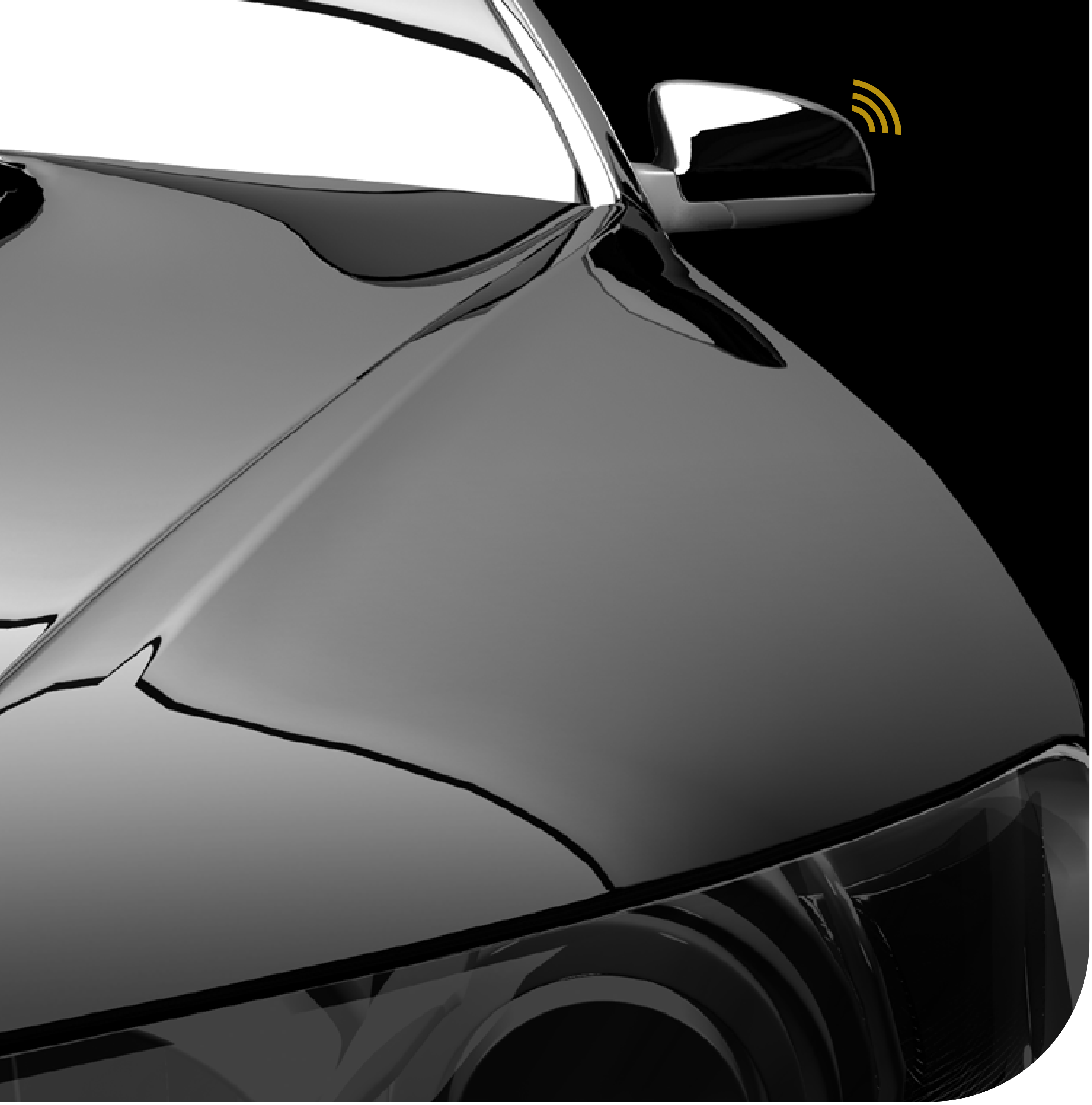

Autonomous Vehicles

REVOLUTIONIZING
OUR WORLD

2016

Borden Ladner Gervais

Foreword

Autonomous vehicle technologies, and in particular, fully autonomous vehicles have the potential to be among the most disruptive technologies since the advent of the automobile itself. Some of the largest and most influential companies in the world have made billion-dollar investments in “driverless transport” – and these are not speculative bets.

It is anticipated that multiple industry sectors will face substantial issues – more significant than many might think. Industries such as manufacturing, technology, transport, logistics, insurance, health, municipal planning, infrastructure, and hospitality will all be impacted, economically and operationally. So too, the legal and regulatory frameworks on which business and our society are based will have to anticipate the magnitude of change, prepare for, and adjust accordingly.

Marshaling studies and opinions from a variety of third-party sources, this report delves into the impact of autonomous vehicles. It discusses the technology, identifies the issues, defines the sectors of the economy most likely to be affected, and explores possible implications.

It is our hope that this report will enhance your understanding of how autonomous vehicles promise to revolutionize transport, and with it, alter our industries, economy and society. Specifically, we trust it will enable you to proactively approach the issues affecting your industry sector in a more knowledgeable way.

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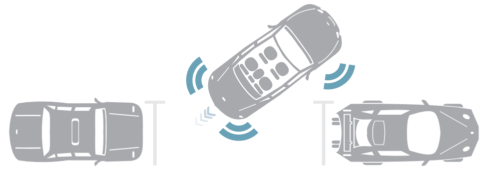
AUTONOMOUS VEHICLES

$65 billion
in potential annual savings to
Canadians:

$37.4 billion in collision costs
$20 billion in time
$2.6 billion in fuel
$5 billion in congestion avoidance

5 billion hours
of Canadians' time could be saved over five years.



Autonomous Vehicles | Revolutionizing our World

If they fulfill their advocates' expectations, automated and autonomous vehicles will fundamentally change the way we and our goods travel. **But that is just the beginning.**

Mobility will exponentially increase. The need (but perhaps not the desire) for one's own car will give way, in large part, to the sharing economy and all that entails. For example, vehicles called to one destination will coordinate with other requests, serving multiple riders along the way. Vehicle autonomy and coordination will allow us to meet transport demands while utilizing fewer vehicles, on a round-the-clock basis, and with greater efficiency.

There are other, broader impacts as well. Making more efficient use of fewer cars will lower the demand for parking spaces, garages, automobile repair services and road infrastructure, while simultaneously decreasing negative impacts to the environment. Faster vehicular travel times will have implications for short-haul air flights and the hotel and car rental industries as well. Automated, round-the-clock commercial vehicles will redefine supply chain logistics and give new meaning to just-in-time inventory systems. Automated municipal transport will reduce costs and change the dynamics of urban planning.

Morgan Stanley believes that these changes have the potential to save the American economy $1.3 trillion annually, with global savings estimated at more than $5.6 trillion.[1] The Conference Board of Canada predicts up to $65 billion in potential savings to Canadians, including $37.4 billion in collision costs, $20 billion in time, $2.6 billion in fuel, and $5 billion in congestion avoidance. Over a five-year period, fully autonomous vehicles could save Canadians approximately 5 billion hours of their time.[2] Autonomous vehicles will impact a variety of sectors of the economy, ranging from automobile manufacturing to technology to insurance to logistics, to name a few – effectively revolutionizing many aspects of business and society.

Vehicle autonomy and coordination will allow us to meet transport demands while utilizing **fewer vehicles**, on a round-the-clock basis, and **with greater efficiency**.

Definitions and Standards

Broadly speaking, an autonomous vehicle is one equipped with technologies that facilitate aspects of its operations. Examples range from systems which simply ease the driver's task (such as self-parking) to self-driving vehicles that do not require a driver. This is the difference between automated-driver-assistance systems (ADAS) and the fully autonomous vehicle. This report addresses both.

Ontario Regulation 306/15, which came into force on January 1, 2016, uses SAE Standard J3016, "Taxonomy and Definitions for Terms Related to on Road Motor Vehicle Automated Driving Systems"[3] to define the levels of automation in an autonomous vehicle. A summary table, produced by SAE follows below.

A summary table of Ontario Standards Regulation 306/15

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving 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	Human driver	Human driver	Human driver	n/a
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*	Human driver and system	Human driver	Human driver	Some driving modes
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*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving 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*	System	**System**	Human driver	Some driving modes
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*	System	System	**System**	Some driving modes
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*	System	System	System	**All driving modes**

Source: *SAE International*

The United States, on the other hand, uses a slightly different system, defined by the National Highway Traffic Safety Administration.

In a global world where technology has all but erased boundaries, the existence of two separate standards underscores the **need for international standardization** – not merely of definitions, but for laws and technologies as well. The SAE levels offer a great basis for global regulators.

U.S. Standards

Level **0**

No automation: The driver has complete control of the vehicle's main controls (brakes, steering, throttle, and motive power) at all times and is solely responsible for monitoring the roadway and for safe operation of all vehicle controls. Vehicles that have certain driver support/convenience systems, but do not have control authority over steering, braking, or throttle are still considered "level 0" vehicles.

Level **1**

Function-specific automation: Automates one or more specific control functions; if multiple functions are automated, they operate independently from each other. Essentially, the driver has overall control and is solely responsible for safe operation – but he or she can choose to hand over limited authority of a primary control (as in adaptive cruise control); the vehicle can automatically take limited authority over a primary control (as in electronic stability control); or the automated system can provide added control to help the driver in certain normal driving situations or situations where a crash is likely (e.g., dynamic brake support in emergencies).

Level **2**

Combined-function automation: Automates at least two primary control functions designed to work together (such as adaptive cruise control *and* lane centering). These vehicles can share authority when the driver hands over primary control in certain limited driving situations. The driver is still responsible for monitoring the roadway and safely operating the vehicle at all times and on short notice.

Level **3**

Limited self-driving automation: The driver gives up full control of all safety functions under certain traffic or environmental conditions and the vehicle lets the driver know when to take back control. The driver is available for occasional control.

Level **4**

Full self-driving automation: By design, the vehicle itself safely drives and monitors roadway conditions for an entire trip. The driver provides destination or navigation input, but does not control the vehicle at any time during the trip, for both occupied and unoccupied vehicles.

When? Now. | Fully Autonomous Vehicles Could Take to the Streets as Early as 2018

While autonomous vehicles are already available, offering features such as self-parking, future technologies are expected to continue to build on each other, providing increased levels of automation, such that fully autonomous vehicles are expected by some people to roll out in commercial quantities between 2020 and 2025.[4,5,6] An alternative perspective held by many global Original Equipment Manufacturers (OEMs) holds that we may see a more immediate and dramatic shift, where level 4 and 5 vehicles will enter the market as early as 2018. An active debate as to exactly when we will see the arrival of fully autonomous vehicles is ongoing.

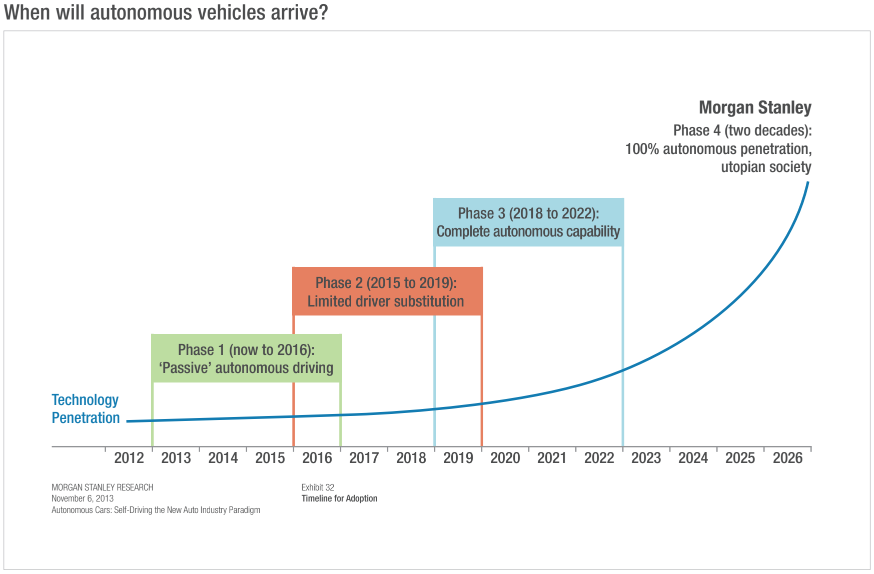
In September, 2014, Elon Musk, CEO of Tesla, predicted that the technology to make a fully autonomous car would be available by 2020, and that such a vehicle would have a safety factor 10 times greater than that of a car operated by a human driver.[7] In December, 2015, Mr. Musk is reported to have updated that prediction, suggesting an autonomous car will be ready for market in 2017.[8]

Carlos Ghosn, CEO of Nissan, has expressed a more cautious mindset, indicating autonomous cars will not be available until 2020 at the earliest.

Mr. Ghosn also pointed out that there is a difference between being able to buy a car that is labelled self-driving and being allowed to use it for that purpose.[9] Uber foresees having an entirely driverless fleet by 2030, at which point the service will be so inexpensive and ubiquitous, car ownership will be obsolete.[10]

Regardless of the exact date of arrival of commercially available, fully autonomous vehicles, it is clear that the level of automation will increase rapidly.

When will autonomous vehicles arrive?



Source: Morgan Stanley Blue Paper, *Autonomous Cars: Self-Driving the New Auto Industry Paradigm, November 6, 2013*

From the perspectives of planners and decision-makers – whether in the private or public spheres – the practical answer to the question of **when autonomous vehicles will arrive**, is **now**.

Understanding the Technology
Behind Autonomous Vehicles

The technology that supports the operation of an autonomous vehicle is complex and multi-faceted. Simply put, fully autonomous vehicles process map and sensor information in order to ascertain their specific location, and then apply that information (using predictive software) to determine their course. A helpful description of these components is provided in a 2015 report by the RAND Corporation.[11]

As the RAND report notes, localization and navigation are critical components. Autonomous vehicles use both global positioning and inertial navigation systems (GPS and INS respectively). Overcoming geographic and time lag error though represents a challenge. Either can induce positional error. Some of that can be overcome by sensors which detect any objects that surround the vehicle. Autonomous and fully autonomous vehicles use a combination of sensors, including LIDAR (light detection and ranging), radar, cameras, ultrasonic, and infrared. A suite of sensors operating in combination can complement one another and make up for any weaknesses in any one kind of sensor.

Software and sensors work together

Software is an equally critical component. Autonomous vehicle software classifies objects which the sensors detect based on their size, shape and movement. The software knows where the vehicle is in relation to these objects and predicts what they might do next. The software then chooses an appropriate speed and trajectory for the vehicle.[12]

Using software that allows a vehicle to make decisions involving passengers or other drivers and pedestrians in urgent situations raises ethical questions for many.[13]

Additionally, software produces technical challenges because it must be updated on an ongoing basis – meaning autonomous vehicles need to be in regular, if not constant, communication with software providers.

Interacting with infrastructure

As also noted in the RAND report, how communication [vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I)] will impact operation is unknown. While these technologies might help with autonomous vehicles in many circumstances, whether either or both are necessary is not 100 percent clear, although V2V is considered an essential construct, integral to the success of autonomous vehicles. As well, V2I would require substantial infrastructure investments – for example, equipping all traffic signals with radios for communicating with autonomous vehicles.[14]

Telematics devices and security

Autonomous vehicles are telematic devices – they merge telecommunications and informatics. By their very nature, telematic devices are creators, aggregators and communicators of huge amounts of data. Thus autonomous vehicles will create and communicate substantial amounts of information on position, location, speed and destination – some of it personal, raising significant privacy and cybersecurity issues.

The role of the driver

One of the most difficult issues to address is what the role of the driver will be – and whether there is to be any driver at all. As the RAND report notes, it is anticipated that the first commercially available autonomous vehicles will operate on the principle of shared driving – that is, vehicles will drive autonomously only within a set of defined operating conditions (for example, below a particular speed, on certain types of roads, in specific types of weather). Outside of these parameters, autonomous vehicles are expected to revert to traditional, manual driving in all other conditions or at the request of a human driver.[15]

However, re-engaging the human driver poses a key challenge. To get the greatest benefit from the technology, human drivers will need to be able to perform other tasks while the vehicle drives itself – OEMs will have to account for methods to compel drivers to re-engage as required.

Autonomous vehicles will create and communicate substantial amounts of information on position, location, speed and destination – some of it personal, **raising significant privacy and cybersecurity issues.**

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How V2V and V2I communication will impact autonomous vehicles operation is also unclear.

Re-engaging the human driver poses a key challenge.

Potential Roadblocks Ahead

There are five key challenges to getting full-fledged autonomous vehicles out on the road anytime soon: consumer concerns, market demand, technology, regulation, and tort law.

> The systems must work, and they must work every time.

1. Consumer concerns

Consumers are unlikely to readily accept autonomous technologies of any kind – if they are perceived to have the potential to fail or not perform as expected and essentially put human lives at risk. However, if autonomous vehicles are rolled out incrementally – building on the initial introduction of simpler technologies (such as self-parking) with progressively more complex technologies and, ultimately, launching the fully autonomous car – the public may well develop greater faith and confidence in them. Public education will be critical. Some of that is taking place now in terms of general awareness, whenever Google and Tesla's autonomous vehicles make the news.

Consumer perception of data security is also a key issue. In an age in which privacy and cybersecurity are top-of-mind concerns for most consumers, the advent of the autonomous vehicle poses a particular challenge. Autonomous vehicles rely on their ability to communicate with GPS satellites, software providers, and other devices. Each communication becomes a data point or multiple data points and may include information about a vehicle's occupants. Such data needs to be secure, along with access to and control over the vehicle's autonomous systems.

Cost is another precursor to consumer acceptance. A 2014 U.S. telephone survey by Insurance.com, indicated that 75 percent of licensed drivers would at least consider buying a self-driving car, rising to 86 percent if car insurance were cheaper.[16] Considering the technologies required, it is very unlikely autonomous vehicles will be cheaper than traditional vehicles, at least at the outset.

Consumers' perception of cost is based on perceived value, which, in this instance is inextricably bound with the question of whether there must be a driver who, while not engaged in the operation of the vehicle from moment to moment, must be prepared to assume control of it – as and when needed. For many consumers, that is a significant limitation. Not much is gained, in terms of personal freedom and utility by having a vehicle which, while driving itself, requires the unceasing standby attention of a driver. Many commentators believe that the real value is in the fully autonomous vehicle. Google, among others, has made it plain that it considers that the real innovation is the fully autonomous view. Its car has no steering wheel.

2. Market demand

Cost and perceived utility are two factors that tie into the broader subject of market failure – the differences in the market between supply and demand. Manufacturing capacity, the availability of insurance, and a favourable regulatory environment are others. Government may step in to play a role if it believes the value to consumers and society warrants the investment, for example, by offering various forms of subsidies.

3. Technology

Even now, in 2016, just less than two years away from when some predict fully autonomous vehicles will be a reality, significant technological challenges exist. Serious injuries or fatalities, such as the recent tragic Tesla Autopilot incident will significantly hinder adoption. The risks are substantial. This is not an area that will tolerate much in the way of technology failures. The systems must work each and every time. There are a myriad of technical challenges and just as many proposed solutions, as evidenced by the high level of patent activity for related technologies.

Some commentators argue that the problem facing autonomous vehicles is not technology, but rather the question of accountability: *who will be held responsible once there is no one inside the vehicle?* That raises the twin questions of regulatory oversight and legal liability – the answers to which hold a particular interest for lawyers.

> Increased safety, comfort and efficiency are the main goals of piloted driving. Government support to create enabling infrastructure and legal frameworks (including behavioural laws) are essential to support this evolution beyond conventional driver assistance systems.
>
> *Raseeka Rahumathulla, Manager, Government & Regulatory Affairs, Volkswagen Group Canada*

4. Regulation

The 1968 Vienna Convention on Road Traffic requires a human driver to be present and have control over the vehicle at all times. The UN Economic Commission for Europe has formed a Working Party on Road Traffic Safety to draft amendments to the Vienna Convention. This will address the main international hurdle to many ADAS technologies.[17] Moving to autonomous vehicles, however, requires making more basic amendments to the Vienna Convention.

At a country level, it is not only the technologies that raise regulatory questions, but also the perceptions and assessments of their social impacts by consumers and governments. That said, the primary regulatory assessment is likely to address the ***how*** question: *Under what circumstances and conditions will autonomous vehicles be allowed and to what extent?*

This question is of particular interest to car and car part manufacturers and technology companies currently involved in vehicle automation. Many governments have already implemented legislation allowing testing,[18] or are working on it. In Germany, for example, the Federal Ministry of Transportation just announced that they are working on a draft law which will allow autonomous vehicles (SAE levels 3 and 4) on the road in serial operation. The plan is to have this legislation come into force at the latest by mid-2017. Compared to other countries, the German draft currently represents the most progressive and technology-enabling legislation. Similarly, the National Highway Traffic Safety Administration of the United States (NHTSA) is set to issue revised guidelines at any moment. Currently, the U.S. operates under NHTSA's Preliminary Statement of Policy Concerning Automated Vehicles, which was issued in June of 2013.[19]

As fully autonomous vehicles did not yet exist and the technical specifications for semi-automated systems were still in flux, NHTSA focused on testing regulations. It suggests, for example, those states which allow manufacturers to test self-driving vehicles should, at the very least, require drivers to:

- be specifically licensed to drive them,
- sit in the driver's seat, and
- be available to take control of the car when the technology is not able to safely control the vehicle.

California, the District of Columbia, Florida, Michigan, Nevada and Tennessee, meanwhile, have, as of December 31, 2015, enacted autonomous vehicle regulations which vary widely. In Tennessee, for example, laws prohibit local governments from prohibiting the use of a vehicle solely on the basis that it is autonomous, while California and Michigan have enacted full-scale testing regulations. Legislation and/or regulations are being contemplated in many other States.[20]

In July 2014, the Uniform Law Commission (ULC) in the U.S. struck a committee on state regulation for driverless cars. A report prepared by that committee for the Technology Law and Policy Clinic of the University of Washington Law School in 2015 examined provisions on the books in California, Michigan, Florida, Nevada and the District of Columbia, and proposed autonomous vehicle testing regulation including:[21]

- **The definition of an autonomous vehicle** versus a vehicle with autonomous features
- **Categories for autonomous vehicles** at different stages in testing and certification, ranging from limited personal testing to limited public testing through to certification
- **Insurance requirements** *assume control* requirements by human drivers, incident and accident reporting, and geographical limitations for public test permits
- **Amended distracted driving laws**
- **Mandating safety features** that must remain operative while in autonomous mode
- Endorsements for operator **drivers' licenses**, and
- **Requirements** for:
    - **Permits**, including that manufacturers certify the autonomous vehicle is safe for public testing, controlled environment testing, application review and cost recovery, and test driver permit and training requirements
    - **Plating**
    - **Crash data recorders** on test and/or deployed autonomous vehicles
    - The operation of autonomous vehicles to **meet Federal and State traffic standards**
    - **Return of control**, that is for autonomous vehicles to be able to actively give control back to a human driver, for example, when safety or efficiency are compromised.

While there is no Canadian equivalent, the Minister of Transport convened a Canada Transportation Act Review Panel with a very broad mandate to review transportation policy and needs in Canada generally. While interested groups such as the Canadian Automated Vehicles Centre of Excellence (CAVCOE)[22] and the Intelligent Transportation Systems Society of Canada (ITSSOC)[23] made submissions to the panel about autonomous vehicles, the panel's mandate does not address them, except in the broadest fashion.[24, 25]

Ontario is the only Canadian province that currently has regulations (Regulation 306/15).[26] These regulations are focused on the higher levels of autonomous vehicles and are for testing purposes only. A driver must be present and remain seated in the vehicle at all times, be trained to safely operate it, monitor its safe operation throughout the test, and be able to assume immediate control. The vehicle must be registered as a passenger vehicle and be equipped by recognized manufacturers. Also, a testing application, accompanied by extensive documentation, must be submitted to the Ministry of Transport for a vehicle permit and plates.

5. Tort law

Tort law can assign liability for damages from negligence. Liability can be assigned to drivers for human error or to manufacturers for machine error. When and in what circumstances is liability assigned to one versus the other?

A driver must be present and remain seated in the vehicle at all times, and be able to assume immediate control.

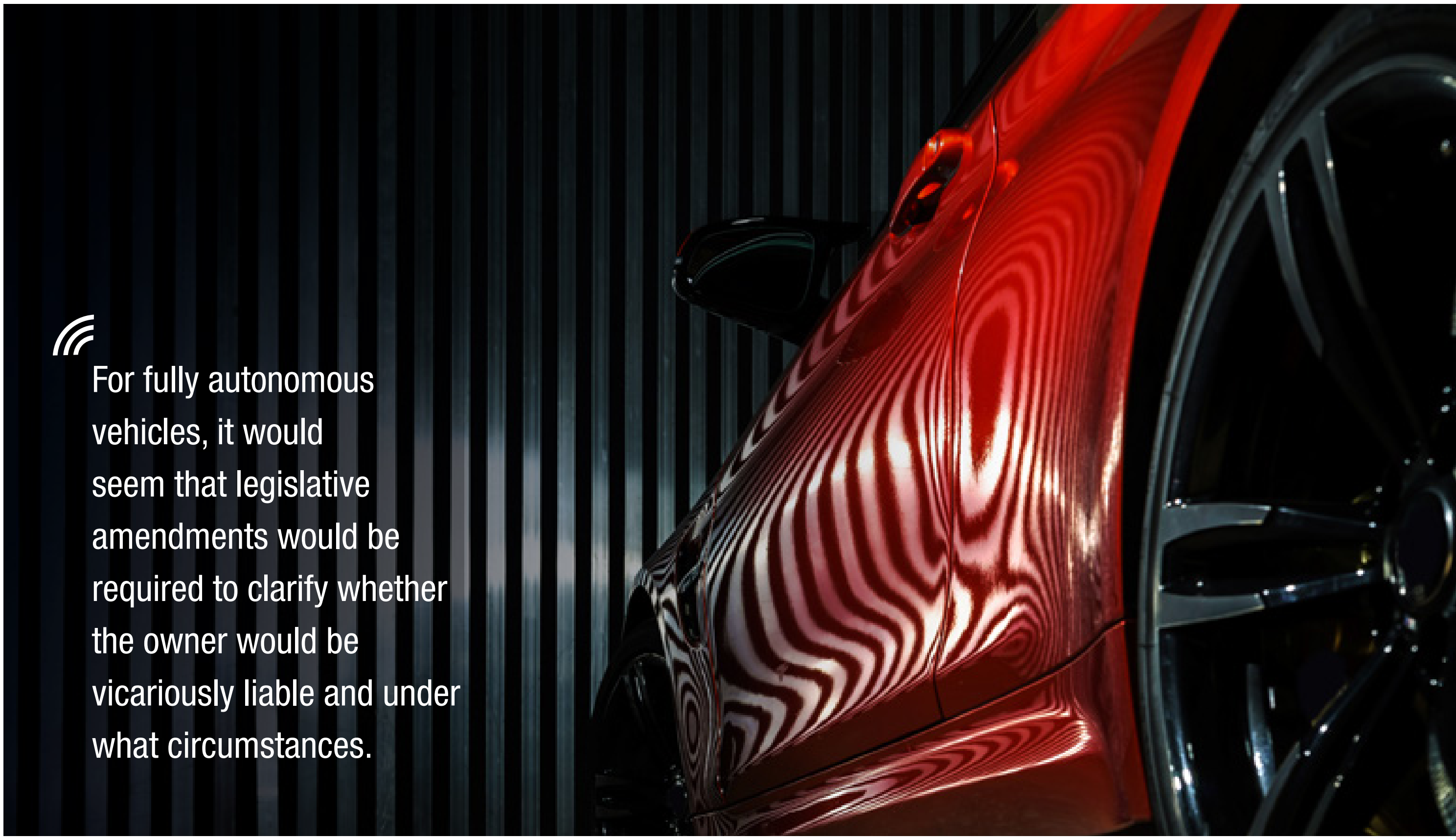
Liability – Canada

In Canadian common law jurisdictions, liability for motor vehicle accidents is governed primarily by case law rather than statutory law.

Several different sources of liability exist. Traditionally, a driver can be held liable for the negligent or reckless use or operation of a vehicle. Some, if not all, provinces have enacted legislation making the owner of the vehicle vicariously liable for the negligence of a driver. Apart from vicarious liability, an owner can also be liable for the failure to maintain the vehicle or negligently lending it to a driver whom the owner knows is not competent.

A manufacturer is another potential source of liability. Product liability is also generally governed by common law, not legislation. Currently, manufacturers of vehicles can be found liable for manufacturing and design defects, misrepresentation, and failing to warn consumers of the risks associated with the reasonably foreseeable use of their products. Legislation can be applicable in product liability claims where the purchaser of the vehicle makes a claim against the seller, such as a vehicle dealership. Provincial *Sale of Goods Act* legislation typically implies warranties and conditions with respect to the merchantability and fitness of products, including vehicles, into all contracts of sale. Thus, vehicle purchasers can sue retailers of motor vehicles in contract and in tort.

It is against this legal framework that we try to answer the question of how the introduction of autonomous vehicles will impact the potential liability of vehicle owners, drivers, retailers and manufacturers.



> For fully autonomous vehicles, it would seem that legislative amendments would be required to clarify whether the owner would be vicariously liable and under what circumstances.

With regards to driver liability, common law, coupled with the current legislation, may be sufficient to address liability involving all levels of autonomous vehicles, short of fully autonomous vehicles which do not require any level of human control. As long as a driver with some ability to assume or resume control of the vehicle is present, there would seem to be a continuing basis for driver negligence and liability as they presently exist. It is not much different than operating a vehicle with cruise control. Presumably, drivers would also be liable for negligently or recklessly engaging or disengaging autonomous technology.

While perhaps not a necessity, legislators may establish that a human driver of an autonomous vehicle, if present, is primarily liable. This presumption might be rebuttable depending on the circumstances, for example, the ability of the human driver to both perceive the danger and to intervene and assume control quickly enough to avoid it. When driver liability arises because an individual was, or is presumed to have been, in control of the autonomous vehicle, that individual's liability, as a driver would likely be determined based on ordinary negligence laws for operators of motor vehicles.

Owner liability for autonomous vehicles will likely be governed by the pre-existing law (both common and statutory) governing this issue. In addition to potential liability for failing to properly maintain an autonomous vehicle, current legislation holding the owner vicariously liable for the driver's negligence would continue to apply, unless of course the vehicle was driverless. For fully autonomous vehicles, it would seem that legislative amendments would be required to clarify whether the owner would be vicariously liable and under what circumstances.

In no-fault jurisdictions and systems, owners and drivers do not have personal liability. Insurance payments are made regardless of fault. There is no particular reason why this cannot continue to apply to minor accidents involving autonomous vehicles. It is largely a matter for insurers to work out between

> Drivers would be liable for engaging or disengaging autonomous technology negligently or recklessly.

> Legislators may establish that a human driver, if present, is primarily liable.

themselves. Typically, however, no-fault systems have exceptions for accidents that cause serious harm. In these cases, fault determination could be addressed as discussed above.

There is no reason why retailer liability, as founded under *Sale of Goods Act* legislation, should not continue with autonomous vehicles.

Product liability law in Canada in its common law form should be able to adapt to the introduction of autonomous vehicles into the market. Absent legislative intervention, however, product liability exposure for manufacturers of autonomous vehicles and their component parts is much more difficult to predict given that the development of product liability law will lag behind the rapid technological advances being made in the automotive industry. It is likely that the industry will be operating in an autonomous vehicle environment of varying levels for some time before common law develops to the point of being able to provide guidance on the standard of care that is required, as well as what the appropriate apportionment of fault should be between manufacturers, owners and drivers.

In situations falling short of fully autonomous vehicles, it would make sense that if both the owner or driver of a vehicle and the manufacturer are negligent, under the present rubric of product liability, the courts ought to be able to apportion liability among the various parties who have collectively caused or contributed to the loss or damage. There may be a continuum of liability between the owner/driver and the manufacturer which is more heavily weighted against the manufacturer as the number of autonomous features that are causative of the loss or damage increases. This would lead to almost full responsibility on the part of the manufacturer for fully autonomous vehicles that are properly maintained.

The RAND report suggests that some manufacturers are concerned that shifting the responsibility for operating a vehicle from the driver to the vehicle itself may increase their risks and raise vehicle prices to offset expected liability costs.[31] That, in turn could lead to lower adoption rates. While incorporating risk-utility analysis into duty-of-care determinations might produce socially optimal results, the fact remains that even where risk-utility analysis is an accepted part of the law, it is only one consideration.

Autonomous vehicles may also expand the scope of sources for potential liability. Those vehicles capable of plotting and navigating a route to a destination under the supervision of a driver will rely (at minimum) on weather reporting, global position, and LIDAR systems, as well as additional proximity sensors. The vehicle's software will process routing locational information to pilot it to a set destination. While en route, the vehicle will remain in communication with the weather and GPS systems and will also likely communicate with other similarly equipped vehicles. It may even communicate with public infrastructure (such as traffic lights). Its GPS and sensor systems must continually update its position, not only in terms of its destination but also in relation to the road itself, other vehicles, hazards, traffic controls, pedestrians, etc. A failure in any of these systems may result in harm.

Those systems that are internal to the autonomous vehicle would most certainly be captured by the current product liability laws. Whether a third-party provider of weather or GPS services which are required for navigation could face liability for damages or injuries arising from their use will likely be based on a standard analysis for the imposition of a duty of care. The question of whether one owes a duty of care is a threshold question. If the answer is "no", liability will not flow from the service provider to the injured party. The standard legal test for imposing a duty of care is whether sufficient proximity exists between the parties, thereby justifying the imposition of a duty. If a duty of care exists, the next question is "*what is the appropriate standard of care?*" followed by determination of whether that standard was met in the circumstances.

What can be seen from the above is that Canada's current tort law system is likely capable of responding to various levels of autonomous vehicles but legislative intervention would seem to be required in order to address the liability issues that arise from fully autonomous vehicles. With the rapid acceleration of technological advances towards autonomous vehicles, the real issue lies in whether advances in the common law and enactment of legislation can come close to keeping up with the revolutionary aspects of a fully autonomous vehicle.

Liability – U.S.

Should the manufacturer be liable, product liability laws will apply; however, product liability in the context of ADAS systems and autonomous vehicles must more broadly take into account the meanings of what a "product" is and what a "manufacturer" is. As illustrated above, a failure in any of an autonomous vehicle's system may result in harm.

In order to ensure U.S. product liability laws are effective when it comes to ADAS and autonomous vehicles, the term "manufacturers" must also encompass suppliers of data and services, including cloud-based and communication services. Similarly, the term "products" must comprise at least both software and data.

Whether existing product liability laws offer enough certainty for manufacturers to enter the market and enough protection for consumers to use the vehicles is a concern for many. For example, whether defective information (as opposed to defective software) is a "product" subject to product liability claims is a question for debate and consideration.[28]

Is there a need for new legislation?

As John Villasenor recently opined in a paper for the Brookings Institution, resolving the question of fault will require lawmakers to consider novel and in some cases challenging positions[29] but it may not need new legislation.

Those considering liability legislation for autonomous vehicles should consider the following:

- Preemptively **resolving liability issues** should not be a precondition to commercial rollout
- **Manufacturers of non-autonomous vehicles** should not be liable for alleged defects introduced through third-party conversions into autonomous vehicles
- In the long-term, **safety standards** will be needed which have liability implications enforceable in the courts
- **Liability related to autonomous vehicles** for commercial use should, at least in part, be addressed by regulation or legislation.

In addition, legislators will want to be sure to allow for flexibility as any premature regulation may result in stifling innovation. Dr. Bryant Walker Smith (University of South Carolina and Stanford) posits that autonomous vehicles may also create new sources of product liability. He considers that commercial sellers collecting information about, access to, and control over their products, product users and uses could significantly expand their point-of-sale and post-sale obligations toward people endangered by these products.[30]

This is a possibility that might actually drive companies to move closer and closer to their customers' interests in order to control risk. Shielding manufacturers and distributors of autonomous vehicles from what consumers do with them is a problem that does not yet exist and invites regulation of innovation.

...commercial sellers collecting information about, access to, and control over their products, product users, and product uses could significantly expand their point-of-sale and post-sale obligations toward people endangered by these products.

Remaking the Auto Industry | Autonomous Vehicles Will Drive Fundamental Changes

New technologies, particularly disruptive ones, often result in new entrants to markets. In this instance, some of the companies leading the autonomous vehicle revolution, such as Google and Apple are not car manufacturers. Others, like Tesla, are the newest and most technologically focused entrants. The likely consequence is, as Apple CEO, Tim Cook, has said, "massive change" in the auto industry.[33] Many traditional auto manufacturers understand this and are reported to be in negotiation, or already partnered with companies like Google and Apple to jointly develop certain autonomous vehicle technologies.[34]

Google's self-driving car, now being tested in prototype in California and elsewhere, is a fully autonomous, self-driving urban transport vehicle that has already been tested over one million miles.[35] It appears to be on the verge of a limited, experimental entry into the commercial market within the next few years.[36] As already noted, Elon Musk, CEO of Tesla, says his company is a year away from producing a fully autonomous vehicle and anticipates regulatory approval one to three years after production.

Every traditional automotive manufacturer is committed to developing and selling increasingly autonomous and ultimately fully autonomous motor vehicles. Virtually every automotive manufacturing CEO has made a public commitment to that effect. As Mark Fields, CEO of Ford Motor Company, said in 2015, "*We believe in the industry that there will be a fully autonomous vehicle, probably within five years*". He went on to say Ford was committed to making autonomous vehicles widely available: "*Unlike our luxury competitors, when we do come out with an autonomous vehicle, we want to make sure it is accessible and affordable to everyone.*"[37]

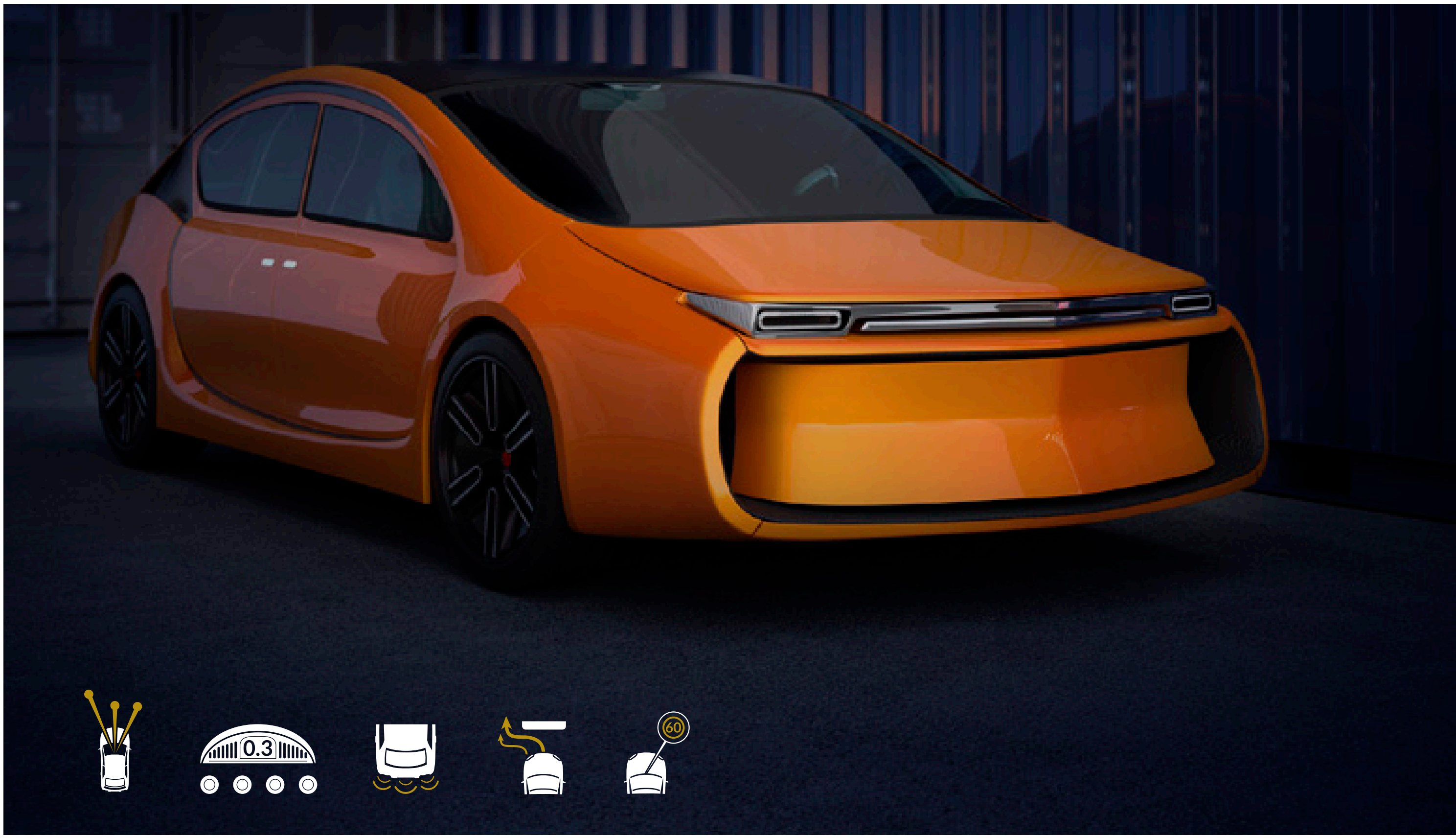
General Motors CEO, Mary Barra, has described GM as "*among the leaders*" in the development of self-driving cars.[38] GM's Super Cruise system, a semi-autonomous driving technology that will be available in the 2017 Cadillac, has been in development for several years. Super Cruise, however, is an ADAS rather than an autonomous vehicle system – it allows the driver to hand over highway driving to the vehicle.[39]

In 2017 – just months away, Audi will present the new A8; the brand's first series-produced car capable of piloted driving. With the traffic-jam pilot, it will be able to drive itself temporarily at speeds up to 60 kilometers per hour[40] – crossing the threshold from partial to highly autonomous vehicles. CEO Rupert Stadler is convinced: "By 2025, we will see fully autonomous vehicles."[41]

The automotive industry is poised to embrace more change than at any time since Henry Ford developed the automotive production line and made cars and personal mobility attainable by the masses. The emergence of the complementary technologies of automotive electrification, artificial intelligence, the Internet of Things and automated driving will converge and result in much cleaner, safer and faster personal mobility.

It's exciting to be at the dawn of this new era for the automotive industry and to contribute toward a regulatory regime to make it possible.

Norm Letalik, General Counsel, Volkswagen Group Canada



Commentators such as Paul Gao and colleagues at McKinsey & Company foresee a number of impacts for automotive manufacturers, including:

- **The creation of more and more valuable data on automobile use and performance** will allow automakers to better design their vehicles
- **Disruptive technologies** will give new market entrants a chance to leapfrog existing automotive leaders
- **Attracting talent will become more difficult** and costly as competition for key talent – engineers and automotive researchers – intensifies between software-driven innovation hubs (such as Silicon Valley and Tel Aviv) and OEMs
- **Cybersecurity** will become an increasingly important aspect of vehicle communications, especially if V2V communications are made mandatory
- **Autonomous technology and conductivity will cause consumers to rethink ownership**. Car sharing may become the norm, which may affect sales .[42]

"Cloud" transportation, especially if provided by fleets owned by "profit maximizers", could also create an entirely new set of demands for automakers. Ride-sharing companies will be less concerned about incremental features that personalize cars than they will be with features that align with their business models, which emphasize fast, low-cost transportation.[43] In a market where transportation becomes a service rather than a product, brand matters less.

"Cloud" transportation, especially if provided by fleets owned by "profit maximizers", could also create an entirely new set of demands for automakers.

Tech Companies Stand to Benefit Significantly

Semiconductors are ubiquitous, even in today's vehicles. Growth in the automotive semiconductor field has been driven, in large part, by increases in the number of vehicles which manufacturers sell and the new technologies they incorporate in their vehicles. In fact, automotive manufacturing was the fastest growing market for semiconductors from 2009 to 2012. A Blue Paper by Morgan Stanley Research suggests that trend will continue as new technologies are introduced into autonomous vehicles; semiconductors, in fact, are instrumental to their evolution.[44]

As more and more sophisticated technology is incorporated into vehicles over the next few years, the amount and frequency of data collected, transmitted, processed and stored will increase dramatically, benefitting organizations in the computational, networking, communications and data storage fields. Semiconductor companies feeding those industries include Intel, Qualcomm, Broadcom, Cavium Networks, Inphi Corp, and LSI Corp. Those providing computational infrastructure include Intel, Advanced Micro Devices, Nvidia and Cavium.[45]

The move toward autonomous vehicles presents three opportunities for software vendors: OEM design; standardizing software within cars; and managing and analyzing the large data sets which car sensors will generate. The more autonomous the vehicle, the more software becomes critical. Software design companies such as Dassault Systèmes and PTC may be likely beneficiaries, especially if the task of software development is left to OEMs and OE suppliers.[46]

In the medium term, Morgan Stanley forsees a move from custom development towards more packaged infrastructure and application components because as markets mature, vendors will be less able to differentiate their products and the cost of maintaining custom code will increase. There is also a need for software to connect with other functionalities and platforms.[47]

In the longer term, analyses big data will likely be used to lessen congestion on roads, help drivers avoid hazardous conditions, and more easily find roadside amenities. Companies involved in providing technology to store, analyze and turn that data around in real time will be the real beneficiaries.[48]

Over the next few years, the amount and frequency of data collected, transmitted, processed and stored will increase dramatically....

Also promising are the possibilities offered by the Internet of Things (IoT) as communications between all connected devices becomes a reality. From in-car applications to retrofitting twenty-year old pickups with transponders so as to include them in the "monitoring" of what's happening on the roads, through to the provision of higher bandwidths, technology companies will continue to be in demand and at the helm of innovation.

Reshaping the Insurance Industry

One key argument supporting the addition of autonomous features in cars is that they make driving safer.[49] The vast majority of accidents are caused by human error and, in theory, by replacing human input with well-programmed computers, we can help reduce the risks of driving. However, technologies fail and systems are only as good as their designers and programmers. Because autonomous vehicles bring with them increased emphasis on product liability, manufacturers and suppliers will have a greater need for product liability insurance.

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But the picture for insurers is a good deal more complicated than just the need for more insurance. A 2015 study for Swiss Re notes that ADAS technologies will precede the fully autonomous vehicle[50] and each level of technology will have its own impacts. The effect of these technologies on auto claims and premiums will depend on a number of factors: the technologies themselves, their availability, usage, regulatory intervention and market penetration. The Swiss Re study concludes that the insurance sector is likely to be reshaped by reduced risks and losses, and by shifts to new types of coverage, alternative distribution channels and redefined customer segments due to:

- **Risk shifting** from drivers to the manufacturers, that is to say from drivers liability to product liability, making the distributor the point of sale for the policy
- **Risk slicing between drivers and manufacturers**, depending on whether the vehicle is being operated by the driver or in autonomous mode. This creates different pricing options
- **Risk slicing between different drivers**, in the context of car-sharing services, in circumstances where different drivers rely more or less on autonomous features and when not in autonomous mode, they have substantially different driving habits
- **Risk reduction**, depending on the nature and level of the autonomous features in any given vehicle, which will complicate underwriting.[51]

Widespread adoption of ADAS technology creates not only challenges, but opportunities for innovation as well – for insurance products themselves, along with how they are underwritten and distributed. For example, ADAS and autonomous vehicles, as telematic devices, can provide substantial data on the risk of each trip, such as, duration, speed, ADAS features used and those not used. It is possible that insurance policies will provide a base level of insurance, with a higher or lower premium charged on the basis of each trip or on the basis of the insured's driving habits generally. In fact, policies where premiums adjust according to the operational habits of drivers, as determined and reported by in-vehicle sensors, already exist.[52]

Transport and Logistics | Massive Changes Coming

Fully autonomous vehicles could end the need for professional transport drivers, creating substantial labour-cost savings for transport companies. The most obvious result will be the unemployment of tens of thousands of professional drivers, ranging from cabbies to local haulers to long-distance truckers. In the U.S. alone this could amount to just short of four million jobs.[53]

DHL, one of the world's largest logistics companies believes that the logistics industry may adopt self-driving vehicles much faster than other industries because different rules apply when a vehicle is moving in a secure, private zone and liability issues are less pressing. There are already numerous examples of autonomous technology in logistics – the next evolutionary step is to apply it on public streets including outdoor logistics, line-haul transportation, and last-mile delivery.[54]

Outdoor logistics includes warehouse yards, as well as container and unit-load device transportation within harbours and airports. This is an area where autonomous vehicles already operate. The Altenwader Harbor Container Terminal in Germany uses 84 driverless transport vehicles between the wharf and storage areas. Navigation is performed using 19,000 transponders that are installed in the ground.

Autonomous vehicles could be especially useful in line-haul or long-distance inter-city freight transportation where they can:

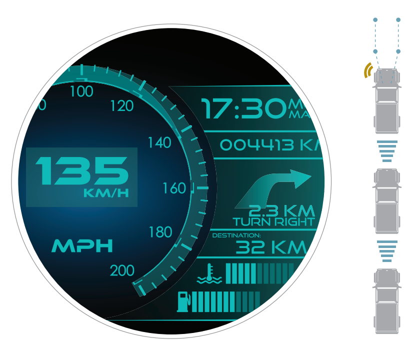
- Substantially **reduce driver error** and accidents
- **Reduce fuel consumption by five to 10 percent** – a significant savings in an industry that typically operates on small margins
- **Develop convoy ring systems** (where the driver of the first truck retains control of steering functions and sets the pace while trucks and other vehicles following in the convoy can manage without drivers).[55]

The impact on last-mile delivery is perhaps the hardest to ascertain. A key question is whether autonomous vehicles will understand the last-mile environment and react appropriately. Despite the challenge, the last-mile environment offers a particular advantage for self-driving vehicles in cities, for example, where traffic moves slowly – ideal for self-driving vehicles because autonomous technology is best executed at low speeds. Moreover, in an effort to combat driver fatigue, many long-haul trips are currently done in the daytime, overlapping with passenger transport. Autonomous vehicle long-hauls could make better utility of overnight trips.

The transport-related workforce

Occupation	Average Annual Wage	Number of Jobs	Total Annual Wages
Taxi drivers & chauffeurs	$25,690	178,260	$4,579,499,400
Bus drivers – transit & intercity	$39,410	158,050	$6,228,750,500
Drivers/sales workers (delivering food, newspapers)	$27,720	405,810	$11,249,053,200
Bus drivers – school or special client	$29,910	499,440	$14,938,250,400
Postal services mail carriers	$51,790	307,490	$15,924,907,100
Light truck or delivery services drivers (UPS, FedEx)	$33,870	797,010	$26,994,728,700
Heavy and tractor-tailor truck drivers	$41,930	1,625,290	$68,148,409,700
Total	**$35,760**	**3,971,350**	**$148,063,599,000**

Source: The Huffington Post, June 11, 2015.



5% to 10%
Less Fuel Consumption

Dramatic Changes in Travel

When it comes to personal travel between cities, autonomous vehicles will significantly impact air travel, car rental and taxi services associated with inter-city travel. The anticipated higher highway speed limits and vehicle designs focused exclusively on passengers will make autonomous vehicles a cheaper, faster alternative to flying. At 160 km/h, the travel time from Toronto to Montréal is a mere 3.5 hours – less than the time required to fly and cab, and with no airport security delays and half the anxiety.

The self-driving car will also disrupt the airline and hotel industries within 20 years because it is believed that many people will prefer to travel and sleep in their vehicles.[56] As long-distance car travel becomes safer and more comfortable, short-haul air travel will become increasingly uncompetitive. Autonomous vehicles may make air travel for distances less than 500 km disappear for anything other than hub (spoke feeder) flights, especially in North America. This might lead to consolidation – fewer airports overall but a greater number of major airports.[57]

Air cargo tends not to be used to ship items less than 750 km (cargo being shipped less than that distance now has unique air requirements, such as perishability), which means autonomous vehicles will likely not substantially impact this sector.[58]

The impact on the taxi industry is already apparent. The CEO of Uber, Travis Kalnick, has indicated that he intends to replace human drivers with autonomous cars as soon as possible, saying his company will purchase every fully autonomous car Tesla can produce – an estimated 500,000 electric cars in 2020.[59] Google's fully autonomous car also appears to be tailor-made for urban transit – it is the perfect taxi.

As go the short-haul airline and taxi sectors, so go rental cars. This is especially true in urban markets, where autonomous vehicles will find their first foothold. A reduction in short-haul airline traffic in favor of autonomous cars will reduce the need for taxis at airports and train terminals. Replacing human-driven taxis with autonomous vehicles also reduces the need for rental cars.

Short-haul air travel will become increasingly uncompetitive.

Playing an Important Role in Municipalities

In a December 2015 submission to the Government of Canada, CAVCOE suggests mobility-as-a-service. Autonomous vehicles will take market share from traditional fixed-route, fixed-schedule transit, resulting in reduced ridership and revenue and greater subsidy requirements for public transit systems.[60]

The Canadian Urban Transit Association (CAUT) suggests highly or fully automated vehicles have the potential to radically transform urban transit over the longer term and that publicly-owned or shared self-driving vehicles (akin to taxis acting as part of an urban mobility system) are a possibility.[61] CAUT and CAVCOE warn that the transit industry needs to pay particular attention to these trends and develop strategies to take advantage of them. While autonomous vehicles will not become the only form of transit, their position within the overall network of transit options and services needs to be considered.

Transit planning is only one aspect of transportation planning and that, in turn, is only one element of urban planning; all of which will be affected. Transportation and urban planning change substantially when we alter our assumptions about cars. The difficulty for urban planners is to understand what assumptions ought to be made going forward. It is likely that autonomous vehicles will increase mobility. If they can use them, those persons who have mobility issues, whether because of age or infirmity, will be much less hampered.

But will an increase in mobility mean an increase or decrease in the number of cars on the road? If there are fewer cars on the road, what does that mean for the roads themselves? For traffic planning? For parking? These are all important questions and ones which urban planners are closely considering (that is, if the number of conferences and symposia devoted to regional planning and the modelling implication of autonomous vehicles are any indication).[62]

CAVCOE's submission to the federal government also notes that autonomous vehicles will have a significant impact on policing. It cites a U.S. study, which indicates traffic-related offences account for 53 percent of the public's interaction with the police. Accepting that autonomous vehicles will be safer and more law-abiding than human drivers, the police may be assigned to other duties. There will, not incidentally, also be a reduction in revenue from traffic fines and penalties, an important revenue stream for many municipalities. This shortfall in revenues will also be met with a need for additional funds necessary to provide the increased bandwidth requirements as autonomous vehicles communicate with infrastructure (e.g. traffic lights).

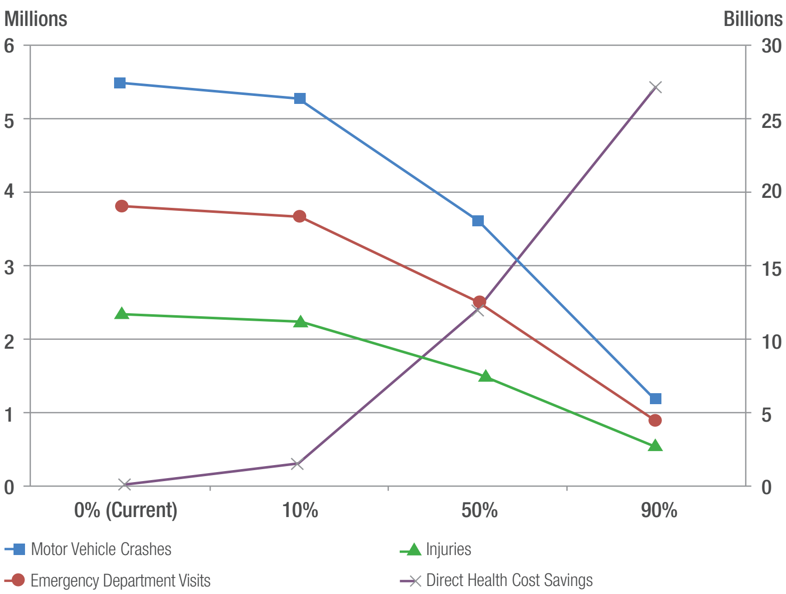
Accepting that autonomous vehicles will be safer and more law-abiding than human drivers, the police may be assigned to other duties.

Healthcare Transformed | Fewer Injuries, Lower Costs

Motor vehicle accidents are a leading cause of accidental injury.

A recently published study in *The Journal of Trauma and Acute Care Surgery* makes the point that motor vehicle accidents impose very substantial costs on the healthcare system, in terms of acute and long-term care. In fact, 28 percent of traumatic injuries in the U.S. are the result of road traffic accidents; the median stay in hospital because of a motor vehicle accident is three days; and car accidents are the leading cause of global mortality, killing more than 1.3 million people each year.[63] Even if only a small percentage of current predictions about the increased safety of autonomous vehicles are accurate, there will be significant reductions in the number and cost of traumatic injuries:[64]

Autonomous vehicle market penetrance (U.S.)



Source: *The Journal of Trauma and Acute Care Surgery*, U.S. October 2015

Even if only a small percentage of current predictions about the increased safety of autonomous vehicles are accurate, **there will be significant reductions in the number and cost of traumatic injuries.**

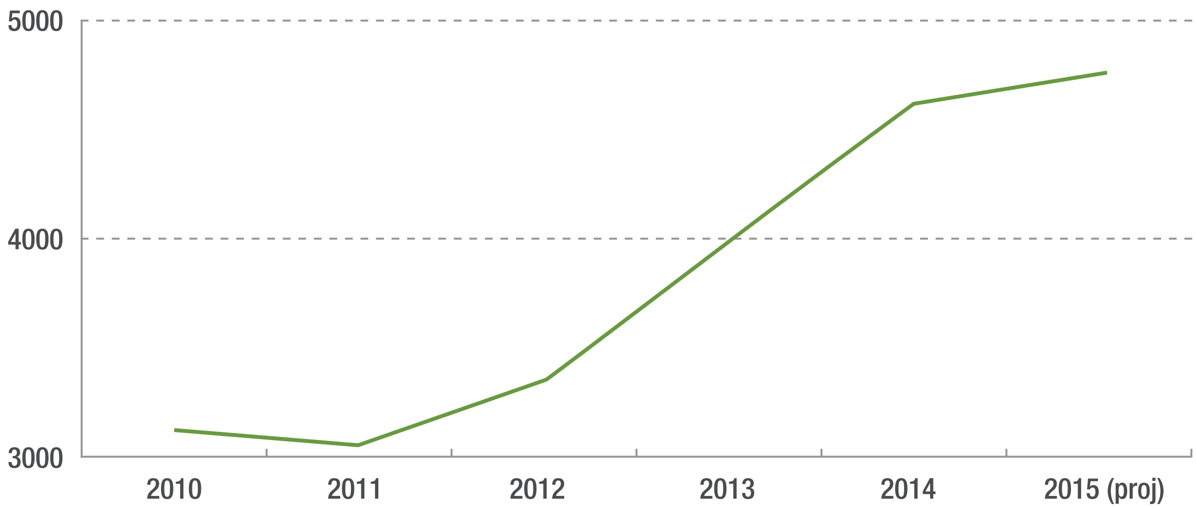
Criminal Liability: A Question of Control

The Criminal Code and provincial Highway Traffic Acts contain various provisions with respect to the operation of motor vehicles, ranging from speeding offenses to impaired driving through to reckless driving causing death. The advent of ADAS systems and autonomous vehicles will clearly require legislative changes, especially on the question and definition of vehicle control.

Patenting Activity Skyrockets

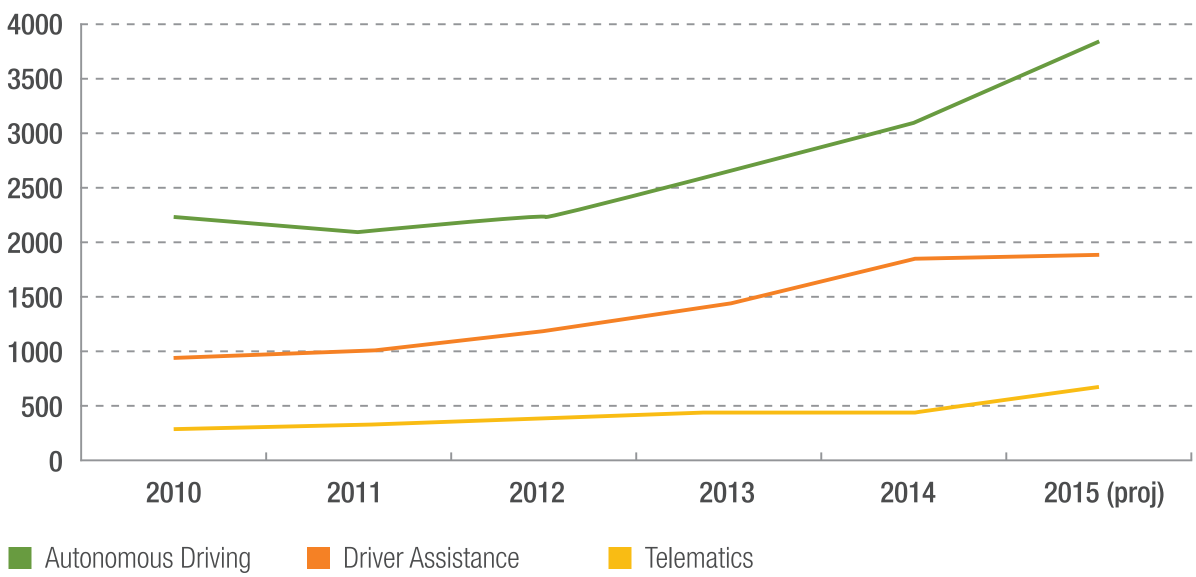
Patent databases and business intelligence software provide key insights about patenting activity related to autonomous vehicles. In January 2016, Thomson Reuters published an informative global study[65] on patenting in this space – after reviewing 22,000 unique self-driving inventions published or issued from January 2010, through October 2015.

Self-driving inventions by publication year on a global basis



Source: *The 2016 State of Self-Driving Automotive Innovation, Thomson Reuters, January 2016*

Self-driving inventions across the three main categories (2010 – 2015, projected) on a global basis



Source: *The 2016 State of Self-Driving Automotive Innovation, Thomson Reuters, January 2016*

Conclusion

Stated conservatively, there is a reasonable-to-high likelihood that many of the readers of this report will find themselves in what is a substantially autonomous vehicle within the next four to five years, and a fully autonomous one within the next eight to ten years. The extent to which manufacturers overcome technological challenges and address market and regulatory/legal issues will significantly impact how consumers respond to and accept their use and how these vehicles will reshape society.

The issues are not insurmountable. If proponents can demonstrate that autonomous vehicles provide substantial efficiencies at acceptable safety levels and costs, regulatory and legal issues will be resolved. When that happens, the subsequent impact on commerce and society will be broad and substantial. Indeed, autonomous vehicles, as their proponents suggest, may revolutionize our world.

When will
autonomous
vehicles
arrive?

Reasonable/high likelihood
4 to **5** Yrs

Fully autonomous
8 to **10** Yrs

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