Preparing for Autonomous Vehicles in Canada

A White Paper Prepared for the Government of Canada

by the

Canadian Automated Vehicles Centre of Excellence

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Preparing for Autonomous Vehicles in Canada

Executive Summary

The Canadian Automated Vehicles Centre of Excellence (CAVCOE) is a not-for-profit centre of excellence that is dedicated to helping the public and private sectors prepare and plan for the arrival of automated vehicles (AVs). This unsolicited White Paper describes the huge opportunities and challenges facing the country and the Government of Canada in the AV era and proposes a road-map.

CAVCOE makes the following 30 recommendations to the Government of Canada:

Government of Canada
1. Appoint a Minister for AVs that has a voice in the Cabinet who would champion and coordinate this nascent sector across all of the Federal Government. A government led proposal for such a Minister has already been made in the UK. The Canadian Minister of Communications role (1969 – 1996) can be considered a precedent for a Minister to oversee an emerging technology sector.

2. Appoint a senior-level working group to coordinate AV activities across all relevant federal departments and agencies.

3. Create the Canadian Autonomous Vehicle Initiative (CAVI) to coordinate the deployment of AVs in Canada, and to promote R&D and testing to create an AV ecosystem, with significant levels of funding.

4. Set the necessary federal standards and regulations for AV testing, manufacture and deployment, in coordination with the US.

5. Prepare Canada and Canadians for the profound socio-economic benefits and challenges of AVs.

6. Coordinate with the provinces, territories, municipalities, the United States, professional and trade organizations, and major stakeholders to ensure a rapid and smooth deployment of AVs.

The Economy
7. Recognize the substantial economic benefits of AVs.

8. Develop plans to maximize the socio-economic benefits of AVs as soon as possible whilst seeking to mitigate the downsides.

Transportation and Traffic

9. Given the impact AVs will have on transportation and traffic, require that all new major transportation infrastructure projects seeking federal funding include a critical assessment of how the proposed work will advance/support the deployment of AVs. In this way, the risks and opportunities that AVs might present are included in the project development and the analysis will demonstrate prudent due diligence in determining how robust the operational and business models are for that project.

10. Assuming that some of these analyses result in cost savings, and given the importance of AVs to the future efficiency, safety and environmental sustainability of the transportation system, include a specific category of dedicated funding for projects that would stimulate AV technology development, trials, testing and deployment.

11. Given the expected employment displacement, that the Government divert some of the savings to help mitigate the impact of job losses caused by AVs and promote workforce re-training.

Transit

12. Require that all new major transit infrastructure projects seeking federal funding include a critical assessment of how the proposed work will advance/support the deployment of AVs. Consideration should also be given to the value of similar analyses on projects that are already underway where an analysis could provide a net overall benefit.

13. Assuming that some of these analyses result in cost savings, and given the importance of AVs to the future efficiency, safety and environmental sustainability of the transit system, include a specific category of dedicated funding for projects that would promote AV technology development, testing and deployment.

14. Encourage municipalities, regional transit authorities and transit companies to consider the impact of AVs in their strategic plans.

Quality of Life, Health, Climate Change and Mobility Equity

15. Conduct studies to determine the potential health and quality of life benefits associated with AVs, particularly if there are policies to promote electric propulsion systems. CAVCOE is not currently aware of a great deal of research work in this area and thus Canada could become a world leader in the study of these health and quality of life benefits.

16. Recognize the potential quality of life, health and environmental benefits of AVs and require that AVs be considered as an option in any new transportation or infrastructure projects where these characteristics are important to the final solution. We note that is only a matter of time before there will be a legal

challenge to an Environmental Impact Statement (EIS) connected with a major infrastructure project where an AV solution has not been considered as being potentially more environmentally friendly.

17. Recognize that the convergence of AVs with electric propulsion systems and renewable energy can contribute to achieving a significant reduction in emissions from surface transportation, in line with the climate change accord reached at COP21.

Auto and Technology Industries

18. Make a significant investment in AV development, testing, and related activities in the auto and technology industries, universities and the National Research Council, starting with the 2016-17 budget

19. Help the Canadian auto industry prepare for a major disruption in the number of cars that are made here, as well as how they are designed, manufactured and sold.

20. Invest in the Canadian auto and technology industries to help create an AV ecosystem that can compete in the global automated, connected and electric (ACE) vehicle market.

21. Engage in developing a national cyber-security strategy and standards for AVs. Without this, the first major hacking event will neutralize a lot of progress -- perhaps for a long time.

Oil and Pipeline Industries

22. Consider the options for the oil industry, given the anticipated widespread adoption of AVs and the likely impact on the global demand for oil.

23. Plan now for diversifying the economy.

24. Recognize the impact on government revenues.

National Security & Policing

25. Treat the national security threat that will be posed by AVs as a priority and proactively work to avoid or mitigate the opportunities for abuse by criminals and terrorists.

26. Encourage the RCMP to continue monitoring the status and plans for AVs in Canada and to develop strategies and plans for policing in the AV era.

Provinces. Territories and Municipalities

27. Support provinces, territories and municipalities in understanding the impacts of AVs, benefiting from the upsides, and mitigating the downsides.

28. Encourage provinces, territories and municipalities to include AVs in their Transportation Master Plans, their strategic plans for transit (for municipalities), and evaluate how it affects other aspects of government.

29. Require an analysis to assess the risks and opportunities that AVs pose to major transportation and infrastructure projects in order to determine how robust current forecast business and operational models might be. This is a form of prudent due diligence to ensure that tax-payer dollars are invested wisely in infrastructure that will be useful for many decades.

30. Encourage the provinces, territories and municipalities to review their laws and regulations to determine if they promote or hinder the benefits of AVs and to determine if additional laws and regulations are needed in light of this potentially transformative technology.

Preparing for Autonomous Vehicles in Canada

Introduction

The Canadian Automated Vehicles Centre of Excellence (CAVCOE) is a not-for-profit centre of excellence that is dedicated to helping the public and private sectors prepare and plan for the arrival of automated vehicles (AVs).

Among the G7 countries, Canada is unfortunately last in its preparations for AVs. This White Paper describes the huge opportunities and challenges facing us and proposes a road-map for the Government of Canada.

Background

AVs will be here much sooner than most people expect. We estimate that the four key dates for their deployment are:

2015 Special-purpose fully-automated vehicles are already commercially available. These include fully-automated heavy haulers in the Alberta oil sands and low-speed, electric pods and shuttle buses capable of operating on private land, and on public roads where special permission is provided. Virtually all car manufacturers are introducing advanced driver assistance features (ADAS). The car manufacturers and a number of new entrants to the auto industry are developing fully self-driving cars.

2018 The first fully-automated low speed vehicles will probably be providing a low-speed automated service in designated areas in cities with limitations for adverse weather. This will likely be a shared vehicle service, with ride-sharing being promoted to improve efficiency and reduce costs. Automated vehicles (including trucks and utility vehicles) will become common on private land including their use for transit, goods movement in mining, and in construction.

2020 The first fully-autonomous cars will be commercially available in show rooms[1]. Fully-automated shared and ride-sharing services will be rolled out in cities in all climates, with vehicles also capable of highway driving.

2025 The number of AVs in use will reach a tipping point. Although comprising a small percentage of the total vehicle fleet, each shared AV will be capable

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[1] *Ford CEO predicts driverless cars on roads in 5 years* is one of many articles on the launch of AVs; the Globe and Mail: January 2015.
http://www.theglobeandmail.com/report-on-business/ford-ceo-predicts-driverless-cars-on-roads-in-5-years/article22319662/

of replacing 2-13 private vehicles and thus will do a significant amount of work on the road network. At this point, it will be clear to most individuals, organizations and businesses how much they would benefit from utilizing AVs.

AVs are a highly disruptive technology that will impact not just transportation, transit and logistics, but also lead to major changes in our lives, our cities, and society as a whole. AVs will literally change how and where we live and work, just as the modern automobile did when it replaced horse power. The following describes some of the major impacts and CAVCOE's recommendations for action.

Government of Canada

The policy impacts of AVs are broad and extend far beyond transportation. They will impact all levels of government including the economy and GDP, jobs, health-care, electricity generation and distribution, national security, urban planning and housing, policies for the auto and technology industries, R&D, policing, transportation and transit including infrastructure, taxes, revenues from fines for traffic penalties, investments by pension funds, etc.

A number of governments have established special centres to coordinate and stimulate mobility technology. Examples include the Australian Driverless Vehicle Initiative (ADVI)[2], the Dutch Automated Vehicle Initiative (DAVI), and the United Kingdom's Transport Systems Catapult[3]. We recommend that the Government of Canada create the Canadian Autonomous Vehicle Initiative (CAVI) modelled on these existing initiatives and with a significant level of funding[4]. CAVI's mandate would be to promote R&D and testing in Canada to create an AV ecosystem, and to coordinate the deployment of AVs across the country.

CAVCOE's recommendations to the Government of Canada are:

1. Appoint a Minister for AVs that has a voice in the Cabinet who would champion and coordinate this nascent sector across all of the Federal Government. A government led proposal for such a Minister has already been made in the UK.[5] The Canadian Minister of Communications role (1969 – 1996) can be considered a precedent for a Minister to oversee an emerging technology sector.[6]

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[2] https://www.arrb.com.au/Transport/Self-Driving-Vehicles.aspx
[3] https://ts.catapult.org.uk/who-we-are
[4] In the UK, Transport Systems Catapult has £100 Million funding from the UK Government. https://ts.catapult.org.uk/-/catapult-hails-100-million-government-investment-in-driverless-vehicle-technology
[5] '[UK] MPs Propose a Minister for Driverless Vehicles' http://www.trl.co.uk/news-hub/transport-news/transport-news-archive/transport-news-arcticle/?id=801778692
[6] Minister of Communications, Canada https://en.wikipedia.org/wiki/Minister_of_Communications_(Canada)

2.   Appoint a senior-level working group to coordinate AV activities across all relevant federal departments and agencies.

3.   Create the Canadian Autonomous Vehicle Initiative (CAVI) to coordinate the deployment of AVs in Canada, and to promote R&D and testing to create an AV ecosystem, with a significant level of funding.

4.   Set the necessary federal standards and regulations for AV testing, manufacture and deployment, in coordination with the US.

5.   Prepare Canada and Canadians for the profound socio-economic benefits and challenges of AVs.

6.   Coordinate with the provinces, territories, municipalities, the United States, professional and trade organizations, and major stakeholders to ensure a rapid and smooth deployment of AVs.

The Economy

AVs will have a major, positive impact on national economies, including Canada's. The UK Secretary of State for Transportation recently said "G7 countries are realizing the importance of these [AV] technologies for the future of our economies".[7]

A joint report earlier this year by the Conference Board of Canada, CAVCOE and the Van Horne Institute showed that AVs will benefit the Canadian economy by $65 Billion per year (3.6% of GDP).[8] This includes savings from fewer collisions and reduced expenses for insurance, car repairs and health care. This estimate is much more conservative than the Morgan Stanley report which preceded it, and which estimated savings to the US of $1.3 trillion per year (8% of GDP), and $5.6 trillion/year globally.[9]

When people can do other things in their cars instead of driving, the value of their time that is freed up could be immense for the economy. Research is needed to explore ways that employers in particular could make better use of this time and possibly include this time within contracted work hours, thus freeing up employees to enjoy more personal time not lost to commuting.

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[7] Patrick McLoughlin, Secretary of State for Transport in the UK at the meeting of G7 Transport Ministers, September 2015.
[8] Automated Vehicles: The Coming of the Next Disruptive Technology. A joint report by the Conference Board of Canada, CAVCOE and the Van Horne Institute. January 2015.
[9] Morgan Stanley Blue Paper, 'Self-Driving the New Auto-Industry Paradigm'
http://orfe.princeton.edu/~alaink/SmartDrivingCars/PDFs/Nov2013MORGAN-STANLEY-BLUE-PAPER-AUTONOMOUS-CARS : -SELF-DRIVING-THE-NEW-AUTO-INDUSTRY-PARADIGM.pdf

In addition, CAVCOE estimates that money flows around AVs could be as high as 20% of GDP. This includes disrupted and impacted business models, newly created business models, assets changing value e.g. land, properties, stocks, investments by pension funds, etc.

However, there will be downsides, including direct employment displacement especially in driving-related industries: transport truck and courier service drivers; taxi drivers / chauffeurs; bus drivers; auto-body repair; auto insurance; traffic police; tow-truck drivers; driving instructors/trainers; parking lot / parking garage operators, etc.

There will also be significant indirect socio-economic ripple effects resulting in employment displacement in many other aspects of daily life. For example a significant reduction in car crashes will affect staff required for emergency rooms, critical care, rehabilitation in the community etc., and will also significantly impact organ and tissue donation.

On the plus side, as we are still discovering with the rise of the Internet and connectivity, there will be numerous business models that evolve or are created by AVs that will spawn many new industries, sectors and business models. If Canada creates the right environment for such innovative businesses to thrive then it could easily become a world leader in the new mobility paradigm.

CAVCOE's recommendations to the Government of Canada are:

7. Recognize the substantial economic benefits of AVs.

8. Develop plans to maximize the socio-economic benefits of AVs as soon as possible whilst seeking to mitigate the downsides.

Transportation and Traffic

US Transportation Secretary Foxx has taken his most positive stance on AVs to date in an article that he wrote earlier in 2015:

> "*Widespread adoption of automated vehicles would change transportation as we know it"* and *"Automated and connected vehicle technologies can increase the capacity of the existing road system by a factor of five."*[10]

This opinion by such a senior person raises some interesting opportunities and challenges when we consider current proposals for transportation infrastructure projects across Canada and the many billions of dollars they will cost. It is possible that the traffic, ridership and parking forecasts, as well as the planned operational and business

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[10] "*What lies beyond traffic*" by US Transportation Secretary Antony Foxx; *Thinking Highways* magazine: April 2015.
http://edition.pagesuite-professional.co.uk/launch.aspx?eid=d4f1c48b-5e24-435d-8b99-1283bb8678b9

models for these infrastructure might not be as robust as currently considered.

Roads and highways that are less congested because of AV and connected vehicle technologies will likely see increased traffic. The benefits of AVs will be significant, and hence the 2020s will likely see the introduction of automated, connected and electric (ACE) cars in large numbers. The market will see the introduction of driverless taxis and Mobility-as-a-Service, essentially a new form of personalized mass transit. This in turn will lead to a substantial decrease in personal car ownership, more efficient use of the road network (as predicted by Secretary Foxx), a decrease in emissions, and much safer roads.

The other underlying trends that will lead to this are:

- Susan Shaheen's work[11] shows the increase in worldwide car-sharing members has jumped over 360% in the past 3 years from 1.8M in 2012 to 6.5M in 2015, primarily in the millennial generation. Projected to be 26.0M by 2020 according to Berg Insight a Swedish market research firm.

- Car sharing companies will likely be the first to adopt driverless technologies and incorporate them in their fleets, leading to Mobility-as-a-Service.

A report earlier this year by the Organization for Economic Development and Cooperation (OECD) stated:

> "*Automated taxis combined with high-capacity public transport could remove 8 or 9 out of every 10 cars in a mid-sized European city.*"[12]

While we agree that the impact will be very substantial, removing "8 or 9 out of every 10 cars" is probably optimistic. We have seen other studies ranging from a single AV replacing anywhere between 2 and 13 vehicles. Whatever the actual number of private vehicles that are replaced by AVs, all studies indicate that it will be higher than 2, and therefore the impact of AVs on the road network operational efficiency will be significant.

Other predictions are that automated and connected vehicle technologies will substantially reduce urban gridlock by using technology to reduce gaps between vehicles, smooth traffic flows, optimize route planning and reducing crashes. At CAVCOE, we estimate that if a jurisdiction puts policies in place to promote ride-sharing of shared AVs, then any increase in average vehicle occupancy during peak periods above the current level of 1.1 - 1.2 (to say, greater than 1.6 – 1.8) will see a corresponding decrease in congestion and increase in road network efficiency.

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[11] http://www.slideshare.net/AlanWoodland/susan-shaheen-worldwide-carsharing-trends-and-research-hightlights

[12] *Urban Mobility System Upgrade: How shared self-driving cars could change city traffic; a report by the International Transport Forum* (ITF), part of the Organisation for Economic Co-operation and Development (OECD); April 2015.

Perhaps the most important forecast of all relates to the fact that traffic collisions currently kill about 2,000 people in Canada annually. We hope and we expect that AVs will be able to prevent more than 80% of all road collisions, injuries and fatalities.

CAVCOE's recommendations to the Government of Canada are:

9. Given the impact AVs will have on transportation and traffic, require that all new major transportation infrastructure projects seeking federal funding include a critical assessment of how the proposed work will advance/support the deployment of AVs. In this way, the risks and opportunities that AVs might present are included in the project development and the analysis will demonstrate prudent due diligence in determining how robust the operational and business models are for that project.

10. Assuming that some of these analyses result in cost savings, and given the importance of AVs to the future efficiency, safety and environmental sustainability of the transportation system, include a specific category of dedicated funding for projects that would stimulate AV technology development, trials, testing and deployment.

11. Given the expected employment displacement, that the Government divert some of the savings to help mitigate the impact of job losses caused by AVs and promote workforce re-training.

Transit

Mobility-as-a-Service (MaaS) is a natural extension of the rapidly emerging 'Uber-type' business model where a person can order the type of vehicle that they need on their smart device, pay electronically in advance, and ride to where they want to go. The vehicle then seeks other passengers. If the passengers choose to ride-share as well, the cost decreases and the road network efficiency increases. This is essentially a hybrid of the best parts of private vehicle ownership and transit, providing a point-to-point, on-demand service, and using a shared resource in an efficient manner.

The trend to Mobility-as-a-Service with its on-demand, door-to-door service will take market share from traditional fixed-route, fixed schedule transit, resulting in reduced ridership, reduced revenue, and a need for increased subsidies from municipalities for publicly operated transit systems. It should be noted that at least one US municipality has already approached Uber about the possibility of taking over low-ridership bus routes to ensure that workers and students can still get to work and school, subsidised with funds from government sources.[13]

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[13] *'Rockford [IL] explores partnership with Uber'* http://www.sj-r.com/article/20141115/NEWS/141119646

It is not just CAVCOE that is predicting disruptive changes in the transit industry. The Canadian Urban Transit Association wrote:

> "*Highly or fully automated vehicles ….. have the potential to radically transform transit in the longer-term. It is possible to imagine publically-owned, or shared, self-driving vehicles (akin to taxis) acting as part of an urban mobility system. The transit industry must pay particular attention to these trends and develop the strategies which will enable transit systems and municipalities to take advantage of them. While automated vehicles will not become the only form of transit, their position within a network of modes and services must be taken into consideration.*"[14]

Another voice predicting disruption in the transit industry is the OECD, which wrote in its April 2015 report:

> "*For small and medium-sized cities, it is conceivable that a shared fleet of self-driving vehicles could completely obviate the need for traditional public transport.*"[15]

CAVCOE's recommendations to the Government of Canada are:

12. Require that all new major transit infrastructure projects seeking federal funding include a critical assessment of how the proposed work will advance/support the deployment of AVs. Consideration should also be given to the value of similar analyses on projects that are already underway where an analysis could provide a net overall benefit.

13. Assuming that some of these analyses result in cost savings, and given the importance of AVs to the future efficiency, safety and environmental sustainability of the transit system, include a specific category of dedicated funding for projects that would promote AV technology development, testing and deployment.

14. Encourage municipalities, regional transit authorities and transit companies to consider the impact of AVs in their strategic plans.

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[14] *Transit Vision 2040*; Canadian Urban Transit Association; document p58; pdf p60
[15] *Urban Mobility System Upgrade: How shared self-driving cars could change city traffic; a report by the International Transport Forum* (ITF), part of the Organisation for Economic Co-operation and Development (OECD); April 2015.

Quality of Life, Health, Climate Change and Mobility Equity

AVs can have a significant impact on the quality of life in our cities for a number of reasons.

AVs will reduce crashes which will improve traffic flows and reduce the societal burden of fatalities and injuries, as well as the direct and indirect burden on the healthcare system, support networks, and families and friends.

AVs can improve traffic flows because they drive more consistently and can drive closer together (if laws allow) and travel in platoons (if laws allow) and therefore help to reduce congestion.

AVs can reduce the number of vehicles on the road if policies are used to allow large shared fleets of automated taxis that will increase average vehicle occupancy, which will result in reduced congestion, more reliable travel times and less stressful journeys.

Vehicle emissions will reduce with AVs because the natural convergence with electric propulsion systems that are cheaper to operate and maintain will result in fewer fossil fuel vehicles in our cities. It should be noted that cities like Beijing, Paris and London are already being pressured to take steps to promote electric vehicles (EVs) due to pollution levels exceeding World Health Organization limits. A Canadian study has shown that traffic emissions pollute up to one-third of Canadian homes.[16]

At the COP21 meeting in Paris in December 2015, a major global accord was reached with regard to fighting climate change. Prime Minister Justin Trudeau stated:

> "*We will move towards a climate resilient economy, and we will invest in public transit, green infrastructure and clean technologies to create new jobs and support our communities.*"[17]

We note that the Federal Government has identified public transit as a key area to achieve transportation emissions reductions; and we also note that approximately 27% of all emissions come from transportation (US figure[18]) and therefore a concerted effort in this sector could have a significant impact on total emission reduction. However, it seems likely that this statement was made in the current paradigm without recognizing the impending AV paradigm. We believe that the definition of 'public transit' should include new modes of transport offered by AVs. We also believe that there is a growing body of evidence to support the argument that electric AVs powered from renewable sources can help achieve substantial reductions in the emissions from vehicles used in in transportation.

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[16] *'Traffic emissions may pollute 1 in 3 Canadian homes'*
http://news.engineering.utoronto.ca/traffic-emissions-may-pollute-1-in-3-canadian-homes/
[17] '*Historic' Paris Climate Deal Adopted*
http://www.cbc.ca/news/world/cop21-climate-change-talks-saturday-announced-1.3362354
[18] EPA Basic Information http://www3.epa.gov/otaq/climate/basicinfo.htm

AVs will be safer for vulnerable road users to be around and will therefore facilitate greater use of active transportations modes, e.g. walking, bicycling etc., which are known to promote health and well-being.

Because AVs are more controllable and courteous drivers, they will allow pedestrians and other active transportation users to be safer, feel safer, and have priority in certain locations at certain times of the day, e.g. automated vehicle zones, during a street festival etc. This will give cities much greater scope to promote community events, create walkable neighbourhoods and give the streets back to residents as places where they, and their businesses, can thrive.

AVs will significantly improve access to transportation for people who either don't have a driving license and/or can't drive, e.g. those that are disabled, seniors, too young, too poor, medically-at-risk etc. Because these demographics will not be reliant on someone else to drive when they have access to AVs, it will be cheaper and easier to arrange transportation than it is today. Many of these may be considered vulnerable riders, that are not currently well-served by existing transit, para-transit and other modes. Low-cost, easy access AVs will bring a level of mobility equity that many in these demographics will probably not have experienced before.

CAVCOE's recommendations to the Government of Canada are:

15. Conduct studies to determine the potential health and quality of life benefits associated with AVs, particularly if there are policies to promote electric propulsion systems. CAVCOE is not currently aware of a great deal of research work in this area and thus Canada could become a world leader in the study of these health and quality of life benefits.

16. Recognize the potential quality of life, health and environmental benefits of AVs and require that AVs be considered as an option in any new transportation or infrastructure projects where these characteristics are important to the final solution. We note that is only a matter of time before there will be a legal challenge to an Environmental Impact Statement (EIS) connected with a major infrastructure project where an AV solution has not been considered as being potentially more environmentally friendly.[19]

17. Recognize that the convergence of AVs with electric propulsion systems and renewable energy can contribute to achieving a significant reduction in emissions from surface transportation, in line with the climate change accord reached at COP21.

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[19] '*The Impact of Automation on Environmental Impact Statements*'
http://cyberlaw.stanford.edu/blog/2013/10/impact-automation-environmental-impact-statements

Auto and Technology Industries

AVs will likely have a significant impact on the auto and technology industries. For example, a recent report from Morgan Stanley[20] said:

> *Autonomous cars will offer better safety features and more efficiency. They will transform the auto-industry business model, pivoting from engines, gears and wheels to software, content and "user experience." Getting anywhere could literally become half the fun.*

And:

> *Related businesses, such as telecoms, software, media, freight transportation, semiconductors and insurance, will also face disruption and opportunity.*

The trend to driverless taxis and Mobility-as-a-Service is expected to significantly reduce personal car ownership and hence the market demand for new cars. This will decrease the number of jobs in the auto industry as we now know it.

Although the focus of this White Paper is automated vehicles, there are two other relevant key trends in the auto industry: Connected Vehicles(CVs) and Electric Vehicles (EVs). These technologies will converge to create ACE vehicles: Automated, Connected and Electric. Individually, each brings substantial improvements to vehicle operation, safety, convenience and the environment. Together, ACE vehicles will have a major, beneficial influence on our lives, our cities, society and our world.

Other trends in the auto industry in the 2020s include the adoption of additive manufacturing (3D printing), and changes in the sales strategy from consumer-oriented showrooms to fleet sales directly to operators of self-driving taxi businesses.

At the same time, the value of technology in cars will increase from the current 4-5% to 40-60%, creating huge opportunities for Canada's technology companies and many new jobs. The opportunities are in a wide variety of fields: sensors, software, communications systems, Internet usage for business and pleasure, car-smartphone integration. robust anti-hacking systems, glass dashboards, cloud computing and data analytics.

AV technology will be able to function on any type of vehicle platform, and we are already seeing the potential for new modes not currently in existence e.g. autonomous shuttles, lightweight pods that combine into road-trains / buses, sidewalk friendly delivery robots and self-delivering bicycles. We believe that the Canadian automotive sector could play a key role in developing these new modes and then bringing them to market.

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[20] http://www.morganstanley.com/articles/autonomous-cars-the-future-is-now/

CAVCOE's recommendations to the Government of Canada are:

18. Make a significant investment in AV development, testing, and related activities in the auto and technology industries, universities and the National Research Council, starting with the 2016-17 budget

19. Help the Canadian auto industry prepare for a major disruption in the number of cars that are made here, as well as how they are designed, manufactured and sold.

20. Invest in the Canadian auto and technology industries to help create an AV ecosystem that can compete in the global automated, connected and electric (ACE) vehicle market.

21. Engage in developing a national cyber-security strategy and standards for AVs. Without this, the first major hacking event will neutralize a lot of progress -- perhaps for a long time.

Oil and Pipeline Industries

We believe that electric vehicle (EV) propulsion systems are on a significant deployment growth curve, driven by the objective of sustainable energy and advances in battery and drive train technologies. The forecast acceleration in the adoption of EVs in the 2020s will likely cause a significant decline in the global demand for oil. It is also likely that the current low price for a barrel of oil is not temporary – as many analysts think -- but the beginnings of a systemic effect that will lead to even lower oil prices through the 2020s.

The price of oil is sensitive to minor fluctuations in supply or demand, and the EV trend is already becoming increasingly clear in California which is invariably a prediction of what is to come in the rest of North America. In 2014, EVs accounted for 0.85%[21] of all vehicles sold in the US, with approximately 40% of all US EVs being sold in California[22]. Thus indicating that over 2% of all vehicles currently sold in California are EVs. This combination of solar energy, EV and AV trends has been clearly identified by Tony Seba of Stanford University[23,24] as being on a growth curve that indicates that fully autonomous EVs will dominate vehicle sales by 2030.

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[21] *'Highest Percentage Yet of US EV Sales'*
https://content.sierraclub.org/evguide/blog/2014/10/highest-percentage-yet-us-electric-vehicle-sales
[22] *'40% of US EV Sales are In California'*
http://cleantechnica.com/2015/11/21/40-of-us-electric-car-sales-are-in-california/
[23] *'Clean Disruption of Energy and Transportation: How Silicon Valley Will Make Oil, Nuclear, Natural Gas, Coal, Electric Utilities and Conventional Cars Obsolete by 2030 (Book Review)'*
http://cleantechnica.com/2015/03/30/book-review-clean-disruption-of-energy-and-transportation-how-silicon-valley-will-make-oil-nuclear-natural-gas-coal-electric-utilities-and-conventional-cars-obsolete-by-2030/
[24] Youtube video *'Clean Disruption – Tony Seba'* https://www.youtube.com/watch?v=_r4sjkkRGkM

CAVCOE's recommendations to the Government of Canada are:

22. Consider the options for the oil industry, given the anticipated widespread adoption of electric AVs and the likely impact on the global demand for oil.

23. Plan now for diversifying the economy.

24. Recognize the impact on government revenues.

National Security & Policing

There are all manner of national security issues that will result from the deployment of AVs on public roads and from the related autonomous delivery robots on sidewalks. AVs can be used as mules to deliver almost anything to anywhere on the road network, and possibly off the road network too. From terrorist tools to drug mules, from criminal activity to personal vendettas, AVs could very quickly become the tool of choice for criminals and terrorists. Canada simply cannot afford to be complacent in light of the threat scenarios created by AVs.

Policing will change significantly when AVs are introduced. A US study showed that 53% of the public's interaction with the police is for traffic-related offences. Given that computers will be safer and more law-abiding drivers, will we need as many police officers patrolling the highways? Do police forces re-assign them to other duties?

There could be many other downsides. Routine traffic stops have the beneficial side effect of identifying and arresting people wanted for more serious offences. People who are wanted will be able to drive or be driven in a manner that is consistent with all other road users, or program their vehicles to do a fast U-turn to get away from the traffic stop driving with the skill of a top racing driver. The result could be that having fewer police officers on traffic patrol results in fewer arrests for more serious crimes.

Many municipalities rely on the revenue from traffic fines and penalties in their annual budgets. If AVs are programmed to obey all traffic laws, then this revenue stream will rapidly diminish, with consequential effects on municipal budgets.

The RCMP is actively monitoring the AV file. A representative attended an AV summit in late 2013, and CAVCOE made a presentation to the Manitoba RCMP Highway Patrol in October 2015.

CAVCOE's recommendations to the Government of Canada are:

25. Treat the national security threat that will be posed by AVs as a priority and proactively work to avoid or mitigate the opportunities for abuse by criminals and terrorists.

26. Encourage the RCMP to continue monitoring the status and plans for AVs in Canada and to develop strategies and plans for policing in the AV era.

Other Federal Departments and Programs

In addition to the above, AVs will impact most if not all government ministries, departments and programs, and in particular those related to climate change, health care, and electricity generation and distribution.

Provinces, Territories and Municipalities

Although the focus of this White Paper is the Government of Canada, it is important to include a brief mention of the impact of AVs on provinces, territories and municipalities, which is expected to be substantial.

As we have mentioned above, AVs will lead to new public transit models; reduced congestion; less pollution from car emissions; improved road safety; changes in land use; changes in land values; changes in land-zoning; a reduced need for parking lots and garages; reduced revenue from traffic-related offences; an opportunity for urban spaces to be used more creatively; an opportunity to develop policies for densification of inner city and suburban nodes (or more sprawl); improvements in livability based on more walking and biking, fewer cars, less congestion, and more time not driving; the creation of Autonomous Vehicle Zones; etc.

CAVCOE's recommendations to the Government of Canada are:

27. Support provinces, territories and municipalities in understanding the impacts of AVs, benefiting from the upsides, and mitigating the downsides.

28. Encourage provinces, territories and municipalities to include AVs in their Transportation Master Plans, their strategic plans for transit (for municipalities), and evaluate how it affects other aspects of government.

29. Require an analysis to assess the risks and opportunities that AVs pose to major transportation and infrastructure projects in order to determine how robust current forecast business and operational models might be. This is a form of prudent due diligence to ensure that tax-payer dollars are invested wisely in infrastructure that will be useful for many decades.

30. Encourage the provinces, territories and municipalities to review their laws and regulations to determine if they promote or hinder the benefits of AVs and to determine if additional laws and regulations are needed in light of this potentially transformative technology.

Conclusions

Automated vehicles are coming soon and will lead to substantial disruption, benefits and challenges. The changes that will result from AVs in the 21st Century will be as substantial as the impact that cars had on our lives, cities, business, society, and the world in the 20th Century. The recommendations in this roadmap are intended to help Canada maximize the benefits and mitigate the downsides of this exciting and yet challenging technology as rapidly as possible, because this technology is coming whether we are ready, or not.

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