EVALUATION OF POTENTIAL POLICY ISSUES WHEN PLANNING FOR AUTONOMOUS VEHICLES

Adekunle Mofolasayo
Proceedings of the 53rd Annual Conference
Canadian Transportation Research Forum

Introduction

Autonomous vehicle technology is a new development that has immense potential to change a range of factors that affect transportation systems globally. Benefits received from autonomous vehicles such as improved safety, greater mobility, and lower emissions has encouraged great research interest in the field (Christos, Mohammed, Wen-Hua, & Lipika, 2015). The global status report on road safety that was produced by the world health organization with information from 180 countries indicated that fatalities that occur on the road worldwide has reached 1.25 million every year. This is an unacceptably high number. It is long known that majority of the road traffic crashes are caused by human errors. The National Academy of Sciences, Engineering, and Medicine published a report (by Echterhoff, W., 1977) on psychophysical limitations as a cause of accidents, which indicated that 90% of accidents are caused by human error. If this number is projected to the global scale, it indicated that in 180 countries globally, 1,125,000 fatalities occur every year due to human error. Turning this tide around, will certainly save many families from avoidable grief over loss of loved ones to road traffic crashes. Mankind has been able to develop machines to help make up for human limitations in various facet of life. The use of tractors in the agricultural industry has helped humanity to be able to cultivate large expanse of farmland that a number of people may not be able to cultivate within a short period of time. Various construction equipment has also been developed to make life easier for humanity. Even though various challenges and limitations that face humanity at large is not hidden in the transportation sector, implementation of some innovative technologies that could be of help to mankind in reducing the number of fatalities on the road has faced challenges in various areas. It is a fact that traffic crashes, and the resulting losses (fatalities, property damages, financial loses, emotional pains, etc) do not discriminate against the rich, or the poor, the educated, and the uneducated, the farmers or the politicians. In the interest of humanity at large, all people everywhere, needs to take the issue of transportation safety very seriously, in a bi-partisan way, and come together to evaluate innovative ways by which humanity at large can overcome this pertinent challenge in the transportation industry. Proper incorporation of the beneficial effects of autonomous vehicles is a clever way forward in eliminating the human error.

Recently, the United Kingdom, in the 2016 Queen's speech introduced the "modern transport bill". The bill supports new forms of transportation including autonomous and electric vehicles. Among other things, the bill seeks to position the UK at the forefront of technology, allow innovation to flourish, ensure that appropriate insurance that will support autonomous vehicles exist, and ensure that new technology can facilitate safer travels. The US Department of Transportation (DOT), and the National Highway Traffic Safety Administration (NHTSA) in the federal automated vehicle policy (September 2016), noted that the introduction of self-driving brings both more possibilities, and more questions than perhaps any other innovation in transportation that is being discussed at the moment. As noted by NHTSA, & USDOT, the concerns about autonomous vehicles include questions about if they will completely replace human drivers, the socio-economic impact from such change, the ethical judgements the autonomous vehicles will need to make, and the effect on privacy and security. These are indeed valid things to be concerned about, and it certainly requires a great deal of planning, and regulations to ensure

that the technology is not misused against anyone. Recognizing the potential benefits of Highly Automated Vehicles (HAV), the Federal Automated Vehicle policy (2016) seeks to provide a guideline that can form a baseline for future improvement, and help accelerate HAV revolution. Being a fairly new technology, it is expected that autonomous vehicle technology may face some challenges in its implementation on a large scale, as a result, there is need to ensure that there is a good understanding of the challenges that faces road transportation sector at this age, and what part autonomous vehicle technology could take in tackling some of these challenges.

Critical issues in urban transportation

The executive committee of the Transportation Research Board [TRB] (2013), identified certain factors such as huge number of avoidable deaths, and injury that occur on the roads annually, inadequate funds for research and development to realise technological breakthrough in transportation, insufficient funding for public infrastructures, undependable performance of the system, poor performance of public transportation as compared to private transportation, and unsustainable effects on environment, energy, and climate as critical issues in transportation. Although some of these issues may be linked to each other, one of the biggest issues of concern in transportation is the huge amount of fatalities that occur on the roads globally every year. In 2015, in the United States alone, 35,092 people died on the roads (NHTSA & USDOT, 2016). It is certain that no amount of money can be paid to get human life. These sad statistics in transportation safety should be enough, as a call of action for humanity at large to make a concerted effort to develop, support, and implement technology that can help prevent avoidable fatalities either on the land, sea or air. This study will focus a little more on the possible safety benefits from elimination of human error in driving of automobiles. Regarding undependable system performance, it is hoped that a broader implementation of autonomous technologies will result in reduction in traffic collisions, and more deterministic system performance. There is certainly need for more research to ensure that the *health* of the vehicles can be automatically communicated to both the owner, and the manufacturers, and vehicles that are not road worthy or are likely to result in breakdown, and delay are taken off the road. A report by the American Association of State Highway and Transportation Officials indicated that having policy-related steps to ensure that minor incidents are cleared on time can help result in reduction in delays caused by such incidents (AASHTO, 2004). When evaluating transportation equity issues and prospective benefits of making laws to eliminate vehicles that do not meet certain safety standards from the road, it is good to note that it is much better not to drive an automobile, and live, than, to drive an automobile, and become one of the statistics in the global traffic fatalities.

Why autonomous / Highly automated vehicles (HAV) may be a good idea

Some of the reasons why autonomous vehicles are desirable are as follows:

(1) Elimination of Traffic crashes that results from distracted driving
(2) Improvement in traffic flow
(3) Improvement in mobility for the physically impaired, and the aged.
(4) Allowing multi-tasking, and reduction of in-vehicle time wastage for drivers
(5) Reduction in overall traffic crashes

Elimination of traffic crashes that results from distractions

It has been estimated that at least 25% of police reported accidents are caused by some form of the driver's inattention (Jane, Donald, Loren, Eric, 2001). In a study about the role of driver distraction in traffic crashes, Jane et al., (2001) gave a list of sources of distraction to distracted drivers. The sources of distraction listed includes: outside person or object (29.4%), adjusting radio cassette CD (11.4%), other occupant in vehicle (10.9%), moving object in vehicle (4.3%), other devices or object brought into the vehicle (2.9%), adjusting vehicle climate control (2.8%), eating or drinking (1.7%), using or dialling cell

phone (1.5%), smoking related (0.9%), other distraction (25.6%), and unknown distraction (8.6%). It was noted that the different distraction types should be seen as preliminary estimates, that may have some differential underreporting biases, as a result, the given percentages were not to be used as a guiding principle for policy development. However, the result of that research is useful in having a good understanding of distractions to drivers. More details about the variability of the source of distraction to drivers is in the report by Jane et al., (2001). Looking at the possible sources of distraction for the drivers, it is obvious that some of these things comes with basic human needs. Although an effort may be made to provide enforcement to reduce distracted driving, it may be difficult for humans to achieve a zero degree of distraction while driving. As shown above, it is of good note that outside object or person takes the highest position in the sources of distraction. How does any law enforcement officer want to stop this? Distraction for other car occupants can also be challenging. For example, can a mother that is driving not be distracted by the voice of a crying baby? When evaluating the effect of distraction on human drivers with autonomous vehicle system; certainly, it is known that a computer cannot be distracted in the same way that humans may be distracted. As a result, autonomous vehicles or HAVs with proper functions is expected to help eliminate the trouble with distracted driving.

Improvement in traffic flow

Traffic congestion is one of the issues that face the transportation industry. The Queen's speech (2016) indicated that congestion has been estimated to cost the United Kingdom's economy £ 20 billion every year. A review of flow and operation implications of autonomous and connected systems by Hani, (2016) noted that autonomous vehicles, and connected vehicles could increase the throughput of vehicles on the road. Dedicated lanes for autonomous vehicles has also been discussed in the literature (Hani, 2016). However, although autonomous vehicles are expected to increase the throughput on the road, there is concern about the non-autonomous vehicles that may interfere with the flow.

Reduction in overall traffic crashes

Statistical summary of critical reasons for crashes as provided by the National Highway Traffic Safety Administration (NHTSA, 2015) indicated that factors that interact during traffic crash includes the driver, the car, and the environment. Jane et.al (2001), on review of the crash worthiness data system (CDS) of the National accident sampling system (NASS) noted that between 1995 – 1999, the percentage of drivers that were attentive at the time of the crash sits at 48.6%. While 8.3% were distracted, 5.4% were categorized as 'looked but did not see' 1.8% as asleep or sleepy, and 35.9% are recorded as unknown or no driver present. NHTSA placed the driver as the highest causal factor for traffic crash at 94% ± 2.2%, the vehicle is rated at 2% ± 0.7%, the environment at 2% ± 1.3%, and unknown critical reasons at 2% ± 1.4%. While autonomous driving is expected to help eliminate human error, there is still a need to put in good effort to ensure that adequate systems are in place that will ensure that no crash will result from an error from the autonomous vehicle. There is also a need to ensure that transportation infrastructures are consistently in good condition to support autonomous driving.

	Number of fatalities by road user class in Canada (2006 - 2010)						Total
Year	Drivers	Passengers	Pedestrians	Bicyclists	Motorcyclists	Not Stated / Other	
2006	1519	617	371	75	217	71	2870
2007	1434	608	375	66	222	50	2755
2008	1316	498	305	43	219	53	2434
2009	1172	442	317	44	198	57	2230
2010	1148	480	296	60	189	54	2227

Table. 1.0 Canadian traffic fatalities by road user class (2006 – 2010)

*Adapted from Canadian motor vehicle collision statistics (Transport Canada, 2010)

A review of Transport Canada's information on collision statistics between 2006 – 2010 showed that drivers are most likely to be involved in fatality, if the traffic crash resulted in a fatality. Although the data showed that there is downward progression in the road traffic fatalities for the drivers between 2006

– 2010, (As seen in table 1.0, and figure 1.0) when compared to the total number of collisions for each year, the percentage of drivers that are involved in traffic fatalities on a yearly basis is fairly constant between 51% - 55% of the total number of road traffic fatalities for each year.

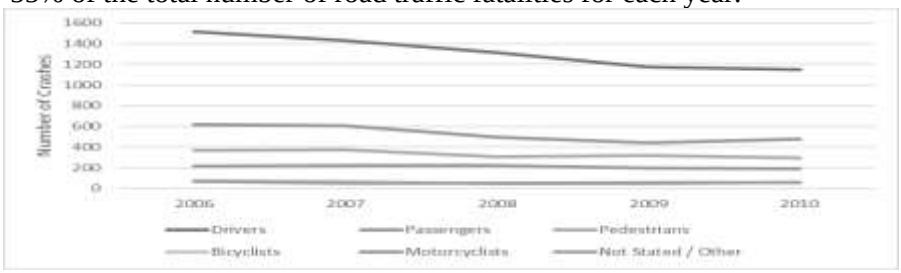

Figure 1.0. Canadian traffic fatalities by road user class (2006 – 2010)
*Adapted from Canadian motor vehicle collision statistics (Transport Canada, 2010)

As shown in Table 1.0, and figure 2.0, passenger fatality is next to driver fatalities. Within the 5-year period, in Canada alone, 6,589 drivers, 2645 passengers, 1664 pedestrians, 288 bicyclists, 1045 motorcyclists, and 285 others lost their lives due to traffic crashes. This is a total of 12,516 lives lost on the road within 5-year period. Applying the 90% factor that is reported (published by the National Academy of Science Engineering and Medicine) as human error in traffic crashes to the above numbers, with an assumption that a reduction in road traffic crashes will transfer into a reduction in road traffic fatalities at the same degree, a forecasted reduction in road traffic fatalities that could have been achieved for the given period was evaluated as presented in figure 2 below. With a simple mathematical calculation, about 11,264 road traffic fatalities could have been prevented in Canada alone, within the study period, if systems that effectively eliminate human error in transportation was adopted. Figure 2 showed that we will expect to see a great reduction in fatalities. Similarly, applying the 90% factor to the 35,092 fatalities that occurred on US roads alone in 2015, about 31,583 fatalities could have been avoided if human factor is removed from the cause of traffic crashes. Every nation of the world may apply the same concept to evaluate the potential benefits that can be achieved with a good implementation of technological innovations that can help eliminate human errors in road transportation. Note that earlier references indicate that driver error causes up to 45% – 75% of traffic crashes, and contributes to majority of the road traffic crashes (USDOT, & FHWA, 2003). The federal automated vehicle policy by the US department of Transportation, and the National Highway Traffic Safety Commission (2016) indicated that 94% of crashes can be related to a human error or choice (NHTSA & USDOT, 2016). Whichever percentage is used, eliminating human error is still expected to result in a significant reduction in road traffic crashes.

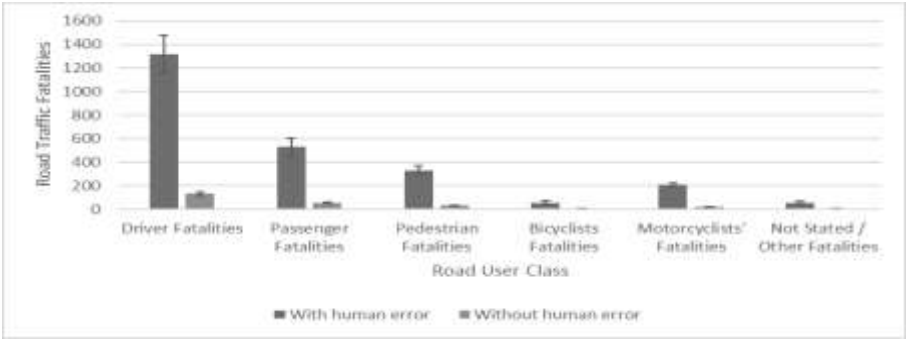

Figure 2.0: Forecasted reduction in road traffic fatalities in absence of driver error in Canada
*Adapted from Canadian motor vehicle collision statistics (Transport Canada, 2010)

Other potential benefits of autonomous driving technology

With a well-designed system, someone who is physically challenged on wheel chair, or a blind fellow can have access to automobile without the need for a driver. Mobility may be improved for the aged with

autonomous vehicles. Fatigued, and sleepy individuals should have the opportunity to be in the car while the full autonomous vehicle does the driving. It has been noted that a scenario where you can get in your car, and sleep while the autonomous vehicle takes you around seems to be closer now than it was few years ago (Rory Cellan-Jones, 2017). Delivery services could be made easier when an order is made. Imagine food and grocery delivery to various households by autonomous vehicles. In-vehicle time wastage could be greatly reduced with autonomous driving systems. Car occupants can multi-task, or even concentrate on other important things while the driving is left for *reliable* autonomous systems to handle.

Different levels of automation

SAE international standard J3016 (2014) identified 6 levels of driving automation beginning with no automation to full automation. This was done to provide a common terminology in automated driving. The six levels include: No automation (level 0), driver assistance (level 1), partial automation (level 2), conditional automation (level 3), high automation (level 4), and full automation (level 5). More details about the levels of automation is available in SAE International standard J3016.

What minimum level of automation should be mandated as a law for everyone

Given that the world now knows that collision avoidance technology exists, at a minimum all new vehicles should have collision avoidance technology. Even when the driver is present, no driver should have the capability to override a system to hit an external object. The Insurance institute for highway safety (IIHS), and Highway Loss Data Institute (HLDI) indicates that six of the most common modern technologies in crash avoidance system includes: autobrake, forward collision warning, lane departure prevention, lane departure warning, blind spot detection, and adaptive headlights. Other desirable features include front crash prevention, park assist and back-over protection (crash prevention using auto braking system). Although everyone has the right to be in control of personal vehicle, no one should have the right to hit another vehicle or person. Making it mandatory (a law) to ensure all vehicles on the road (at a minimum) have efficient crash avoidance systems will be a good idea in the effort to reduce road traffic fatalities globally. In addition to this, those who perpetrates the act of terror will not be able to use automobiles to kill innocent people if all vehicles on the road have highly automated functions that incudes collision avoidance technologies which no one can override and still have a working vehicle. There may be a need to also ensure that systems exist in every automobile that automatically alerts the law enforcement agencies in every jurisdiction if anyone tries to override the collision avoidance system in any vehicle. At a minimum, legislation that mandates every automobile on the road to have efficient autobrake system for both frontal, and backward movement will be a big step to greatly reduce accidental traffic collisions.

Potential Policy Challenges

Some concerns that were mentioned in the September 2016 Federal automated vehicle policy by the US department of transportation and the National Highway Traffic Administration includes question about: if the autonomous vehicle will completely replace human drivers; the socioeconomic impacts of a dramatic change like this; the ethical judgements the autonomous vehicles will have to make, and if there will be a disruption in the nature of security and privacy. These, and other issues are addressed below.

Will autonomous vehicles fully replace human drivers?

Certainly, in the immediate, considering the number of people that does not have autonomous vehicles, there cannot be a complete replacement of human drivers on the road at the present. Having been used to driving, the change probably may not be an easy task for some folks. However, in the near future,

depending on how efficient the technology proves itself to be, on a large scale, and how favourably the technology is accepted, the world may witness considerable changes in automobile use. There may be a need to have pilot projects in more areas with the use of only autonomous vehicles on the road for a particular length of time, and see if there is any traffic crash. If there is no traffic crash at all while only autonomous vehicles are on the road, this may form a basis to have a full replacement of human drivers with autonomous driving. If there exist issues about some people not trusting the judgement of autonomous vehicles, this concern may also be respected and such people may be given an opportunity to be able to override some of the decisions of the autonomous vehicle, such as applying the break when needed, controlling the steering when needed (if equipped with steering), but such interventions should not include an ability to collide with another vehicle, person, or external object. All vehicles on the road should be equipped with efficient collision avoidance systems that cannot be overridden by the driver.

Economic impact from the change to autonomous vehicle

Gas tax may be reduced if there are more autonomous vehicles that are electric powered. Hence, new forms of revenue will need to be planned. Some jobs may no longer be needed depending on the level of societal acceptance, and confidence in the technology. Some taxi drivers, including some truck drivers may not be needed, there may be a reduction in the need for driver testing / licensing officers. There will be a need to make plans for these transition, and think of alternative jobs for such people. If majority of the autonomous vehicles use electricity, sales of fossil fuel may reduce, this may also result in reduction in air pollution, if the source of the energy that is used to power the vehicle comes from a clean source. If the chance of road traffic collisions becomes very negligible under autonomous / highly automated driving conditions, there may be considerable reduction in the cost of automobile insurance in various places. Should these potential changes discourage the embracement of this technology? Considering the potential safety benefits, and reduction in roadway fatalities, the socioeconomic changes should not discourage wide scale implementation of the autonomous vehicle technologies.

Privacy and security issue

As regards privacy, in a vehicle to vehicle (V2V) communication environment, the level of confidential information that will be available to 3rd parties (in an autonomous, and connected vehicle environment) may be of concern. Privacy issues that destination information of people in a vehicle may be visible to people in other vehicles may exist. In this circumstance, there may be a need to ensure that appropriate legislation exists that limits the amount of information on surrounding vehicles that will be visible to occupants of various vehicles on the road. An ideal thing may be to limit the information that is visible to other drivers to what someone may see when following a human driver. For example, following a human driver, the occupants in the vehicle following another vehicle may see the break light, left or right signals. Allowing this kind of information to be visible to occupants in other vehicles may be ok. However, it may not be a good idea to make information about road user's planned-route, (from origin to destination) visible to occupants in surrounding vehicles. Exceptions may be made for law enforcement officers in certain situations. Each vehicle occupant should be able to see the planned route for his / her vehicle, but not for the other vehicles on the road. Security of everyone should be taken into consideration.

How ready is the technology to ensure safety of end users?

The issue about safety of end users is one that everybody needs to be concerned about. There have been various concerns about the efficiency of the autonomous vehicle technology. Some of the concerns that was raised by Christos et al., (2015) includes the inability of autonomous vehicle to recognize the intension of human drivers; synchronization of vehicle capacity and constraint with trajectory planning, and manoeuvres: like the effects of road surfaces, and weather on manoeuvre capabilities of the vehicle, such as steering, acceleration, or braking constraint. Using straight line for calculation of time to

collisions on curved roads has also been identified as having a potential to confuse hazardous situations with safe ones (Christos et al., 2015). There is certainly need for more research and field testing to address these concerns, in various weather conditions, and various terrains. More advertisement of the technology as regards how the autonomous vehicles are able to navigate sharp corners effectively, avoid collisions etc should be demonstrated to increase people's confidence. Any possible limitations of the technology should also be made known to end users. For example, if an autonomous vehicle relies on cameras for vision system, and if the vision will be obscured in certain weather conditions, to the extent that people's safety will be at risk, the end users need to know this, to ensure that people can take adequate precautions not to activate full autonomous driving mode when the prevailing environmental condition cannot guaranty safety of people. To begin reaping the benefits of technologies that are designed to eliminate human (driver) errors in a conscientious way, it may be a good idea to ensure that during route planning, and also while en-route, the autonomous vehicle system is able to continuously read information from weather stations, constantly monitor immediate conditions in the driving environment, and alert end users when it will not be safe to have the vehicle in full autonomous mode. Full autonomous vehicles should also be equipped with security alert systems to ensure that rescue operations can be efficiently deployed if the vehicle encounters situation where it will not be safe to operate in full autonomous driving conditions. In the initial stage of implementation of full autonomous systems, it may be a good idea to have signs that can alert human drivers to recognize full autonomous vehicles, to ensure that human drivers can give these vehicles due preference. For example, if a full autonomous vehicle is being used by an aged or a senior citizen that no longer qualify to have a driver's license, or if someone that is physically challenged, such as the blind is using the full autonomous vehicle as a means of transport from one place to the other, such people deserves due respect from human drivers. Hence, having signs that could alert human drivers about the use of full-autonomous vehicles in such situation could be helpful. Prior to the legislation of collision avoidance systems for all vehicles on the road, heavy fines / penalties may be legislated for any driver that does not exercise due care in dealing with full autonomous vehicles on the road. This is aimed at preventing people from intentionally sabotaging technologies that are designed to improve traffic safety for humanity at large.

Ethical judgements the vehicles will be expected to make

All autonomous vehicles should be designed to transport people, goods, and services in a safe way from various origin to destinations. Some of the basic commands for an autonomous vehicle should be, do not hit any object (avoid all collisions). If need be, slow down and come to a complete stop, if there is no way to avoid an object / obstruction. The responsible controller in a vehicle should have the opportunity to be able to select the route, and also override any suggested route by the autonomous vehicle. However, if the autonomous vehicle recognises that there is a hazard, such as a river or an obstacle on the way, the autonomous vehicle should reserve the right to stop (not work), until the identified hazard is removed. Autonomous vehicles should never be used as a means for suicide missions. If testing of an autonomous vehicle indicates that the vehicle is not safe for the public at a certain weather, or environmental condition, such as during heavy snow, heavy rain, or poor visibility conditions; fog, night time, etc, in addition to having capabilities to adequately alert the user at the time of route planning, such vehicles should be made to not even work in a full autonomous mode when the system has sensed hazardous environmental conditions that is beyond the design limits of the vehicle.

Autonomous vehicle technologies have great potentials to help put an end to a considerable amount of avoidable deaths on the roads globally. However, continuous research, and testing under various environmental conditions is recommended to ensure that the world can achieve a state where no one will meet with untimely death on the roads. In the meantime, the design limitations of each brand of autonomous vehicles needs to be clearly stated to ensure that end users are aware of the present limitations of the vehicles. Having standardized vehicle efficiency testing systems, that will be continuously improved upon for all autonomous vehicles under all kinds of environmental conditions, in various municipalities globally will be a good culture. It will also be good to ensure adequate

investigation of any kind of crash involving autonomous vehicles in every community, ensure adequate documentation of lessons learned, and incorporate the findings for continuous improvement of the technology.

It is high time that the world began to take bolder steps in rejecting technologies that are not properly developed to guarantee human safety. Noting that human life is priceless, the safety of humanity at large should not be compromised for money. As regards policy improvement for vehicles on the road, the world needs not wait another year to record numerous road traffic fatalities in various places. This report recommends a swift action on policy improvements for minimum standards for vehicles on the road in all jurisdictions globally. All automobiles on the road should have a non-negotiable minimum standard for collision avoidance systems.

Conclusions and recommendations

Autonomous / highly automated vehicles have been identified as promising technology that has enormous potential of addressing some of the major challenges that face the transportation sector. Giving the fact that human factor accounts for the reason behind majority of traffic crashes, great improvement is envisaged from the use technologies that introduce some autonomous systems to assist humans. Various potential issues that may arise with autonomous vehicle technology has been discussed. The following recommendations are made:

(1) Introduce legislations that mandates all new vehicles to be equipped with collision avoidance technologies.

(2) All autonomous vehicle system should be subjected to rigorous vehicle efficiency field testing under various road conditions (including extremely hazardous road conditions, in various weather conditions) to validate the safety benefits of the vehicles, and any limitations should be clearly communicated to end users.

(3) If the safety benefits are validated, great government support for the autonomous or highly automated vehicles is recommended to ensure that people are able to afford these vehicles.

(4) More research be made on how to update existing vehicles in the traffic stream to having collision avoidance technologies, and reasonable incentives should be given to people to upgrade their vehicles.

(5) Set a timeline in which all vehicles on the road must be equipped with adequate collision prevention technologies.

(6) Great research efforts should be made to ensure that highly automated, and autonomous vehicles are able to adjust operating efficiency to the capabilities that can guaranty safety of the users, at various weather and road conditions, given consideration to limitations of different parts of the vehicles, like friction between the tires and the road surface.

(7) Efforts should be made to implement systems that can automatically capture, and report the vehicle mile travelled by all vehicles, (in all jurisdictions) for periodical billing system in a road usage finance system, to ensure that electric powered autonomous vehicles can pay their share of road maintenance fee.

(8) Smooth idea, and technology transfer in the global community is recommended to ensure that humanity at large around the globe can achieve the safety benefits of collision prevention technologies, and highly automated vehicles.

It is recommended that all vehicles that are allowed on the roads globally should have collision avoidance technologies, to improve traffic safety for all. At the minimum, it will be desirable to see that all vehicles are equipped with autobrake systems both for forward, and backward movements to prevent collisions. With time, other desirable collision avoidance systems may be introduced. Periodic review, and updates to transportation policies is recommended until no life will be lost due to mishap in transportation system. A bi-partisan support of technologies that are aimed at improving transportation safety for humanity at large is recommended.

References

American Association of State Highway and Transportation Officials (2004). *"Optimizing the system. Saving lives, saving time."* AASHTO.

Christos, K., Mohammed, Q., Wen-Hua, C., & Lipika, D., (2015) *"Real -time motion planning methods for autonomous on road driving state of the art and future directions"* Transportation Research Part C 60 (2015) 416-442.

Hani, S. M., (2016). *"Autonomous vehicles and connected vehicle systems: Flow and operation considerations"* Transportation science. Vol. 50 no. 4

Insurance Institute for Highway Safety (IIHS) and Highway Loss Data Institute (HLDI). *"Crash avoidance features by make and model"*. Retrieved from http://www.iihs.org/iihs/ratings/crash-avoidance-features Accessed 6/14/2017

Jane C. S., Donald W. R., Loren S., & Eric A. R., (2001) *"The Role of Driver Distraction in Traffic Crashes"*. University of North Carolina Highway Safety Research Centre Chapel Hill, NC. Retrieved from https://www.forces-nl.org/download/distraction.pdf Accessed 5/5/2017

Matt Brian (2017). *"UK Government finally draws up laws for autonomous cars"*. Retrieved from https://www.engadget.com/2017/02/23/uk-government-vehicle-technology-aviation-bill/ Accessed 02/25/2017

Rory Cellan-Jones, BBC (2017). *"Driverless cars no half way house"*. Retrieved from http://www.bbc.com/news/technology-39050538 Accessed 02/24/2017

SAE International TM (2014). *"Automated Driving. Levels of driving automation are defined in new SAE international standard J3016"*. Retrieved from http://www.sae.org/misc/pdfs/automated_driving.pdf Accessed 3/11/2017

Echterhoff, W. (1977) *"Psychophysical limitations as a cause of accidents"*. The National Academies of Science Engineering and Medicine. https://trid.trb.org/view.aspx?id=1061699 Accessed 2/24/2017

The Queen's Speech (2016). Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/524040/Queen_s_Speech_2016_background_notes_.pdf Accessed 2/24/207

Transport Canada. *"Canadian Motor Vehicle collision statistics 2010".* https://www.tc.gc.ca/media/documents/roadsafety/tp3322-2010eng.pdf Accessed 2/25/2016.

Transportation Research Board (2013). *"Critical issues in transportation 2013"*. Washington DC: Retrieved from http://onlinepubs.trb.org/Onlinepubs/general/criticalissues13.pdf Accessed 01/24/2017

US Department of Transportation (USDOT) & National Highway Traffic Safety Administration (NHTSA) (2015). *"A brief Statistical Summary. Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey"*. Retrieved from https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812115 Accessed 02/24/2017.

US Department of Transportation (USDOT) &, Federal Highway Administration (FHWA) Research and Technology (2003). *"Driver error report".* https://www.fhwa.dot.gov/publications/research/safety/humanfac/02003execsum.cfm Accessed 06/14/2017

US Department of Transportation (USDOT) & National Highway Traffic Safety Administration (NHTSA) (2016). *"Federal Automated Vehicles Policy. Accelerating the Next Revolution in Roadway Safety"*. Retrieved from https://www.transportation.gov/sites/dot.gov/files/docs/AV%20policy%20guidance%20PDF.pdf Accessed 02/25/2017.

World Health Organization (2015). *"Global status report on road safety 2015".* Retrieved from http://www.who.int/violence_injury_prevention/road_safety_status/2015/en/ Accessed 2/24/2017.