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BARRISTERS AND SOLICITORS

Insurance & Liability Implications of the transition to Self-Driving Vehicles

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Adam Howden-Duke

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[1] This is an updated version of a paper first presented in May, 2018, and was prepared for presentation to London Market Insurers, adjusters and claims professionals

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Introduction

It is an exciting time in the automotive industry; new technologies are emerging and as is often the case, regulatory authorities are struggling to keep up.[2] Autonomous vehicle operation is at the forefront of emerging technology, in large part due to the expectation that removing the human factor from the role of the driver will result in far fewer collisions. According to data published by the National Highway Traffic Safety Administration ("NHTSA") in the US, from 2014-2016, the number of road fatalities increased from 32,744 to 37,461. Over that same period the rate of fatalities per 100 million vehicle miles travelled also increased (1.08 to 1.18), as did the per-capita rate of fatalities (.0103% to .0116%). While it may not be unexpected that, broken down by vehicle type, the fatality rate for motorcycle riders is over than 25 times that of passenger cars, given the advances in vehicle safety, the upward trend in per-capita and per-mile fatalities is surprising.[3]

Currently, where a collision occurs that results in damage to the person or property of another, the driver & vehicle owner are generally the potentially liable parties, and it is very seldom that a party not directly involved (such as the vehicle manufacturer, software service provider, mechanic, or highway designer or maintainer) is involved. This is likely to change as we move control of a vehicle from a human driver, to computer hardware and software. That shift in control is also likely to bring about changes in how the automotive and transportation industries are regulated and insured.

This paper canvasses the current 'state of play' in levels of autonomy of vehicles, some of the liability and insurance issues thrown up by that, and some issues likely to arise in the near future as we see ever higher levels of autonomy, and more autonomous and semi-autonomous vehicles on the road.

Terminology

The Society of Automotive Engineers ("SAE") developed a scale of 6 levels of vehicle autonomy (revised in 2016). These are now generally recognized.[4] The full table is at Appendix "A". The levels are described by the NHTSA as follows[5]:

[2] As recently as June, 2018, the World Forum for Harmonization of Vehicle Regulations (part of the United Nations Economic Commission for Europe – "UNECE") created a working party on Automated/Autonomous and Connected Vehicles, and held its first session in September. See report here: https://www.unece.org/fileadmin/DAM/trans/doc/2018/wp29grva/ECE-TRANS-WP.29-GRVA-01e.pdf

[3] https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812451

[4] SAE J3016 "*Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems*"; SAE International 2016; See NTSB Accident Report NTSB/HAR-17/02, at page 24

[5] "Automated Driving Systems 2.0: A Vision for Safety" NHTSA DOT HS 812 442, September 2017

Level	Descriptor	Narrative
0	No automation	Zero autonomy; the driver performs all driving tasks.
1	Driver assistance	Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.
2	Partial automation	Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.
3	Conditional automation	Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.
4	High automation	The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.
5	Full automation	The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

Generally, levels 0-2 apply where it is intended that the human driver monitors the environment. Levels 3-5 apply where an automated driving system monitors the driving environment. Vehicles in levels 3-5 are often referred to as "HAV's" (Highly Automated Vehicles), and exhibit the levels of automation that are currently being tested, rather than being generally able to legally operate on roads. Current levels of automation of 'on the road' production vehicles fall within levels 0-2.

The current landscape

> *Because more than 90% of motor vehicle crashes are attributed to driver error, automation in cars offers significant potential to save tens of thousands of lives every year by eventually replacing the driver. However, introducing automation into such a complex and unstructured environment will be very challenging and must be pursued thoughtfully and with considerable caution.*[6]

Many vehicles on the road today have technology that assist the driving function, such that very few vehicles fall under level "0" on the above scale. Transport Canada groups these assistive technologies as follows:[7]

- Vehicle Control:
  Electronic Stability Control (ESC), Roll Stability Control, and Traction Control;

[6] NTSB Board member statement in the investigation of a collision between a car operating with automated vehicle control systems and a tractor-trailer Near Williston, Florida, May 7, 2016 - Supra, note 4 at p. 45

[7] https://www.tc.gc.ca/eng/motorvehiclesafety/safevehicles-vehicle-safety-related-technologies-1068.htm

- Warning and crash mitigation:
  Blind Spot Detection, Forward Collision Warning and Braking, Lane Departure Warning, and Lane Keeping Assistance;

- Visibility:
  Advanced Forward Lighting Systems, Backing Aids, Night Vision Systems, and Pedestrian Detection;

- Other driver assistance:
  Adaptive Cruise Control, Brake Assist, Anti-Lock Braking Systems, Driver Monitoring, Speed Alert, and Tire Pressure Monitors.

Some of the above technologies are not new; for example BMW first introduced ESC in the late 1980's and Mercedes Benz was the first to offer adaptive cruise control in 1999.

Many predict that the trucking industry will be the first to adopt fully autonomous vehicles, due to the high turnover of drivers, and that drivers account for approximately one third of the per-mile operating cost of a tractor trailer.[8] However, Uber Freight's foray into this was short lived. For a time, Uber's autonomous test trucks moved freight for customers in Arizona with regular hauls operating with both human drivers and autonomous trucks working in tandem. Uber Freight's model was to load up on a conventional human driven truck that collects the load from the shipper and makes a short haul trip to a transfer hub. The short haul truck then loads its cargo onto a long-haul freight transport, which was autonomous for the purposes of these trips. That self-driving test truck handled the highway driving for the longer portion of the trip, handing it off once again to a human-driven short haul trip at the other end for delivery.[9] However, Uber closed this unit mid-2018 to concentrate instead on self-driving cars.[10]

Google, BMW, Uber, Nissan, Ford, General Motors, Tesla, Mercedes Benz, Toyota, Waymo and Bosch are all currently testing fully autonomous vehicles (with human monitors) in those States that allow it (currently 36). So far in Canada, only Ontario allows fully autonomous testing on public roads (under its AV pilot program). B.C., Alberta and Saskatchewan are all discussing bringing in similar legislation, however it is only Ontario who has had an automated vehicle pilot project to allow for driverless testing for the past 10 years. There, changes that came into force on January 1st this year, allowed automated vehicles equipped with SAE Level 3 technology that are available for public purchase in Canada to be driven on Ontario roads (i.e. they are no

[8] See "*The Autonomous Vehicle Revolution Expands to Trucks*" (DRI "For the Defense" December 2017 pp. 77-81 & 95), Arthur D. Spratlin Jr.
[9] https://techcrunch.com/2018/03/06/uber-self-driving-trucks-are-now-moving-cargo-for-uber-freight-customers/
[10] https://techcrunch.com/2018/07/30/ubers-self-driving-trucks-division-is-dead-long-live-uber-self-driving-cars/

longer restricted to registered pilot participants),[11] and the pilot program now allows driverless testing on public roads. While full human oversight of the vehicle's functionality is required while it is operating on a public roadway, that overseer can be a passenger onboard the vehicle, or someone monitoring the vehicle remotely (and able intervene to bring the vehicle to a safe stop).[12]

Probably the highest level of autonomy on a current production vehicle is Tesla's suite. These comprise:

- Autopilot (consisting of adaptive cruise control, Autosteer, and Auto Lane Change systems), forward collision avoidance (comprising forward collision warning and automatic emergency braking);
- Speed Assist,
- Lane Assist, and
- Autopark.

Current Tesla production models are equipped with hardware to allow full self-driving capability. Tesla say that the hardware includes 8 surround cameras and 12 ultrasonic sensors, in addition to the forward-facing radar with enhanced processing capabilities. Tesla advertises that the system will operate in "shadow mode" (processing without taking action) and send data back to Tesla to improve its abilities until the software is ready for deployment via over-the-air upgrades. After the required testing, Tesla hopes to enable full self-driving in the near future under certain conditions.

However currently, Tesla's active assistive technology is still only considered sufficient enough by the US National Transportation Safety Board (NTSB") to place the vehicle at SAE level 2.[13]

The zone between assistance and autonomy

Across the vehicles currently in operation on North American roads, there exists a significant range of functions that are automated (and within those; of levels of automation). Both these divergences are constantly changing as competitor manufacturers bring new technologies to market and others catch up. As these technologies are closely linked to the safe operation of vehicles, the current landscape adds a layer of complexity from a liability perspective, in ways not seen in prior automotive advances (such as cruise control and intermittent wipers).

[11] However, vehicles with aftermarket SAE Level 3 technology (technology that has been added to a vehicle after sale, not by an original equipment manufacturer) will remain restricted to the pilot program and will not be permitted for public use.

[12] http://www.mto.gov.on.ca/english/vehicles/automated-vehicles.shtml

[13] Supra, note 4 at p.9

A particular current issue is over-reliance on, and/or misunderstanding of, the limitations of current assistive vehicle technology.[14] Two separate fatal accidents involving Tesla vehicles appear to be clear illustrations of this.

In Florida on May 7, 2016 a Tesla Model S collided with a tractor trailer, when it made a left turn in front of that vehicle. The Tesla was travelling at highway speed on a paved roadway consisting of 2 lanes in each direction separated by a grass median. At the time, the Tesla's Autopilot was engaged and the vehicle did not slow as it approached the tractor-trailer.

In California, on March 23, 2018, a Tesla Model X struck the 'bull nose' of a highway divider, also at highway speed, while Autopilot was engaged, and also with no prior slowing.[15]

Some explanation of Tesla's Autopilot system is required to understand the significance of the driver interaction data that the Tesla recorded in the lead up to each fatal collision.

Tesla imposes 2 types of constraints on the driver's use of Autopilot; hard constraints that the system imposes automatically, and soft constraints that Tesla provides as cautions to the driver through the instrument screen, and instructions in the vehicle owner's manual.

The owners' manual includes the following warnings[16]:

> *"Traffic-Aware Cruise Control is primarily intended for driving on dry, straight roads, such as highways and freeways"* (at p. 68).
>
> *"Warning: Do not use Traffic-Aware Cruise Control on city streets or on roads where traffic conditions are constantly changing and where bicycles and pedestrians are present"* (at p. 68).
>
> *"Warning: Autosteer is intended for use only on highways and limited-access roads with a fully attentive driver"* (at p. 74).

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[14] See e.g. "AUTOMATED VEHICLES: DRIVER KNOWLEDGE, ATTITUDES, & PRACTICES" (Traffic Injury Research Foundation), September 2016

[15] https://www.ntsb.gov/investigations/AccidentReports/Reports/HWY18FH011-preliminary.pdf

[16] As recorded in the NTSB collision report; supra note 4 at p. 13. The report also notes: "*The 10-page-long section in the owner's manual concerning driver assistance, which addresses TACC and Autosteer, contains 16 items designated as warnings and 4 items designated as cautions*"

"Autosteer is intended for use on freeways and highways where access is limited by entry and exit ramps" (at p. 75).

"Autosteer is a hands-on feature. You must keep your hands on the steering wheel at all times." (at p. 74)

The system-imposed hard constraints include (1) setting an upper limit on lateral acceleration that affects the system alert sequence; (2) limiting the maximum cruising speed, depending on the detection of the speed limit on a restricted road; and (3) measuring the level of driver engagement and deactivating Autopilot if the level is insufficient.

As regards the 3rd constraint above, Autopilot assesses the driver's level of engagement by monitoring driver interaction with the steering wheel through changes in steering wheel torque. The system uses the driver's interactions with the wheel as a surrogate means of determining the driver's level of attentiveness. Autopilot uses a sequence of warnings to encourage the driver to interact with the steering wheel:

- The first alert is a visual warning, which appears in the instrument panel display and reads "Hold Steering Wheel."
- If the system does not detect driver-applied torque on the steering wheel after this visual warning, it sounds an auditory chime.
- If there is again no driver interaction with the steering wheel, the system sounds a second, louder chime.
- If the driver still does not apply detectable torque to the steering wheel, the system presents a final visual warning in the instrument panel display, which reads "To Maintain Set Speed Place Hands On Steering Wheel."
- If the driver does not respond to the final visual warning, Autopilot decelerates the Tesla to a full stop in the current travel lane and activates the car's hazard warning flashers. (This situation would likely occur only in the event of an incapacitated or completely unresponsive driver.)

We pause to note that this system does not match the warning in the manual for Autosteer to "*…keep your hands on the steering wheel at all times.*"

In the Autopilot system in use on the Teslas that were the subject of the collisions, this sequence could be repeatedly restarted by engaging with the steering wheel. In the case of the vehicle involved in the 2016 collision, the timing for the initial visual warning ranged from 1 to 5 minutes when traveling above 90kph, depending on the system conditions. However, when traveling at 90kph and below, the warning for hands-off driving would not occur, unless the car exceeded the lateral acceleration threshold, such as when traveling on certain curves. When traveling above 90kph, the initial warning would occur earlier when another vehicle was not detected ahead of the Tesla—and later when following another vehicle. The timing of the visual warning did not depend on the type of roadway being traveled. Note that, at 90kph (56mph), in 5 minutes, a vehicle has travelled 7.5km (4.67 miles).

Data downloaded from the vehicle involved in the 2016 collision showed that for the 41 minutes prior to the collision, Autopilot was active for 37 minutes. While Autopilot was in use, the system detected driver-applied torque on the steering wheel on 7 occasions for a total of 25 seconds. The longest period between alerts during which Autopilot did not detect the driver's hands on the steering wheel was nearly 6 minutes. The system displayed the initial visual warning to the driver 7 times. It progressed to the initial auditory warning (alert chime 1) 6 times. It did not progress to the second, louder chime.

The data for the vehicle involved in the 2018 collision showed that the Autopilot system was engaged on 4 separate occasions during the 32-minute trip, including a continuous operation for the last 18 minutes 55 seconds prior to impact. During that period, the vehicle provided two visual alerts and one auditory alert for the driver to place his hands on the steering wheel. These alerts were made more than 15 minutes prior to impact. During the last 60 seconds, the driver's hands were detected on the steering wheel on 3 separate occasions, for a total of 34 seconds. For the last 6 seconds, the vehicle did not detect the driver's hands on the steering wheel.

Put another way, it appears that for approximately 40 minutes preceding the 2016 collision, the driver of the Model S was merely touching the steering wheel when cued to do so by the auditory warning (indicating that he was not looking out the windscreen), although on one occasion, he did so upon cuing by the visual warning. The cruise control appears to have been set for most of the time at approximately 60mph (it was increased to 74mph, 1 minute and 51 seconds before the collision), so that he covered approximately 40 miles during this time.

However the driver of the Model X involved in the 2018 collision was more attentive; at least, using Autopilot's proxy of hands on the steering wheel - they being there for slightly more than ½ the time in the minute prior to impact. That vehicle's cruise control was set at 75mph, although it was travelling slower as it was following another vehicle (in the 3 seconds prior to impact, its speed increased from 62 to 70.8mph as it steered away from the vehicle it was following). Assuming an average speed of 60mph, the Model X covered 18.5 miles while on autopilot; and the driver's hands were last on the wheel approximately 170 metres (570 feet) prior to the 'bull nose'.

While to date, the NTSB has only released a preliminary report into the 2018 collision, in its report into the 2016 collision, it concluded that the probable cause of the collision was the truck driver's failure to yield the right of way to the car, combined with the car driver's inattention due to overreliance on vehicle automation, which resulted in the car driver's lack of reaction to the presence of the tractor trailer. It found that there were no defects in the automatic emergency braking system; like peer systems, it was designed to avoid rear end collisions - it was not designed to brake for crossing path collision. The NTSB also noted:

> "*Contributing to the car driver's overreliance on the vehicle automation was its operational design, which permitted his prolonged disengagement from the driving task and his use of the automation in ways inconsistent with guidance and warnings from the manufacturer*."[17]

According to the NTSB report, following the collision Tesla made design changes to its Autopilot firmware and hardware.[18] On September 23, 2016, Tesla made a fleetwide firmware update to a new version (8).[19] The update reduced the period of time that the Autopilot system allows a driver to have hands off the steering wheel before being alerted. Version 8 also provided that if the driver is warned on 3 separate occasions by alerts, Autosteer will deactivate and be unavailable for an hour or until an ignition restart. However, this was not enough to prevent a second fatality, as above, in March last year.

Using physical interaction with the steering wheel as a measure of driver attentiveness, seems a less than optimal measure, particularly given other auto manufacturers are now starting to use better proxies such as eye and head movement.[20]

The driver of the Tesla involved in the 2016 collision was able to activate Autopilot system on roads for which it was not intended to be used according to the user manual. How many drivers read the owner's manual, let alone get to pages numbered in the 60s and 70s? Consider the case of the non-owner driver – are they to be expected to read the manual before operating the vehicle systems?

There have been other collisions, involving seemingly inattentive drivers operating Teslas in Autopilot. For example, in January 2018, a Tesla rear-ended a fire-truck parked with its emergency lights activated[21], and in late 2018, a Floridian collided with a stationary Ford Fiesta on the side of a highway[22]. In addition, also last year, an Uber test vehicle fatally injured a pedestrian in Arizona. There, while the self-driving system determined that an emergency braking manoeuvre was required to mitigate a collision, the NTSB preliminary report noted that autonomous emergency braking was not

[17] Supra, note 4 at p.42
[18] Supra, note 4 at p.16
[19] The current is version 9.0.
[20] E.g. Lexus (http://www.traffictechnologytoday.com/opinion.php?BlogID=212) and GM (http://www.seeingmachines.com/blog/2018/04/17/seeing-machines-fovio-driver-monitoring-technology-features-in-gm-cadillac-ct6-super-cruise/)
[21] https://www.engadget.com/2018/05/17/tesla-crash-autopilot-driver-checking-phone/
[22] https://www.wired.com/story/tesla-autopilot-crash-lawsuit-florida-shawn-hudson/

enabled while the vehicle was under computer control, to reduce the potential for erratic vehicle behavior, and instead the vehicle operator was relied on to intervene and take action. However, according to press reports, state police concluded the operator was streaming a television program to her mobile device at the time of the collision.

Liability issues

Many driving safety experts predict that once driverless technology has been fully developed, traffic collisions caused by human errors, such as delayed reaction time, tailgating, rubbernecking, and other forms of distracted or aggressive driving will be substantially reduced, if not eliminated. However, there will still be collisions and injuries. Furthermore, as computers assume more and more control over the operation of a vehicle, the claims that result from these collisions are likely to shift toward product liability focused lawsuits. These are generally more complex and costly to both prosecute and defend, than current motor vehicle liability claims. In the near term, as these technologies are introduced, there is likely to be particular emphasis on the nature, adequacy and efficacy of instructions as to use and warnings as to limitations. The 2 highlighted Tesla collisions provide useful examples.

1. Background

Tort liability for property damage or personal injury caused by a defective or dangerous product is based on the claim of negligence. There are 3 main types of negligence establishing tort liability for damages or injuries caused by defective products: negligent manufacture, negligent design, and failure to warn.[23]

To prove negligence, the plaintiff must prove the following:

- the product was defective or dangerous;
- the defendant owed a duty of care to the plaintiff with respect to the product;
- the defendant was negligent in failing to meet the applicable standard of care;
- the defendant's breach of the standard of care caused or contributed to the defect;
- the defect caused or contributed to the plaintiff's damages or injuries; and
- the plaintiff's damages or injuries were reasonably foreseeable.

In Canada, the tort is not one of strict liability. Canadian courts have described the standard of care expected of a manufacturer as follows: "*a manufacturer has a duty to take*

[23] Summary adapted from CLE seminar "Product Liability" 2010

reasonable care in the manufacture of his product, including all of its component parts, and failure to take such reasonable care can result in liability to the ultimate user or consumer."[24]

Generally speaking, as regards negligent design, a manufacturer owes a duty not to manufacture a dangerous product if the same product can be manufactured with a substantially reduced risk of injury. However, a manufacturer is not required to use the most advanced design or the best materials, in manufacturing a product. Rather, a manufacturer must only use a design that is reasonable in all of the circumstances.[25] Where a design is 'state of the art', there will not be another, better one; even if the impugned design failed to perform as intended.

In some products, the risk of injury is inherent due to the nature or type of the product, as opposed to a design or manufacturing defect. Many non-defective and useful products are quite dangerous, and must be so if they are to be useful (e.g. motorized lawnmowers). Canadian courts have held that where there is an inherent risk in using a product, a duty is imposed upon manufacturers to warn users of the risk and how to avoid it.[26] Where a manufacturer knows or should have known of an inherent risk, and fails to communicate that to the consumer, it will be liable for breach of duty to warn, also known as failure to warn.[27]

There are a number of positive defences in Canada which may be raised by a defendant in a products liability claim. In addition to asserting that the plaintiff has not established the requisite elements of the claim (as above), a defendant may advance one or more of the following, the availability of which is very fact-specific.:

- the plaintiff knew of and accepted the risk or defect;
- the plaintiff improperly used or maintained the product;
- the plaintiff or a third party repaired or modified the product in an improper or unforeseeable way;
- there was an unforeseeable intervening act or event which caused or contributed to the plaintiff's injuries; and
- the plaintiff contractually waived his or her right to sue.

2. The Tesla collisions

According to press reports, the family of the driver involved in the 2016 collision did not pursue a lawsuit, however the family of the driver involved in the 2018 California one are doing so. [28]

[24] ***Farrow v. Nutone Electrical Ltd***. (1990), 68 D.L.R. (4th) 268.
[25] ***London & Lancashire Guarantee & Accident Co. of Canada v. Cie F.X. Drolet,*** [1944] S.C.R. 82.
[26] ***Murphy v. St. Catherine's General Hospital*** (1963), 41 D.L.R. (2d) 697
[27] ***Hollis v. Dow Corning Corp.,*** [1995] 4 S.C.R. 634
[28] http://www.minamitamaki.com/huang/

While the information about theses collisions is very limited, the potential liability issues that arise from both include:

- The sufficiency of the warning(s) given by Tesla in the owner's manual, of the need for driver attentiveness;

Here, as is noted above, the relevant instructions appear to commence at page 68 of the manual. Given the potential for danger to human life, depending on what else is in the manual and how these sections are presented, without more, this seems to present a risk for a finding that the warnings are inadequate.

- The design of the system;

There are 2 main apparent issues; the disconnect between the systems' limitations and operational parameters, and the choice of proxy to measure driver attentiveness. As to the former; an example of this disconnect is seen in the manual warning not to use the system unless the drivers hands are on the steering wheel at all times, versus the system design which allows operation with not only intermittent hand contact, but very minimal hand contact. In addition, it is intended for use on highways (where lateral access is restricted in the form of on & off ramps), however the system design did not block its use on other roadways. As to the second; as is noted above, hand contact seems an unreliable proxy for driver attentiveness, and this aspect of the design does not appear to be state of art, given the use of more reliable proxies by other manufacturers.

- The importance of accuracy in advertising and marketing around the Autopilot's capabilities;

As is noted above Tesla assert that their vehicles are essentially ready to be fully autonomous, where these collisions illustrate that is not the case.[29]

- Whether Autopilot should have been designed so as to be able to detect cross-traffic, given the likelihood of that occurring;

In addition to negligent design arguments directed at the manufacturer, this gives rise to potential liability on the part of regulatory agencies. That is, ought this have been

[29] Indeed, according to press reports (supra, note 22), the Floridian driver who collided with the stationary Ford Fiesta has commenced a lawsuit and alleges "*Tesla has duped consumers, including* [the plaintiff], *into believing that the autopilot system it offers with Tesla vehicles at additional cost can safely transport passengers at highway speeds with minimal input and oversight from those passengers*. That same press report says the lawsuit: "*accuses Tesla of negligence, breach of implied warranty or fitness for a particular purpose, and violation of Florida's Deceptive and Unfair Trade Practices Act, among other things*."

mandated before the system was allowed to be sold in a vehicle to the general public for use on public roads?

In addition to the above issues (which focus on the interface between the driver and the automation systems) the alleged circumstances 2018 collision bring liability of the hardware and software manufacturers into focus. There, it is alleged the driver did not intend to leave his lane, and that the Autopilot actively steered into the bullnose.

3. Issues from divergent levels of automation

Each vehicle manufacturer (and companies providing hardware and software for vehicle automation systems such as Waymo, Google and Uber) are working towards levels of autonomy of SAE 3 and above to be commercially available. However, the current landscape involves varying levels of autonomy across comparable models. The most obvious examples are adaptive cruise control, emergency autonomous braking and lane keeping. Unlike prior systems (like cruise control and ABS), because of the nature of their operation (as either an addition to cruise control, or only evident in an emergency) arguably these require better notice to consumers of not only whether they are installed, but their capabilities and limitations.

This lack on homogeneity gives rise to unique issues for rental car fleets, where vehicle users are far less likely to open a vehicle manual. For example, at which point will a court find that it was incumbent on a rental agency to advise that the cruise control on the vehicle they rented did not have lane keep assistance, or ensure a set distance was kept behind the vehicle it was following?

Another area of potential liability encompasses cyber - and in particular the need to ensure that automated vehicles are secure from unauthorized access and manipulation. In addition to liability to those who have suffered injury to person or property in a collision, as has already been seen, cyber breaches can result in shareholder derivative actions and securities related class actions against directors and officers for failing to ensure proper protections were in place.

Government will continue to have a role in developing rules around the safe operation of vehicles on roadways. The hands-off warning interval that is a feature of Tesla's Autopilot is under consideration elsewhere in the world, particularly in Europe, where the UNECE last year adopted a regulation requiring lane-keeping systems to provide an initial visual warning after 15 seconds of hands-off driving and deactivate in a controlled manner after 1 minute of hands-off driving.

Policy wording issues

Currently, the transportation regulatory and insurance model focusses on each vehicle's owner and driver as the responsible parties. There are exclusions and regulations relevant to driver competence, including the number hours heavy trade operators may drive, intoxication levels and requiring drivers to have demonstrated competence by holding a valid driving licence. In Canada, each Province mandates that the owner of a vehicle have minimum terms of coverage.

With the shift of responsibility for vehicle operation from drivers to machines, the insurance landscape is likely to change, as the determination of the human 'operator' of an autonomous vehicle may not necessarily determine responsibility. In the US, the NHTSA's policy guideline published in September 2017 encourages States to:

> "*a. Begin to consider how to allocate liability among autonomous vehicle owners, operators, passengers, manufacturers and other entities when a crash occurs.*
>
> *b. For insurance purposes, determine who (owner, operator, passenger, manufacturer, other entity etc.) must carry motor vehicle insurance.*
>
> *c. States should begin to consider rules and laws allocating tort liability.*"[30]

This may mean that all manufacturers are required to carry insurance that covers occupants. Fixing manufacturers with the primary insurance obligation would seem to follow the current system where it is the person primarily responsible for the operation of the vehicle that is required to be insured. This could be on an at-fault or no-fault basis.

Given the nature of product liability litigation, an at-fault system could see increased claims exposure of component manufacturers and designers, whereas a no fault system requiring manufacturers to carry insurance, would have the opposite effect.

Also as regards a no-fault system, automation does not change the current concerns as to sufficiency of recompense for injuries associated with moving from an at-fault to a no-fault system. However, on the other hand, apart from removing the 'crystal ball gazing' that is required to assess damages for personal injury under the current model, no fault may have benefit in sharing the risk where the number of manufacturers is far more manageable than the number of vehicle owners and drivers currently on the roads. In addition, for the reasons above, litigation may become more complex, leading to obvious costs savings in claims costs, under a no-fault system. Those factors in favour of retaining an at-fault system include society's reluctance to leave the allocation

[30] "Automated Driving Systems 2.0: a vision for Safety" p. 24

of risk (and recompense) to profit-centric corporations that are in competition with each other, particularly where the risk is one to human life and safety.

Legislation will also need to be adapted from the current statutes regulating safe driving, which use driver-focused language. For example the Motor Vehicle Act,[31] s144 (careless driving prohibited); "*A person must not drive a motor vehicle on a highway … without due care and attention, …*", and s214.2 (prohibition against use of electronic device while driving) "*(1) A person must not use an electronic device while driving or operating a motor vehicle on a highway.*"

As the current insurance policy wording is also based on risks posed by humans being in control of vehicles (exclusions, where they exist, generally being tied to compliance with statutes governing the operation of vehicles on roadways), policy language will instead need to focus on those risks posed by machines being in control. We may therefore see exclusions related to satellite service interruption, system hacking, and currency of software updates.

Finally, shifts in responsibility may drive shifts in ownership models, and in turn the pricing of insurance. For example, current car-share models recoup the cost of insurance coverage when the vehicle is in use, by a user pays model; the cost being added into the per-minute rate. If manufacturers start being the primary entity holding coverage, they may want to retain better control over their products (i.e. maintenance and roadworthiness) and move to more of a shared ownership so that we wider adoption of the 'pay as you go' model. This in turn may lead to more business risk sharing by insurers, who may prefer to recover premium directly from the vehicle user.

Ethical dilemmas

The primary ethical dilemma caused by putting a computer in control of a vehicle on a public road revolves around the "least worst case scenario". This has its roots in a classic philosophical thought experiment known as the trolley problem, which was introduced in 1967 by Philippa Foot.[32] However, that scenario lacks the vested interest introduced in the case of autonomous vehicles, as the following example illustrates.

Your car is driving along a rural highway with you and your family in it when a pedestrian, without any warning, runs into its path. Your vehicle has 2 options; collide

[31] RSBC 1996 chapter 318

[32] The problem is generally described as follows: You see a runaway trolley moving toward 5 incapacitated people lying on the tracks. You are standing next to a lever that controls a switch. If you pull the lever, the trolley will be redirected onto a side track, and the 5 people on the main track will be saved. However, there is a single person lying on the side track. You can either o nothing and allow the trolley to kill the five people on the main track, or pull the lever, diverting the trolley onto the side track where it will kill one person. Which is the more ethical option?

with the pedestrian, or collide with a utility pole. It calculates the risk of injury to your family as zero if you collide with the pedestrian, but the impact will be fatal to the pedestrian. It calculates that if it collides with the utility pole, while it will write the vehicle off, the risk of a fatal injury to any of your family is small (but still exists).

Which option should the car take? Most people have little difficulty in choosing between damage to property over human life, but would you be willing to risk injury to your family over the life of a total stranger? Should the occupants be able to choose, or should the response be mandated by someone else?

Do the pedestrian's circumstances make a difference? For example if they are on the roadway due to intoxication, versus an emergency they are attending to? If so, should the vehicle be allowed to know the pedestrians circumstances?

Should vehicles be able to be programmed to differing levels of worst case scenario (i.e. of self-preservation over injury to others), or should all vehicles conform to the same rules? Given the prevalence of large passenger vehicles currently on the road in North America, which are motivated in part by a need to keep families safe from other large passenger vehicles on the road, is there already a differential level of risk in place? How likely is it that, left to their own devices, vehicle occupants would allow any risk to themselves to save a stranger?

At least one study, looking into this issue has shown differing moral preferences. The "Moral Machine" experiment launched by scientists at the Massachusetts Institute of Technology presented volunteers in a number of countries with scenarios involving driverless cars and unavoidable accidents that imperiled various combinations of pedestrians and passengers. The participants had to decide which lives the vehicle would spare or take, based on factors such as the gender, age, fitness and even species of the potential victims. According to "Inside Science",[33] while not truly representative, the researchers found there were a number of moral preferences shared across the globe, including saving the largest number of lives, prioritizing the young, and valuing humans over animals. Those spared the most often were babies in strollers, children, and pregnant women. However, the results also revealed that ethics varied between different cultures, and we have extracted the comparison data between the survey results from the United Kingdom, USA and Canada, at Appendix "B".

These are unique issues, given rise to, by the shift of control from a human to a computer able to undertake thousands of calculations in a split second and make evaluations that humans cannot do in the 'agony of the moment'. Presently it is government that regulates the use of roadways. While those rules and regulations go nowhere the level of detail at issue here, there are certainly many that believe these

[33] https://www.insidescience.org/news/moral-dilemmas-self-driving-cars

moral rules should be universal and the province of elected officials. For example in Germany, in 2017 the Federal Ministry of Transport and Digital Infrastructure released report for that country's government on the ethical issues of automated driving. That proposed ethical rules for automated and connected vehicular traffic that included;

> *In the event of unavoidable accident situations, any distinction based on personal features (age, gender, physical or mental constitution) is strictly prohibited. It is also prohibited to offset victims against one another. General programming to reduce the number of personal injuries may be justifiable. Those parties involved in the generation of mobility risks must not sacrifice non-involved parties*.[34]

Of course, the question of what moral basis would be used by an autonomous vehicle to make decisions, is only half of the problem. How those be could translated into software code also would need to be addressed and answered - clearly something more would be required than Asimov's 3 laws of Robotics.[35]

How this inter-relates with insurance is an interesting topic too. Presumably, left to their own devices, insurers of vehicles and their occupants would prefer self-preservation of that insured over all else. Should insurers be able to price premium according to self-preservation levels (when that may result in more injury or property damage to others)? Should they be able to price premium based on where and when the vehicle is operated?

Apart from this ethical issue, truly autonomous travel - removing the task of driving - will bring about huge social change. First, as to employment; eliminating large numbers of employment positions in the transportation industry, from taxis and busses to freight movement. Second, as to urban planning – when people can engage in other productive tasks while they travel instead of having to be attentive to driving.[36] In addition to possible urban sprawl, this in turn may move people away from public transit and increase the number of vehicles on roads & need for more highways (although the efficiency of use of roadways ought to increase with autonomy).

Finally, privacy concerns abound over the amount of data that is currently being collected and will only continue to expand in scope. This information gathering ranges from tracking of routes, voice recording, video recording, preferences in media that is consumed in the car, behavioral patterns, to many more streams of information. The dissemination of "least worse case scenario" settings of course raises a raft of other

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[34] https://www.bmvi.de/SharedDocs/EN/publications/report-ethics-commission.pdf?__blob=publicationFile

[35] A robot may not injure a human being or, through inaction, allow a human being to come to harm.
A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.
A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

[36] According to the press report at note 22, one of the reasons that driver purchased a Tesla, was to free up time during his long driving commute

privacy concerns, reflecting as it must on the personal values of the operator as a member of society.

Concluding remarks

The NTSB in its investigation into the 2016 Tesla fatality in Florida, after examining the increasing autonomy in vehicles commented using the aeronautical industry as an analogy:

> *In aviation, although automation has generated substantial safety, efficiency, and other benefits, we will not see airliners without pilots any time soon because no graceful exit has yet been developed from that scenario (a) if the automation encounters a situation that was not contemplated by the designer, such as in Sioux City, Iowa, in 1989, when an uncontained engine explosion resulted in the loss of all three of the airplane's hydraulic systems, or in New York City in 2009 when both of the airplane's engines were damaged beyond operability by ingesting birds; or (b) if the automation fails.*
>
> *The potential benefits of automation on our streets and highways are truly phenomenal, but they must be pursued carefully and thoughtfully, and hopefully the automakers will inform the process with automation lessons learned from aviation and elsewhere.*[37]

Whether there will be a "graceful exit" of the human driver remains to be seen. In the meantime, with one foot in the fully autonomous world and another in one where the driver is supposed to be attentive and in control, the liability and insurance landscapes are changing. That change is likely to be away from a focus on the driver, to the manufacturer of the vehicle; away from relatively straight forward analyses of liability to more costly and complex ones focused on product liability.

Adam Howden-Duke
January 12, 2019

[all URL's in footnotes accurate as of date of this paper]

[37] Supra note 4 at p. 46

Appendix A

Figure 1: SAE International's Levels of Automation

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**

Key definitions in J3016 include (among others):

Source: SAE International

Appendix B

The Moral Machine - Massachusetts Institute of Technology (extract):

World Ranking (117 countries)	**Preferring Inaction**	**Sparing Pedestrians**	**Sparing Females**	**Sparing the Fit**	**Sparing the Lawful**
United Kingdom	16th	46th	71st	16th	83rd
Canada	34th	61st	50th	20th	81st
USA	35th	67th	47th	37th	95th
		Sparing Higher Status	**Sparing the Younger**	**Sparing More**	**Sparing Humans**
United Kingdom		53rd	34th	10th	56th
Canada		46th	29th	12th	32nd
USA		48th	49th	14th	68th

(source: http://moralmachineresults.scalablecoop.org/)