**Automated Vehicles and the Ethics Involved**

**Final Report - Team 4**

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Executive Summary

In this document, we will explore many aspects of the autonomous vehicle industry, ranging from civilian and military applications to the ethical dilemmas surrounding the technology. Commonly, we recognize these vehicles through the lens of Tesla’s ‘Autopilot’ program making headlines and UAVs that are deployed in the Middle East by the Department of Defense. Major ethical dilemmas also include questions such as, “How does the vehicle’s AI program determine the logical or correct choice when put in an unexpected situation?” and “Do autonomous vehicles always choose to save the passengers, no matter the circumstance?”. These will be covered and we will also go through the current cybersecurity risks & vulnerabilities present with autonomous vehicles. This includes popular methods from hackers & thieves, such as Bluetooth or Relay attacks and data alterations on real-time data fed from the vehicle’s sensors.

Along with the theme of ethics surrounding these vehicles, we will also analyze how they can be beneficial and problematic in civilian & military applications. These vehicles make travel more efficient and safe, while also costing more and not having security vulnerabilities fixed just yet. Autonomous vehicles will be the dominant mode of transportation in the next ten to twenty years and we as a collective need to better understand this emerging technology. Without understanding the ethical implications and the pressing security issues with these vehicles, society will have a much harder time coexisting with new technology and could lead to taking a few steps back in terms of progressing with these issues. But, things are looking good with promising companies in the industry taking actions to combat the issues above. It is the nature of technology, and this is the path that we are going with the eventual automation of most daily tasks, including transportation.

What are Autonomous Vehicles?

Autonomous vehicles have been a recent topic in the news due to the boom of advancements in technology in these past decades. As it is stated in the Technopedia dictionary, Autonomous Vehicle, “An autonomous vehicle is a vehicle that can drive itself without input from a human driver. There are several levels of self-driving vehicles, depending on their level of automation. These levels have been defined by the Society of Automotive Engineers (SAE) which has set 6 of them adopted by the U.S. Department of Transportation ranging from Level 0 (fully manual) to Level 5 (fully autonomous).” Autonomous vehicles are an idea that existed long before we had the tools to bring this idea to reality but have become more popular since companies have begun testing and creating the cars.

History of Autonomous Vehicles

Autonomous vehicles have been in the sci-fi realm of media for almost a century. It became a reality in 1925 where the remote controlled vehicle called the *American Wonder* drove on Broadway in New York. From 1931 to 1949 the car was shown off throughout 37 states. It was very popular being used as a way to demonstrate road safety to the public and that their safety depended on them. From there in the 1970s big strides were made in creating an autonomous car with Sadayuki Tsugawa’s team building a vehicle the first visually guided autonomous vehicle that could process pictures of lateral guide rails on the road.

Then in 1987, Ernst Dickmanns test drove the VaMoRS; it used cameras with no GPS or radar and went at 20 mph but could go upto 96 mph. It was the first car to use a 4-D approach which added to the three dimensions and had integrated feedback of prediction errors. This gave the concept of vision based driving a boost and created new ways for autonomous vehicles to drive longer distances without human intervention. In 1995 the members of NavLab presented an almost autonomous car that used images of the road that the car stored while a driver controlled acceleration and braking. This project caused UniBmW to respond by having a fully autonomous vehicle drive with a 95% trajectory using video image processing and helping increase the use of video based direction.

The 2000’s got us closer to the idea of driverless cars to what we see now. Google announced their effort to create a self-driving car and with the help of another company Waymo it was able to have its first public trail and ask regular citizens for volunteer drivers.

The present-day application of automated vehicles

With electric vehicles at the forefront of personal travel in this day and age, companies are spending more and more on research and development on automated vehicles. All the buzz is deserved considering the way autonomous vehicles could completely revolutionize transportation and work among other use cases being developed and deployed today. Beyond civilian transportation there are many business sectors that are looking towards automated vehicles to accomplish jobs traditionally done by workers. From self driving tractors to plow fields, self driving trucks for long-haul shipping, and even drones that can deliver small consumer packages. There is no corner of the business world that isn’t looking towards autonomous vehicles as a means to advance their company. Military’s all over the globe are putting more research into autonomous vehicles than ever before, the goal being to put the least amount of citizens and personnel in harm's way as possible.

Rising tech companies in the industry

*Tesla*

By now I think it’s fair to say the most notorious company out there now for autonomous vehicles is Tesla. As of today Tesla’s autopilot feature it has available for its vehicles is the most advanced self driving technology on the market ready for consumer purchase. Tesla claims that their vehicles come with the necessary hardware needed to handle full autonomous driving in the future with continuous updates to the cars software. Full self driving for short and long distance trips isn’t available quite yet but they do plan on reaching that potential in the near future. As of now human supervision is necessary when using autopilot features. There have been many news headlines of people crashing their tesla’s while using the autopilot feature because of the lack of human supervision and in some cases people being asleep while the car is driving. This has led to government regulations being put in place to curb these incidents.

*Pony.ai*

Founded in 2016 in Fremont, California this is the most advanced automated vehicle company you’ve most likely never. Their focus is on what they call robotaxis, you can guess from the name what their company is about. Through years of testing permitted in china by the chinese government and a partnership with toyota, they launched their app in 2018, the app allows users to hail the robotaxis to act as an automated taxi service. While robotaxis are only available in Guangzhou, Beijing, Irvine, CA, and Fremont, CA. They plan on expanding in the near future.

They didn’t just stop at robotaxis though. In 2020 they formed a partnership with e-commerce platform Yamibuy to provide autonomous delivery service in Irvine, California. Not long after that in the same year they received their first license to test automated semi trucks for shipping goods in the city of Guangzhou, China. The truck testing has advanced into many more major cities in China which shows the growth and confidence China has in this company. This year the Pony.ai Autonomous Driving Controller (ADC) built on NVIDIA DRIVE Orin, is set for mass production. NVIDIA being the leading business in the chip and computer harddrive industry which means very big things for the company.

Automated vehicles in the workplace

Many companies use AI or autonomous vehicles to support the many infrastructure needs in their business. These AI and automated vehicles not only make it so project completion is more efficient but that workflow is made easier in tandem with human workers. Jobs are being completed with more accuracy due to AI help, and ability to detect deficiencies 80% more when compared to traditional manual labor. From automated vehicles that sort inventory in warehouses to self driving tractors for commercial farming. Autonomous vehicles are in every sector of the workplace.

‘Civilian consumers application

Most major players in the automotive industry have been putting money into research and development of autonomous vehicles. Tesla, BMW, Chevy, and Ford just to name a few already have autonomous capability features in their vehicles. This is making consumer life that much easier even if it is just dealing with a fraction of their life that is traveling.

Military/government application

This technology has also made military and government goals easier to obtain. Autonomous vehicles such as bomb defusal robots, Aerial attack drones, and recon drones have made it so the conventional use of soldiers for certain missions is obsolete. This changes the way military efforts can be used completely by taking the soldier out of the equation.

Ethical dilemmas

In terms of cybersecurity with the current state of the automated vehicle industry, the vehicles do not have a stand out characteristic that makes them safe. Rather, they pose a major security risk and public health hazard that can endanger the lives of the passengers and other individuals surrounding them if the vehicle were to be compromised. There have already been numerous headlines over the past few years as Tesla’s ‘Autopilot’ program had incidents where a user’s vehicle would get hacked. In certain situations, the hacker may only be able to adjust the windows or interior controls, but there have been instances where they gained control to drive the vehicle. These cases are few and far between, but still poses a major cybersecurity dilemma for engineers and security analysts to resolve. How do you keep the car secure enough to prevent common hacks while maintaining a user-friendly environment that does not become complex and confusing?Obviously implementing a system like multifactor authentication for regular use of the vehicle would make sense to cybersecurity individuals like ourselves, however many people would see this as an inconvenience to their daily routine. So, some would argue to go back to basics and use things such as a physical key to start the vehicle, like most vehicles used to be before passive key fobs. Though, hackers and thieves found a way to get into these vehicles by having several types of physical keys to run through and unlock the vehicle. With every new way of entry to accessing a vehicle, there will always be a workaround found by these individuals. So, people have to understand the consequences of using one method for their convenience. Passive keys are great because you don’t even have to pull the key or phone out to access your vehicle, but thieves can spoof the signal and steal your vehicle. There will always be vulnerabilities with these vehicles, as mentioned, it is up to the individual to decide what risks they want to take and also up to the manufacturers on how they want their vehicles to be perceived: complex & secure or simple & potentially risky?

A classic ethical dilemma that has commonly been brought up when talking about automated vehicles is the trolley problem. Say in this hypothetical situation, the vehicle is in autopilot mode and comes to a fork in the road with no way to avoid it: take a left turn where you can’t avoid a group of young children in the road and potentially end their lives or take a right turn off a cliff that would result in a fatal accident for the passengers. In a bizarre situation like this, how would the AI software onboard the vehicle be able to make a logical and ethical decision? AI software does not know moral standards or have an emotional connection, so how could it possibly make a ‘right’ decision when both end terribly? Few automotive manufacturers have answered this dilemma; infamously Mercedes-Benz came out with their solution. Christoph von Hugo, Mercedes-Benz’s Manager of Driver Assistance Systems, Active Safety & Ratings, presented the new S-Class self-driving vehicle concept at the 2016 Paris Motor Show. When asked about the trolley problem, he stated, “If you know you can save at least one person, at least save that one. Save the one in the car… If all you know for sure is that one death can be prevented, then that’s your first priority.” Not many manufacturers have answered this question, as there is no true answer to this problem. If Christoph would have said that the car would opt to save the children and not the passengers, the public would be outraged that their own M-B vehicle would sacrifice them to save bystanders. Who would buy that vehicle if they saw that statement in marketing?

Deontology perspective

According to Britannica, deontology in the context of ethics is defined as, “...ethical theories that place special emphasis on the relationship between duty and the morality of human actions.” Philosophers involved with deontology would be in the position to say that actions are considered morally good, not because of the result of said action but rather a good characteristic associated with it.

To bring this around to automated vehicles, a characteristic of the vehicle that would make it morally good is that it reduces human error. The vehicle can make more adjustments and decisions that a human could not match, adding one safer vehicle on the road. Problem is, with this methodology, it makes it hard for an AI system to make a true unbiased logical decision that will be dug further into the next section.

Teleology perspective

Teleology is defined on Britannica as, “A theory of morality that derives duty or moral obligation from what is good or desirable as an end to be achieved.” This methodology looks purely at the consequences of an action, and is understood that an ethical agent must seek the least consequential decision. Teleology is opposed to deontology, as demonstrated with the trolley problem scenario (reminder of it being one path takes out a child, the other takes out an elderly person). A Deontology view would have understanding of both possibilities as each party has individual rights and/or life ahead of them. A Teleology view or Consequentialist take would highly favor pulling the lever and hitting the elderly person as the child has potential for a longer life ahead of them, it would go against the view if they hit the child instead and the elderly person only lives for another 3 months versus seventy plus years presumably for the child. Oddly, one can perceive this view as looking at people like they have a battery life. Elderly person sits at 15%, the child at 95%. The child has plenty of charge left so it would be hurtful to them if they were not utilized over the elderly person as they are close to expiring.

The future of the automated vehicles industry

The future of Autonomous vehicles is a race to see who can get there first and who can do it the best. With both, traditional automakers and new comers all going after this goal. Nothing substantial has been announced. But from projections we know, technology is ever growing and evolving. LiDar sensors have experienced a drop in price as well as in size. And with Tesla working with Cameras and sensors, technology is becoming more readily available.

Projected future of automated vehicles in the lives of civilian consumers

While more Auto companies are investing in such projects, many have different ideas. Volkswagen is looking into subscription based service rather than owning the car. GM is looking to sell straight to the public. While Volvo is planning on fleets or to supply other competitors.

The future of automated vehicles in advanced warfare

As we get closer to Autonomous vehicles, one thing has stuck out for military uses, The security of it. Autonomous vehicles, like any other piece of computerized technology, are by definition susceptible to some degree of would-be attackers. Those attacks can potentially occur by tricking a vehicle’s cameras and sensors into veering into the wrong lane or by targeting software vulnerabilities much like one would on any other computer.

Benefits/deficits of automated vehicles

In order to understand the benefits or deficits we need to understand that we are not only comparing autonomous vehicles to human-operated vehicles. But we are also comparing them to the hypothetical existence where we want it to be. For starters let’s compare the Autonomous vehicle to a human-operated vehicle. The benefits of Autonomous vehicles are better vision of the road using sensors and cameras, reduced accidents, and it gives the disabled and people with reduced mobility to travel. The Deficits would be A huge data protection issue, High cost of vehicles, and High cost to implement it on a life scale.

For the Industry

Autonomous vehicles in industry have some different Benefits then in civilian life. Some advantages are lower labor costs, higher efficiency, and faster shipping. Some disadvantages are the cost of production, Data protection issues, and maintenance of the vehicles.

For civilian consumers

Civilian use is probably the easiest to imagine, because we already have some tools in modern cars that emulate parts of autonomy. Some benefits are reduced accidents and less traffic, safer roadways, and it’s more efficient. The disadvantages would include the cost of the cars, operation on roads with vehicles that aren’t autonomous, and data security.

Military use

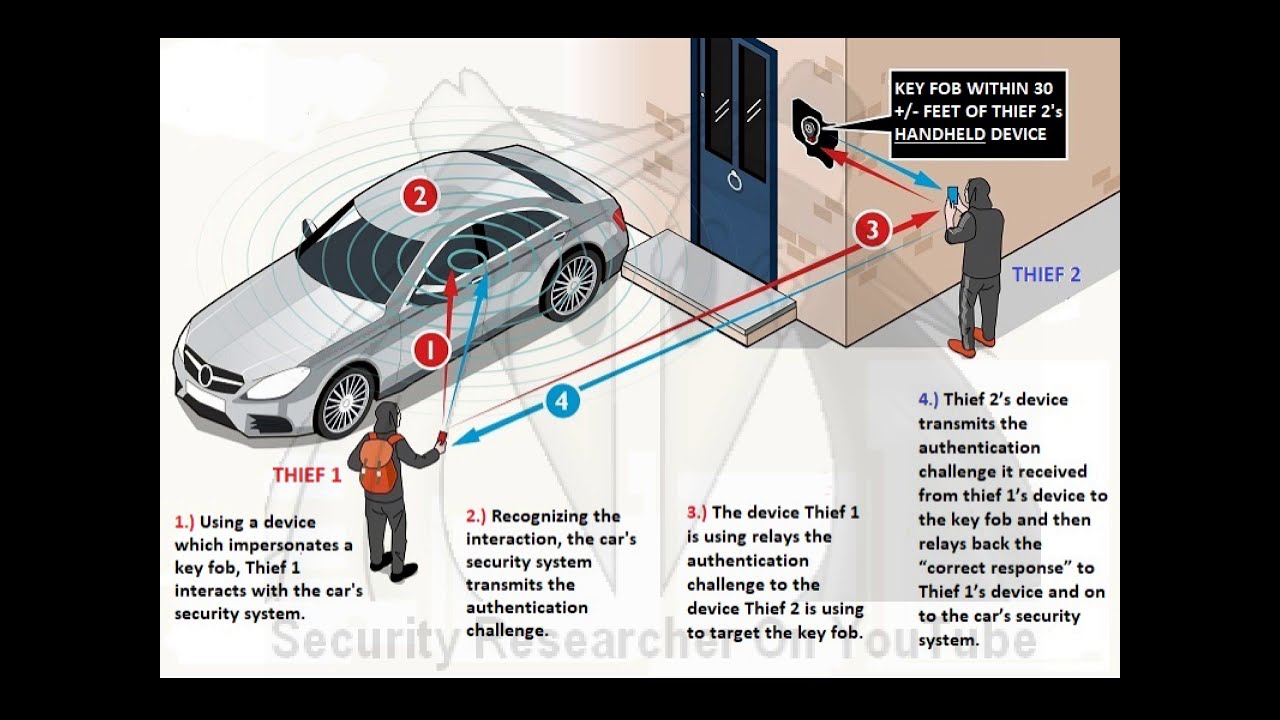
Military use is probably far more advanced than the public knows but that being said the US military has some of the most advanced autonomous vehicles in the world. Some benefits include making missions safer for humans by being able to send in an autonomous drone for reconnaissance, faster deployment of equipment and supplies, and the versatility AI operated vehicles bring to situations. Drawbacks would include issues of morality, especially speaking on the use of weapons on autonomous vehicles, the ability to manufacture these vehicles for military use in general, and data security if these got into the wrong hands.

Security Risks

With the emerging technology of automated and autonomous vehicles, major vulnerabilities have developed as well. Hackers have abused these holes in the vehicle’s security to manipulate functions of the vehicle, being as severe as taking control of the vehicle. Popular methods of hacking automated vehicles include Bluetooth or relay attacks, and data alterations.

First method is to commit a relay or Bluetooth attack, which has become more common with vehicles that feature remote keyless entry. This attack can be categorized as a man-in-the-middle attack that involves two individuals or one person with two devices. The process is described in the image below, and this attack can be completed within 60 seconds:

One thief goes to the vehicle and interacts with the security system by being in proximity, then captures the authentication challenge sent out from the vehicle. That signal is then relayed to the second thief near the key fob and the authentication challenge is transmitted to give the correct response to the first thief’s device. Once it completes, the thieves are able to get into the vehicle, steal whatever possessions are left in it, and can even start it without the key fob to steal the vehicle.

This attack happens due to the nature of Bluetooth technology. Compared to key fob systems back in the day, the old signals generated were at 315mHz and would generate different patterns (rolling codes). With Bluetooth technology, the frequency emitted by the vehicle constantly changes every 100 milliseconds. This does make it more difficult for thieves to easily steal your vehicle, however when the right software is deployed and used by thieves, they can spoof your key fob or smartphone’s signal within 15 seconds to steal your vehicle.

Another method of attack used involves altering the real-time data logged by the onboard AI system. This includes re-formatting the video files of real-time recording to throw off the sensors of the vehicle. Also, hackers can delete frames in those video files at various intervals to cause the AI system to have interrupted signals.

In the past, replay attacks were a problem for turn-key ignition style vehicles. Similar to a relay attack, the thief would capture the outgoing signal from the key fob when a button was pressed and then could replay the signal to unlock the vehicle. However, automotive manufacturers had a system in place to prevent this from happening: rolling codes. Every time that the key fob is pressed, a new signal is created, thus making a recorded signal impossible to use on the vehicle.

Praise of benefits and proposal to problems for automated vehicles in society

Automated vehicles have many benefits to society. The physically diabled and the elderly would gain the most from the ability to use an autonomous car. The blind can finally use transport and travel without issue or stress, as well as people who may not be able to use their limbs will no longer have to operate certain parts. The elderly face similar issues as the physically diabled and might have the same issues from.

Some solutions for the problems that may arise from autonomous vehicles though, include the ethical analysis of what should the robot do to benefit the human. A proposal to this problem is just that, the robot should help the human. Continue the research and development of autonomous vehicles so that they serve and benefit humans in completing tasks that would otherwise be too difficult. This, rather than the alternative of the autonomous vehicles replacing the humans all together, whether it is in the workplace or on the road. Many of the problems that arise from autonomous vehicles arise from the lack of human intervention, as seen when cars do not stop for people because it cannot sense they are there in some cases. Make it so that they work independently, under human use, so that the task is being completed with the assistance of an autonomous vehicle, rather than the replacement of a human.

Ethical importance of the knowledge of automated vehicles in society’s future

Ethical Importance of the knowledge of automated vehicles stands under our knowledge of human development. As automated vehicles evolve we must understand they will evolve to fulfill the needs of humans, and by understanding how humans focus their needs-based approach to solutions, we can peek into the future of what automated vehicles may look like. Automated vehicles affect our everyday lives, and will only continue to do so in the future, therefore a universal understanding will make it easier to implement solutions to problems that may arise, morally, and ethically. As we explore and circulate knowledge of ethical dilemmas that may be presented when dealing with autonomous vehicles, we can further the conversation of what to do when those dilemmas come into play with reality. It’s through researching the consumer market, industrial infrastructure, and military war effort that we are able to see the benefits and deficits of the advancement of autonomous vehicles.

**Bibliography (MLA9 Citations)**

Boyd, Christopher. “Car Owners Warned of Another Theft-Enabling Relay Attack.” *Malwarebytes Labs*, 17 May 2022, <https://blog.malwarebytes.com/hacking-2/2022/05/car-owners-warned-of-another-theft-enabling-relay-attack/>.

Breunig, Matthias, et al. “Building Smarter Cars with Smarter Factories: How Ai Will Change the Auto Business.” *McKinsey & Company*, McKinsey & Company, 13 Feb. 2020, <https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/building-smarter-cars>

Dans, Enrique. “The Future of Autonomous Vehicles: Product or Service?” *Forbes*, Forbes Magazine, 29 June 2021, <https://www.forbes.com/sites/enriquedans/2021/06/11/the-future-of-autonomous-vehicles-product-orservice/?sh=e6acae15892f>.

“Deontological Ethics.” *Encyclopædia Britannica*, Encyclopædia Britannica, Inc., 20 July 1998, <https://www.britannica.com/topic/deontological-ethics>.

Orlove, Raphael. “Mercedes Decides Who an Autonomous Car Should Save and the Answer Is Worrying.” *Jalopnik*, Jalopnik, 13 Oct. 2016, <https://jalopnik.com/mercedes-decides-who-an-autonomous-car-should-save-and-1787749419>.

Rathore, Abhimanyu. “Autopilot Applications for Autonomous Vehicles.” *Electronics For You*, EFY Group, 5 Aug. 2021, <https://www.electronicsforu.com/market-verticals/autopilot-applications-autonomous-vehicles>.

Reiser, Anya. “History of Autonomous Cars.” *TOMORROW'S WORLD TODAY®*, 24 June 2022, <https://www.tomorrowsworldtoday.com/2021/08/09/history-of-autonomous-cars/>

“Teleological Ethics.” *Encyclopædia Britannica*, Encyclopædia Britannica, Inc., 24 Apr. 2008, <https://www.britannica.com/topic/teleological-ethics>.

“The Pentagon's Long Road to an Army of Autonomous Vehicles.” *Gizmodo*, 7 Apr. 2022, <https://gizmodo.com/the-pentagons-long-road-to-an-army-of-autonomous-vehicl-1848761669>

Weiler, Reed. “Artificial Intelligence and Ethics: An Exploration of Machine Morality.” *The World Mind*, The World Mind, 11 Mar. 2020, <https://www.theworldmind.org/home/2019/4/26/artificial-intelligence-and-ethics-an-exploration-of-machine-morality>.

Fabian, Kroger.”Automated Driving in Its Social, Historical and Cultural Contexts.” Autonomous Driving, Springer Berlin, Heidelberg, 22 May 2016

<https://www.researchgate.net/publication/303480861_Automated_Driving_in_Its_Social_Historical_and_Cultural_Contexts>