaving the sector all-together. The automotive and mobility ecosystem will need to balance competition with the sector-wide goal of growing and retaining key talent.

Changing demographics – retaining and retraining in response to the ageing workforce, and reflecting diverse communities

Individuals 65 years of age and older constitute the fastest growing age group in Ontario. It is projected that by 2041, as much as 25% of the population may fall into this demographic.[117] This demographic represents a group with **diverse education and experience**, but also distinct health needs, education, finances and family circumstances. Talent efforts will need to include strategies for retaining employees and retraining based on skills to meet emerging demands, and **designing solutions that reflect and serve our diverse communities**. Where the population is leaving the workforce, organizations and government will need to proactively look at the size and changing dynamics of the available talent pool and continuously adjust.

Ontario's Key Opportunities – Talent development

The following are key opportunities related to Talent development.

Building off Ontario's Strengths

- ✓ Strong immigration programs attracting global skilled talent
- ✓ High quality education

Addressing Key Challenges

- ✓ Changing talent needs
- ✓ Attracting new talent
- ✓ Competitive landscape
- ✓ Changing demographics

Developing Opportunities

- ✓ On-the-job learning
- ✓ Synergistic curriculum with industry partners
- ✓ Retaining and retraining

KEY TALENT DEVELOPMENT OPPORTUNITIES

Promote on-the-job learning initiatives in software and hardware development
To provide more sustainable learning and talent growth, the automotive and mobility ecosystem should develop a province-wide program with the sector-wide goal of exciting, growing, and retaining key talent in this ecosystem. This includes on-the-job learning initiatives derived from both public and private sector partnerships.

Develop a synergistic curriculum with industry partners
The skillset required for the future automotive and mobility ecosystem will require a novel approach to education in order to support the industry with the necessary human capital requirements. By integrating across related courses, there is an opportunity to identify synergies between industry and academia, and to develop a shared curriculum. Additionally, industry and public sector stakeholders should be encouraged to be closely involved in both curricula development, co-op and internship design, and outcomes analysis based on tracking the success of students once they graduate from a program or complete a specific milestone or certification.

Focus on retaining and retraining underrepresented or aging populations
Ontario has the opportunity to create a clear strategy for retaining or retraining underrepresented and aging populations, to increase their involvement in the automotive and mobility sector, and develop a plan for filling any expected talent gaps. This should be done together with existing initiatives and organizations across Ontario who promote relevant innovation and collaboration across governments and public agencies, together with private sector partners.

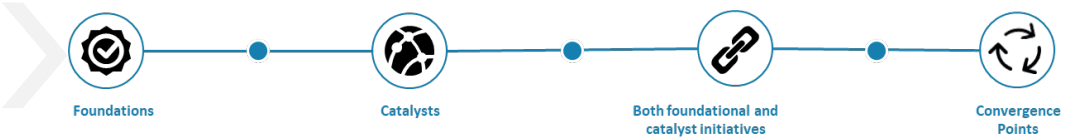
Ontario's opportunity roadmap

Ontario's opportunity roadmap

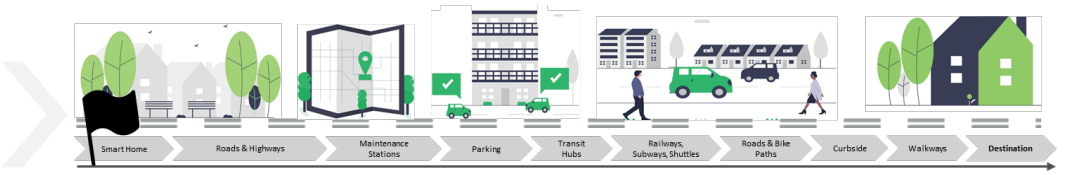
How to read the roadmap

The roadmap section of this report paints a picture of the various opportunities and related activities across the Ontario ecosystem. Each of these opportunities and activities has been evaluated according to the criteria below in order to identify the opportunities that represent the biggest positive impact in the short to long term for Ontario. Although some opportunities will continue to progress over multiple timeframes, the timelines in the following slides reflect that each opportunity can be initiated and pursued, to varying degrees, starting today.

Each stakeholder plays an important role in the automotive and mobility ecosystem. Some create **foundations** and important dependencies for other initiatives, some propel initiatives forward through **catalysts**, and others **connect** stakeholders and initiatives together to create new synergies and opportunities through **convergence points**.

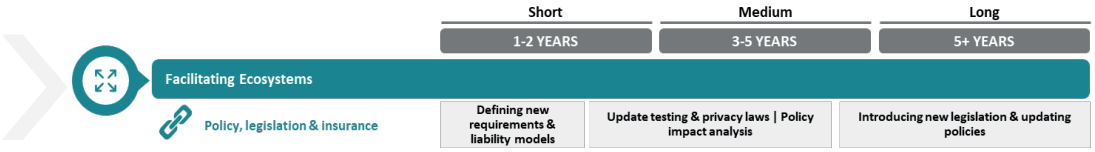


Key **services and technology** across the automotive and technology ecosystem provide the foundation for Ontario's roadmap activities across the mobility lifecycle.



Key **roadmap activities** have been organized under 5 focus areas, based on key strengths and capabilities, challenges, and opportunities identified as part of the Ontario analysis.

The **detailed roadmap** provides **prioritization and sequencing** of the different opportunities based on existing foundations, dependencies, and impacts to Ontario. Relevant **convergence points** for key activities will be referenced and explained at the end of the roadmap.

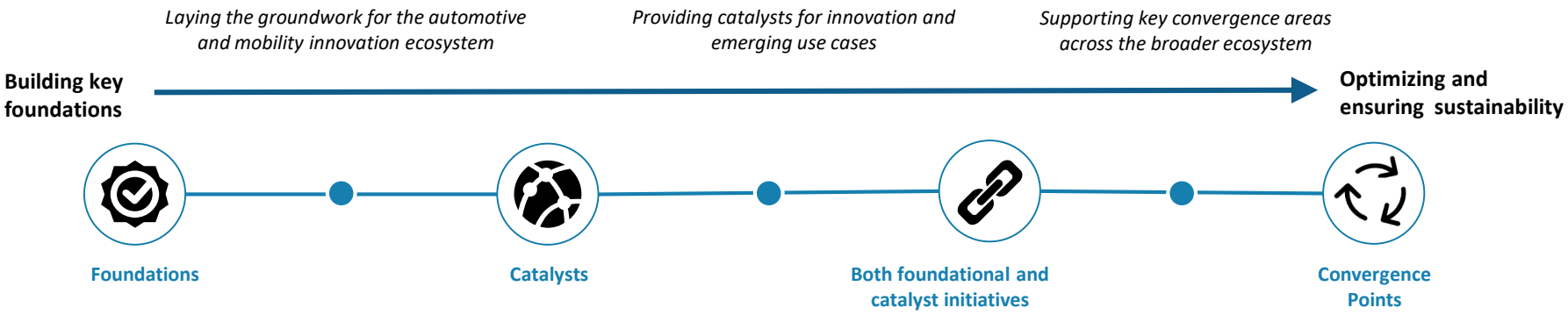


Ontario's opportunity roadmap

Overview of ecosystem components

Building foundations, activating catalysts, and accelerating convergence points

Ontario strongly supports the foundational components of the automotive and mobility ecosystem – fostering talent, supply chain resilience, and innovation. These foundations should continue to grow in the short term (the first two years), and will need to be supported by key catalysts in the short and medium term (Years 1-5), with a focus on initiatives that play both foundational and catalyst roles. Understanding new use cases and how to leverage emerging technology will be important, together with a focus on the convergence points that will allow for improved resilience and sustainability of these innovations over the long term (5 years on).



See page 72 for more details.

Ontario's opportunity roadmap

Overview of services and technology within the ecosystem

The automotive and mobility ecosystem depicted below illustrates the key convergence and dependency points that make up the extended ecosystem. These include Mobility Management, Infrastructure Enablement, Experience Enablement, Development and Manufacturing, and Facilitating Ecosystems such as pricing, payments, investments, insurance, policy and legislation.

Mobility services

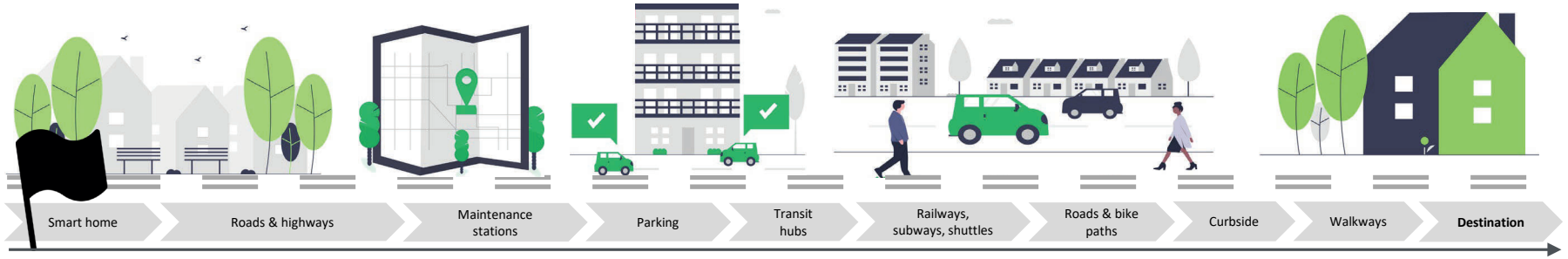
- Relationship Management
- Mobility Data Collection
- Planning & Management Systems
- Predictive Analytics
- User Control

Vehicles & mobility related technologies

- Car, Truck, Shuttle, and Pod Original Equipment Manufacturer (OEM)
- Telematics Control Unit (TCU), IoT and Sensors
- Additive Manufacturing (AM)
- Advanced Robotics
- Parts and Suppliers (Tier 1-3)
- Augmented & Virtual Reality (AR/VR)
- Autonomous Drive Hardware and Software

In-vehicle experience

- Content Creation
- In-car Voice Assistant
- Biometric-based Authentication
- Vision-based Driver Monitoring
- AR-enabled Displays
- Vehicle Ergonomics



Fleet operations

- ITS Operations
- Vehicle Finance & Insurance
- Vehicle Tracking & Routing
- Asset Management
- Procurement

Physical infrastructure

- Highway Tolls
- Road Marking
- Smart Pavement
- Flow Management
- Curbside Management
- Roadside Unit
- Parking Management
- Intelligent Transportation (ITS) Infrastructure

Digital infrastructure

- Cybersecurity
- Privacy and Data Risk
- Cloud
- Connectivity
- Computing Resources
- Telecom Networks
- Big Data Analytics
- Mobility Platforms
- Dedicated short-range communications (DSRC)

Energy infrastructure

- Supply Chain Management
- Battery Management
- Smart Consumption
- Charging Stations

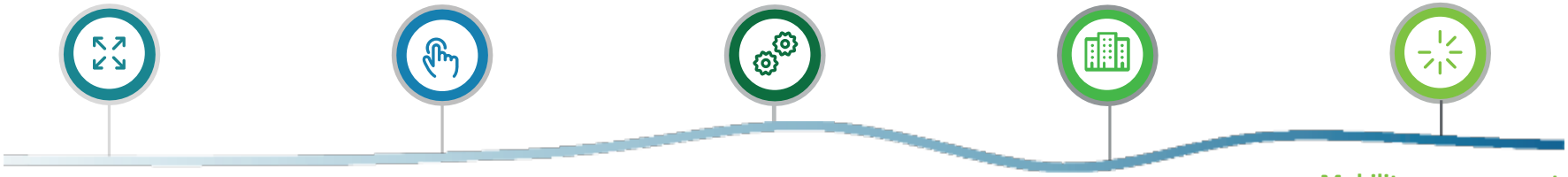
Facilitating ecosystems

Policy and legislation | **Insurance** | **Talent development & acquisition** | **Investments (e.g. VCs, government funding/grants)** | **Pricing and payments**

Ontario's opportunity roadmap

Overview of key opportunities and activities

Key activities and opportunities within the five major themes of the automotive and mobility ecosystem are illustrated below. The roadmap represents a conceptual view, and timelines may vary depending on scoping objectives and priorities.



Facilitating ecosystems

- Policy, legislation, & insurance
- Talent development & acquisition
- Payments
- Investments

Public adoption & experience enablement

- In-vehicle experience
- Public sentiment

Development & manufacturing

- OEMs & parts suppliers
- Autonomous driving hardware & software

Infrastructure enablement

- Data analytics
- Security (cyber & physical)
- Digital infrastructure
- Physical infrastructure
- Energy infrastructure

Mobility management

- Mobility services management
- Fleet operations
- Vendor management & procurement

Legend: Foundational initiative | Catalyst initiative | Both (foundational & catalyst)

Ontario's opportunity roadmap

Short to long-term opportunities (1/2)

Key activities in the short, medium, and long term are illustrated below.

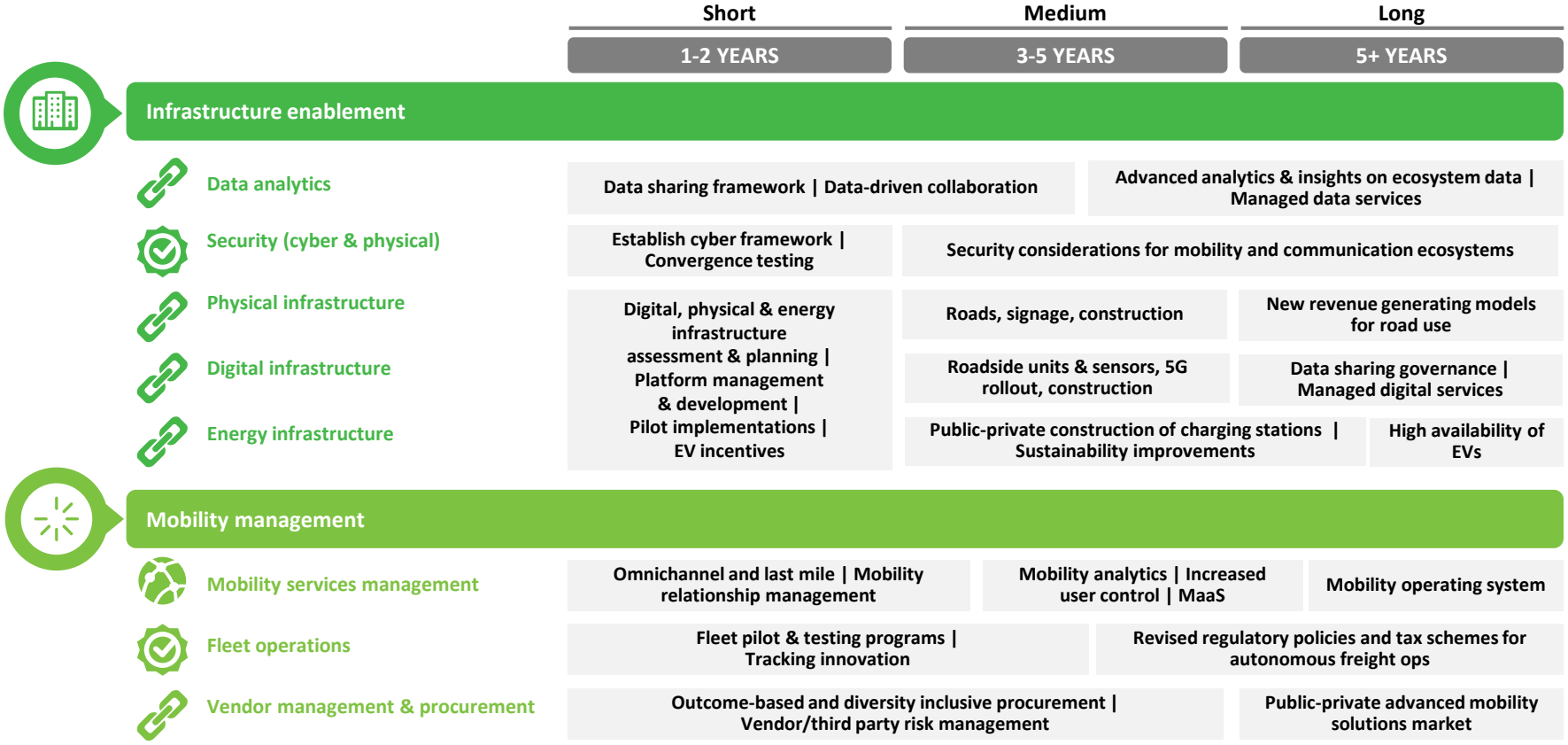
	Short 1-2 YEARS	Medium 3-5 YEARS	Long 5+ YEARS
Facilitating ecosystems			
Policy, legislation & insurance	Defining new requirements & liability models	Update testing & privacy laws | Policy impact analysis	Introducing new legislation & updating policies
Talent development & acquisition	Local talent development projects (e.g., internships, courseware, retraining incentives)		Cross-sector skills convergence & SMEs support
Payments	Connected & contactless payment solution development	New service payment structures | Data portability	Mature identity & consent management
Investments	SME support programs | Public-Private investments		High ROI with advanced mobility solutions
Public adoption & experience enablement			
In-Vehicle experience	User experience R&D | Safe ergonomic design	User experience & services formalization | Enhanced public exposure to new use cases | Biometrics-based authentication	
Public sentiment & trust	Public engagement & awareness | Consultations | Trust building		Public sentiment driven enhancements | Equity
Development & manufacturing			
OEMs & parts suppliers	Use of existing plants & infrastructure | Manufacturing innovation | Strengthening supply chain & manufacturing capabilities		Key global supplier status | Supply chain resiliency
Autonomous driving hardware & software	Commercialization of R&D | Cross-sector innovation		Integration with infrastructure

Legend: Foundational initiative | Catalyst initiative | Both (foundational & catalyst)

Ontario's opportunity roadmap

Short to long-term opportunities (2/2)

Key activities in the short, medium, and long term are illustrated below.

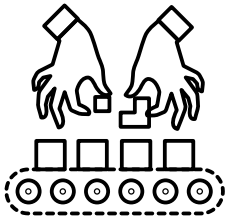


Legend: Foundational initiative | Catalyst initiative | Both (foundational & catalyst)

Ontario's opportunity roadmap

Overview of opportunity spaces

Facilitating ecosystems



Policy, legislation & insurance

In the immediate term, public and industry **consultations** need to be conducted to **define or update requirements** to align with new technologies and the use and testing of these innovations. An iterative approach to **proposed updates to Ontario privacy laws and testing legislation** are likely to initiate in the next 2-3 years, after detailed discussions with the entire ecosystem. The introduction of new legislation specifc to the automotive and mobility landscape (e.g., liability and insurance models as well as privacy requirements), and new corresponding policies will take place after this period, with **new laws coming into force** in the next 4-5 years and beyond.

Talent development & acquisition

Building on existing talent development initiatives, the next 3 years in Ontario will be a critical time for the automotive and mobility ecosystem to **take advantage of Ontario's unique programs.** This includes investing in skills development and retraining of the existing and upcoming labour force. Partnerships between industry, the public sector, and academia are particularly important to the success of these programs. A future focused on **cross-sector skills development** as well as **multi-disciplinary talent programs**, will be necessary for Ontario to maintain and grow this competitive talent pool, and continue to attract innovative SMEs.

How is Ontario positioned for these roadmap activities? What is the potential impact?

Opportunities in Legislation & policy – Ontario is already undertaking public and industry consultations for a "made in Ontario" approach to private sector privacy, which may have policy, guidance, or legislative impacts to this ecosystem in the coming years.

Opportunities in Talent development – Ontario's unique talent programs, large talent pool, and growing connections between industry and academia in developing tailored curricula, position Ontario extremely well to continue to advance the development and growth of talent in this ecosystem.

Impact to Ontario – These next steps contribute to new opportunities and skills development in Ontario, with large downstream impacts to the development of new technology, testing and piloting methods, and services, leading to wide-ranging labour force and economic impacts.

- ✓ New skills areas developed leading to new R&D opportunities and attracted investment
- ✓ New academic and industry partnerships, leading to new and sustained market opportunities for Ontario
- ✓ Increased jobs and GDP attributed to this space in Ontario

Convergence Point – Data sharing & privacy

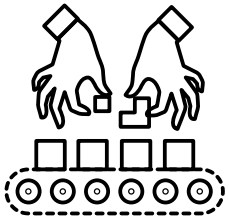
Innovation in infrastructure & manufacturing | Physical & digital safety | **Data sharing & privacy** | In-Vehicle experience & trust

See page 72 for details on relevant convergence points for Ontario.

Ontario's opportunity roadmap

Overview of opportunity spaces

Facilitating ecosystems (cont.)



Payments

Innovation in the solutions that support payment will increase quickly in the next two years, with a large focus on **authentication and secure contactless payment**. Increasingly, tying purchases to the way users move around – across a number of mobility options – and allowing users to take their data with them with enhanced control ("data portability"), will be important catalysts for the mobility services space. It will likely take over 5 years until the ecosystem sees **mature identity and consent management platforms** that are fully interoperable across the mobility lifecycle, but Ontario's current payment innovation players are already at the cutting edge of this space and well-poised to move this forward globally.

Investments

Ontario is already seeing an increase in investments from both public and private sector investors. In the next few years, **public-private partnership investments** and private investment programs that work closely with clusters of SMEs on developing their innovations are likely to increase. Future investments will see an increased focus on **high-ROI areas of the extended automotive and mobility landscape,** including new use cases being highlighted or accelerated due to the COVID-19 pandemic, like safe micro-mobility options, ecommerce and payments innovation, and healthcare transportation (of both people and goods).

How is Ontario positioned for these roadmap activities? What is the potential impact?

Opportunities in R&D – Ontario is a leader and continuing to grow in innovation in the automotive and mobility space, developing new solutions and creating unique mobility services for the global market.

Opportunities in Economic development – The growth in public-private partnerships and VC investment across sectors, together with increased return on investment demonstrated in the broader automotive and mobility ecosystem, is leading to larger, longer-term investments in Ontario SMEs, with increased scale-up and commercialization opportunities on the horizon.

Impact to Ontario – These advances contribute to market growth and expanding services in Ontario, putting Ontario on the global stage as a competitor in the new automotive and mobility landscape.

- ✓ New mobility services innovation, increased security, and enhanced public trust
- ✓ Increased market growth and competitiveness in the global ecosystem
- ✓ Increased jobs and GDP attributed to this space in Ontario

Convergence Point – In-vehicle experience & trust

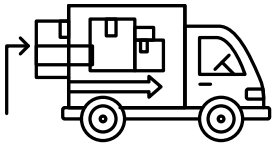
Innovation in infrastructure & manufacturing | Physical & digital safety | Data sharing & privacy | **In-Vehicle experience & trust**

See page 72 for details on relevant convergence points for Ontario.

Ontario's opportunity roadmap

Overview of opportunity spaces

Public adoption & experience enablement



In-vehicle experience

Over the next three years, user-centric innovation within the automotive and smart mobility technology ecosystem will be a large **R&D** focus in Ontario. Advancements in **interior vehicle design and in-vehicle services** will encompass human factors, human to highly automated vehicle interaction, as well as **safe ergonomic design** for personal and shared mobility. This will be followed by a medium-long term goal of standardized products and services. Organizations across the ecosystem will begin to work closely with each other and share learnings with the intention of developing **safe, standardized practices and common frameworks**. Over the next 3-5 years, advanced forms of in-vehicle services (such as **biometrics-based authentication**), will expand the number of **use cases** the public is exposed to, such as healthcare, safety, as well as vision-based driver monitoring.

Public sentiment & trust

In the immediate term, **engaging with the public through consultations and awareness campaigns** will be necessary to both provide education and build trust around the use and impacts of advanced automotive and mobility solutions. As public encounters with advanced mobility increase, and particularly where concerns and sentiment inform automotive and mobility enhancements, a **strong cultural shift** towards the future of mobility will emerge with benefits such as **increased access and mobility equity**, reduced commute times and increased productivity, and environmental sustainability.

How is Ontario positioned for these roadmap activities? What is the potential impact?

Opportunities in R&D – Ontario is quickly identifying new use cases and increasing research in user-centric mobility design, enhancing the in-vehicle experience. This is further supported by cross-border R&D initiatives and opportunities to lead standardization efforts.

Opportunities in Legislation & policy – Ontario is well positioned to lead cross-jurisdictional collaborative efforts to harmonize and standardize requirements in the automotive and mobility ecosystem, which would provide support for innovation with national and global partners, and enhance public sentiment and trust.

Impact to Ontario – Advances in in-vehicle solutions and engaging closely with the public will contribute to increased trust and adoption in Ontario, with several potential benefits.

- ✓ Enhanced safety and productivity due to advancements in in-vehicle design
- ✓ Advancements in in-vehicle services, growing the local and global user base and supporting new use cases
- ✓ Highly positive public sentiment and trust, leading to increased use and adoption
- ✓ Improvements in commute time and productivity, access to equitable mobility options, and positive environmental impacts

Convergence Point – In-vehicle experience & trust

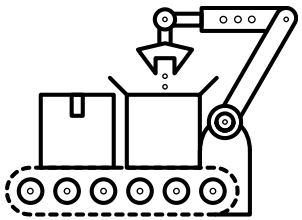
Innovation in infrastructure & manufacturing | Physical & digital safety | Data sharing & privacy | **In-Vehicle experience & trust**

See page 72 for details on relevant convergence points for Ontario.

Ontario's opportunity roadmap

Overview of opportunity spaces

Development & manufacturing



OEMs & parts suppliers

Over the next five years, there is an opportunity to better **leverage the existing industry assets and infrastructure**, including **restructuring and retooling** existing manufacturing plants, to support innovation in vehicle and parts manufacturing. OEMs and vehicle parts suppliers across the entire supply chain who innovate in manufacturing techniques (e.g., robotics, 3D printing, AI and ML) will see efficiencies, new local talent opportunities, and the enhanced sustainability of the supply chain.

In the long term, Ontario's activities will support a leading status as a global supplier and heightened local **supply chain resiliency,** with the ability to support and respond effectively to changing demands and global events, including health and environmental concerns.

Autonomous driving hardware and software

Today, Ontario is leading innovation in the development of both hardware and software supporting the automotive and mobility ecosystem. While the speed of this technological development remains uncertain, over the next 3-5 years, Ontario has several **scale up and commercialization opportunities**, together with existing infrastructure, to support these developments. A focus on **cross-sector innovation** will help to maintain momentum and develop more collaborative and interoperable innovations, supporting new use cases. In the longer term, autonomous drive solutions will be **fully integrated with infrastructure** – leading to enhanced access and usability.

How is Ontario positioned for these roadmap activities? What is the potential impact?

Opportunities in R&D – All use cases in the automotive and mobility space rely on technological development. Ontario's increase in long-term, sustained investment in R&D and continued support for innovation in critical infrastructure, robotics, 3D printing, and AI/ML, will promote the development of the key technical and physical components of this ecosystem.

Opportunities in Economic development – Ontario has many manufacturing plants that can readily be converted to support the development of innovative technologies, EV production, and leverage advanced manufacturing including autonomous robotics.

Impact to Ontario – These advances will contribute to Ontario's position as a global leader, while supporting economic development, interoperability, and usability.

- ✓ Effective use of existing infrastructure and updates to existing plants leading to new jobs and increased GDP attributed to this space in Ontario
- ✓ New local manufacturing innovation, increasing the sustainability and resiliency of the supply chain, including the ability to respond to global events (e.g. pandemics)
- ✓ Increased partnerships and cross-sector innovation, enhancing interoperability and usability

Convergence Point – Innovation in infrastructure & manufacturing

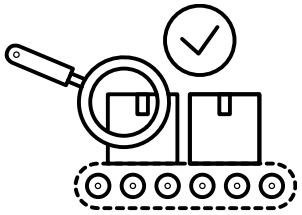
Innovation in infrastructure & manufacturing | Physical & digital safety | Data sharing & privacy | In-Vehicle experience & trust

See page 72 for details on relevant convergence points for Ontario.

Ontario's opportunity roadmap

Overview of opportunity spaces

Infrastructure enablement



Data analytics

In the immediate term, organizations in the automotive and mobility ecosystem will look for new ways to understand innovation impacts, adoption, and ecosystem growth, and will need to use data in a collaborative way to do so. This will result in new **data sharing frameworks and models** being used, enhancing innovation in the collection and use of data. In the future, as organizations mature over the next 3-5 years, more advanced uses of data and more holistic data services will become a key component to the economic health of the ecosystem, resulting in new **mobility data services**, increasingly managed analytics, and new insights across the entire mobility lifecycle.

Security (cyber & physical)

Both physical security and cybersecurity are foundational components to the secure functioning of the automotive and mobility ecosystem. In the near term, cybersecurity leaders will work together on establishing a **cybersecurity framework for the automotive and mobility space**. Increased testing of both physical and cyber risks through **convergence security testing** – leveraging today's testing facilities and academic centres – will provide a better understanding of existing threats and safety requirements.

In the longer term, advancements in mobility and communication ecosystems will require innovation in authentication and trust, security across the entire supply chain, and enhanced connectivity controls, to **support safety, public trust, and adoption**.

How is Ontario positioned for these roadmap activities? What is the potential impact?

Opportunities in R&D – Ontario is a leader and continuing to grow in innovation in the authentication and cybersecurity in the automotive and mobility space, developing new solutions and creating unique mobility services for the global market.

Opportunities in Legislation & policy – Ontario is a leader from a regulatory perspective, with a history of supportive and advanced regulations in CAV pilot testing and privacy guidance. Both are supportive of innovation in data use and protection, positioning Ontario to develop a secure approach to be used globally.

Impact to Ontario – These advances contribute to market growth and expanding services in Ontario, putting Ontario on the global stage as a competitor in the new automotive and mobility landscape.

- ✓ Increased security, safety, and public trust
- ✓ New insights and improved ability to measure the growth of the sector
- ✓ Increased market growth and competitiveness in the global ecosystem through enhanced data services
- ✓ Increased jobs and GDP attributed to this space in Ontario

Convergence Point – Innovation in infrastructure & manufacturing, Physical & digital safety, and In-vehicle experience & trust

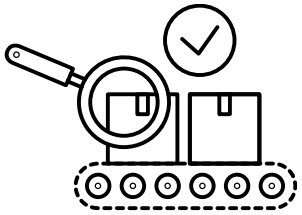
Innovation in infrastructure & manufacturing | Physical & digital safety | Data sharing & privacy | In-Vehicle experience & trust

See page 72 for details on relevant convergence points for Ontario.

Ontario's opportunity roadmap

Overview of opportunity spaces

Infrastructure enablement (cont.)



Physical infrastructure

In the near term, mobility assessment and planning will focus on the **use of existing physical infrastructure** – including urban and rural infrastructure, roads and highways, and physical assets used to support mobility features such as road signs, transit stations, and micro-mobility hubs. Based on these assessments, including the identification of any gaps in physical infrastructure to meet future needs, new assets will be constructed, opening the door for new R&D, testing and piloting, and increased public use and adoption. In the long term, **new revenue generating models** will reflect and promote changes in mobility infrastructure and road use, increasing financial and environmental sustainability.

Digital infrastructure

Digital infrastructure is changing rapidly, supporting connectivity and the movement of data across the expanding automotive and mobility ecosystem. In the immediate term, Ontario will continue to see large **digital infrastructure investment and development** from the private sector, with increasing returns. This enhanced connectivity across both urban and rural settings, including further 5G rollout across the province, will be met with an increase in **roadside units and sensors** in the next 3-5 years. In the long term, advancements in privacy, data sharing and data governance will support managed digital and location services across **connected infrastructure**.

How is Ontario positioned for these roadmap activities? What is the potential impact?

Opportunities in R&D – Ontario is a leader and continuing to grow in the development of both physical and digital services innovation in the automotive and mobility space. This includes the development of sensors, testing sites, and cybersecurity and data protection tools.

Impact to Ontario – These advances provide a foundation for innovation, market growth, and adoption in Ontario, while also provide key catalysts to support more collaborative, forward-looking innovation.

- ✓ Increased collaboration and interoperability across the ecosystem, streamlining and promoting advancements
- ✓ Advancements in infrastructure available for public use, increasing public sentiment and adoption of new mobility solutions
- ✓ Increased jobs and GDP attributed to infrastructure developments
- ✓ Increased security and safety due to infrastructure enhancements, leading to increased public trust

Convergence Point – Innovation in infrastructure & manufacturing, Physical & digital safety, and In-vehicle experience & trust

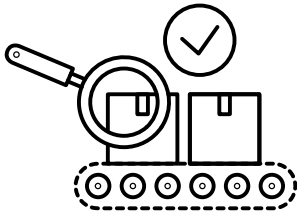
Innovation in infrastructure & manufacturing | Physical & digital safety | Data sharing & privacy | In-Vehicle experience & trust

See page 72 for details on relevant convergence points for Ontario.

Ontario's opportunity roadmap

Overview of opportunity spaces

Infrastructure enablement (cont.)



Energy infrastructure

In the immediate term, existing infrastructure supporting energy in the automotive and mobility ecosystem – including OEM and parts manufacturing plants and gas stations – will be assessed for restructuring and retooling for the future of mobility. **New platforms** for organizations and users, including mobile apps, will be developed to support the effective use of energy and how to make efficient and reliable mobility decisions.

Both public and private sector incentives and initiatives will support **restructuring, retraining, and planning** efforts, building the types of physical, technical, and talent resources to develop future mobility use cases.

In the longer term, public-private partnerships in the space of EV infrastructure, multi-use mobility hubs – including transit, micro-transit, and micro-mobility – and mobility sustainability will move advances in R&D from academia and testing, into the public sphere. The increased **availability and accessibility of EVs and EV infrastructure** will lead to increased adoption of EVs and energy-efficient or sustainable features.

How is Ontario positioned for these roadmap activities? What is the potential impact?

Opportunities in Economic Development – Ontario has many manufacturing plants that can readily be converted to support EV production.

Opportunities in Legislation & policy – Ontario's supportive and advanced regulations in CAV pilot testing and sustainability policies could be leveraged together with EV testing, moving this area forward faster than other jurisdictions globally.

Impact to Ontario – These advances contribute to both the environmental and economic sustainability of Ontario's automotive and mobility ecosystem.

- ✓ Commercialization of innovation in energy infrastructure and EVs leading to increased adoption
- ✓ Retrained workforce and retooled plants for the future of energy infrastructure, leading to increased jobs and GDP attributed to this space in Ontario
- ✓ Increased sustainability and minimized environmental footprint

Convergence Point – Innovation in infrastructure & manufacturing

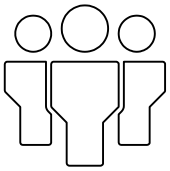
Innovation in infrastructure & manufacturing | Physical & digital safety | Data sharing & privacy | In-Vehicle experience & trust

See page 72 for details on relevant convergence points for Ontario.

Ontario's opportunity roadmap

Overview of opportunity spaces

Mobility management



Mobility services management

Advancements in **omnichannel, ecommerce, and middle and last mile delivery** services continue to be the focus in the short term, accelerated by the impacts of COVID-19 on work locations and purchasing behavior. Medium term opportunities over the next 3-5 years include advancements in middle mile technology and fleet operations (see below), together with expanded mobility analytics to support the transportation of goods and supply chain management. In the longer term, **MaaS and Mobility on Demand** services that enhance user control will be prevalent, with more mature and complex **mobility-specific operating systems** being developed.

Fleet operations

The short term will see an increase in **fleet testing and pilot programs** in Ontario in response to demands on the movement of goods and supply chain resiliency. Innovation in **tracking** will support the development of new mobility services. In the longer term, the **regulatory and tax frameworks** for autonomous freight will need to be reconsidered and revised to further enable the future of fleet.

Vendor management & procurement

Developing **innovative procurement** mechanisms and managing vendor and supply chain risks will be a key focus for the next 5 years in Ontario. Consultations with both industry and the public will be important to informing key considerations and desired outcomes. In the long term, a **marketplace of solutions** should be available to the entire ecosystem.

How is Ontario positioned for these roadmap activities? What is the potential impact?

Opportunities in R&D – Ontario's broader ecosystem supporting automotive and mobility innovation is increasingly collaborating across sectors to develop new mobility services and advanced technology supporting complex operations and automated features.

Opportunities in Economic development – The growth in public-private partnerships across sectors and increasing ROI shown in the broader automotive and mobility ecosystem is seeing larger, longer-term investments in Ontario SMEs, with increased scale-up and commercialization opportunities on the horizon.

Impact to Ontario – These advances contribute to market growth and expanding services in Ontario, putting Ontario in the position to lead in mobility services, fleet operations, vendor management and procurement innovation – with direct benefits to the Ontario public.

- ✓ New mobility services innovation, increased security, and enhanced public trust
- ✓ Increased market growth and competitiveness in the global ecosystem
- ✓ Increased jobs and GDP attributed to this space in Ontario

Convergence Point – **In-vehicle experience & trust**

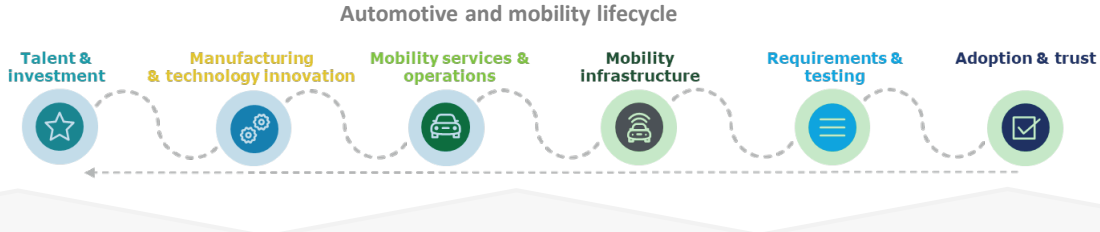
Innovation in infrastructure & manufacturing | Physical & digital safety | Data sharing & privacy | **In-Vehicle experience & trust**

See page 72 for details on relevant convergence points for Ontario.

Ontario's opportunity roadmap

Convergence points promoting resilience and sustainability across the broader ecosystem

Technology is the foundational fabric driving the maturity of the automotive and mobility ecosystem. Revisiting the automotive and mobility lifecycle and Ontario's Opportunity Roadmap activities, there are four key convergence areas that Ontario should continue to explore to support these roadmap activities: innovation in infrastructure and manufacturing, physical and digital safety, data collection and privacy, and in-vehicle experience and trust.



Innovation in infrastructure & manufacturing

Within the Ontario ecosystem, important roadmap activities will depend on the convergence of innovation in vehicle and parts production and infrastructure development and use. By leveraging **cross-sector emerging technologies** (further detailed in Appendix B) such as AI, 5G, advanced manufacturing, cybersecurity, privacy enhancing technologies (PETs) and blockchain, Ontario can accelerate innovation in the automotive and mobility space.

Key relevant roadmap activities:

- Physical, digital, and energy infrastructure
- OEMs & parts suppliers
- Autonomous drive hardware & software
- Talent development & acquisition

Physical & digital safety

Enhancing the physical safety of drivers, passengers, and the public is a key driver for the advancement of connected and autonomous vehicles. Safety must also be considered from a digital perspective, with increasing privacy and security risks related to existing and new solutions. The convergence of physical and digital security – "**convergence security**" – is an area that Ontario is positioned to advance globally.

Key relevant roadmap activities:

- Security (physical and digital)
- Data analytics
- Physical and digital infrastructure
- Policy, legislation, & insurance

Data sharing & privacy

The volume and variety of data in the automotive and mobility ecosystem will need to increase to provide better solutions and measure the impacts of the ecosystem. This demand comes together with an increased need to protect organization's and the public's data, and ensure a user-centric approach to data use. The **convergence of data sharing and privacy** can allow for collaboration and communication to be facilitated in a safe, secure, and public-conscious way.

Key relevant roadmap activities:

- Policy, legislation, & insurance
- Mobility services management
- Data analytics
- Security (physical and digital)

In-vehicle experience & trust

The public sentiment regarding advanced automotive and mobility technology will impact the level of interest and adoption of these innovations. Focusing on solutions that **enhance the in-vehicle user experience and foster positive consumer sentiment and trust** around the use and reliability of automotive and mobility technologies, will provide more sustainable outcomes. A focus on reflecting diversity, improving access, and enhancing equity in mobility will be particularly important.

Key relevant roadmap activities:

- Public sentiment & trust
- In-vehicle experience
- Mobility services management
- Security (physical and digital)
- Payments

Note: Only select relevant roadmap activities are indicated above.
Please see preceding pages for additional relevant roadmap activities.

Conclusion

Conclusion

Key takeaways on Ontario's opportunities in 2020 and beyond

The automotive and mobility ecosystem in Ontario operates within a hotbed of technology innovation, growing economic activity, and a favourable policy and regulatory landscape that has attracted some of the world's best talent and innovative organizations. These organizations are leading the world in innovative programs, pilots, products, and services enhancing mobility.

Across the areas of Legislation and Policy, Economic Development, R&D, and Talent Development considered in this analysis, Ontario is able to tackle new challenges and emerging opportunities by building on existing strengths. The convergence of innovative activities and technologies, and the harmonization of strategies and policies, will support Ontario in becoming a truly unique jurisdiction advancing automotive and mobility capabilities globally.

Increased partnerships and collaborative initiatives with multiple stakeholders across industries will be crucial to help drive this advancement in automotive and mobility technologies and services, data use, safety, and security. In the development of such strategic synergies, the province of Ontario is supported by AVIN, who is uniquely positioned to continually bring the broader ecosystem and its partners together.

Enhancing collaboration – Building on Ontario's strengths and overcoming challenges will require collaboration from numerous stakeholders across the automotive and mobility ecosystem. AVIN has worked with stakeholders to support enhanced collaboration across talent development, R&D, economic development, and regulatory and policy initiatives. Looking to the future, the ability of each ecosystem player, including AVIN, to collaborate with multiple stakeholders and across jurisdictions will provide a significant advantage for Ontario.

Leading globally in emerging technologies – The development of technology continues to fuel the entire automotive and mobility ecosystem. Ontario's strong talent pool is making large advancements across a number of important technology capabilities including AI, Blockchain, Cybersecurity, Privacy Enhancing Technologies (PETs), 5G, and advanced manufacturing. As these technologies continue to evolve and mature, automotive and mobility capabilities have the opportunity to become increasingly automated, integrated, and secure. These instances of technological convergence will be critical to generating lucrative market outcomes and setting Ontario apart as a global leader. To enhance technological convergence opportunities, the channels of communication must remain open across the entire ecosystem and allow for the secure exchange of ideas between innovators, regulators, investors, manufacturers, and the public.

Strengthening public trust – Safety, security and privacy, accessibility and equity, and healthcare are some of the most pressing issues in Ontario this year, only increased in the context of COVID-19. The automotive and mobility ecosystem plays an important role addressing these issues and improving the quality of life of our communities. Each of these issues requires a multi-disciplinary approach that is inclusive of the diverse stakeholders across Ontario. By providing platforms and channels for collaboration across stakeholder groups, and facilitating consultations with the public and industry, the automotive and mobility ecosystem can create a foundation of trust embedded in the communities adopting these solutions. Ontario's automotive and mobility ecosystem is well-positioned to address emerging and complex issues through a "made-in-Ontario" approach to the future of mobility.

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Appendix A

Ecosystem overview (additional details)

Automotive and mobility ecosystem overview

Size of Ontario's extended ecosystem – Data sources and descriptions

The extent of the broader automotive and mobility ecosystem depicted in the report is based on the latest Statistics Canada – Canadian Industry Statistics (Ontario data for 2018), looking not only at motor vehicle and transportation related areas, but sectors that are impacted by, support, and depend on mobility. Below is a description of the data included.

Industry	Value	Source Statistics Canada, tables 36-10-0434-06 and 36-10-0402-01 (see sector-specific links below)
Retail (motor vehicle related, including vehicle and parts dealers, and gas stations)	$5.2 billion (vehicle) + $1.9 billion (gas stations) = $7.1 billion **Note**: This does not include auto repair and maintenance or rental and leasing. **Note**: Total retail (not only motor vehicle related) was $37.1 billion, which may be relevant to the broader movement of goods.	Motor Vehicle & Parts Dealers: https://www.ic.gc.ca/app/scr/app/cis/gdp-pid/441 Gasoline Stations: https://www.ic.gc.ca/app/scr/app/cis/gdp-pid/447
Wholesale (motor vehicle related, including vehicle as well as parts and accessories wholesalers)	$5.6 billion **Note**: Total wholesale (not only motor vehicle related) was $46.7 billion, which may be relevant to the broader movement of goods.	Motor Vehicle and Motor Vehicle Parts and Accessories Merchant Wholesalers: https://www.ic.gc.ca/app/scr/app/cis/gdp-pid/415 Total Wholesale: https://www.ic.gc.ca/app/scr/app/cis/gdp-pid/41
Manufacturing (Transportation equipment incl. motor vehicles)	$17.1 billion **Note:** Only transportation equipment included (e.g. motor vehicles)	Transportation Equipment Manufacturing: https://www.ic.gc.ca/app/scr/app/cis/gdp-pid/336
Transportation	$29.5 billion (up 3% from 2017)	Transportation & Warehousing: https://www.ic.gc.ca/app/scr/app/cis/gdp-pid/48-49
Finance & Insurance	$67.8 billion (up 1.9%)	Finance and Insurance: https://www.ic.gc.ca/app/scr/app/cis/gdp-pid/52
Educational services	$42.1 billion (up 2.8%)	Professional, Scientific and Technical Services: https://www.ic.gc.ca/app/scr/app/cis/gdp-pid/61
Energy (extraction - non-retail, manufacturing, and utilities)	$7 billion (extraction) + $4 billion (petroleum and coal product manufacturing) + $14 billion (utilities) =$25 billion	Extraction: https://www.ic.gc.ca/app/scr/app/cis/gdp-pid/21 Petroleum and Coal Product Manufacturing: https://www.ic.gc.ca/app/scr/app/cis/gdp-pid/324) Utilities: https://www.ic.gc.ca/app/scr/app/cis/gdp-pid/22
Public administration	$52 billion	Public Administration: https://www.ic.gc.ca/app/scr/app/cis/gdp-pid/91
Professional, Scientific and Technical Services	$50.9 billion **Note:** Includes legal services, design services, computer design services, scientific initiatives, etc.	Professional, Scientific and Technical Services: https://www.ic.gc.ca/app/scr/app/cis/gdp-pid/54
Health and Social Assistance	$49.4 billion (up 3.5% from 2017)	Health and Social Assistance: https://www.ic.gc.ca/app/scr/app/cis/gdp-pid/62
Information and cultural industries	$28.9 billion **Note:** Includes telecommunications and data processing but also other cultural industries	Information and cultural industries: https://www.ic.gc.ca/app/scr/app/cis/gdp-pid/51

Automotive and mobility ecosystem overview

COVID-19 impacts on industry and consumers

Survey respondents have indicated that COVID-19 has changed their priorities as well as the priorities of most automotive technology and mobility stakeholders. This impact has been two-fold, causing **big changes** and focus on a **steady course** of actions for the long term.

Big changes

- ✓ Some survey respondents reported having to **stall or delay** operations due to COVID-19. Activities such as networking and collaboration – that would have been in-person – now have to **go online**
- ✓ Increased focus on **crisis management** and navigating potential **sources of venture and government funding**
- ✓ Organizations are seeking **new partnerships** that they believe will be less impacted by COVID-19 causing increased Mergers & Acquisition (M&A) and market consolidations
- ✓ **Pivoting** business models to meet new market needs – led by market opportunities
- ✓ Renewed interest in **EV** as we reflect on the **long-term impacts of health and safety** as a high-priority use case

COVID-19 impacts from respondents

1. **Health has become a top of mind consumer concern.** Ontario's advanced mobility ecosystem now sees health and the availability of infrastructure and incentives as top consumer concerns, impacted by COVID-19 and emerging economic and infrastructure challenges.
2. Equity, accessibility, and ease of use remain key concerns. COVID-19 has further highlighted that the future of mobility will need to be **equitable and user-friendly for all communities**.
3. While health was top of mind in 2020, **affordability and safety** also remain key focus areas. The public have **higher safety expectations** for CAVs than traditional driver vehicles.

Steady course

- ✓ Focus **on R&D and long term growth** based on design key use cases
- ✓ **Taking a long-term position –** Those focusing on longer term plans and R&D have not changed direction as rapidly, or are still unsure of the impact
- ✓ Some who say that while **direction remains the same**, investment has dropped
- ✓ Continued focus on **public transportation** – the connected vehicles and intelligent transportation focus has not changed
- ✓ Continuing to focus on **high-growth business** (e.g., through business case analysis)
- ✓ **Health and availability of infrastructure** are top consumer priorities creating opportunities (e.g., on-demand delivery)

Automotive and mobility ecosystem overview

COVID-19 opportunities for the automotive sector

As identified in AVIN's Quarterly Specialized Report (June 2020), **the COVID-19 pandemic has introduced opportunities for the automotive sector to excel and transform**.[118] Both globally and domestically, key players in the automotive sector are continuing to thrive by refocusing their strategy from expansion to recovery and marketing smart mobility technologies as key solutions to solving challenges introduced by COVID-19.

Through repurposing production and leveraging support platforms, as well as upskilling and supporting employees, the following are some of the key opportunities transforming the sector.

TRANSFORMING THE SECTOR

Produce Healthcare Essentials

- Canadian companies such as **Cavalier Tool and Manufacturing have leveraged their production capabilities** to meet increasing demand for medical supplies by shifting production to wall-mounted hand sanitizers.

Market Driverless Vehicles

- Canadian start-ups such as **Tiny Mile** have innovated through **service delivery robots** that mitigate risks of contamination exposure.
- Canadian start-ups such as **Gatrik** offer retail companies **autonomous delivery services** to limit human contact when transporting products from distribution centres to retail stores.

Support On-Demand Transit

- Technology companies such as **Pantonium** have enabled Canadian municipalities to **schedule transit service routes that ensure services run at a safe capacity** that allows social distancing.
- SME companies such as **RideShark** have innovated to **provide mobility software solutions that allow consumers to select sustainable ways to travel**.

Source: AVIN Specialized Reports, June 2020

Appendix B

Emerging technologies (additional details)

Emerging and innovative technologies

Artificial intelligence

Artificial Intelligence (AI) is a crucial enabler for CAVs and is becoming a key technology for elements across the automotive value chain. Deep Learning systems can be trained to mimic human decision-making which could systematically ease human-machine interaction on the roads. Behaviour prediction of other vehicles and pedestrians can enhance safety and operational effectiveness of transit usage.

Key characteristics of an AI system include:

Big Data: Ability to process massive amounts of structured and unstructured data.

Reasoning: Ability to provide deductive and/or inductive reasoning and draw context-driven inferences based on the situation.

Learning: Ability to learn based on patterns, expert inputs and feedback loops.

Problem solving: Ability to analyze and solve complex problems in special and general purpose domains.

Vector Institute for Artificial Intelligence

Based in Toronto, Vector Institute is an independent, non-for-profit corporation dedicated to research and talent development in the field of AI, excelling in machine and deep learning with a strategic vision to become a top 10 world-leading center for AI research.

Recent examples include development of 'first of its kind' AI-powered search engine to pre-train models.[96]

AVIN's Toronto Regional Technology Development Site (RTDS) focusing on AI for CAVs

Hosted by MaRS Discovery District in collaboration with the University of Toronto, Ryerson University and York University, the RTDS provides business and technical advisory services in data science, product development, software development and more.

The AVIN Data Index is a data sharing platform which allows data owners and users to facilitate research and product development for CAVs in Ontario.

Emerging & innovative technologies

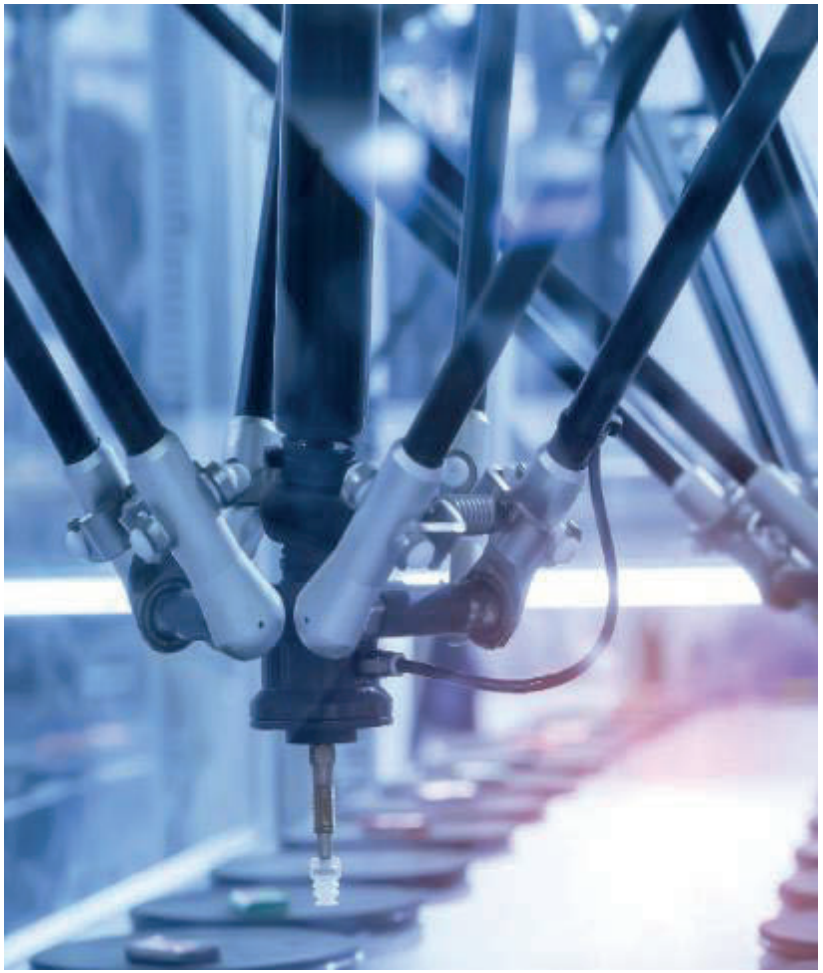
5G and advanced manufacturing

The convergence of advanced communications and manufacturing innovation is accelerating development in the mobility ecosystem.

5G technology

The introduction of fifth generation cellular technology (5G) for mobile networks opens up new possibilities in the advanced automotive and mobility ecosystem. 5G technology brings promising results for autonomous driving and vehicle communication, and aims to provide a consistent and real time experience by allowing for ultra-low latency and increased bandwidth. This may impact Vehicle-to-Vehicle (V2V) and Vehicle-to-Everything (V2X) communications, providing high-speed communications that could maximize the benefits from IoT and AI.

Canada's **Big 3 Telecom** companies (Bell, Rogers and Telus) have all started the introduction of 5G networks in major cities across the country.



Advanced manufacturing

Advanced manufacturing techniques such as additive manufacturing (AM), also known as 3-D printing, facilitates the creation of three-dimensional objects in layer-by-layer manner that would otherwise be time consuming or not possible. AM is especially useful for rapid prototyping and iterative design of parts required in product development and testing. Furthermore, AM helps to lower overall vehicle weight by allowing for innovative ways to produce light weight structural components for vehicles, achieving longer ranges for EVs.

Striving to be a global leader, **University of Waterloo's Additive Manufacturing Research** includes developing methods to use new materials for production.[100]

Emerging & innovative technologies

Cybersecurity innovation

In order to defend against the range of evolving and new cyber threats to the connected and autonomous vehicles ecosystem, organizations operating in this sector must develop robust defense mechanisms to improve their data security, manage identities and rights, secure the cloud, and enhance incident management.

Cybersecurity – Building trust and resilience into advanced mobility

Four leading considerations for defending against major cyber threats across the advanced mobility ecosystem include the following:

Headquartered in Waterloo, Ontario, Blackberry's QNX software is embedded in 175 million cars on the road (as of Jun 2020). Blackberry provides a broad portfolio of security and software for CAVs.[59]

Identity & Access Management (IAM)

Trust and authentication are critical to the entire advanced mobility ecosystem, as vehicles, users and infrastructure need to trust identity and the validity of multiple communications continuously, in real time. To prevent the compromise of user credentials and safeguard information assets, IAM processes need to appropriately define and manage roles and access privileges of users, and the circumstances of those privileges.

Data Risk and Privacy by Design

In order to increase adoption, consumers and citizens need to feel that their **data is being protected and used appropriately**. A unified approach to data strategy and governance, incorporating risk and privacy perspectives, is needed to establish an accountable and sustainable foundation for growth across the ecosystem. Incorporating the concepts of privacy and security by design into all innovations will be key to supporting this.

Cyber Governance and Cloud Cyber Risk Framework

Cybersecurity governance will need to extend to the use of cloud across the mobility ecosystem. Developing a holistically secure cloud environment **across the full threat landscape**, organization's will need to establish a framework that identifies the major cyber cloud risk domains to manage on premise, hybrid and multi-cloud environments.

Incident Response & Testing Resilience

The COVID-19 pandemic has further demonstrated that planning for and testing our responses to incidents is increasingly important. An Incident Response plan, and use cases can allow entities to prepare for and prevent cyber threats, detect and analyze them, contain and recover from cyber attacks when they occur, and review major lessons learned. Ecosystem members will need to **plan for resiliency across their supply chain and infrastructure partners**.

Emerging & innovative technologies

Privacy enhancing technologies

Changing the dynamics of data sharing, Privacy Enhancing Technologies (PETs) provide systematic, risk-driven capabilities to enable meaningful data sharing amongst the mobility ecosystem players while maintaining data security and privacy.

Collaboration across the ecosystem through secure disruption

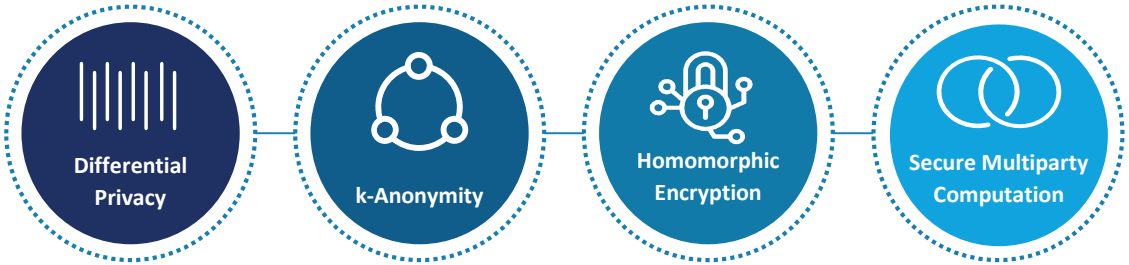
The data sharing requirements for CAVs will require engagement in innovative technology strategies to realize the value of unshared data assets. By adopting PETs, multiple parties can collaborate to gain the required insights into data assets which are currently not shared, without forfeiting any competitive insights or sensitive information.

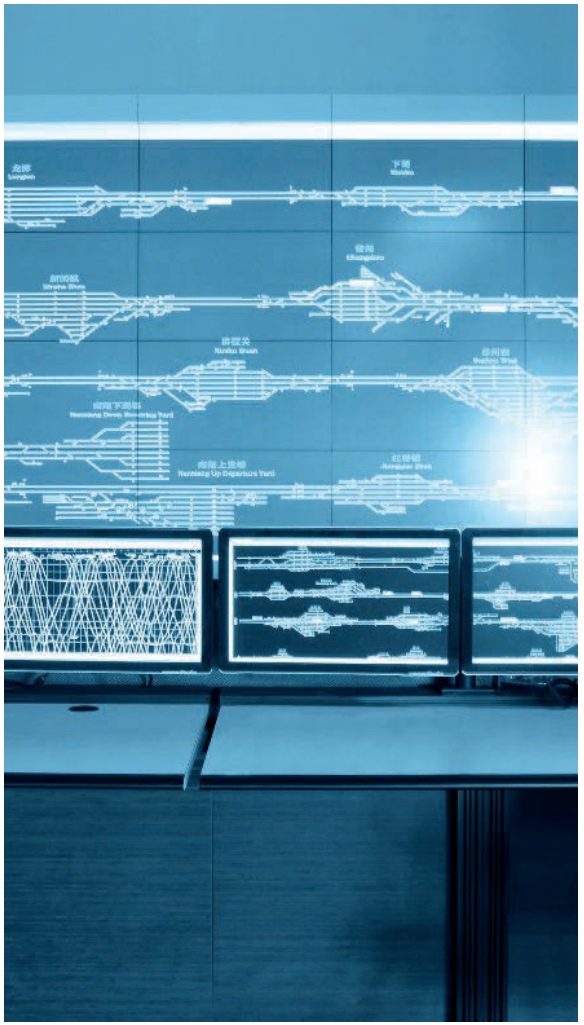
Techniques supporting the development of insights while protecting data

There are a number of PETs that could support the data sharing across the CAV industry to drive insights and identify privacy risks. Considerations of customer privacy, data governance and intellectual property will be important for those hoping to deploy these technologies effectively.

- **Differential Privacy** – Where noise is added to a dataset so that it is impossible to reverse-engineer the individual inputs.
- **K-Anonymity** – Where data attributes are suppressed, generalized or bucketed to provide anonymization.
- **Homomorphic Encryption** – Where data is encrypted before sharing such that it can be analyzed, but not decoded into the original information.
- **Secure Multi Party Computation** – Where data analysis is spread across multiple parties such that no individual party can see the complete set of inputs.

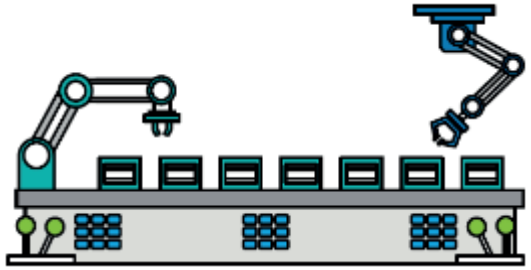
Other privacy enhancing techniques or solutions that can enable data sharing include Generative Adversarial Networks (GAN), Federated Analysis, and Zero Knowledge Proofs.





Emerging & innovative technologies

Blockchain



The fragmented nature of the automotive ecosystem and value chain has traditionally resulted in a complex and slow processing of services. Blockchain is a digital, decentralized, distributed ledger that enables information to be shared and processed by a network of participants. It enables exchanging value without the use of an intermediary. Key characteristics of Blockchain that would enable the mobility and autonomous vehicles ecosystem includes[119]:

Near real time	Digital	Irreversible and immutable	Transparent	Reliable and available
Enables almost instant settlement of recorded transactions	Almost any asset can be expressed in code and referenced by a ledger entry	Irrevocable transactions increase accuracy and reduces fraud opportunities	Transactions are visible to all participants increasing trust and auditability	No single point of failure and resilient in the face of outages
Example opportunities				
Share data between vehicle owners, manufacturers and dealers	Enable ecosystem players to trace and verify the origin of parts and commodities through supply chain	Build consumer trust in adoption of autonomous vehicles and services including targeted recall for repairs	Link data held by businesses across automotive industry including auto finance providers & insurance	Enable consumers to save money through pay-per-use access to mobility infrastructure

Mavennet is a Toronto based start-up that provides Blockchain-enabled and AI products with a focus on large enterprise implementations. In November 2019, the US Department of Homeland Security (DHS) contracted Mavennet to build a cross border oil tracking platform to accurately track the evidence of oil flow through pipelines between the USA and Canada.[120]

Appendix C

Participating stakeholders

List of participating stakeholders

A number of stakeholders across the broader ecosystem were consulted for this report.

Below are organizations Deloitte interviewed or surveyed as part of this report.

Organization Name	
Arcturus Networks Inc.	Invision AI
Autonomous Transportation Canada	ITS Canada
Autzu Inc.	Joyride Technologies
Blackberry	MaRS
Cloud DX	Miovision
Communitech Corp	NuPort
EatSleepRIDE Mobile Inc.	Pantonium
Economical	Pitstop
Gatik	SensorCortek
Geotab	Trans-Plan
Infrastructure Ontario	Transport Canada - Innovation Centre

Deloitte.

About the Autonomous Vehicle Innovation Network

AVIN is a key component of Driving Prosperity, the Government of Ontario's initiative to ensure the automotive sector remains competitive and continues to thrive. The Government of Ontario has committed $85 million in innovative programming to support research and development funding, talent development, technology acceleration, business and technical supports, and testing and demonstration sites. AVIN programs support small- and medium-sized enterprises (SMEs) to develop, test and commercialize new automotive and transportation products and technologies, and cultivate the capacity of a province-wide network to drive future mobility solutions, reinforcing Ontario's position as a global leader. The AVIN Central Hub is the driving force behind the programming, province-wide coordination of activities and resources, and Ontario's push to lead in the future of the automotive and mobility sector globally.

AVIN, led by OCE, is supported by the Government of Ontario's Ministry of Economic Development, Job Creation and Trade (MEDJCT) and Ministry of Transportation (MTO).

About Ontario Centres of Excellence

Ontario Centres of Excellence (OCE) Inc. drives the commercialization of cutting-edge research across key market sectors to build the economy of tomorrow and secure Ontario's global competitiveness. In doing this, OCE fosters the training and development of the next generation of innovators and entrepreneurs and is a key partner with Ontario's industry, universities, colleges, research hospitals, investors, and governments.

About Deloitte

Deloitte, one of Canada's leading professional services firms, provides audit, tax, consulting, and financial advisory services. Deloitte's Future of Mobility practice serves the entire ecosystem of companies working in and around mobility. The entire way we travel from point A to point B is changing, and this transformation is creating a new ecosystem of personal mobility, with implications affecting more than just the automotive industry.

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