The Future of Driving

Policy Directions for Automated Vehicles and New Mobility Services in Metro Vancouver

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TRANSLINK

Contents

Introduction

Technology's influence on transportation continues to grow, just as its influence continues to grow in all areas of society. While driver systems, such as parking assist and in-car entertainment are now commonplace, a much more significant set of trends is emerging that could transform the way we travel.

Automated and connected vehicles could represent a fundamental change in the role of automobiles, trucks and buses. The ability to operate without a driver creates the potential for drastic reductions in collisions, congestion and infrastructure designs that account for human factors. When combined with advances in car sharing and vehicle pooling, entirely new modes become possible that offer affordable, on-demand mobility without the need to own a vehicle.

The immediate future of this technology is uncertain as there is a range of political, social, demographic, environmental and legal hurdles to be addressed. Industry is responding by investing billions into vehicle technology and mobility services, leaving public policy lagging while governments try to comprehend whether the advantages of automation will be tempered by rebound effects including increased vehicle dependency, reduced revenues from driving, competition for public transit and creeping privatization. Moreover, as with all technological changes, threats to jobs in driving and transportation-related industries must be balanced against the potential gains in efficiency.

Automated, connected and shared vehicles have come to represent a "wicked problem" characterized by incomplete, contradictory, and changing requirements. To date, two approaches have been adopted, either to press ahead with technical testing while solving policy issues in real time, or a more conservative approach of observing and waiting. With the exception of Ontario and Transport Canada's work on technical and safety standards, Canada has largely taken the conservative approach.

TransLink is in a unique position to respond to these trends both as the region's transportation authority, and as the transit operator. Acting under the remit of Regional Transportation Strategy policies to investigate vehicle sharing and new vehicle technology (Actions 2.2 & 2.3), TransLink started by convening meetings with municipalities titled the Future of Driving between September 2015 and April 2016.

Alongside industry and government, the Future of Driving Project provides a vision for how vehicle technologies could assist in meeting Metro Vancouver's mobility aims. This report recommends potential research and policies that will help shape progress towards that vision. It also clarifies some opportunities and preparatory work for TransLink to consider as an operator. These are explained in the body of this report.

Summary of policy recommendations:

1. Update transportation policies and regulations to promote shared automated vehicles in support of regional objectives;
2. Proactively position TransLink to navigate rapid change while maintaining the resiliency of transportation operations and improving the customer experience; and
3. Create opportunities for government, industry and experts to explore and test innovative ideas to harness the positive benefits of automated vehicles and new mobility services.

The Emergence of Vehicle Automation

The following is a brief summary of various studies and reports (see also Works Cited).

Fully-automated (or self-driving) vehicles are cars, buses or trucks that can perform all of the functions of driving using only sensors, communications and computing. These vehicles can operate in all conditions with no driver inputs or with no driver present.

Automation

An automated vehicle is significantly different from driver assistance systems like parking and lane assist which are already available. The Society of Automotive Engineers (SAE) has produced a six-level range of automation.

	SAE Level	Name
Human monitors environment	0	**No automation** the full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems
	1	**Driver assistance** the driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task.
	2	**Partial automation** the driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task
Car monitors environment	3	**Conditional automation** the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene
	4	**High automation** the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene
	5	**Full automation** the full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver

At the highest levels (SAE Level 4 and 5) it is argued that total computer control could drastically reduce crashes and congestion as well as remove the barriers of disability or legal driving age.

The magnitude of possible benefits has fuelled enormous investment in developing fully-automated vehicles. Some countries, such as the United Kingdom, are also strongly promoting introduction by allowing controlled testing on public roads. This environment means the technical challenges are gradually being overcome.

Timing

Rapid progress and a degree of hyperbole have led some of the major interests including Google, GM, Volvo, Uber and Tesla to predict fully-automated vehicle launches by 2020, though many technological and automotive experts remain skeptical that this is a feasible timeline.

What is less clear is how automated vehicles will penetrate the consumer market and when they might reach a tipping point of use.

Practical considerations suggest that fleet users may be amongst the earliest adopters. This prediction is supported by the economic reality that driver overheads are a major cost in fleet operations and the fact that commercial vehicles are replaced more frequently than private vehicles.

Interest in fleet uses may also create opportunities for new mobility services to evolve from various current models. For example, it is possible to imagine driverless taxis shared with other users on similar routes as blending taxis, car sharing (Car2Go, Modo) and ridesourcing services (Uber, Lyft).

Automation and dynamic route planning would allow these services to be hailed on demand and may be highly competitive in denser areas where there are

many possibilities for shared trips. If booking these services could also be integrated with transit, bike sharing and other services and paid for simply, the concept of mobility as a service (MaaS - see figure at right) becomes possible.

Consumer confidence may also influence where automation begins to grow. A reported survey by Morning Consult in February 2016 suggests 43 per cent of Americans thought automated cars are dangerous, and that 63 per cent were not likely to buy one in the next decade.

Besides confidence, the potential for private ownership is also influenced by the cost of vehicles. Although the cost of technology will decrease, current automation systems are very expensive and too complex to be retrofitted commercially.

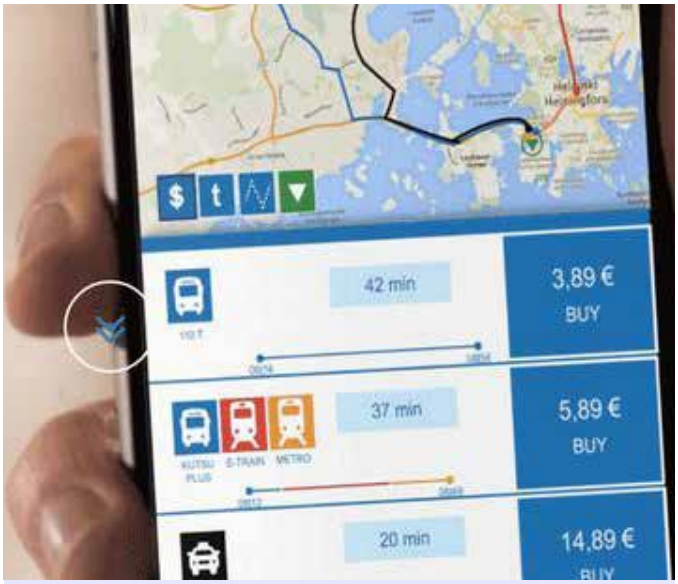
The prevailing technological solution is also a factor on possible expansion. One approach is to make a vehicle fully autonomous, that is to say relying on radar and other sensors to navigate. This approach may require highway infrastructure such as signage and lines to be provided and maintained to a much higher standard than now.

The alternative option is a fully-connected vehicle that uses communication between vehicles (V2V), road infrastructure beacons (V2I) and being part of the "internet of things" (V2X) to complete journeys. This approach may require transponders to be fitted to road infrastructure and carried by road users.

Legislation

It is clear that any one solution, or a combination of autonomous and connected vehicles, will have different implications for governments.

Whatever the technological approach adopted by industry, law-makers never anticipated an absence of human control in vehicles. One critical step will be if software can be widely assumed to have the same role as a human driver, as the US National Highway Traffic Safety Administration decided was the case in February 2016.



MaaS could bring every kind of transport together through a simple smartphone app. MaaS combines transport options from different providers, and manages all trip planning and payments. Users can buy journeys on demand or subscribe to an affordable monthly package similar to a cable contract.

Image credit: MaaS.fi

Other governments are adopting more experimental approaches. The Ontario Ministry of Transportation (MTO) have created experimental legislation to launch Canada's first automated vehicle testing program in January 2016. This pilot will inform provincial and federal definitions.

Regulation of vehicles in use may be even more complex considering the ethical and liability issues in the event of a crash. Furthermore, the definition of mobility services enabled by automated vehicles may require new definitions for car sharing, taxis and transit, similar to the ongoing debate in this region about the role of ridesourcing services such as Uber.

While there is huge investment and energy directed at testing vehicle technologies, there is relatively little evidence of policy frameworks being created

to address the social, economic and environmental impacts of automated vehicles. To this point, in February 2016, Federal Transportation Minister Marc Garneau requested the Senate's Transportation and Communications Committee to report on the regulatory, policy and technical issues for smooth introduction of automated vehicles.

Policy Context

National policy

The *Canada Transportation Act* Review "Pathways: Connecting Canada's Transportation System to the World" provides important recommendations and high-level context concerning federal direction on harmonizing and coordinating innovation in transportation and automated vehicle systems.

Relevant recommendations are included below.

Chapter 5 Innovation

Recommendation 1

The Review recommends that the Government of Canada continue to collaborate with other countries through international organizations to ensure that Canada plays a strong role internationally in the development, adoption and regulation of new technologies and innovation that will enhance the performance of transportation systems.

Recommendation 2

The Review recommends that Transport Canada, in the context of the new governance arrangements proposed for federal involvement in the transportation sector, ensure that an action plan is developed, with specific objectives, implementation plans, and measurable outcomes, to guide Canada's long-term investments in transportation technologies and innovation.

Recommendation 3

With the advent of automated vehicles, the Review recommends that the Government of Canada develop a national regulatory framework that will harmonize Canada's approach with United States legislation with respect to the testing and operation of autonomous vehicles on public roads.

Transport Canada's "Developing a Long-Term Agenda for Transportation" also investigates how new technologies can make transportation systems safer, more secure and competitive while also minimizing impacts on the environment.

The 2016 Federal Budget approved $7.3 million over two years to support the development of a regulatory framework for emerging vehicle technologies including automated vehicles. This announcement came just a few months after the Ontario Ministry of Transportation invited proposals for the development and testing of automated vehicles under a 10-year long pilot project.

Provincial policy

The BC Ministry of Transportation and Infrastructure (MoTI) has not issued any policy guidance at this time on automated vehicles. Its apparent position remains that MoTI jurisdiction on legislative amendment cannot be considered until the Federal Government determines the legality of the vehicles. MoTI staff have, however, contributed to the Future of Driving process and are supportive of further regional discussions including, among others, TransLink, ICBC and the Passenger Transportation Board.

The Minister of Community, Sport and Cultural Development (and responsible for TransLink) is also undertaking a consultative process to examine the regulation of passenger transportation in the province in response to new entrants into the existing taxi industry. There is no date slated for the outcome of this process.

Regional policy

The current Regional Transportation Strategy provides general direction in two main areas:

Strategy 2.2 – Make travel easy and attractive for all users, a key action:

Make it easy to share – by supporting car sharing, ridesharing, bike sharing and taxis including undertaking research on how best to increase trips by multiple-occupancy vehicles.

Strategy 2.3 – Optimize roads and transit for efficiency, safety and reliability, a key action:

Explore opportunities and potential impacts of new vehicle technologies including low carbon, connected, and self-driving automobiles.

The Mayors' Council Vision includes a number of priorities that could be influenced by the trends in automated vehicles if, as expected, this technology develops quickly over the next five to ten years.

These include:

- **Mobility pricing** - across new modes/services
- **Transit ridership growth** – impacts and integration
- **Major Road Network** – demand and capacity forecasts
- **Parking regulation** – management and planned repurposing

Municipal policy

The City of Vancouver accepted a motion in February 2016 asking staff to report back on how automated vehicles will affect existing land use, economic and sustainability plans, and how those documents should be updated. City staff have asked TransLink to contribute regional recommendations to their process.

In addition, the City of Coquitlam, City of Port Coquitlam and Langley Township councils have all indicated their support for the introduction of new mobility services and specifically Uber.

Municipal interests highlight the many uncertainties concerning how different levels of government will need to work together to regulate, plan and manage the impacts of automated vehicles and services. Some regulations will be amendments to accommodate change, such as the legal status of the vehicles; some may require new structures, such as the regulation of services that effectively create new modes; and some will be entirely new, such as the regulation of cyber security in transportation.

Opportunities and Challenges

At this early stage of development, most studies have speculated about potential opportunities and challenges arising from automated vehicles. Some of the potential benefits, such as safety, are being vigorously promoted by industry, but uncertainty suggests a sceptical approach may be wise at this point. The following represents priority considerations for Metro Vancouver:

Safety

The largest opportunity is the potential elimination of automobile crashes caused by human error. Economic impacts caused by traffic incidents, health care costs and lost productivity are at least $10 billion annually in Canada or about one per cent of GDP. In 2013, ICBC reported 61,000 road crash injuries in Metro Vancouver alone. ICBC also reported that 80 per cent of fatalities result from speed, intoxication or distraction, none of which would affect a computer.

Full automation in the vehicle fleet could potentially reduce human suffering and save millions of dollars.

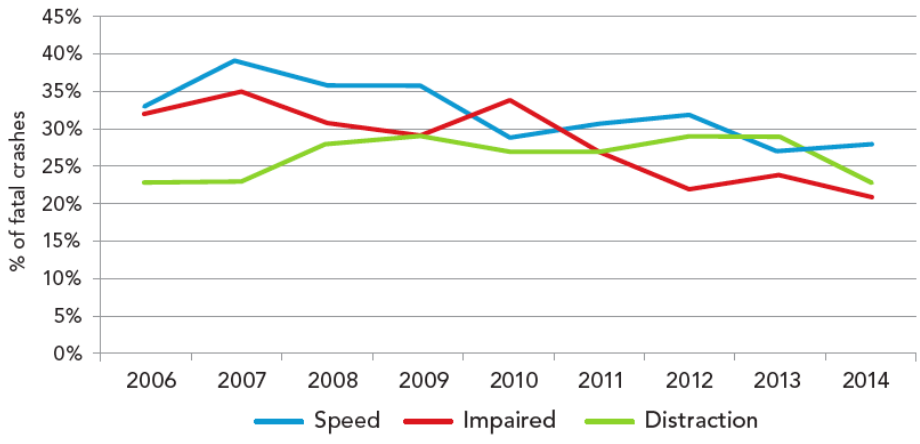
Before these benefits can be harnessed, issues of liability in the event of a crash involving a driverless vehicle need to be resolved. The legal process suggests the need for precedents with the potential to slow or block progress compounded by a potentially long period of transition where both human-controlled and driverless cars drive together.

One particular concern relates to perverse outcomes from risk management. For instance, it is imaginable that there may be calls for automated vehicle-only lanes with subsequent restrictions on access for motorcyclists, pedestrians and cyclists. These vehicles may also pose challenges for traffic-animal interactions.

Accessibility

Automated vehicles could provide accessibility for some seniors unable to drive and for other people with disabilities. In 2012, Statistics Canada reported that 375,000 people in BC had a moderate to very severe disability and that by 2030, one in four people in Metro Vancouver will be a senior.

Top contributing factors in fatal crashes



	2006	2007	2008	2009	2010	2011	2012	2013	2014
Speed	33%	39%	36%	36%	29%	31%	32%	27%	27%
Impaired	32%	35%	31%	29%	34%	27%	22%	24%	21%
Distraction	23%	23%	28%	29%	27%	27%	29%	29%	23%

TransLink's experience with HandyDART suggests that vehicle services in the form of taxis can work well for some people but that everyone has unique needs. While automated vehicles may offer independence to those physically able to use them, many others will always require human assistance no matter how sophisticated the vehicle.

These vehicles could also offer mobility to people without a driver's licence. Related to this, ICBC has reported a marked drop in licensing amongst 18-30 year olds since 2001. It is no coincidence that these Millennials (aged 18-34 in 2015) are described as digital natives and most likely to be early adopters of new technology. This same demographic is also in the vanguard of our multi-modal city dwellers. Removing the need to have a license may be liberating for them but also liable to incentivize vehicle travel unless other controls are in place to manage demand.

Vehicle ownership

Privately-owned vehicles are often reported to be parked for 90-95 per cent of the time. Shared use of this valuable resource could drastically reduce the privately-owned vehicle fleet needed to maintain mobility. Recent growth in car sharing and ridesourcing services has grown at a time when the sharing economy has become a lucrative business model.

Although taxi-like ridesourcing (Uber, etc.) has grown quickly in a short time, peer-to-peer vehicle sharing, where a personal vehicle is rented, is yet to take hold. Automation could enable this using a model similar to AirBnB for private vehicles or through sharing networks under private leasing agreements. Several auto manufacturers are exploring these concepts including partnerships between GM and Lyft, and Google and Uber. Overall, automation may provide the opportunity for vehicle ownership to become far less common.

Modelled impacts of reduced ownership include a 2015 study by the International Transport Forum (ITF). The ITF found that taxibots, or automated minibuses, reduced the number of vehicles needed to maintain mobility in Lisbon, Portugal by 65 per cent, while autovots, or single occupancy shared vehicles, reduced 23 per cent of the vehicles needed.

This positive effect was reduced by the further finding that these services also increased vehicle kilometres travelled (vkt) by six per cent (taxibots) and 89 per cent (autovots). Managing the convenience of vehicles while embracing the opportunity to reduce ownership is therefore an important and complex policy discussion.

Land use

It has been estimated that at a fixed separation of seven metres between vehicles traveling at 100kph, highway vehicle capacity increases from the regular 2,000 vehicles per lane per hour to 5,700 vehicles per lane per hour, though other studies reflect a wider range of estimates.

Connected vehicles may allow this type of close platooning to be possible safely and the technology is well-established with the US Department of Transportation trials dating back to 1997. Again, a caveat for this opportunity exists because while effective for highway travel, platoons are not possible in most urban situations unless provided segregated lanes.

The advantages of lane efficiency through high-speed highway platoons on highway systems have also been cited as risking the promotion of urban sprawl. In Metro Vancouver, limited highway access and the urban containment boundary should reduce any sprawl effects in Metro Vancouver, but these vehicles could make living outside of the region with long distance commutes easier and so support suburban densification.

Relatedly, land use for transportation infrastructure may also change. Vehicles that don't crash could eventually remove the need for human factors to be included in highway engineering. Fewer or narrower lanes and smaller intersections in some areas may

one day be possible but not before a complex period of transition where traffic management would need to consider human-robot interaction.

Finally, a major transportation land use effect could be the reduction of vehicle parking. In the same ITF study mentioned above, both taxibot and autovot scenarios completely removed the need for on-street parking and up to 80 per cent of off-street parking. To give a sense of scale, a 2008 study of downtown Vancouver found 60,500 commercial parking spaces, equivalent to roughly one square kilometre of land.

Reduced parking presents the potential for street space to be repurposed as parks, sidewalks, bike lanes or transit lanes and for development to be more compact and affordable. But once again this presupposes an efficient way to manage a prolonged transitional period and the need for advice on when and how to repurpose space.

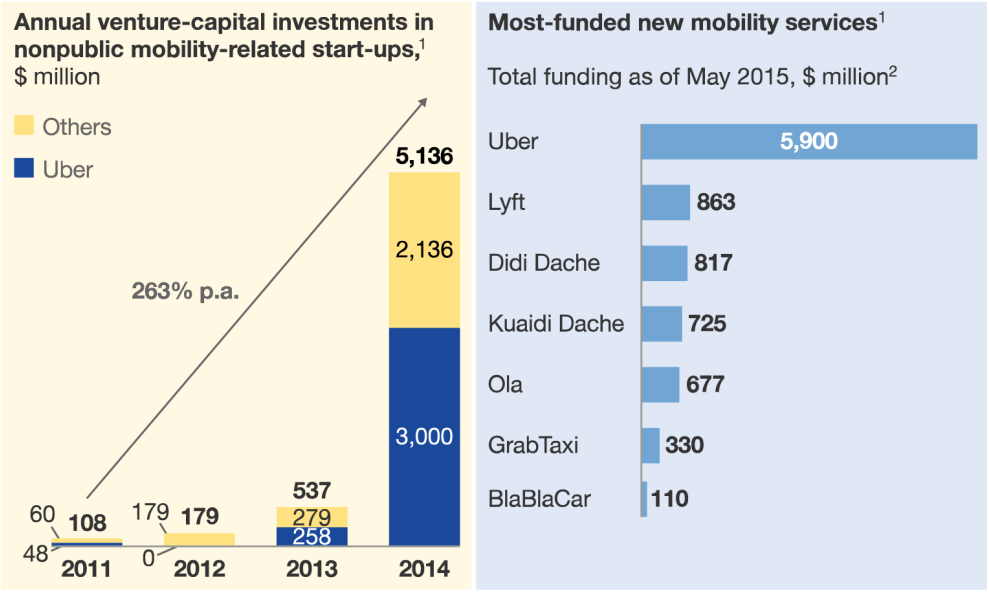
Privatization

Advances in vehicle technology have previously been progressed incrementally by auto manufacturers to improve comfort and safety. Some tech-based companies have leap-frogged this in a push for full automation and in the process have created pressure on government to change regulations as they race to launch services.

It is important to consider that industry ideas for how automated vehicles will come to market are typically private with on-demand or member-based services.

It is too early to predict business models but a risk of increased privatization in transportation could lead to aggressive competition for profitable transit markets in preference to offering access for lower income or low-density communities. It is relevant that, depending on the metric used, between one in seven and one in 10 in BC live below the poverty line and about 90,000 low-income seniors and persons with disabilities receive a subsidized BC Bus Pass.

Infographic: McKinsey & Company chart the fund raising progress of new mobility services as a means to illustrate the exponential growth in capital and diversification.



[1]By total funding raised to date. Publicly disclosed information only.
[2]Does not include mobility services offered by automotive OEMs (eg, DriveNow, Car2Go), as data are not disclosed.

McKinsey&Company | Source: CrunchBase; PitchBook Data; Preqin; Venture Scanner

Irrespective of the business model, indications are that new mobility services could be operated more affordably than conventional transit in some circumstances and so could allow greater coverage for the same resources.

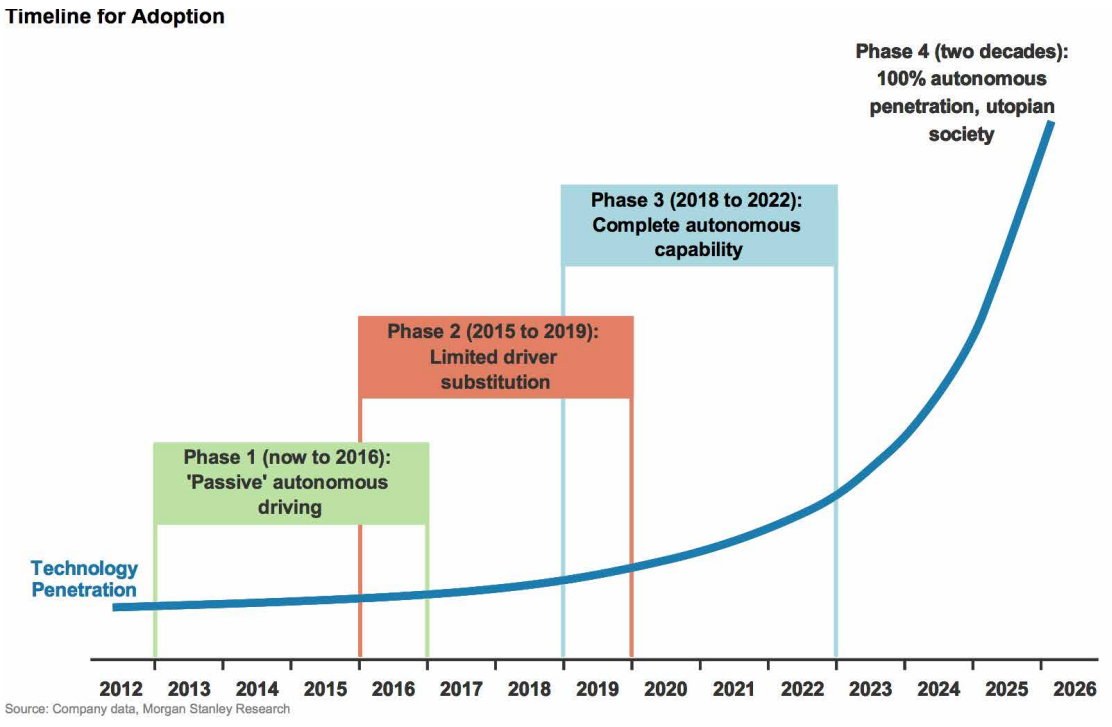
The possibility of new service options expanding access to transit raises some regulatory questions, for instance, in relation to minibus ridesourcing (micro transit) which is similar in practice to Independent Transit Services but could be regulated under the Passenger Transportation Board similar to taxis. To be efficient and fair requires effective regulation as part of more integrated network management of multiple services.

Emissions

Greenblatt/Taxena (2015) estimated that a self-driving, electric taxi in 2030 would produce 90 per cent lower greenhouse gas (GHG) emissions than a 2014 privately-owned gasoline vehicle, and 63 to 82 per cent fewer GHG emissions than a privately-owned hybrid vehicle due to reduced dependancy on privately-owned vehicles and improved efficiency of networked vehicles.

There are suggestions that the flexibility of vehicle design offered by automation could increase the opportunity for new zero or super-low emission vehicles. This would be accelerated in Metro Vancouver if regulations on emissions are strengthened under the provincial Climate Action Leadership Plan.

Nevertheless, current trends are not as hopeful. In 2014, all hybrid vehicles only represented two per cent of the of the personal vehicle fleet in Metro Vancouver. It is also notable that between 2001 and 2013 gas powered light trucks increased from 30 per cent to 40 per cent of all vehicles.



Employment and economy

In 2014, 19,000 people in BC were employed in vehicle manufacturing and an additional 75,000 were professional drivers. A major expansion of driverless vehicles could heavily impact the viability of these jobs, although major changes would likely happen gradually, allowing some people time to retire and others to convert skills.

There could also be a range of allied professions that may be impacted including auto retailing, crash repairs, driver licensing, enforcement, and emergency services. At the same time, many new jobs could be created in design, software, sensor manufacture and data management.

In addition to employment change, automated vehicles could change how government revenues are derived from driving. Depending on how vehicle services develop, parking revenues, enforcement penalties and fuel taxation could all be heavily reduced. Alternative methods to pay for transportation and other public services will take on greater importance, including distance-based pricing or tolls to manage growth and to ensure service providers pay towards the infrastructure they will use.

Data privacy

Automated and connected vehicles will produce huge amounts of data from on-board and remote systems that must be protected from cyber attack.

Positively, the data produced would present an unprecedented opportunity to model and manage traffic in real time, which could be used to improve customer information and fine tune pricing. Naturally, this proliferation of data comes with huge responsibility and the need for complex management to maintain privacy and protection from hacking.

The access to detailed vehicle data, which could identify drivers, also raises new social, policy and ethical questions that may not be easy to answer. An example of the dilemmas includes whether the police should be allowed to take remote control of a vehicle containing a suspect.

Future of Driving Project

The Future of Driving project was initiated in response to municipal interest in automated vehicle technology and the potential need to accommodate this technology in future transportation and land use policies. A series of municipal information sessions was arranged in Fall 2015 and early 2016.

The objectives of the project were to work with municipal, government, research and industry stakeholders to:

- Establish a common understanding of the key issues for stakeholders in regards to automated vehicles in the region.
- Explore how automated vehicles and services might impact:
  - Mobility pricing and regulation;
  - Land use and parking policies;
  - Managing transportation network capacity;
  - Travel demand growth forecasts and infrastructure needs; and
  - Implications for goods movement and mass transit operations
- Support municipalities to respond knowledgeably to public and Council interest about automated vehicles as they relate to local, regional, and provincial planning objectives.

The project included four information sessions starting in September 2015, each with a particular discussion theme and supported with expert speakers:

- **September 24, 2015** - Municipal Information
- **October 29, 2015** - Carsharing Systems
- **November 26, 2015** - Infrastructure and Street Management
- **February 1, 2016** - Policy Gaps and Opportunities

A final forum was then arranged in April 2016 that used scenario-planning techniques to establish consensus on an ideal end state for automation.

This session produced a **preferred scenario for a Mobility as a Service** (MaaS) **system linked to structured mobility pricing to manage increased potential for vehicle distance travelled and support increased use of public transit**.

The forum exercise concluded with a facilitated discussion to agree potential research, policies and actions needed to shape the development of automated vehicles towards the preferred scenario. These thoughts have been included in the policy recommendations that follow.

Details of the forum process are included in Appendix A with a record of the outcomes from the discussion in Appendix B.

Future Policy Recommendations

To frame regional policy, it must be assumed that other levels of government are actively working to resolve issues related to the legislative status of automated vehicles; the regulation and licensing of related services; and the public interest issues of data privacy and safety. These assumptions allow these recommendations to focus on regional actions for Metro Vancouver.

Note: In light of the pace of development, these recommendations are time-sensitive and may need regular review.

Recommendation 1:

Update transportation policies and regulations to promote shared automated vehicles in support of regional objectives.

Issues:

Automation could solve some of the most pervasive problems of vehicle-based mobility. Equally, automation could make vehicle travel cheaper, more convenient and easier to access adding to other problems. This risk is acute if automated vehicles grow through private ownership and create unmanaged opportunities for discretionary use by people who did not previously drive.

In addition to effective management policies, the encouragement of shared multi-occupancy vehicle use may become a much more important objective in the near-term. It could be desirable to help create a market demand for more sharing now to influence new services in the future and to enable a long-term decoupling of ownership from mobility.

Potential actions:

- Introduce region-wide road usage charging to manage demand for increase vehicle usage resulting from automated vehicles;
- Encourage car sharing and multi-occupancy vehicle use through incentive programs and priority parking, including at transit hubs; and
- Strengthen the role of active transportation by rapidly increasing investment in safe, attractive and direct walkways and bikeways and pedestrian and bicycle priority areas.

Recommendation 2:

Proactively position TransLink to navigate rapid change while maintaining the resiliency of transportation operations and improving the customer experience.

Issues:

The general expansion of technology in transportation provides opportunities for access to new services, safety, system efficiency, payments and customer services.

Changes in how private vehicles may be owned and used may also significantly change employment and sources of funding.

In addition to collaborative work required to shape policy outcomes, action is warranted to prepare operational strategies that manage transitional phases and embrace the benefits while also minimizing risk. Keys to this will be developing better forecasting and developing an understanding of opportunities as trends evolve.

Potential actions:

- Actively participate in any review of the regulatory relationship between ridesourcing, micro transit services and Independent Transit Services;
- Plan for reductions from parking and fuel sales taxes; and
- Work with operators to review near-term opportunities to implement driver assistance systems.

The driver assistance technology, called Mobileye Shield+ by Rosco Vision Systems, uses four bus-mounted vision sensors to identify and alert bus drivers when pedestrians, cyclists or vehicles are in close proximity to a bus.

Photo credit: King County Executive Department of Transportation

Recommendation 3:

Create opportunities for government, industry and experts to explore and test innovative ideas to harness the positive benefits of automated vehicles and new mobility services.

Issues:

There are great uncertainties concerning the pathway to increased automation and how the end state will affect personal mobility. Many jurisdictions are approaching this by encouraging industry to test technology while they review legislation and regulations in parallel. This will undoubtedly advance the technical competency of vehicle systems but could create difficulties in achieving user-centred outcomes.

A way to achieve a greater appreciation for the needs and impacts on people is to take a user-centred design approach. For such a complex and interconnected issue as automated vehicles, this approach would require collaboration between government, industry and other experts, possibly using a social innovation lab. Labs are testing beds used widely to address complex social issues in other fields of work and could provide a useful way to facilitate the necessary multi-disciplinary interests in automated vehicles and services.

A social innovation lab also offers a space to combine other related and similarly complex issues such as mobility pricing and the sharing economy to help establish parameters for Mobility as a Service type payment and information systems.

Potential actions:

- Collaborate with partners to set up and fund a social innovation lab that would explore:
  - Concepts for Mobility as a Service (MaaS) systems including integrated payment across all modes from a single mobility account;
  - Ways to expand car sharing and multi-occupancy vehicle use across the entire region;
  - Expand public transit service delivery models including flexible last-mile services; and
  - New geometric designs that reflect the impact of automation on traffic and engineering.

Next steps

This briefing sets out policy directions from a first stage of investigation and discussions into the potential transformation indicated by our current understanding of automated and connected vehicles.

The Future of Driving project has shown that much more work is needed and that no one organization is ideally placed to shape policy. The next step is to find ways to collaborate across government, industry, academia and communities to increase common understanding and purpose.

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Appendices

Appendix A – Future of Driving Forum

Forum process and findings

Following four Future of Driving information sessions, a final forum was organized to conclude the first phase of the Future of Driving Project. The forum summarized feedback and interests from previous information sessions, and went on to debate potential future scenarios as a means to agree possible policy actions.

Staff recognized that the innovations and technologies discussed in the four information sessions could be used, combined, and taken up by the public in countless ways. Rather than tracing all these variations and making projections into the future, scenarios were constructed as an established method of grappling with uncertainty and considering how they might impact existing policy objectives.

Scenario 1 - Status Quo (single occupancy, auto-dependent)

Mobility		Vehicle occupancy: Single occupancy	Vehicle occupancy: Multi-occupancy
Mobility	Multi-modal	Uncoordinated Mobility	Coordinated Mobility
Mobility	Auto-dependent	Status Quo	Motor City

Four scenarios were developed using two axes of uncertainty that have particular relevance to regional planning aims: mobility and vehicle occupancy. The characteristics of the four scenarios are described at right.

By 2030, automated driving has led to major improvements in the efficiency and economics of automobiles. Metro Vancouver residents are still highly dependent for transportation on single-occupancy vehicles. This takes the form of mainly personally owned vehicles in suburban and rural areas while driverless taxis become prevalent in denser centres.

Even though automated driving of personal vehicles has improved efficiency of the road network, a significant amount of automated vehicles will be privately owned with low occupancy leading to increased urban congestion. However, the technology's efficiencies will reduce highway congestion from levels seen today. This means people are now able to commute longer distances in the same amount of time. However, as this style of mobility comes at a higher cost, public transit is still a competitive option for those living in certain areas (e.g. transit-oriented developments and regional centres) and of certain income brackets.

Planned investment in key transit projects has expanded access to new areas of the region, but improved vehicle efficiency prevents significant shifts in overall mode share towards transit.

Scenario 2 - Motor City (multi-occupancy, auto-dependent)

By 2030, automated vehicles and mobile technology are highly advanced and ubiquitous.

While advances have made vehicle travel more economical, broader market conditions have made ownership prohibitively expensive – overall there is a continued dependence on cars, but a major shift toward sharing.

A wide array of vehicle-based services evolve to meet most needs. Shared self-driving taxi services are seen widely, carpooling is increasingly common, and new contracts for private vehicles allow them to be shared when not in personal use. With cars less likely to be under-used, the price for vehicle mobility is greatly reduced.

The availability and cost-effectiveness of vehicle mobility reduces the viability of some transit services and constrains expansion. Over time less income from transit ridership as a whole reduces service expansion with resulting declines in use.

Patterns of use reduce downtown parking demand but increase distances travelled in reverse peak directions as automated vehicles leave core areas after dropping clients at destinations. To reduce distance travelled and the costs of down-time for these services (e.g. parking costs or continued circulation), demands for out-of-centre holding centres with cheap parking and charging facilities create large new parking land uses.

Scenario 3 - Uncoordinated Mobility (single occupancy, multi-modal)

By 2030, residents of Metro Vancouver are comfortable using a variety of modes to satisfy their mobility needs and they have many free market options.

For longer commutes, mass rapid transit is highly competitive (in terms of efficiency and cost) with cars. 'Last mile' trips are accomplished through a choice of active transportation and vehicles, depending on the economics of the final destination (i.e., within a transit-oriented development, walking and cycling is preferred over cars; for more distant destinations, vehicles are used). A new breed of small, light, clean micro vehicles designed for denser city living come in a range of configurations from bikes to single-occupant vehicles and are available as pay-per-use services or are privately owned. New facilities for storing and charging them replace downtown parking.

Last mile vehicles also provide part of the transit offering in suburban centres where they replace some traditional bus demand. The integration of last mile services into transit operations allows a focus on fixed route bus and rail transit to support interurban links.

Outside of centres, where transit services are less economical, traditional vehicle ownership remains high. Peer to peer sharing (AirBnB for autos) grows as service models emerge which enable people to earn income to offset the cost of vehicle ownership.

Scenario 4 - Coordinated Mobility (multi-occupancy, multi-modal)

In 2030, automation and connectivity have revolutionized transportation. A regulated mobility industry has developed to allow many new services to develop to support niche needs. The public is able to buy mobility similar to a utility where a package is purchased customized to their needs.

Price is regulated to maintain a viable role for traditional and new variants of bus transit including self-driving micro transit and shuttles. The revenue from this regulated system pays for high-quality interurban fixed routes with seamless last-mile service connections, reducing the need to use an automobile.

Sophisticated scheduling enables high average occupancy in shared vehicles. Private vehicles are increasingly purchased or leased as part of shared mobility contracts, which make them available to a membership when not in personal use.

For those not able to afford a mobility package, and despite price concessions for some groups, there are claims of social inequalities.

Impacts to objectives

The four scenarios were then assessed for their potential impacts against nine key objectives from the Regional Growth and Transportation Strategies as well as importance to municipal participants. The objectives were edited assuming that some would be similarly affected under all scenarios. The nine objectives assessed against the scenarios are shown below with the metric used to score the anticipated effect.

Objective	Measure	Scale (1 – 5)		
		1	3	5
Increase in walking, cycling and transit	Mode Share	Less than now	Same	Even more
Reduce need to own a car	Cars per household	More	Same	Less
Reduce distance driven	VKT	More	Same	Less
Improve regional accessibility including for those with limited auto availability	Population able to access the region through non-auto modes	Less	Same	More
Ensure efficient and reliable movement of people	Travel times	More	Same	Less
Reduce reliance on fossil fuels	Consumption	More	Same	Less
Ensure transport safety	Fatal injuries	More	Same	Less
Support a compact urban area	Sprawl	More	As is	Denser
Reduce cost to individual	Cost of mobility	Costlier	Same	Cheaper

This process was conducted for all four scenarios and generated a general consensus that the greatest benefit would arise from a Coordinated Mobility scenario of shared, multi-modal and multi-occupancy transportation as shown below.

Note: The Compact Area objective could not be scored in time.

Objectives	Scenarios			
	Status Quo	Motor City	Uncoordinated Mobility	Coordinated Mobility
Increase in walking, cycling and transit	3	2	3	4
Reduce need to own a car	3	4.5	4.5	4.5
Reduce distances driven	3	5	4.5	5
Improve regional accessibility including for those with limited auto availability	3	4	4.5	5
Ensure efficient and reliable movement of people	2.5	3.5	4	5
Reduce reliance on fossil fuels	2	3	4	5
Ensure transport safety	4	4	4	4
Support a compact urban area	Not scored			
Reduce cost to individual	3	4	4	3

Appendix B - Gaps, Research & Next Steps

Collaboration, coordination and role clarification

Policy Gaps

- Define roles of federal, provincial, regional district, municipalities in AVs
- Municipal policy coordination and linkages
- Policies to encourage private – public coordination
- Organize consensus amongst all municipalities adopting the policy advice

Research needs

- Hierarchy of policies related to automated and new mobility service providers needs to be defined from Federal (Transport Canada) through the Province (MOTI/ Minister of TransLink), Regional (Metro Vancouver) and Municipal.
- Mobility service providers to react/gauge/plan for future mobility
- Baselining current government activities in Canada relative to the US

Next steps

- Continuing forum group and expanding to industry, public and others
- Determine TransLink's role and other roles – federal government down
- What is TransLink appetite for change? - (Re) defining transit and TransLink's role as a mobility authority
- Government (definition of who's doing what and hierarchy) - in many respects will influence next steps for TL/ Future of Driving
- Define what we (MOTI, TransLink, MV, Muni's) Can and can't do/ have a say in
- Advocate to senior level governments for preferred changes (policies, regulations/ deregulation)

Communications, education and public awareness

Policy gaps

- Consultation & outreach (will be affected by the definitions from higher-levels of government about what we're allowed to do/ have say in)

Research needs

- What are residents interest, values, ideas, acceptance of AVs, willingness to participate

Next steps

- White paper/TransLink policy statement
- Be used as a reference for a request of funding to assess impacts and interplay of changing / autonomous vehicles and how municipalities, TransLink should respond
- Policies recommendations for further study in areas noted
- Setting a framework for discussion with stakeholders on proactive measures to provide proactive steps to manage potential
- Higher level assessment of risks and opportunities
- Potential actions for government organizations
- How we move forward
- Communicate to residents why we are doing this work
- Communication network – forum and others to continue discussion (Same as Forum in collaboration category)
- Communication and engagement with industry
- Establish a communication network for FoD ongoing – work with MoTI/ Metro Vancouver
- Establish a communication process for industry
- Internal (agency staff) - planners to allow for improved understanding of future of driving

- Operators to offer proactive insight to how new technologies/ service change the landscape of transportation provision

Consumer protection and equity

Policy gaps

- Protecting against price gouging / surge pricing
- Ensuring equity/ uniformity of pricing across demographics, geographies
- Accessibility/equity – research concessions

Research needs

- Research policies to protect all levels socio-economic levels to ensure equality of all users

Controlled trials

Next steps

- Controlled AV trials (TransLink and/or Industry) in one neighbourhood (UBC, YVR, other)
- Testing for safety of vehicle + occupant
- BC allows controlled trials
- Businesses / mobility service providers: pilot testing
- Options – coverage areas + service integration

Data

Policy gaps

- Encouraging sharing – incentives, insurance, regulation
- Addressing privacy concerns
- Central location to store all data collected and organized
- Requiring data sharing (trip and mode information) to and from government
- Service providers providing valuable data to government
- Government making its of transportation data available in open data formats
- Licencing and access

Research needs

- How will technological “refresh” cycles effect:
- The ability for regulatory/ government reaction
- Change management

Insurance and licensing

Research needs

- Encouraging insurance
- Licensing / Operators / Drivers

Modelling, scenario development and behavioral studies

Policy gaps

- Need to develop a new model, trigger and decision making framework transportation forecasting.

Research needs

- Modeling a transitional period – traffic management and service access & decision criteria
- Using scenarios to forecast and see impacts to objectives
- Forecasts on modes and how new services and automation may impact:
- Impacts to accessibility + equity
- Revenue impact
  - To municipalities - parking
  - TransLink – fuel tax, fares etc.
- Labour
  - Disruption
  - Re-skilling needs
- Financial
  - Marketability of scenarios
  - Impacts

- On user cost – savings?
- Businesses
- Government investment
  - Infrastructure costs, roads, paint etc. – will require more updates/ technological investments?
- Neighbourhood – level scenario development and evaluation
- AVs + forecasting / projections standards
- Market uptake of new services (and uptake under different regulatory controls/ levers)
- User behaviour as a result of new services
- Across different demographics, geographies and land uses
- Research how user's mobility behaviours are forecast to change under different scenarios of service introduction/ uptake
- Land use – testing service uptake in areas that are explicitly design for these mobility service to serve them directly (think of communities that are explicitly built around no car ownership)
- Develop business case for various scenarios
  - Models
  - Service levels
  - Cost for users
  - Impacts to traditional transit services
  - Impacts to private transportation companies
- TransLink should review:
  - Potential impacts to traditional services
  - Review options for coverage areas and how competition could compliment or integrate service.

Municipal and regional goals and plans

Policy gaps

- Sustainability / policy objectives need to be updated/ revisited because they may not apply when new tech and services are available
- Confirm priorities / position
- Ensuring new services meet sustainability objectives
- Municipal bylaw revisions
- Regional Needs Coverage / Adaptability not just City of Vancouver

Research needs

- Develop framework that permits /encourages technological advancement but also protects users to ensure accessibility, safety and a level of socio-economic equality
- Bylaw scan – what has to change?
- Parking guidance

Price regulations

Policy gaps

- Mobility pricing

Research needs

- Price regulation – define and investigate, revenue/costs splits

Safety

Policy gaps

- Regulations in vehicle construction
- Policies on communication coverage
- Communications security

Research needs

- Safety of:
  - Vehicle occupants
  - Vehicle to vehicle
  - Vehicle to infrastructure
  - Vehicle to other road users (pedestrians, cyclists, dogs etc.)

Transportation systems and infrastructure

Policy gaps

- Road classification / traffic calming
- Revisions to Motor Vehicle Act
- Communication with enforcement to pull over vehicles
- Policies on judicial process for motor vehicle incidents
- Geometric standards and urban design advice – modernization fund
- Retrofitting infrastructure
- Technical infrastructure investment – municipal traffic management centres – ITS Canada feasibility
- Parking regulation and guidance

Research needs

- Understanding service characteristics for MaaS models for diverse communities
- Technical direction on vehicle recognition vs. infrastructure (V2I, mapping, maintenance)
- Designing for AVs not retrofitting – guidance
- Transportation demand management
- Impacts to transportation discipline
- Model projections
- Capacity
- Traffic impact studies for developments
- TDM forecasting for volume / capacity analysis – need to change