AUTONOMOUS VEHICLES

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*Abstract*— Engineers try to explore and make things easier by introducing new concepts to the world to take advantage of newly discovered ideas. The concept of “Autonomous Vehicles” happens to be one of these ideas that relies on Artificial Intelligence as a result of smart programming.

Today autonomous equipment has enabled the creation of vehicles that are autonomous and are efficient in terms of cost and benefits, planning and decision making (optimal road, parking etc.), and effective travel activity [1]. This research study was conducted to understand, learn, and explore more about autonomous vehicles. This paper looks at autonomous vehicles and focuses on the basic manufacturing, technologies involved, flaws and advantages, its impact on society, economy, and environment as well as future progression of autonomous vehicle technology. The proposed research is entirely based on the autonomous vehicle and its stages. There are six basic certain levels in driving autonomously, they consist of; no automation, driver assistance, partial automation, conditional automation, high automation and full automation [2]. This paper presents the research study conducted showing different modes, design methodology, artificial intelligence involved and vehicle impacts. It looks at what is preventing the advancement of autonomous vehicles and the impact of the cars on the economy and on the society. To accomplish the objective and learn more about the industry in detail including the challenges and downsides of designing an autonomous vehicle, this research was done with the help of scholarly articles, magazines and articles from IEEE Xplore. The study concludes that once the barriers are overcome, the number of autonomous vehicles will increase in number.

***Keywords—component, formatting, style, styling, insert***

**Introduction**

Autonomous vehicles are cars in which human drivers are never needed to take control, to safely operate the vehicle. Also known as “driverless” cars, they combine sensors and software to control, navigate, and drive the vehicle

Autonomous cars have become important for the community first because they help reduce the number of accidents on our roads. Driver error contributes to 94% of road accidents and autonomous vehicles can highly reduce this statistic. High levels of autonomy have the capacity to reduce risky and dangerous driver behaviors.

The concept of an autonomous vehicle was first introduced in the 1860s by Robert Whitehead who invented the first ever self-

propelled torpedo. Later on, many inventions were introduced on the autonomous vehicle. In 1935, Normal Bel Geddes introduced a self-driving car and it wasn’t until 1950’s that the concept which was beyond dreams, was introduced in an advertisement ‘A family car which can navigate the complex world’s city streets, avoiding fragile and litigious human beings by America’s electric light and Power Company’. The idea of a self-guiding car that carried away the torpedoes was pushed forward.

By the early 1940s these torpedoes known as the German V-1 drone bomb were flying their way to their London destinations on their very unique and magnificent stubby wings that made it a huge success. Later on, the V-2 rocket touched the edge of space and opened the door for future inventions and developments in the field of automation [3]. By the 1960s, with the involvement of artificial intelligence (AI) fanatics, the idea of cars that are smart enough to navigate and drive through ordinary streets on their own came about. This idea of smart cars to navigate and drive smoothly on ordinary roads was quite challenging and these challenges were daunting in terms of sensing, processing, decision making in real time, reacting, accurate movement etc. In 1980s, a German pioneer named as Ernst Dickmanns got a Mercedes van that was able to drive hundreds of miles of highway autonomously, and proved to be a tremendous feat especially in terms of computing power at the time. Dozens of other pioneers around the globe added their own improvements to this technology. This study will look at the impediments that are being faced in the journey of rolling out autonomous vehicles and the impact that they have on the economy and the society.

1. **AUTONOMOUS VEHICLE TODAY**

Autonomous vehicles are drastically finding their way to our highways and roads. Earlier this year, Waymo, which is the self-driving unit of Google's sister-company, Alphabet, succeeded in carrying out numerous trials of autonomous taxis in California, which were able to transport over 6,200 people in the first month and then transported a thousand more afterwards.

In the United States, autonomous cargo vans are being promoted and used by Walmart to deliver groceries to their destinations in the city of Arizona. Furthermore, Pizza Hut is working on manufacturing a driverless electric delivery vehicle in collaboration with Toyota Company, which will have an embedded mobile kitchen that will be able to cook pizzas that are later delivered to their destinations. Renault Car Company has brought in tremendous innovation and invention by making great strides in autonomous vehicles. The company began making these vehicles in 2017 and their first invention was beyond the thoughts in the field of automation.

# ADVANCEMENT BARRIERS

There are a few things that are slowing the growth of autonomous vehicles from regulation issues to the business

models and to technology. Waymo has demonstrated the viability of autonomous taxi services in many places in California and eagerly wants to spread and deploy its technology more widely as soon as possible. However, the problem lies with the state governments who are not making it possible and simple but causing various issues, like for instance, in the state of California, Waymo has to provide services free of charge. This kind of behavior or attitude is unbearable and it might jeopardize the reputation of California in terms of becoming the world leader in driverless technology as per industrial analyst [4]. General Motor’s subsidiary, Cruise, after safety concerns that kept it from gaining any regulatory approval from the state government, also experienced some delays in terms of its deployments of its autonomous vehicles in New York which GM bought in 2016 worth around $1 billion. Business models always remains quite a challenge to deployments too. Head of Autonomous Mobility at the World Economic Forum, Michelle Avary said, “We see some big divergence between the whole idea of the business model of the robo- taxi versus what we see in areas like commercial trucking, mining and construction, where the business model case might be more readily made.” Autonomous vehicle car service could be workable and this is something car manufacturers are still trying to work out. Some car owners recently said that they might consider giving up ownership of their cars if autonomous cars, vehicles or autonomous mobility solutions were available in their State in the coming future.

# Levels of automation

Another barrier is seen in the levels of autonomous driving technology. There are some guidelines that are issued by the Society of Automotive Engineers (SAE) that briefly explain the various levels of autonomy and some are discussed below;

**Level 1**

This level is related to driver assistance through computer aided simple driving functions such as cruise control or automated braking systems.

**Level 2**

This level concerns partial automation where the driver is assisted with acceleration or steering so that they can disengage from some other tasks.

**Level 3**

This level is concerned with conditional automation where some monitoring of the environment is taken over from the driver by vehicle functionality using LiDAR type sensor technology. Audi introduced this technology and it has been in use since 2018.

**Level 4**

Level 4 is basically automation at high level with much greater control that has been handed to the vehicle, including things like charge of steering and braking, accelerating along with monitoring of the vehicle and roads, where the vehicle is moving and actuating. It plays an important role in decision making such as, responding to movements and when to change steering and decide lanes, turn right or left or use signals efficiently. Ford Company has stated its intention to go straight to Level 4 in their upcoming vehicles in the near future.

**Level 5**

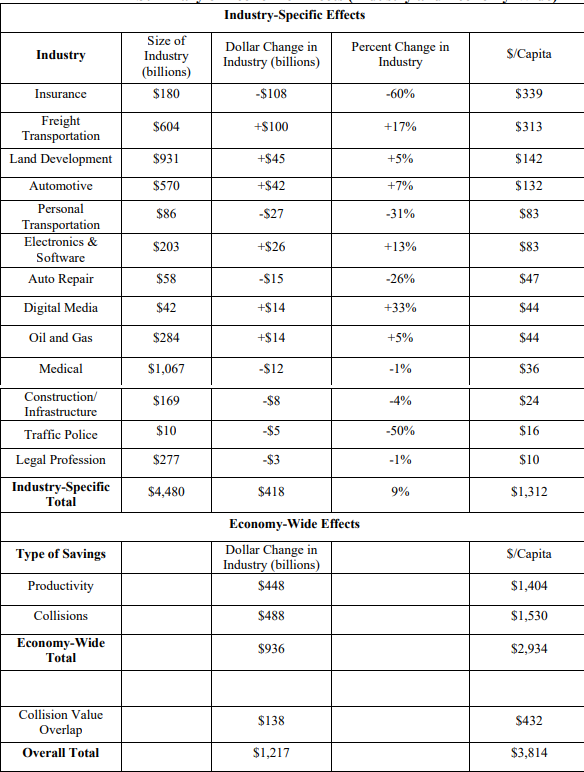
Level 5 is basically the future beyond thoughts where automation is embraced in full with the vehicle being able to control everything with no interference and involvement of a human driver. Whereas this goal is not realistic at the moment, level 5 autonomous vehicles that have complete control of vehicle with human interference are unlikely to be introduced before 2025 [4].

# II. IMPACT ON ECONOMY

The industries of autonomous vehicles are most obviously and directly affected by the design, and adoption methodology, and use of CAVs (Connected and fully automated or autonomous vehicles) in the automotive industry. The autonomous vehicle industry is one of the strongest forces in the U.S. economy, that is employing 1.7 million people, and providing almost $500 billion in worker compensation per year or annually, and claimed for accounting for about 3 to 3.5% of GDP [5]. In 2015 automakers or autonomous vehicle makers sold a total of

17.5 million vehicles including cars and light trucks, at a cost of $570 billion to American costumers or consumers. Connected and fully automated or autonomous vehicles will influence not only the use but the design of motorized vehicles as well and also redefine some of the business strategies of companies inside and outside the automotive industry. High production of this vehicle and the likely market expansion for this type of vehicle is bound to occur. This will happen due to the ability of children, and persons with certain disabilities, and elderly people having certain problems in driving being able to enjoy the convenience of automotive travel without any liability of driving the vehicle physically [6]. VMTs are assuming additional capacities because of shorter headways among smart cars and changes in values of time, along with parking costs, and VMT fees/road tolls. Total of the estimated regional VMT has increased from almost 3.6 percent to 19.6 percent, except when marginal cost tolls were applied, and VMT fell almost

35.4 percent, which is relative business as usual, no automation case [7]. Below article represent the table containing industries and having impacts of autonomous technology on them.[8]



# Table 1. The economic and industry impacts of autonomous vehicles [8]

**III MPACT ON SOCIETY**

In the near future implementation of autonomous vehicles will bring up the problem of replacing humans with computers that are able to do certain kinds of work for them. This will not bring any kind of immediate or instant change in society, but it will surely become more visible and apparent over time as much as they are integrated into society and more and more vehicles on the road become actuate autonomously. The effects of this on everyday life will become more visible. This will also help in the increase of efficiency of many industries as well as companies as much less time will be wasted in travel and also less money be wasted or spent on tasks that autonomous vehicles can perform in replacement of human drivers used previously. But this will bring unemployment for many people and will cause the loss of thousands of jobs all over the world. There would need a proper plan at first to be introduced in the society to handle this huge unemployment crisis when it does happen. This is one of the reasons behind the lack of interest and slow development of fully autonomous vehicles. If the solution regarding this problem is provided, then we could see fully autonomous vehicle systems in the near future [9].

# IV. IMPACT ON ENVIRONMENT

Though there is much research and articles are there that represents and address all environmental issues in terms of AV adoption patterns and potential benefits, low carbon mobility, shared mobility and on demand mobility whose behavior will impact the environment from the usage of new autonomous vehicle and engine technologies, that bring many questions and whose answers are awaited. Taking into account various research results that are only based on

theoretical approaches, necessary experimental studies should be performed in order to completely understand the extent of environmental effects and their significance. It carries a huge importance for real world data that can be used to have a much more realistic evaluation positive effects on environment.

# II. FUTURE OF AUTONOMOUS VEHICLE 5G and autonomous vehicles

France is the only country that is promoting and genuinely making huge steps forward to promote autonomous vehicles in their country. In March 2019 Renault demonstrated a concept car that it intends to deploy as an electric robot taxi. Orange along with Renault has an agreement to work on a connected vehicle and a 5G project. The scheme will work on and measure the capacity of 5G and its ability that can be used to enrich communications between vehicles and surrounding environment, which gives autonomous vehicles more information knowledge and enabling better traffic flow and helps to improve road safety.

Furthermore, Renault announced that it was conducting tests on demand of car services in the city of Paris and partnering with Waymo to investigate driverless transportation possibilities in Charles de Gaulle Airport. Renault’s Valerie Pecresse said that the company is “investing 100 million euros in autonomous vehicle infrastructure and there is hope that we will be able to bring this project to a successful conclusion for the Paris Olympic Games.” Tesla is also stepping forward in this regard making big steps forward in taking autonomous vehicle into mainstream use in terms of real-world use cases as well as potential monetization of self-driving technologies. According to the research conducted, Tesla has provided or supplied customers with almost 780,000 or more vehicles since launch, including majority of which come with pre installation, and having capability of self-driving availability to users who purchase the required requisite software [4]. Tesla autonomous vehicles have embarked on huge driven levels since their introduction, started from 0.1 billion miles in May 2016 to an almost estimated of

1.88 billion miles as of October 2019.

Ford is another company with deployments already in play. At the moment it has self-driving vehicles that are being tested in Pittsburgh, Miami, Palo Alto, Washington D.C. and Detroit, with Austin, as per reports in consideration of joining them soon. Ford along with its partner Argo AI, plans a trial of its fleet of self-driving cars with a view towards launching a wider and farther-reaching autonomous vehicle specifically taxi and delivery service this year (in 2021) in Austin [10].

# CONCLUSION

Autonomous vehicles are widely getting entrenched and replacing human work due to its usefulness, efficiency and unremarkable automation. But there are certain barriers on its way of development as discussed above. As it stands, there aren’t any

companies yet that are offering car services that are fully autonomous and drive on major roads, which means the long-pictured image that we imagined of sitting back and watching a movie in your car while car drives autonomously by itself is not here yet. It is a picture far away but it’s in the works. According to Counterpoint Research’s Internet of Things Tracker, the global market for connected cars will have grown by almost 270% by 2022. There will be more than

125 million passenger cars with embedded connectivity setup to ship between 2018 and 2022 worldwide.

REFERENCES

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S. Kato, E. Takeuchi, Y. Ishiguro, Y. Ninomiya, K. Takeda and T. Hamada, "An Open Approach to Autonomous Vehicles," in IEEE Micro, vol. 35, no. 6, pp. 60-68, Nov.- Dec. 2015, doi: 10.1109/MM.2015.133.

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumb er=7368032

This paper highlighted the approaches that is adopted in our autonomous vehicles, and introduced various components such as ZMP Robocars, sensors, and computers, that are easily found in market. This paper represents the software that can be used as autoware such as ROS, PCL, OpenCV, CUDA, open frame works and android. Autoware is the first autonomous vehicle platform accessible to the public. This paper included the basic introduction to autonomous vehicle then it highlighted their work which is autoware.

# [2]. A Model-Driven Methodology for Vehicular Embedded Systems

A. Bucaioni et al., "MoVES: A Model-Driven Methodology for Vehicular Embedded Systems," in IEEE Access, vol. 6, pp. 6424-6445, 2018, doi: 10.1109/ACCESS.2018.2789400.

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumb er=8252905

This paper is written on a project of methodology for vehicular embedded system. This proposed methodology of model-driven of vehicular embedded system discloses the opportunity of improving the cost-efficiency of the development process of autonomous vehicles by providing automated support which can help to identify viable design solutions with respect to selected non-functional requirements. This paper started from the basic intro of autonomous vehicles which then lead to the main subject which is model-driven methodology for vehicular embedded systems

**[3].** Bekey, G. A. (2005). *Autonomous robots: From biological inspiration to implementation and control*. Cambridge, Mass: MIT Press. Retrieved from

https://[www.jcreview.com/*Autonomous*](http://www.jcreview.com/Autonomous) *robots: From biological inspiration to implementation and control*.pdf

This article represents the autonomous vehicle history starting from torpedoes to autopilot then to modern day technology of self-driving or autonomous vehicle. This article describes the advancement of autonomous vehicle industry in terms of generation of autonomous vehicle and discuss different innovation and advancement in it.

**[4]. Torchinsky, J., & Boeckmann, B. (2019). *Robot, take the wheel: The road to autonomous cars and the lost art of driving***. Retrieved from https://[www.perlego.com/book/959948/robot-take-the-](http://www.perlego.com/book/959948/robot-take-the-) wheel-the-road-to-autonomous-cars-and-the-lost-art-of- driving-pdf

This article showed or represent the state of autonomous vehicle today with 5G and Artificial Intelligence or AI involvement that enrich, establish and develop the autonomous vehicle to next level. This article also represented the level of automation and different industries that are applying them.

# [5]. Contribution of the Automotive Industry to the Economies of All Fifty States and the United States.

Hill, K., D. Menk, A. Cooper. Contribution of the Automotive Industry to the Economies of All Fifty States and the United States. Center for Automotive Research.

Retrieved from

<http://www.cargroup.org/?module=Publications&event=Vie> w&pubID=16

This article focused on how autonomous vehicle industry or automotive is effecting the economy of industries and states. It also described different aspects of economy where the autonomous vehicle industry in embarking huge impacts and listed important industries along with accurate and researched budget showing the amount impacting on industries by autonomous vehicle.

# [6]. Using an Activity-Based Model to Explore Possible Impacts of Automated Vehicles, Proceedings of 94th Annual Meeting of the Transportation Research Board. Washington, DC

Childress, S., Nichols, B., Charlton, B., Coe, S. (2015) Using an Activity-Based Model to Explore Possible Impacts of Automated Vehicles, Proceedings of 94th Annual Meeting of the Transportation Research Board. Washington, DC.

Retrieved from https://journals.sagepub.com/doi/10.3141/2493-11

this basically a discussion or a talk held on 94th Annual meeting of the transportation research board that explore and discussed possibilities and innovation for future advancement introduced to be embedded in the field of autonomous vehicle.

# [7]. Economic effects of automated vehicles

Clements, L. M., & Kockelman, K. M. (2017). Economic effects of automated vehicles. Transportation Research Record, 2606(1), 106-114. Retreieved from

https://[www.caee.utexas.edu/prof/kockelman/public\_htm](http://www.caee.utexas.edu/prof/kockelman/public_htm) l/TRB17EconomicEffectsofAVs.pdf

This article also represents the effects of economy by autonomous vehicle industry. This article highlighted some of the industries where autonomous vehicles are impacting massively and addresses data in terms of accurate amount or money.

# [8]. Autonomous cars and society

Forrest, A., & Konca, M. (2007). Autonomous cars and society. Worcester Polytechnic Institute. Retrieved from

https://web.wpi.edu/Pubs/E-project/Available/E-project- 043007-205701/unrestricted/IQPOVP06B1.pdf

This article represents the impacts of autonomous vehicle on society and highlighting some of problems in adopting this technology by people and society. This article discussed the future impacts on society and unemployment etc. problems that will be caused by autonomous vehicles in detail.

# [9]. Autonomous cars: Past, present and future a review of the developments in the last century, the present scenario and the expected future of autonomous vehicle technology

Bimbraw, K. (2015, July). Autonomous cars: Past, present and future a review of the developments in the last century, the present scenario and the expected future of autonomous vehicle technology. In 2015 12th international conference on informatics in control, automation and robotics (ICINCO) (Vol. 1, pp. 191-198). IEEE. Retrieved from

https://ieeexplore.ieee.org/abstract/document/7350466

10. **Litman, T. (2020). Autonomous Vehicle Implementation Predictions: Implications for Transport Planning.** Retrieved from [www.vtpi.org](http://www.vtpi.org/)

This article discussed in detail in highlighted the 3 generations of autonomous vehicles as past, present and future. This paper helped to study and learn more about future amendments, innovation and advancement in autonomous technology and highlightted the dream of autonomous car at high level where person can watch a movie at the back seat and cars can drive autonomously on roads and highways smoothly and accurately.