Driverless Cars in a Smart City – 2021 and Beyond

Gaurav Yadav

Abstract : Intelligent Transportation Systems (ITS) is an expanding and diverse subject, with some of its constituent parts overlapping or converging.V2X Communication can not only reduce accident rates but can also alter the definition of urban mobility. Autonomous Vehicles (AVs) in future have the ability to create innovative and sustainable cities and business processes. The report investigates how the driverless car has to make a transition, co-existing with human drivers. It further discusses how driverless car would be the catalyst to accelerate Cognitive IoT not just in automobile but in industries all around it. The report also compares the experiments related to autonomous vehicles conducted all around the world with special emphasis on USA and compares it with current practices in Sweden. The report finally discusses about legislation challenges about driverless cars and the expected changes in future planning/infrastructure.

Keywords - Affective Computing,Deep Learning,Driverless Cars, IoT- Internet of Things, ITS,Smart City,V2X

Nomenclature- AV - autonomous vehicle, V2V - vehicle to vehicle communication, V2I - vehicle to infrastructure communication

1. Introduction

According to UN projections world population in 2030 is set to surpass 8.5 Billion. Half of the world's population will be shifted to cities. This rapid urbanisation coupled with budgetary deficits; ageing infrastructure, resource scarcity, integration of labour forces due to globalization, climate change issues due to rising emission of CO_2 levels, require technological solutions to make cities more smart, sustainable, interactive, resilient and responsive. Intelligent Transportation Systems seem to be the need of the hour. ITS, in conjunction with autonomous vehicles, aims to not only modify the landscape of city infrastructure but also appears determined to bring about changes in businesses, human mobility and policy making.[1]

Autonomous Vehicles (AVs) are not merely a fictional idea any more. These driverless cars which will not only communicate among themselves but will also be able to communicate with human drivers and smart city infrastructure ushering us into a new era of urban mobility.

These AVs will set out to challenge our assumptions about driving being a human only domain. AVs with the help of AI and cognitive IoT (Internet of Things) will be able to communicate with traffic lights, parking spots, manufacturer service dealers and other cars on the road which will re-imagine our transportation options in the future.Autonomous vehicles are one of the possible solutions to our most common cause of traffic accidents: drivers' error due to lack of attention. According to several different studies, such as the one by L. C. Davis in 2004 , driverless cars will substantially decrease traffic accidents and traffic jams even if there is just a few of them driving among regular cars.[2]

Our main purpose of report is to critically analyse the ITS current and future applications which have the most potential for safety towards smart city. We will look at the ongoing/current/future trials and results on driverless Cars. Additionally we will look at the new transport policy and legislation that will be prepared/changed due to the introduction of Driverless Cars in real traffic in a country. Finally we will look at practices internationally and Sweden.

2. Smart City – The Journey

"*A Smart City places people at the center of development, incorporates Information and Communication Technologies into urban management, and uses these elements as tools to stimulate the design of an effective government that includes collaborative planning and citizen participation. By promoting integrated and sustainable development, Smart Cities become more innovative, competitive, attractive, and resilient, thus improving lives.*"[3]

- *Gaurav Yadav is currently pursuing Master's Degree Program in Intelligent Transportation System in Linköping University, Sweden, Ph- +46700319761. E-mail: gauya219@student.liu.se*

In the last two decades, the concept of "smart city" has become more and more popular in scientific literature and international policies. To understand this concept it is important to recognize why cities are considered key elements for the future. Cities play a prime role in social and economic aspects worldwide, and have a huge impact on the environment.Smart Cities base their strategy on the use of information and communication technologies in several fields such as economy, environment, mobility and governance to transform the city infrastructure and services.[4]

2.1 Need for a smart city

According to Global Health Observatory data of WHO there were 1.25 million road traffic deaths globally in 2013, with millions more sustaining serious injuries and living with long-term health issues as a consequence of those injuries. Globally, road traffic crashes are a leading cause of death among young people, and the main cause of death among those aged 15–29 years.

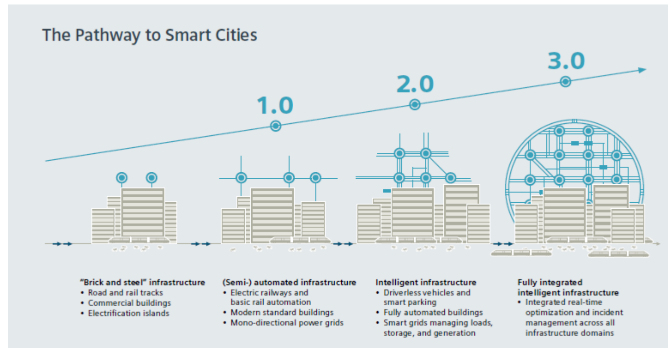
Road traffic injuries are currently estimated to be the ninth leading cause of death across all age groups globally, and are predicted to become the seventh leading cause of death by 2030.[5]

It is also estimated that 90% of these accidents are caused by human error and self-driving cars will reduce accident rates by 90% AI in conjunction with Cognitive IoT can reduce congestions, emissions and fuel consumption. AVs will also reduce vehicle ownership rate and will promote vehicle sharing thereby increasing the road capacity and decreasing traffic demand. It will also aid city planners in effective land use planning.

This conversion of human communication to technology in coming years will give rise to various cognitive IoT devices thereby impacting city infrastructure, industries and urban mobility. These changes will bring about new industries and jobs in automotives, transportation, infrastructure, farming, freight, emergency services, retail and food industry.

However these changes are not possible without strategic planning, regulation, policy making and governance. City planners, municipalities, local authorities and civil societies have to work in tandem studying various socio-economic factors in detail. Aim of driverless world in a smart city is not up gradation on technological front alone but also on betterment of life for its citizens by providing quality delivery, general well-being and economic opportunities. Networking and self-management are major pillars of society without which smart cities would be doomed to fail.

Smart cities forcefully tackle the current global challenges, such as climate change and scarcity of resources. Their claim is also to secure their economic competitiveness and quality of life for urban populations continuously on the rise.[6]



Cities around the world are striving towards integration of cognitive IoT and city infrastructure to provide hassle free mobility to its citizens. The city of Amsterdam started its smart city initiative in 2009 and is already working on projects like IoT Living lab, City zen, rooftop and MX3D.[8]. Government of India has launched smart city mission plan with its target to build 100 smart cities by 2030 which will include better and safe mobility. [9]

3. Autonomous Cars – levels of automation

Issued January 2014, SAE international's J3016 provides a common taxonomy and definitions for automated driving in order to simplify communication and facilitate collaboration within technical and policy domains. It defines more than a dozen key terms, including those italicized below, and provides full descriptions and examples for each level. The report's six levels of driving automation span from no automation to full automation. A key distinction is between level 2, where the human driver performs part of the dynamic driving task, and level 3, where the automated driving system performs the entire dynamic driving task. These levels are descriptive rather than normative and technical rather than legal. They imply no particular order of market introduction. Elements indicate minimum rather than maximum system capabilities for each level. A particular vehicle may have multiple driving automation features such that it could

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operate at different levels depending upon the feature(s) that are engaged. System refers to the driver assistance system, combination of driver assistance systems, or automated driving system. Excluded are warning and momentary intervention systems, which do not automate any part of the dynamic driving task on a sustained basis and therefore do not change the human driver's role in performing the dynamic driving task.[10]

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**

Figure 2. Levels of automation J3016 – SAE

4. Current Development Stage around the World

Connected Vehicles can be broadly divided into 3 categories

1. V2V Communication – AVs interact with each other sending data to each other to assess car's position, speed and what it was seeing at any given point of time. These coded messages exchange between the software installed in cars and there is interchange of data to assess driving conditions for collision avoidance.
2. V2I Communication – AVs interact with the city infrastructure such as traffic lights and compute the data for decision making.
3. V2X Communication = V2V+V2I and much more. In this type of communication AVs interact not only with other vehicles and infrastructure but also interact with bicycles, pedestrians (V2P- Vehicle to people), network or in other words vehicle to everything by use of advanced cognitive IoT.

In 2017, California alone has 32 million active vehicle registrations [11] and Americans spent $160 billion on fuel consumption. Cars are parked 95% of time. Bernard Soriano [12] of the California DMV seriously questioned the logic of owning a car when Uber and Lyft are already making inroads creating a generation which is quite comfortable not owning a car. All this naturally has led to grant of licenses to 20 autonomous vehicles which are running pilot tests in California. London started its driverless project in 2015 and has now begun testing on public roads from January 2017 [13]. John Deere is currently engaged in building pilotless tractors for farms in Germany [14]. Caterpillar also with its flagship project "CAT Command' is trying to build an autonomous hauling machine which can auto shovel, move to dumping points and report on its own for maintenance purposes.[15]

Google which started testing its driverless cars in 2009 is setting up its self-driving car unit as its own separate entity called Waymo under the Alphabet umbrella.[16] The name is derived from its mission of finding "a new way forward in mobility." On October 2016, the Transport Systems Catapult was responsible for putting a self-driving vehicle on UK public streets for the first time. The demonstration of a UK developed autonomous driving system marked the conclusion of the LUTZ Pathfinder Project, which began developing autonomous technology in 2014[17].Oxford University with the help of its software "Autonomy" has been testing the Lutz Pod car in Milton Keys and it is expected that pod cars will be used as public transport in future.

4.1 Developments in Sweden

Sweden is home of Volvo's car sharing service Sunfleet. The subsidiary has the largest fleet with highest coverage in the country. It distinguishes itself by offering the entire range of Volvo vehicles including the latest XC90. Volvo is also pioneering keyless technology, which will open new possibilities like the pilot together with Urb-it to provide in-car delivery services .[18]Volvo Cars will play a leading role in the world's first large-scale autonomous driving pilot project in which 100 self-driving Volvo cars will use public roads in everyday driving conditions around the Swedish city of Gothenburg.[19]

Volvo in collaboration with Chalmers University, Autoliv and Gothenburg Stad began testing cars with self-driving technologies already 2013 under Drive Me project.[20]In unsupervised autonomous mode, a vehicle performs all the driving because it is safe to rely on the technology to steer, brake and accelerate. People on board the vehicle are not expected to have control of the car.

Scania is developing a system called platooning. Using inter-vehicle communication, this system allows heavy vehicles to form fuel-efficient, aerodynamic formations on motorways. Trucks within the convoy automatically follow a lead truck, cutting fuel consumption by as much as 12 percent.

Together with the Swedish National Road and Transport Research Institute, KTH, Volkswagen Research and other partners, tests of platooning have begun on a 520-kilometre route between the Swedish cities of Södertälje and Helsingborg.[21]

Drive Sweden is a Strategic Innovation Program launched by the Swedish government that gathers the best in the area – from all sectors of society. We work closely together to make optimal use of all possibilities, but also to address the challenges that could arise along the way. This could pertain to road safety, adaptation of infrastructure and legislation that needs updating.

The Drive Sweden innovation program started in the spring of 2015. It is funded by the Swedish Energy Agency, the Swedish Research Council Formas and Sweden's innovation agency VINNOVA. Lindholmen Science Park is the host for the program.[22]

Figure 3. Drive Sweden Network Flow

5. Interaction with Human Drivers

Despite these advancements as cited above these vehicles have one thing in common –they all have a human driver sitting inside the vehicle to disengage the autonomous driving software if some technological mishap occurs. Additionally, the speed limit of AVs is currently set to 25 mph. whenever the cars disengage from the driverless mode; the vehicle companies are required to file a disengagement report to the DMV *(Department of motor vehicles)*.[23] The car technology is beyond the understanding of bureaucracy thus disengagement report is the parameter to test the safety of algorithm.

33 Companies are currently testing driverless cars with companies like Google and Drive.io providing the algorithm for self-driving cars. Companies like Zoox are focussed to develop car AI. MIT nuTonomy is Building Software to Power Tomorrow's Driverless Fleets. It aims to radically improve the safety, efficiency, and accessibility of transportation in cities worldwide. To fulfill this mission they've assembled a team of engineers and scientists who are committed to developing the world's premier driverless vehicle technology. They envision a future where fleets of nuTonomy-powered driverless vehicles are available where you need them, when you need them, in cities from Singapore to San Francisco. By eliminating accidents due to driver error and maximizing vehicle utilization, it will

enable safer roads and a healthier planet.[24]NuTonomy technology is currently at test stage in taxis in Singapore and Dubai. Stanford has developed autonomous racing car called 'Shelley'. Apart from these cars shuttles like 'Loco' in Las Vegas strip and 'Auro' which provides self-driving solutions for college campuses, corporate parks, residential communities, and other private-road settings.[25] Its experiment in Santa Clara University Campus has been more successful because of fixed routes and less complications on short travel path encountering few traffic lights and pedestrians.

Amsterdam in its smart city project has started adding sensors to bicycles and boats to enable IoT capability. This addition of sensors on bicycles –has reduced theft, bicycle sensors are also capable of communicating with traffic lights and measure pollution levels in the city. Sensors on boats turn them into IoT devices which can act as bridges whenever the need arises. [26]

However, despite all these advancements, autonomous vehicles of today haven't found a fool proof way of coping with human drivers and their behaviours. AVs of today are not fully equipped to deal with abnormal pedestrian behaviour or how to react when human drivers cut through bike lanes. These machines still need to think like humans which has given rise to another field of study called affective computing.

5.1 Affective Computing

Computers are beginning to acquire the ability to express and recognize affect, and may soon be given the ability to "have emotions." The essential role of emotion in both human cognition and perception, as demonstrated by recent neurological studies, indicates that affective computers should not only pro- vide better performance in assisting humans, but also might enhance computers' abilities to make decisions. [27]

In this field, scientists are studying human behaviour and trying to put it into algorithms so that machines could emulate emotional behaviour of humans. Start-up projects initiated by Sensoria in partnership with Renault is trying to design wearables like a pair a socks or shoes which can measure the alertness of driver. Each smart sock is infused with three proprietary textile sensors under the plantar area (bottom of the foot) to detect foot pressure.he conductive fibers relay data collected by the sensors to the anklet. The sock has been designed to function as a textile circuit board.Each sock features magnetic contact points below the cuff so you can easily connect your anklet to activate the textile sensors.[28]

Sensoria has also hired anthropologists to understand human behaviour and mood swings such as road rage which can help reducing accident rates.

BMW and Ford Motors have envisioned advanced use of affective computing by 2030 when IoT messaging devices can pull over a driver in situations of road rage or call emergency services in cases of heart attack.

However, our current knowledge about affective computing is very limited. For instance, when Ford Motors was asked by Senator Gregg Harper during the US house subcommittee hearing on self-driving –"how will a car respond to honking by a human driven car?" Ford had no answer. [29] This is because human communication is very complex and full of nuances. Algorithms can be built to train AVs on an ideal road condition with no uncertainty. Therefore, it will take some more time for these machines to understand human emotions and emulate them perfectly.

6. Technology behind AVs

Human drivers see the whole road including vehicles on them along with the surrounding environment however AVs take decisions on every step. The car has to identify lanes on the road, identify traffic infrastructure such as sign boards, pedestrian crossings, and be able to distinguish traffic lights from other vehicles on the road. AVs indulge in data processing from these inputs, store it, and send it to the manufacturer via cloud who can then assess and check the driving of AVs. AVs make use of AI and different camera visions to make a decision to stop or go in place of a human vision. AVs make use of triangulation to locate objects, collect data from the road conditions by laser and radar sensors. AVs also have forward collision warning system which came into use when TESLA Model S Autopilot forewarned collision between two cars ahead by V2V communication.[30] This collision was beyond the sight of driver and the car successfully pulled over and saved collision.

AI behind an AV is a result of algorithms developed by machine learning and deep learning technologies. In these technologies, the main computer takes lot of data as input to various models and the software is able to make decisions based on that. AVs learn to identify traffic signs using image recognition software which compares images from thousands of images on cloud. Cloud contains images of traffic signs in all conditions of wear and possible angles as data. Deep learning technology helps the car to identify objects -be it pedestrian or another car. Deep Learning is a new area of Machine Learning research, which has been introduced with the objective of moving Machine Learning closer to one of its original goals: Artificial Intelligence.[31]

Using Deep Learning technology, Tesla cars have developed a model called 'fleet's learning capability' where they capture data of their fleet even when it is driven by a human to study the behaviour of drivers. Fleet Learning is a network effect based machine learning.[32]

This data is daily sent to the Tesla cloud where it is processed to fine tune the software predicting objects and their behaviour on the road. However, this data processing and technique was not open source until Udacity offered open source machine learning program with a vision to have open source AV for the world to use. MIT also joined the foray offering free online course and invited developers to send and test their code on Tesla Cars.

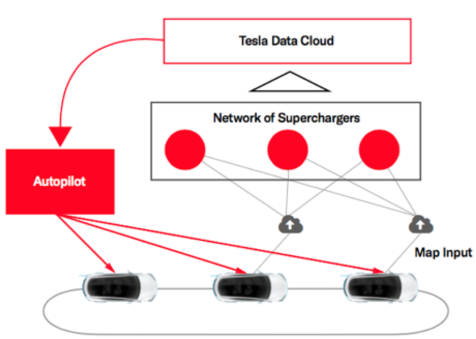

Figure 4. TESLA Fleet Learning Algorithm[32]

7. Autonomous Vehicles and Infrastructure Changes

City planners are constantly trying to design an infrastructure which is sustainable, resilient, citizen friendly, safe and promote urban mobility. However, urban centres are often marred by traffic jams and drivers try to make up lost time by over speeding. Thus, over speeding becomes a primary cause of accidents in urban areas. Another associated area of concern in large cities is the problem of parking where drivers keep on moving in circles to find a suitable parking lot for their vehicle. The act of parking a car has not seen much innovation throughout the past century, but that is starting to change. That's good news for cities, where some studies have found that up to 50 percent of traffic comprises drivers searching for an open parking spot. As wireless sensors became more affordable, rugged and configurable during the past decade, they have helped to spawn a new approach to metered parking spaces, enabling cities and private parking services providers to charge dynamically, based on demand, while also making it easier for drivers to quickly locate available spots, thereby reducing congestion.[33]

AVs in future will also work as pod cars which can reduce the problem of traffic congestion by a significant amount. Pod cars which can act as a shared vehicle will eliminate the need for ownership of a car. Pod cars will also act as a bridge in social dimension as it will increase the mobility of senior citizens, non drivers and physically challenged citizens. Pod cars will also work as revenue generating business model where people will be able to conduct their normal business inside the car. The car will communicate with road infrastructure and objects on road without the need for human intervention.

8. Environmental Impacts of AVs in case of platooning

In October 2014, European Council agreed upon the 2030 Climate and Energy Framework to tackle climate changes and reduce green house gas emissions 80-95% below the 1990 level by 2050. The Council in its conclusions also observed that it is important to reduce green house gas emissions and associated risks in the transportation sector. The European Council further invited the commission to examine ways and methods to promote energy efficiency in the transport sector.

According to EU Transport Sector Economic Analysis the transport industry employs around 10 million people and contributes to 5 % of GDP. It is estimated that by 2025 congestion costs will go up by 50%.

Against this backdrop concept of platooning or optimized logistics emerges as the new field of study particularly in commercial vehicle space. Platooning involves electronic linkage (V2V Communication) between two or more trucks which move in a convoy at a very close distance. Reduction of spacing not only increases the highway capacity but the shared air drag reduces fuel consumption thereby leading to CO_2 emission reduction by 10%. (Berger).

8.1 Basic Concept of Platooning System

Concept of platooning is smart mobility with the help of Intelligent Transportation System (ITS). In this system two or more trucks are connected to each other with V2V communication. These vehicles maintain a close distance with each other. The leader of the convoy is equipped with a forward looking radar system which enables it to have a better vision than a human eye. Leader communicates with the convoy and rests of the trucks simply follow the directions of the leader. This concept is analogous to tournament level cycling competitions where the cyclists move very close to each other and followers experience a reduced air drag. Similarly in platooning system the followers in the convoy are so placed that they face less wind resistance. This results into fuel saving and thereby leading to lesser emissions.

The aim of platooning is not only to evolve as a better and superior technology but it's motive is far beyond that. Platooning leads to reduction in human error thereby causing fewer accidents. (Stanford Law School). Platooning is now seen as technology which can reduce emissions, increase road capacity and reduce operating costs in transport sector. Thus it is also hailed as a technology which is clean, safe and efficient.

9. Legislation Challenges for Autonomous Vehicles in Sweden and USA

There are tremendous challenges which need to be addressed before AVs can freely operate in public streets. These issues can be summed under the following categories:

- Reliability Issues
- Safety issues
- Licensing Issues
- Insurance Issues
- Security Issues
- Privacy Issues

9.1 Regulations in Sweden

It is not possible to introduce completely self-driving cars with respect to today's laws and traffic rules. The European Union is responsible for establishing fellowship rules, and the United Nation Economic Commission for Europe (UNECE) establishes the technical requirements for vehicles. At the national level the Swedish Transport Agency, the Transport Department and local authorities develop the design of future infrastructure. These agencies study the societal advantages of autonomous driving in terms of reliability, safety, urban mobility, environment and health and pragmatism. [34]

The Swedish Transport Agency has initiated a pilot study in the field of autonomous vehicles/driving in order to identify whether and how legislation needs to be modified in order to permit partly or fully automated driving, and if so which legislation. The aim of the pilot study is not to propose legislative amendments, but to identify any need for amendments. In the longer term, the aim is to permit introduction of fully or partly automated driving on roads in 2016.

Current legislation provides scope for test operations in real traffic using vehicles with a high degree of automation. The road traffic legislation does not present an obstacle, and if the vehicles fail to meet the technical requirements the Swedish Transport Agency has the opportunity to grant exceptions. There are vehicle manufacturers who currently have what are known as test dispensations. The fact that road traffic rules in different countries have been aligned has been a success factor for all types of road transport for a long time. Therefore, the starting point is that the issue of special traffic regulations, special road markings and other arrangements for self-driving vehicles should be implemented internationally within UNECE. There are still issues in respect of road traffic legislation, such as the issue of liability: this is essentially an issue for the law enforcement agencies to resolve. The working group is of the opinions that as things stand at present, the Swedish Transport Agency should continue to monitor the application of the law in the projects and investigations taking place in the field of autonomous driving both nationally and internationally.

There are currently no requirements guaranteeing an identified level of safety for the vehicles' self-driving functions. In the opinion of the working group, regulations will be needed which guarantee a sufficiently high level of road safety for vehicles of level 3 or above so as not to impede the market launch. The working group is of the opinion that level 3 vehicles will be technically ready for launch on the market in around 2020. Vehicle legislation is largely controlled by the EU, and this is where the focus can be influenced. The Swedish Transport Agency currently has limited knowledge in the field of the EU's plans for regulations in the field, which will require additional input if the Issues to pursue

The working group has come to the conclusion that the Swedish Transport Agency should continue working with autonomous driving as follows in order to help devise effective regulations. [35]

9.1 Regulations in USA

Level of Automation	WHO DOES WHAT, WHEN
Level 0	The human driver does all the driving.
Level 1	An advanced driver assistance system (ADAS) on the vehicle can sometimes assist the human driver with either steering or braking/accelerating, but not both simultaneously.
Level 2	An advanced driver assistance system (ADAS) on the vehicle can itself actually control both steering and braking/accelerating simultaneously under some circumstances. The human driver must continue to pay full attention ("monitor the driving environment") at all times and perform the rest of the driving task.
Level 3	An Automated Driving System (ADS) on the vehicle can itself perform all aspects of the driving task under some circumstances. In those circumstances, the human driver must be ready to take back control at any time when the ADS requests the human driver to do so. In all other circumstances, the human driver performs the driving task.
Level 5	An Automated Driving System (ADS) on the vehicle can do all the driving in all circumstances. The human occupants are just passengers and need never be involved in driving.

Table 1. Level of Automation as per SAE International

NHTSA (National highway Transportation Safety) follows the definition of AVs according to the levels defined by SAE International as shown in table above.[36] This definition of SAE acts as a benchmark when DMV approves license to AV for road testing. Driver assistance technologies like electronic blind spot, collision avoidance systems, automated emergency braking systems, parking assistance, adaptive cruise control, lane keep assist, lane departure warning, traffic jam and queuing assistance come under level 2 automation and does not require AV permit.

Another area in focus is the liability of loss in case of an accident. Keeping public safety in mind, DMV California set out to create the regulatory framework to allow vehicles to drive autonomously for testing on real roads. DMV kept insurance value as $5 Million and a human driver had to be present in the driver's seat of testing vehicle at all times. Manufacturers are also required to send disengagement report to DMV. This acted as a starting point to address the liability issue.[37]

In 2014, US Federal agencies allowed V2V communication between the cars which forced companies to share minimum information to facilitate communication between AVs. V2V communication evolved over the years to create linkages between different operators using different AI software. This inter-operability has helped to reduce road accidents and reduced the liability of manufacturers. [38]

AVs will bring a new generation of digital insurance because blockhead technologies coupled with AI, deep learning and machine learning will need a foundational change in shifting of liabilities. Today the insurance companies are still contemplating about the liability exposure. Should the liability be shifted from driver to manufacturer or fleet owner? Should the liability change after disengagement? These questions are still debated by the industry because technically, driver in an AV is a *passenger*, and *not a driver*. Risk models based on user data will be developed by insurance industry to assess the liability. Another serious challenge in this domain is because of mixed manufacturing –presently, Google provides the technology, and the cars are built by Volvo or Lexus; and according to the NHTSA manual '*motor vehicle' under ADS laws to include any vehicle operating on the roads and highways of the State; licensing ADS entities and test operators for ADSs; and registering all vehicles equipped with ADSs and establishing proof of financial responsibility requirements in the form of surety bonds or self-insurance. These efforts provide states with the same information as that collected for conventional motor vehicles and improve state recordkeeping for ADS operation (NHTSA Automated driving system 2.0: A Vision for safety).* This definition as per NHTSA will be redefined in accordance to changing needs but there is no doubt that the traditional car insurance model will be fundamentally altered once the AVs manufacturers begin their commercial operation. Car manufacturers are already offering solutions to insurance companies but the issue is still debatable and insurance leaders are still searching for a unanimous solution to protect their business and give a reasonable liability cover to its clients.[37]

10. Cyber Security Issues

Vehicles are cyber-physical systems1 and cyber security vulnerabilities could impact safety of life.[39]NHTSA is focusing on solutions to harden the vehicle's electronic architecture against potential attacks and to ensure vehicle systems take appropriate and safe actions, even when an attack is successful.

A layered approach to vehicle cyber security reduces the probability of an attack's success and mitigates the ramifications of a potential unauthorized access. The automotive industry should follow the National Institute of Standards and Technology's documented Cybersecurity Framework,which is structured around the five principal functions "Identify, Protect, Detect, Respond, and Recover," to build a comprehensive and systematic approach to developing layered cybersecurity protections for vehicles. This approach should:

- Be built upon risk-based prioritized identification and protection of safety-critical vehicle control systems and personally identifiable information;
- Provide for timely detection and rapid response to potential vehicle cybersecurity incidents in the field;
- Design-in methods and measures to facilitate rapid recovery from incidents when they occur; and
- Institutionalize methods for accelerated adoption of lessons learned across the industry through effective information sharing, such as through participation in the Auto ISAC.[39]

11. Transport Policy in Future

Transport planners and authorities have to walk a tight rope between regulation and innovation. Most of the major AV manufacturers have set 2021 as the deadline for their first commercial launch of self driving cars. Udacity is building an open source self-driving car [40] and this has further complicated the issue of ownership. Another issue is that of the quality of algorithm. If an algorithm is poorly written then it can compromise privacy, engage in dishonest business practices by selling data to marketing companies, force users to make decisions based on behavioural AI or can be out rightly hijacked by cyber hackers.

Therefore, permit-issuing authorities and transport planning authorities have to tread this path carefully considering all technical and social dimensions.

Road Map for the future

1. Authorities should issue guidelines for design of vehicles with not only taking into consideration technical specifications based on international standards such as ISO, SAE etc but also the entire transport eco system as a whole.
2. The authorities should ensure that optimum performance condition of each vehicle should be clearly made public. If an AV is driving in a hazard situation or if the algorithm is not suitable for a particular type of road condition, then it should disengage and move back to level 0 or 1 type of automation.
3. AVs should take into account not only regular objects like roads, vehicles, traffic lights but should also be designed to detect unusual objects like pedestrian crossing the road abruptly, an animal crossing the road, construction site with workers, police check posts etc and should be programmed to minimise risk as soon as any emergency situation is detected.
4. V2D interface or Human machine interface should be equipped to alert the human driver in case of any contingency if the driver is not alert or busy in some other activity. During the 2016 Tesla Auto pilot accident where the human driver was killed in a crash failed to alert the driver when the driver was watching a movie in self driving car.
5. Cyber security is a major theme where AV algorithm has to be ethical and safe in order to mitigate risks and calamities.
6. Post-Crash behaviour of an AV should be to shift vehicle to stable state as early as possible by moving the vehicle to a safe place, cutting off fuel and electric supply to avoid further damage.
7. Infrastructure changes will also be required which are the responsibility of city planners because driverless cars can only be a reality if government is determined to. These technologies will bear no fruit if they are not complemented by necessary changes in road infrastructure and required awareness among the citizens.

12. Conclusion

AVs are no more a part of science fiction but we've come very near to the first commercial launch of self-driving cars. According to industry estimates, 50 percent of the cars will be driverless by 2030 and AVs will completely dominate the road by 2050. This transformation from fully human-driven cars to fully automatic self-driven cars will require complete overhaul of our infrastructure. Cities will have to become smart using cognitive IoT communicating with the AI of the car. This change will not only affect road users and vehicles on road but has the potential to change existing industries by forcing them to come up with new business models and markets. New urban mobility will redefine land usage patterns in markets, city centres and malls. This will also have a social dimension with a huge number of drivers going out of business. Policy makers will have to formulate new plans which could redefine the role of human drivers in the new paradigm of self-driven cars.

The ultimate aim of a smart city with self-driven car is to create a knowledge driven society which promotes sustainability of resources, smart mobility, innovation, quality of life, with integrated urban infrastructures.

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