Towards Autonomous Vehicle Implementation: Issues and Opportunities

H. H. Hashim[*1] and M. Z. Omar[2]

[1]Malaysian Institute of Road Safety Research (MIROS), 43000 Kajang, Selangor, Malaysia
[2]Department of Information System, Faculty of Computer Science and Information Technology, Universiti Malaya, 50603 Kuala Lumpur, Malaysia

[*]*Corresponding author: hizalhanis@miros.gov.my*

Abstract – *This paper highlights the factors that should be addressed by any countries when considering Autonomous Vehicle (AV) implementation, along with issues and opportunities that may arise. AV is an emerging technology that has far-reaching applications and implications beyond all current expectations. This paper provides a comprehensive review of the relevant literatures and explores a broad spectrum of readiness factors, issues and opportunities in the aspects of legislations, litigation, liability, road and surrounding infrastructures, map availability, public acceptance, privacy and public perceptions. While the intention of AV implementation may be driven to address several road safety and road efficiency issues, the traffic mix between AV and non-AV at its initial stage of implementation may introduce a negative impact towards the overall road safety and traffic operations. A systematic framework in adopting and implementing the technology should therefore be established to ensure its objectives are met. This paper contributes to the literature on the fronts that it attempts to shed light on future opportunities as well as possible issues associated with AV implementation; and provide an overall guidance on fundamental factors to be considered before implementing AV.*

Keywords: Autonomous vehicle, connected vehicle, intelligent transportation system

1.0 INTRODUCTION

Autonomous Vehicle (AV), or simply known as self-driving vehicle, is a technology that intends to partly or fully replace the driving task that was previously conducted by a human driver. This 'disruptive' technology works by combining the navigational systems, associate pattern recognition with control intelligence, utilise sensing technologies and consume roadside Intelligent Transport System (ITS) and traffic monitoring data to operate the vehicle automatically and efficiently (Figure 1). Due to its potential benefits on traffic safety, driver productivity, road capacity, travel speed, energy consumption, and vehicular emission

(Shladover et al., 2012; Greenblatt & Saxena, 2015; Levin & Boyles, 2016; Mersky & Samaras, 2016), AV has attracted tremendous attention globally.

The AV concept started as far back as in the early 1920s (Weber, 2014) and gained much more momentum in 1980s when automated highway systems was conceptualized and established (Fenton & Mayhan, 1991; Ioannou, 2013). Through the use of ITS build along the automated highways, vehicles can now get connected and communicate with the highway infrastructures. Pioneer pilots of AVs mainly came from the U.S. and Germany during 1980 to 2000 (Anderson et al., 2014; Lantos, 2010). In addition, extensive research on unmanned equipment made by the U.S. Defence Advanced Research Projects Agency, known as DARPA, has accelerated the advancements in AV technology (Blasch et al., 2006).
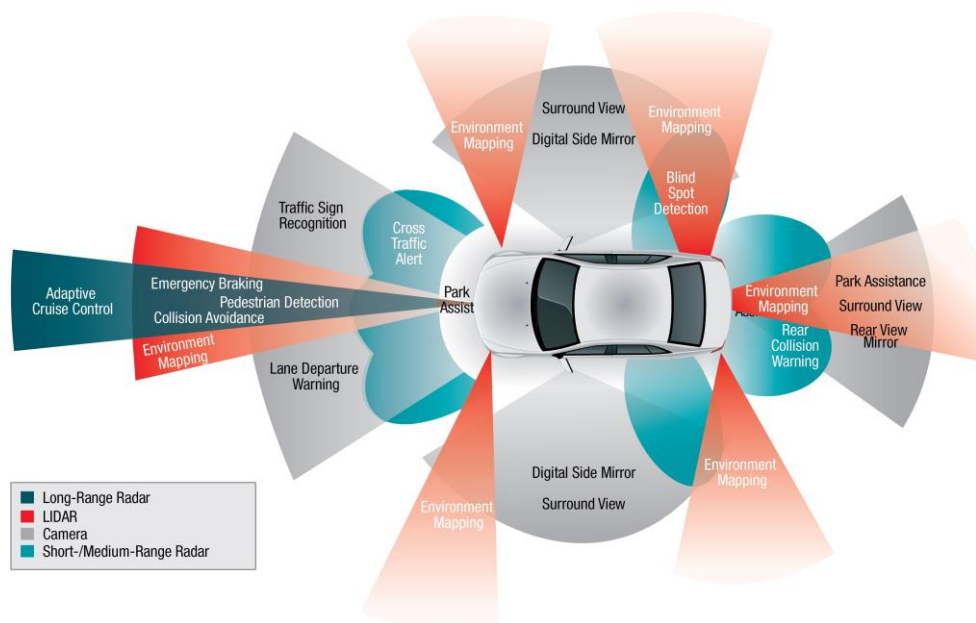

Figure 1: Driving Automation with Sensing Technologies and Control Intelligence (Insights, 2016)

Software and technology companies such as Google, Apple and Intel were among the first to establish their AV programmes, in which it provides huge publicities and attracted talents from various disciplines to work on AV. Google AV (now the division has officially become an independent company known as Waymo) started testing its self-driving technology in California since 2009 and have already achieved a total mileage of over 1.5 million miles (Google, 2016). During the testing, 14 minor crashes were recorded on public roads. However, in all of these cases the AV was not at fault and it was either being manually driven or it was the fault of the other drivers (Google, 2015). Nevertheless, the first crash that Google AV car was found at fault occurred in 2016 during a Valentine's Day, when the car struck the side of a public bus in Mountain View (Muir, 2016).

With the advancements in computational architectures, sensing technology along with significant cost reductions, AV progress has accelerated tremendously. Strong competition among technology companies and conventional car manufacturers has seen various introduction and target date implementation (Table 1). GM, Ford and Renault-Nissan Alliance are among the forerunners in automated driving (Navigant Research, 2017) (Figure 2). Singapore has started their first driverless taxi since August 2016 in a limited public trial on

the streets of Singapore and full services are expected to be ready in 2018 (Reuters, 2016). In addition, Japan has also announced that AVs could be used to ferry people around Tokyo during the 2020 Olympics and Paralympics (2025AD, 2016).

Table 1: Manufacturer plan for AV and target date

| Manufacturer	Plan on AV	Target Date
Waymo (Google)	Testing autonomous driving	By 2018
Tesla	Rolling out software updates for AV	By 2018
Toyota Honda	Fully autonomous highway driving	By 2020
Volvo Nissan	IntelliSafe Autopilot Drive in urban traffic	By 2020
Mercedes-Benz	E-Class and Drive Pilot	Early 2020s
Ford	Ride-hailing and ride-sharing services in a geo-fenced area	2021
BMW	Self-driving electric vehicle	2021
Jaguar Land-Rover	Building fully autonomous car	By 2024
Hyundai Kia	In talk with Google	By 2030
Mazda Mitsubishi	Doing advanced safety systems	No set date
Subaru	Adding partial systems	No set date
Volkswagen	I.D. concept for self-driving mode	No set date
Porsche Ferrari	Refuse AV	None
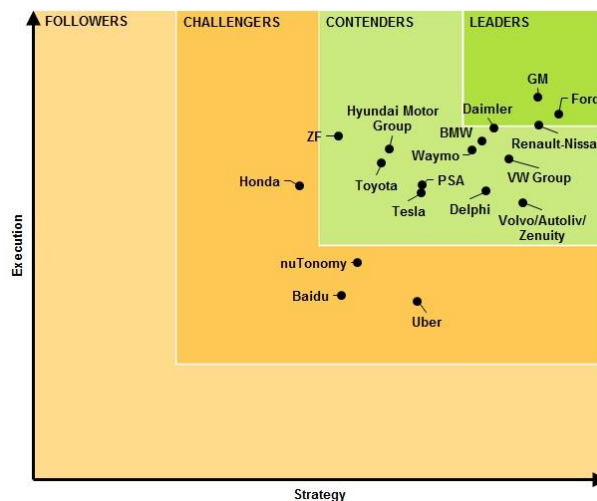
Figure 2: Manufacturers Leaderboard for Automated Driving (Navigant, 2017)

As AV is gaining popularity and seen as the much needed solution to solve various transportation issues, the technology is deemed to enter various markets in multiple countries around the world soon. The aim of this paper is to highlight issues and opportunities upon

introduction and implementation of AV. The paper will illustrate the typical requirements for a country to implement AV within the context of existing transportation systems and society at large. Additionally, issues and opportunities relating to the preparation of AV implementation will also be discussed.

2.0 PREPARING FOR AV

Judging from the period of deployment and adoption for previous vehicle technologies such as automatic transmissions and hybrid powered vehicle, by 2040, AVs are forecasted to constitute half of vehicle sales, 30% of the vehicles population and 40% of all vehicle travels (Litman, 2015). With rapid progress as shown by technological companies and vehicle manufacturers, AV is getting closer to maturity with commercialization and adaptation are next in line. Hence, it is extremely important to understand the potential issues and challenges to facilitate preparation for the upcoming AV applications.

2.1 Legislation

In the context of legislation, most countries are subjected to the 1968 Vienna Convention on Road Traffic (Table 2). This is an agreement between countries for the purpose of facilitating the international road traffic by adopting a uniform road traffic rules and documentations. Currently, a total of 80 parties signed to this convention (UNECE, 2007). One of the fundamental principles in this convention is the concept that a driver is always fully in control and responsible for the behaviour of a vehicle in traffic (UNECE, 2016). AV implementation would not satisfy this condition. AV is controlled and driven by a computer system in which its occupants take no control on how the vehicle is driven. Additionally, with AV, there is no longer a need for a driver and none of the passengers would be required to have a driving license.

Table 2: List of contracting parties to the Vienna Convention on Road Traffic 1968

Region	Countries
Asia (12)	Indonesia, Kazakhstan, Kyrgyzstan, Mongolia, Pakistan, Philippines, Republic of Korea, Tajikistan, Thailand, Turkmenistan, United Arab Emirates, Uzbekistan
Europe (39)	Albania, Armenia, Austria, Belarus, Belgium, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Georgia, Greece, Hungary, Italy, Latvia, Lithuania, Luxemburg, Moldova, Monaco, Montenegro, Norway, Poland, Portugal, Romania, Russian Federation, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom, Holy See (Vatican City)
Americas (9)	Bahamas, Brazil, Costa Rica, Cuba, Ecuador, Guyana, Mexico, Peru, Venezuela (Bolivarian Republic of)
Middle East & Africa (19)	Azerbaijan, Bahrain, Central African Republic, Chile, Cote d'Ivoire, Democratic Republic of the Congo, Ghana, Iran (Islamic Republic of), Israel, Kuwait, Liberia, Morocco, Niger, South Africa, Senegal, Seychelles, Tunisia, Uruguay, Zimbabwe

In order to accommodate for autonomous driving, amendment to the convention was carried out on 23rd March 2016 (UNECE, 2016). With this amendment, automated driving technologies that enables driving task to be transferred to the vehicle will be explicitly allowed in traffic. This comes with the conditions that these technologies conforms to the United Nations vehicle regulations or the driver have the ability to override or switched it off. In

addition, the introduction of technical provisions for self-steering systems is currently under consideration. It will include systems that under specific driving circumstances and able to take control of the vehicle from the driver supervision, such as Lane Keeping Assist Systems (e.g. when the car will take corrective measures if it detects that it is about to cross a lane accidentally), self-parking functions and highway autopilots (e.g. when the vehicle would be self-driving at high speeds on highways).

At national level, many countries has started to amend their laws and traffic regulations to allow AV operations. For example, in the United States, the National Highway Traffic Safety Administration (NHTSA) has agreed to consider the Google self-driving computer system as the "driver" of the vehicle (CNET, 2016). Nevada was the first state to authorize the operation of autonomous vehicles in 2011. Since then, ten other states – Alabama, California, Florida, Louisiana, Michigan, North Dakota, Pennsylvania, Tennessee, Utah and Virginia – and Washington, D.C. have passed legislation related to autonomous vehicles. Governors in Arizona and Massachusetts issued executive orders related to autonomous vehicles.

In Malaysia, currently there are no specific laws and regulations related to AV technologies. None of these technologies are required in any type of vehicle in the country, and there are no mandatory standards related to their specific design or performance. The Ministry of Transport is anticipating on this issue and necessary preparation is underway. Although Malaysia is not one of the signatory parties to the Vienna Convention 1968, current laws still prohibit AV from being operational on the public roads. The main reference in the country for transportation operations, the Road Transport Act 1987, specifies that every motor vehicles can only be operated by a licensed driver (Laws of Malaysia, 2013). The act, however, defined a driver as a person who drives the motor vehicle. In order to allow AV to be operational in Malaysia, amendments should be made to allow the driving task to be transferred to automated driving technologies, similar to the amendments made to the Vienna Convention. Additionally, in bringing AV into the country, the Road Transport Department would need to review their current Vehicle Type Approval criteria and allow for AV to be considered.

2.2 Litigation and Liability

As the driving task is now transferred to automated driving technologies, the driven vehicle on the public roads would open the possibility of many insurance and liability issues (ETSC, 2016). Presently, the driver is expected to remain in control of the vehicle at all times and it is clear that the driver is liable should a crash occur (Duffy & Hopkins, 2013). As long as the driver has the opportunity to take control over a partially automated car and avoid the crash, the liability will remain with the driver (ETSC, 2016). Unlike a computer system, human drivers does not always have all the details prior to a crash and is limited in response time. On the other hand, AV are equipped with image processing, sensors, and algorithms that can enable them to make better and informed decisions (Fagnant & Kockelman, 2013). Decisions made by AV may be challenged in a court of law, as evidence leading to the decision can be easily obtained from the system.

Even with automated driving, there may be instances where road crashes are unavoidable (Fagnant & Kockelman, 2013). Assigning liability would varies by the levels of automation. For example, an AV may become malfunction during its operation on the road and lead to a crash. It will be important to know who would be liable; either the manufacturer or the driver. Investigators would be much interested to know who was in control of the vehicle during the crash and assign the liability accordingly. However, at the highest levels of automation, the

driver is restricted from overriding the system and therefore they will totally rely on the automated driving systems. In this case, the vehicle manufacturer may likely become the party liable (Thomas, 2014).

In forming amendments for rules and regulations for AV to operate, the process may take longer time than expected due to several reasons. First, the process is fundamentally an iteratively and slow, given the cycles of proposals, requests for comments and reviews. Identification and buying in process from the related stakeholders may also goes back and forth for multiple times before reaching consensus. Secondly, AV is an evolving and rapidly changing technologies, making it difficult to anticipate and predict what the final version could be. This would create an uncertainty in the rulemaking process and poses a challenge to prescribe rules that will remain relevant as the technologies reach its maturity level. Therefore, the rules should be adaptive, in which it would accommodate and provide space for the technology to evolve.

Engagement with vehicle manufacturers, AV system providers and insurers can help to establish a comprehensive model in managing liability. Fear of liability transfer, from driver to manufacturer/system owner may hinder the progress of AV (Marchant & Lindor 2012). Provided that the cost for crashes remain relatively the same, a different form of insurance can be established to tackle the issue of liability shift. In contrary with the current practice where drivers are required to purchase insurance, AV manufacturers could possibly subscribe to insurance policy for every AV unit they sold. This is be similar to public transport concept, where liabilities lies with the operators and paid by the passengers in the form of ticket sales. Evidently, during the testing phase, Google and Volvo AVs are insured by their own insurance companies (Pilli-Sihvola et al., 2015). In addition, as AV can help to reduce the risk road crashes, it is expected that the insurance premium would be lower.

2.3 Roads and Surrounding Infrastructures

Another important aspect in preparation for AV is the evaluation of existing roads and its surrounding infrastructures. Essentially, there are two school of thoughts with regards to the extent of how an AV will rely on data input and external information systems to navigate the roads. The first believed that AV should be able to rely on its own sensors and equipped with the capabilities of perception (Pilli-Sihvola et al., 2015). The other visualized that AV may rely on improved digital infrastructure to enable Co-operative ITS technology (ITF, 2015). In any case, at the very least AV should be able to read the road ahead by understanding its lane markings and road signs. Just like drivers, AVs would not be able to function well if the basic lane markings and road signs are non-existent, non-compliant, worn out, obscured, inconsistent or confusing.

Lane markings on the roads can also be regarded as the rails for AV (iRAP, 2013). Various technologies used in partial automation and full AV such as Lane Keeping Assistance (LKA) and Lane Departure Warning (LDW) would read the road markings, provide warnings and gives the driver some steering support. Traffic Sign Recognition (TSR), on the other hand, can read and interpret a range of traffic signs, including speed limits and this will be used to guide the AV. Road authorities should ensure that the basic conditions of roads are satisfying before AV can be allowed to operate.

Connected Infrastructures (CI) would also play a major role in AV implementation. The technologies or systems are installed in either the vehicle or road infrastructure to enable

information collection, processing and exchange between road infrastructures and vehicles. Aside from assisting AV in knowing what lies ahead, CI will allow for AV to exchange information about their positions, speeds and planned routes with other AV. Together, as a cooperative driving approach, each vehicle can let other vehicles to know about their intents and they can agree on common driving strategies that will resulted in optimised driving plan and improved safety.

2.4 Road Mapping

AV would rely on high-definition digital map to navigate the roads. Initially, AV were presumed to be able to position themselves by just using the low-definition maps that are often found in the common turn-by-turn navigation devices and apps (The Economist, 2016). Supported by its sensors, AV would be able to precisely position itself on the road. Provided that road markings can be clearly seen, it is sufficient for visual sensors to keep the vehicles safely within their lanes, and even detect solid or dotted lines that indicate stop signs and exits. However, the trouble comes when road markings are difficult to spot under certain conditions, such as when it is covered by snow, sands or in heavy rains (Fortune, 2016; The Economist, 2016).

In addition, even with the most advanced sensors, like radars and cameras, they are not enough to enable a car to navigate a chaotic and changing world safely enough (The Economist, 2016). Digital maps ease the burden by giving foresight to the vehicle's computers, and adding redundancy to the vehicle's understanding of the situation it faces. It will also help the vehicle to locate itself precisely, in which an error of even a couple of metres could place the vehicle on the wrong side of the road. Commercial GPS systems are accurate only to around 5 metres, but can be wrong by 50 metres in urban environments and fail completely when in tunnels (The Economist, 2016). The high definition digital maps can work with a variety of sensors within the AV to position the vehicle within centimetres' accuracy. Therefore, availability of a comprehensive and high-definition digital map is eminent towards the operational of AV.

2.5 Public Acceptance

Public acceptance on AV is crucial to ensure early and fast adoption. The use of theoretical model such as Technology Acceptance Model (TAM) is proven to be useful in explaining and predicting technology usage behaviour towards driver assistance system (Md Isa et al., 2015). In general, experts and the public are often positive about automated driving, but also exhibit essential concerns. At the early stage of introduction, it is expected that some members of the public might be sceptical about the safety aspect of AV, given the fact that there is no human driver (Schoettle & Sivak, 2014). Applying Water in the Tub view point (Meadows, 2011), progress of changing the number of existing vehicles from non-AV to AV may be slow even when high volume of AVs are introduced into the ecosystem. This is due to the existing vehicles in the ecosystem that will act as shock absorbers or buffers.

In a detailed analysis by Sivak and Schoettle (2015a), it was concluded that AV may be no safer than an average driver and may increase total crashes when AV and human-driven vehicles mix in the traffic. Therefore, to increase AV adoptions, it is important for the public to be well-informed and understood the benefits AV may bring. AV penetration should be targeted to be as high as possible to avoid the opposite safety effect when AV and non-AV mixed in traffic. However, the presumptions that can be used is that safer vehicles introduced

into the ecosystem will gradually replace the existing ones, thus creating an overall safer ecosystem in the meantime (Abu Kassim et al., 2017).

2.6 Privacy

Privacy concerns will likely grow with the use of AV (Glancy, 2012). By not setting a new set of privacy standards, lack of privacy especially for personal travel may become the norm (Fagnant & Kockelman, 2015). AV relies heavily on data to work effectively thus it will constantly capture data from its surrounding areas. In a survey conducted by Kyriakidis et al. (2015), it was found that respondents from countries that has lower crash rates, higher education and higher income were less comfortable for their vehicle to transmit data. With the vast amount of data captured by AV, questions pertaining to the types of data that will be shared, with whom the data will be shared, the mechanism of how the data will be shared and what will the shared party do with the data shared will need to be answered and made clear to the end user.

Protecting privacy would require a combination of both legal and technical security measures (Elmaghraby & Losavio, 2014). For example, in the event of AV crash, crash data will likely be made available to the AV manufacturers and technology suppliers since they are likely to be liable (Fagnant & Kockelman, 2015). However, if a human is manually driving an AV when the crash occurred, then the privacy concerns will arise as the AV may have captured and stored the driving data. Almost no one would want their own vehicle's data recorder being used against them in court. Until this issue is solved, privacy concerns will likely to stay and hinder the adoption of AV.

3.0 DISCUSSION

Autonomous vehicles come with promising impacts in our life. As discussed in the previous sections, the technology is expected to improve the quality of life, comfort and safety. This section will discuss the impact of AV. Presently, the ultimate benefits of AV are unknown. Nevertheless, this paper highlights the benefits based on previous studies in attempting to estimate the brief impacts in the aspect of safety, security and privacy, traffic operation, and cost of technology.

It is worth to note that National Highway Traffic Safety Administration (NHTSA, 2012) recorded over 90% of main factors on road traffic crashes in United States are because of human error and 40% of fatal crashes are because of driving under influence, distraction and/or fatigue. Similar findings can be observed based on Malaysian road safety data where driver faults is one of the main factor for road crashes (RMP, 2015). On public safety point of view, autonomous vehicles have positive inclination in eliminating enormous routine mistakes made by human drivers (Anderson et al., 2014); directly has significant potential in reducing road traffic crashes. In line with the empirical view, Authors, (Fagnant & Kockelman, 2013) agreed that AV will reduce crashes by 90%.

On the other hand, it is observed the implementation and dependency on AV will introduce additional risks including system failures, and other cyber terrorism associated risks which can put human life in danger (Bilger, 2013). The possible security vulnerabilities in AV communication include impersonate, session hijacking, identity revealing, location tracking, repudiation, eavesdropping, and Denial of Service (Schaub et al., 2009; Haus et al., 2016). In

this respect, authentication and privacy issues as fundamental security features must be addressed to mitigate the security risks. Additionally, with the implementation of AV, the potential of unauthorized and malicious interference with in-vehicle computer systems is inevitable. A range of criminal provisions were articulated at the state level that cover the unauthorized and malicious interference with in-vehicle computer systems and suggested that cybercrime investigation and forensic might overarching difficulties (Brady et al., 2016).

Privacy is defined as an individual's right "to control, edit, manage, and delete information about them[selves] and decide when, how, and to what extent information is communicated to others" (Westin, 1968). Recorded and stored data regarding personal travel information to centralized authority is likely controversial. The potential misuse of travel information is enormous and the risk is very high, it is therefore explicitly critical to have a robust safeguard mechanism to this data.

Sivak & Schoettle (2015b) in their study found that the demand for private transportation may increase by up to 11%. However, previous investigations and studies have also shown that AVs could potentially reduce traffic congestion by analytically optimizing the information sent through its communication channel. Study conducted by (Kesting et al., 2008) have discovered that even with partly automated driving, travel times were already significantly reduced for much lower penetration rates. Additionally, empirical evidence suggested that advanced ITS could nearly eliminate intersection delay while reducing fuel consumption with estimation of 95% or more AV-market penetration may be required (Dresner & Stone, 2008). Study on AV acceptance for level 2 and 3 (Blanco et. al, 2015) suggested that there is a high level of trust in automation.

On top of all these impacts, the major barrier of large-scale AV implementation is the cost of the technology. Apart of the new additional sensors are needed, advanced ITS must be in place, upgrade of communication technologies are required, not to mention the cost to manufacture the vehicles itself. It is suggested that with 10% AV market penetration level were assumed to add up to $10,000 to the purchase price of a new vehicle (Ray, 2011). Unfortunately, a case study based on ASEAN NCAP results shows that the fitment of Active Safety Technologies (AST) in passenger's vehicles in the region are still not at the satisfactory level though great improvement can be seen over the years (Md Isa et al., 2015).

The commercialization of AV may just within five-year reach. Nonetheless, the related research gaps are massive. It is therefore useful to identify and address the critical gaps in current investigation to better prepare for the AV's implantation. Policy maker should pay close attention on how AV will affect transportation and land use patterns and strongly support research work on AV.

4.0 CONCLUSION

AV represents a potentially disruptive and beneficial change to the way that we travel. The idea of a driverless vehicles that at first may seem like a distant possibility, but now it is fast approaching. Evidently, some of the automation features are already offered on current vehicle models. The initial costs for owning AV will likely be unaffordable to the general household income group, but as with any new technology introduction, the cost will further reduce as the technology grew and adopted by many more users.

In preparing for AV implementation and operations, countries should look into the legal framework, and their readiness in terms of roads and infrastructures. These are among the pre-requisites to ensure AV can be successfully implemented. Public acceptance would help to move the technology for faster adoption. Caution should be made into the effect of mixing between AV and non-AV as many potential benefits would require most if not all vehicles on a road to operate autonomously.

Over the past century, our way of travel has shaped infrastructure and ideals, landscape and lifestyle, ethics and enterprise. With the introduction of AV, what we do with our vehicles would be exponentially different. Changes can be expected in travel demand, safety, vehicle ownership, how we commute, land use, insurance and job creations. With the advent of AV in various countries around the world, it is important for countries especially the policy makers and road authorities to understand the issues and opportunities that lies with AV implementation.

REFERENCES

2015AD (2016). *Japan's Olympic dream: Driverless cars on the road for 2020*. Retrieved from https://www.2025ad.com/in-the-news/blog/japan-driverless-cars-in-2020/

Abu Kassim, K.A., Mohd Jawi, Z., & Md Isa, M.H. (2017). ASEAN NCAP's contribution to Malaysia's automotive ecosystem. *Journal of the Society of Automotive Engineers Malaysia*, *1*(1), 20-32.

Anderson, J.M., Nidhi, K., Stanley, K.D., Sorensen, P., Samaras, C., & Oluwatola, O.A. (2014). Autonomous vehicle technology: A guide for policymakers. California, US: Rand Corporation.

Bilger, B. (2013). *Auto correct: Has the self-driving car at last arrived*. Retrieved from www.newyorker.com/reporting/2013/11/25/131125fa_fact_bilger

Blanco, M., Atwood, J., Vasquez, H.M., Trimble, T.E., Fitchett, V.L., Radlbeck, J., & Morgan, J.F. (2015). Human factors evaluation of level 2 and level 3 automated driving concepts (Report No. DOT HS 812 182). Washington, DC: National Highway Traffic Safety Administration.

Blasch, E.P., Lakhotia, A., & Seetharaman, G. (2006). Unmanned vehicles come of age: The DARPA grand challenge. *Computer*, *39*, 26-29.

Brady, M., Tranter, K., & Rakotonirainy, A. (2016). 79 The criminal law and unauthorised and malicious interference with automated and connected cars. *Injury Prevention 2016*, *22*(A30).

CNET (2016). *Feds declare that Google's self-driving car is its own driver*. Retrieved from https://www.cnet.com/roadshow/news/feds-declare-that-googles-self-driving-car-is-its-own-driver/

Dresner, K., & Stone, P. (2008). A multiagent approach to autonomous intersection management. *Journal of Artificial Intelligence Research*, *31*(1), 591-656.

Duffy, S., & Hopkins, J. P. (2013). Sit, stay, drive: The future of autonomous car liability. *16 SMU Science & Technology Law Review 101*. Available at SSRN: https://ssrn.com/abstract=2379697

Elmaghraby, A.S., & Losavio, M.M. (2014). Cyber security challenges in Smart Cities: Safety, security and privacy. *Journal of Advanced Research*, *5*(4), 491-497.

ETSC (2016). *Prioritising the safety potential of automated driving in Europe*. Retrieved from http://etsc.eu/wp-content/uploads/2016_automated_driving_briefing_final.pdf

Fagnant, D.J., & Kockelman, K. (2015). Preparing a nation for autonomous vehicles: Opportunities, barriers and policy recommendations. *Transportation Research Part A: Policy & Practice*, *77*, 167-181.

Fenton, R.E., & Mayhan, R.J. (1991). Automated highway studies at the Ohio State University - An overview. *IEEE Transactions on Vehicular Technology*, *40*, 100-113.

Fortune (2016). *Self-driving cars hit a roadblock in the snow*. Retrieved from http://fortune.com/2016/02/10/self-driving-cars-snow/

Glancy, D.J. (2012). Privacy in autonomous vehicles. *Santa Clara Law Review*, *52*(4), 1171-1239.

GlobalAutoRegs (2017). *United Nations Agreement | 1968 Vienna Convention on Road Traffic*. Retrieved from https://globalautoregs.com/rules/157

Google (2015). *Google self-driving car project*. Retrieved from http://static.googleusercontent.com/media/www.google.com/en//selfdrivingcar/files/reports/report-0615.pdf

Google (2016). *Google self-driving car project monthly report – June 2016*. Retrieved from https://static.googleusercontent.com/media/www.google.com/lt//selfdrivingcar/files/reports/report-0616.pdf

Greenblatt, J.B., & Saxena, S. (2015). Autonomous taxis could greatly reduce greenhouse-gas emissions of US light-duty vehicles. *National Climate Change*, *5*, 860-863.

Haus, M., Waqas, M., Ding, A.Y., Li, Y., Tarkoma, & S. Ott, J. (2016). Security and privacy in Device-to-Device (D2D) communication: A review. *IEEE Communications Surveys & Tutorials*, *PP*(99), 1-27.

Insights (2016). *Insights into issues: Autonomous vehicle technology*. Retrieved from http://www.insightsonindia.com/2016/11/30/insights-issues-autonomous-vehicle-technology/

Ioannou, P. (2013). *Automated highway systems*. Berlin: Springer Science & Business Media.

iRAP (2013). *Lane markings 'rails' for self-steering vehicles*. Retrieved from http://www.irap.net/en/irap-news/441-lane-markings-rails-for-self-steering-vehicles

ITF (2015). *Automated and autonomous driving: Regulation under uncertainty*. Paris: International Transport Forum.

Kesting, A., Treiber, M., Schönhof, M., & Helbing, D. (2008). Adaptive cruise control design for active congestion avoidance. *Transportation Research Part C: Emerging Technologies*, *16*(6), 668-683.

Kyriakidis, M., Happee, R., & de Winter, J.C.F. (2015). Public opinion on automated driving: Results of an international questionnaire among 5000 respondents. *Transportation Research Part F: Traffic Psychology & Behaviour*, *32*, 127-140.

Lantos, B. (2010). *Nonlinear control of vehicles and robots*. Berlin: Springer Science & Business Media.

Laws of Malaysia (2013). *Road Transport Act 1987 (Revised 2012) [Act 333]*. Kuala Lumpur: International Law Book Services.

Levin, M.W., & Boyles, S.D. (2016). A cell transmission model for dynamic lane reversal with autonomous vehicles. *Transportation Research Part C*, *68*, 126-143.

Litman, T. (2015). *Autonomous vehicle implementation predictions*. British Columbia: Victoria Transport Policy Institute.

Marchant, G.E., & Lindor, R.A. (2012). The coming collision between autonomous vehicles and the liability system. *Santa Clara Law Review*, *52*(4), 1321-1340.

Md Isa, M.H., Abu Kassim, K.A., Mohd Jawi, Z., & Md Deros, B. (2015). Promotion of active safety technologies in automobile safety ratings. *Proceedings of the Conference of ASEAN Road Safety*, 138-144.

Md Isa, M.H., Md Deros, B., & Abu Kassim, K.A. (2015). A review of empirical studies on user acceptance of driver assistance system. *Global Journal of Business & Social Science Review*, 4(1), 182-189.

Meadows, D.H. (2011). *Thinking in systems: a primer*. White River Junction, VT: Chelsea Green Publishing.

Mersky, A.C., & Samaras, C. (2016). Fuel economy testing of autonomous vehicles. *Transportation Research Part C*, *65*, 31-48.

Muir, H. (2016). *Google self-driving car caught on video colliding with bus*. Retrieved from https://www.theguardian.com/technology/2016/mar/09/google-self-driving-car-crash-video-accident-bus

Navigant Research (2017). *Navigant Research leaderboard report: Automated driving*. Retrieved from https://www.navigantresearch.com/research/navigant-research-leaderboard-report-automated-driving#

NHTSA (2012). *Fatal Analysis Reporting System*. Washington, DC: National Highway Traffic Safety Administration.

RMP (2015). Road accident statistics report. Kuala Lumpur: Royal Malaysia Police Traffic Branch.

Pilli-Sihvola, E., Miettinen, K., Toivonen, K., Sarlin, L., Kiiski, K., Kulmala, R. et al. (2015). Robots on land, in water and in the air. Finland: Ministry of Transport and Communications.

Ray, L. (2011). Notice of funding availability for the Department of Transportation's 22 National Infrastructure Investments under the Full-Year Continuing Appropriations. *Federal Register*, *76*(156), 50289-50312.

Reuters (2016). *First driverless taxi hits the streets of Singapore*. Retrieved from http://www.reuters.com/article/us-autos-selfdriving-singapore-idUSKCN1100ZG

Schaub, F., Ma, Z., & Kargl, F. (2009). *Privacy requirements in vehicular communication systems*. Paper presented at IEEE International Conference on Privacy, Security, Risk, and Trust (PASSAT 2009), Symposium on Secure Computing, Vancouver, BC, Canada.

Schoettle, B., & Sivak, M. (2014). A survey of public opinion about autonomous and self-driving vehicles in the U.S, the U.K., and Australia (UMTRI-2014-21). Michigan, US: University of Michigan Transport Research Institute.

Shladover, S., Su, D., & Lu, X. Y. (2012). Impacts of cooperative adaptive cruise control on freeway traffic flow. *Transportation Research Record: Journal of the Transportation Research Board*, *2324*, 63-70.

Sivak, M., & Schoettle, B. (2015a). Road safety with self-driving vehicles: General limitations and road sharing with conventional vehicles, sustainable worldwide transportation program (UMTRI-2015-2). Michigan, US: University of Michigan Transport Research Institute.

Sivak, M., & Schoettle, B. (2015b). Influence of current nondrivers on the amount of travel and trip patterns with self-driving vehicles (UMTRI-2015-39). Michigan, US: University of Michigan Transport Research Institute.

The Economist (2016). *The autonomous car's reality check*. Retrieved on from http://www.economist.com/news/science-and-technology/21696925-building-highly-detailed-maps-robotic-vehicles-autonomous-cars-reality

Thomas, P. (2014). Driverless Vehicles: From Technology to Policy (PACTS Conference Report 2014). UK: Thatcham Research.

UNECE (2007). List of contracting parties to the Convention on Road Traffic Vienna, 8 November 1968. (67 Contracting Parties at the date of 1 February 2007). Retrieved from http://www.unece.org/fileadmin/DAM/trans/conventn/CP_Vienna_convention.pdf

UNECE (2016). *UNECE paves the way for automated driving by updating UN international convention*. Retrieved on from http://www.unece.org/info/media/presscurrent-press-h/transport/2016/unece-paves-the-way-for-automated-driving-by-updating-un-international-convention/doc.html

Weber, M. (2014). *Where to? A history of autonomous vehicles*. Retrieved from http://www.computerhistory.org/atchm/where-to-ahistory-of-autonomous-vehicles

Westin, A.F. (1968). *Privacy and freedom*. Washington Lee Law Review 166, 25(1).