To what extent will different factors such as ethical programming and cyber security affect the development of self-driving cars?

Introduction:

This project will evaluate the extent to what extent different factors will affect the development of self-driving cars. I plan to find out more about the possible threats to these new kinds of vehicles and what technologies are being tested to enable them to be used on public roads. I will use a diverse mixture of sources of information, such as websites, written papers, television programmes and my own questionnaire to learn more about this topic and allowing me to gain a better understanding of the key aspects of self-driving cars. I received 101 responses to my questionnaire, within a five week period after it was first sent out, giving me sufficient information to analyse for the ten questions included. To ensure that this written report is easy to follow, I will write a brief introduction to the topic, followed by five subtopics explaining different aspects that could influence the development of such vehicles, and I will finish with a conclusion, summarising the points to answer my question.

Brief introduction to topic:

In recent years, the automotive industry has been investigating new technologies that could be used within vehicles that would mean no driver is required to control the vehicle. A self-driving, driverless or autonomous vehicle is one which is completely controlled by an on-board computer system[1], and these often gather information through the use of multiple sensors and GPS technology. Technology is becoming increasingly powerful, getting ever closer to taking over the most complex human activities such as driving. Although, as these computer systems evolve, they will inevitably cause rise to new vulnerabilities on the road, such as the potential for hacking and system failure. In addition to this, it is a known fact that 'computers like rules'[2] giving clear indications as to what should happen in any given scenario, yet it would not be possible to program an autonomous vehicle with possibilities for countless scenarios, and as a result of this other options will need to be considered. With the race underway to create roadworthy autonomous vehicles and make them available to the public, many companies have begun developing their own driverless cars, including established car manufacturers and technology giants such as Samsung, Volkswagen, Uber, Apple, Intel, BMW, Audi, Google, Tesla and Ford[3]. However, there are various factors that could hold back their widespread adoption, such as concerns about the ethics upon which the systems would be based. There were also a variety of potential issues voiced within the questionnaire including safety controls, technical faults or malfunctions leading to crashes, and interaction with non-driverless vehicles e.g. bikes. This may be due to news articles detailing only the flaws and drawbacks within current prototypes of these vehicles which can lead to people being unable to see the benefits that they could bring, and the many successes of large companies trialling such vehicles. Factors like these will need to be thoroughly investigated during testing, with evidence to reassure the public that such concerns do not need to be upheld. For self-driving cars to be used by anyone on public roads, some changes to the law will need to be made in order to determine where the

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[1] "Self-driving cars will need people, too - The Conversation." 29 Apr. 2015, http://theconversation.com/self-driving-cars-will-need-people-too-39835

[2] "Helping autonomous vehicles and humans share the road." 15 Nov. 2016, http://theconversation.com/helping-autonomous-vehicles-and-humans-share-the-road-68044

[3] "Companies working on driverless cars - Techworld." 26 Nov. 2018, https://www.techworld.com/picture-gallery/data/-companies-working-on-driverless-cars-3641537/

liability lies in an accident involving a self-driving car, as well as new insurance policies being produced to insure these new kinds of vehicles. Several other industries may also be heavily affected by these dramatic changes, in particular the taxi and public transport industries where employment may become unnecessary as travelling in a car would most likely no longer require a driving license. As these factors become more apparent, they will undoubtedly cause questions to arise about the feasibility of developing these vehicles to the satisfaction of the general public.

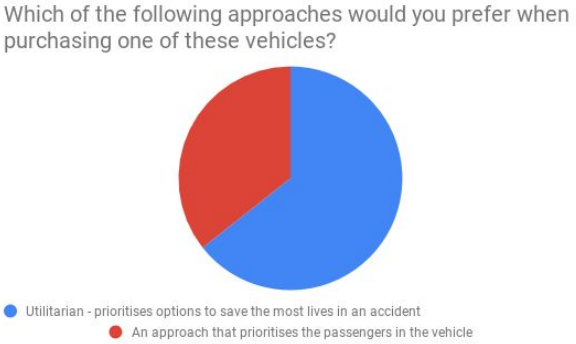
1. Ethics:

Ethical programming is a philosophy taken on by programmers whereby they commit to producing code that is morally acceptable[4]. With the latest advancements in driverless car technologies, systems that will make effective decisions in any kind of scenario are in high demand, meaning that various principles need to be established in order to allow programmers to work on the basis of these complex systems. The ethics upon which these new vehicles are based is anticipated to be one of the greatest holdbacks to the development of self-driving cars.

In order to make this process less complex, a set of ethical rules have been implemented in Germany about how autonomous vehicles should be programmed. The German Ethics Commision on Automated Driving created a report about automated driving which outlines the "technological advances being made to increase automation in cars to make them safer and to reduce accidents"[5], although it acknowledges that it would be impossible to prevent accidents completely. The report consists of 20 guidelines for the motor industry to examine, and this has set a standard for the rest of the world to follow after the German cabinet adopted these guidelines, making the German government the first one to do so. These guidelines suggest that humans should be prioritised over animals and property in any scenario where an accident is unavoidable, and there should be no discrimination involved in the decision. This would make the 'Trolley Dilemma' (an example in which a trolley is travelling at speed down a track towards a group of people and there is the option to move the trolley to a different track where there is a different group of people)[6] irrelevant as this approach considers all humans to have the same worth in any situation, meaning that it is vital for decisions to be made during the programming of the software of "conditionally and highly autonomous driving systems". It is also recommended that the human passenger travelling in such a vehicle should be able to take over in situations where the system is unable to make a decision. These guidelines are due to be reviewed in two years, and German policies on the matter will be updated accordingly.

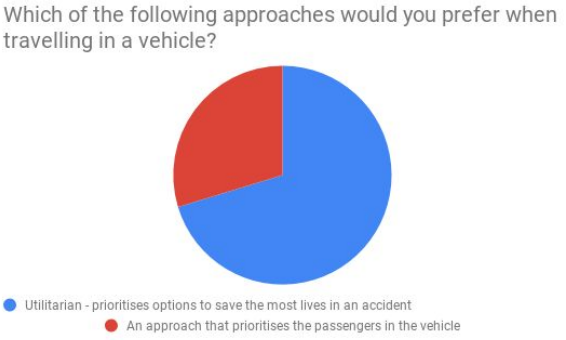
Ethical decisions such as those required to program an autonomous vehicle cannot be made by an individual alone as in any circumstance there will always be differing opinions. 'The Moral Machine' was set up as part of a research study at the MIT media lab and this shows participants scenarios in which they must choose the lesser of two evils[7], and the data collected is being used to influence decisions made by the technologies by evaluating human preferences in situations that are likely to cause disagreement.

When asked about which approach someone would prefer when travelling in a vehicle, such as in a taxi scenario, 70.3% of people said that they would rather a utilitarian approach that prioritises options to save the most lives in an accident over an approach that prioritises the passengers in the vehicle. This shows that the majority of people would not expect a vehicle that



[4] "Ethical issues for IT security professionals | Computerworld." 2 Aug. 2005, https://www.computerworld.com/article/2557944/security0/ethical-issues-for-it-security-professionals.html
[5] "Germany is working on a code of ethics for driverless cars - Business ...." https://www.businessinsider.com/germany-is-working-on-a-code-of-ethics-for-driverless-cars-2017-9
[6] "Helping autonomous vehicles and humans share the road." 15 Nov. 2016, http://theconversation.com/helping-autonomous-vehicles-and-humans-share-the-road-68044
[7] "Moral Machine - MIT." http://moralmachine.mit.edu/

they do not own to prioritise themselves. However, only 64.4% of people said that they would prefer a utilitarian approach when purchasing one of these vehicles and these results are in line with research conducted by academics looking into the approaches that human drivers prefer and subcounsciously apply within their driving[8], and this is often because humans do not want their own belongings to prioritise someone else's life above their own or their family's lives. In a similar question, only one respondent believed that such a system would prioritise vulnerable people in an unavoidable accident, showing that the general public expect these new kinds of vehicles to consider all humans equally.



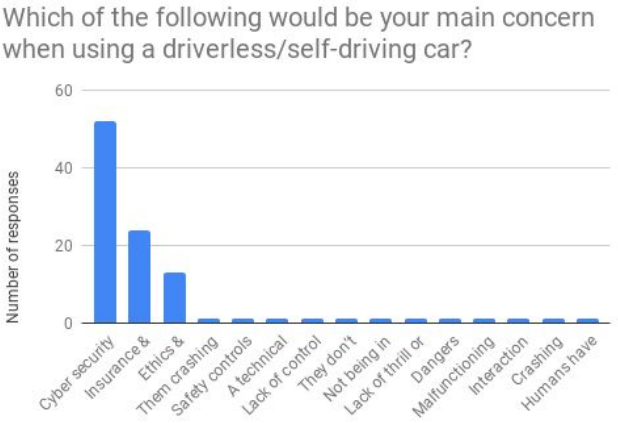
The ethics of autonomous vehicles is undoubtedly one of the most significant threats to their manufacture as the systems need to be designed in a way which allows them to make morally acceptable decisions as well as being suitably transparent to ensure members of the public will invest their trust in the vehicles.

[8] "The social dilemma of autonomous vehicles." 12 Oct. 2015, https://arxiv.org/abs/1510.03346

2. Cyber security and connectivity:

Increased levels of automation will require the introduction of intelligent systems to create the basis for fully autonomous vehicles. One way of doing this may be through the connectivity of all road users and most likely pedestrians too. As systems become more complex, flaws begin to arise and extensive measures will need to be put in place to guarantee the cyber security of all structures controlling and supporting self-driving cars.

Wireless communication has already become a large part of everyday life and could soon be used to make roads safer. If all road users (or at least their software) were able to interact with one another then vehicles would have the power to predict the movements of nearby traffic and alter their decisions accordingly[9]. For example, if car's system anticipated that a car several metres ahead was about to break suddenly, it could control its decision process to ensure an accident did not occur by slowing down as soon as this other action was detected. In an article written by a professor at the University of Michigan, the author explained that "autonomous vehicles that aren't connected to each other is a bit like gathering together the smartest people in the world but not letting them talk to each other". This highlights the notable benefits that could arise as a result of greater connectivity on our roads, and this is evident as the UD Department for Transportation has suggested that it may require all new vehicles to be ready to use vehicle-to-vehicle (V2V) technology, which is expected to prevent up to 80% of road traffic accidents not caused by a driver under the influence of either drugs or alcohol.[10]



The main concern that people anticipate that they will have when using a driverless/ self-driving car is cyber security (e.g. hacking), with 51.5% of respondents choosing this. The security systems for driverless cars are still in the early stages of development, and there is insufficient information available to the public about the types of security that are likely to be implemented, and this is anticipated. However, in recent years there has been a rise in cyber security related car thefts. This is largely due to the use of radio-frequency identification (RFID) technology in modern cars, as this makes it possible for someone gain access to a vehicle in under twenty minutes by standing within about a metre of the key (containing and RFID transponder) and using a laptop to transmit signals to activate the chip within the key, followed by a process of receiving and decrypting the code[11]. This is a major flaw in the movement to digital technologies within the automotive industry and this is a problem that still occurs.

For driverless vehicles to operate optimally, each one will need to collect colossal amounts of data in relation to its surroundings, and this could be a potential privacy issue as this would leave more data open to theft, and it would be practically impossible to ensure that the

[9] "Self-driving cars could be the answer to congested roads." 21 Nov. 2014, http://theconversation.com/self-driving-cars-could-be-the-answer-to-congested-roads-33438
[10] "Saving lives by letting cars talk to each other - The Conversation." 11 Sep. 2016, http://theconversation.com/saving-lives-by-letting-cars-talk-to-each-other-59221
[11] "Are RFID ignition systems secure? - Electronics | HowStuffWorks." https://electronics.howstuffworks.com/gadgets/automotive/rfid-ignition-system2.htm

permission of any person seen by sensors or captured in an image was received before the data is collected and stored. However, this could also reap significant benefits, such as to the police force as such information could be retrieved from vehicles that may have been in a certain area at the time of road traffic accident or other offence, and therefore they would no longer need to rely upon video footage being submitted by members of the public.[12] Additionally, any pieces of software will always be vulnerable to malicious attacks if harmful technologies were to fall into the hands of unlawful citizens, as there is always a potential for misuse. As a result of this, self-driving cars are likely to be more at risk as they are expected to be networked with other road users and pedestrians to make the driving environment safer, but this could have the opposite effect if malfunction occurs within the system of even one vehicle, or if the cyber security is compromised.

Cyber security is anticipated to impede the development of self-driving vehicles to a great extent, and even once a secure system is established it will require extensive work to uphold the security and prevent malicious attacks from causing potentially life-threatening accidents from taking place on public roads.

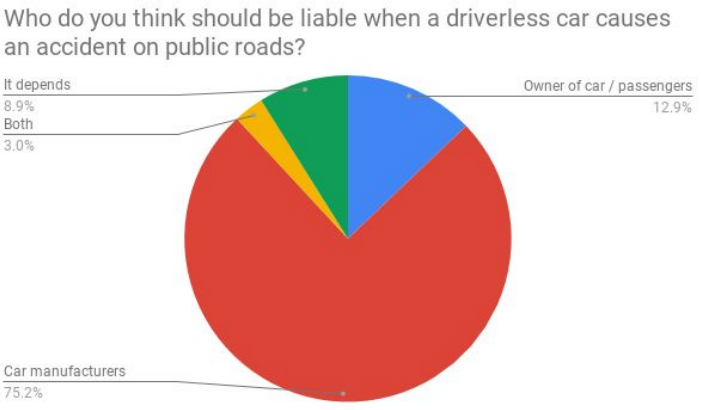
[12] "We're only just starting to understand the side-effects of driverless cars." 4 Aug. 2015, http://theconversation.com/were-only-just-starting-to-understand-the-side-effects-of-driverless-cars-45342

3. Insurance, law and liability:

In the US, current laws state that if a vehicle is involved in an accident and the 'driver' (or person in the driver's seat) does not have their hands on the steering wheel then they are liable for any damage that it may cause, even if the vehicle was in an autonomous mode at the time of the accident. However, UK law is different as the Road Traffic Act of 1998 states that drivers are simple expected to pay due care and attention. As a result of this, the UK Department for Transport (DfT) suggests that the liability for autonomous vehicles will most likely lie with the manufacturer of the car, unless the driver has regained control (and therefore the vehicle is not travelling in an autonomous mode), in which case the driver would be responsible.[13]

The first stage of this lengthy process would be determining whether the vehicle was in full-automation at the time of the accident. With the suggestion of implementing a system with varying levels of automation, such as the SAE one with a proposed six levels from none to full automation, this would be vital in determining where liability lies. Further complications will arise during the handover period in which the driver regains control of the vehicle and the system is not being used, so the vehicle is not operating autonomously. This would need to be an extremely swift process to ensure clarity of what or who is operating the vehicle at any given time. This may require a similar system to the black boxes used in aeroplanes to identify the events that occurred momentarily before the accident happened.

Currently, it is believed that one of the main causes of 'death by driverless car' is if a car's sensors were to incorrectly interpret data received. If the network of sensors implemented into the vehicle were unable to distinguish between roads and pavements for example then the onboard computer would inevitably make a poor driving decision. If, after extensive investigations, an accident causing injury or death is found to be due to a system fault or error then an additional issue is uncovered as to who should pay compensation to the crash victim. At the present time, victims are able to claim compensation from their insurance company, who often recover their losses by pursuing their own case against the manufacturer of the vehicle, such as in the instance of a gearbox fault. However, if the driverless vehicle involved had been hacked prior to the accident then determining liability in this situation would be increasingly difficult.



A staggering 75.2% of people believe that the liability should lie with the car manufacturers when a driverless car causes an accident on public roads, and this is information that will need to be collected on a considerably larger scale in order to set out clear guidelines on which parties should be liable, however 10 respondents stressed that this would be extremely difficult to determine as it would require a very broad generalisation, and that instead the liability should depend on the individual circumstances of each accident. If the government were to decide that liability

[13] "Death by Driverless Car: Who's to blame when ... - Trusted Reviews." 20 Mar. 2018, https://www.trustedreviews.com/news/driverless-car-deaths-insurance-blame-uber-tesla-2945865

should not solely be with the car manufacturers then this would need to be outlined within the End-User License Agreement (EULA).

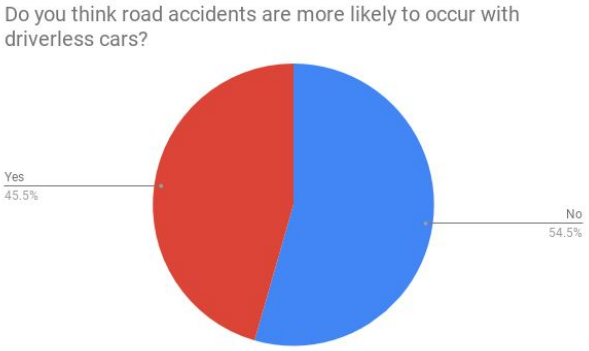
One possibility that could reap extensive benefits in regard to the law is the introduction of RFID readers into self-driving cars. If public roads were fitted with RFID transponders, these could cause the vehicle to carry out a certain action. For example, as the car approaches a junction, there could be an RFID transmitter to force the car to slow down as it receives the signal, before it reaches the junction. This would reduce cases of avoidable accidents due to drivers not abiding the law, as this would not be possible. Furthermore, the use of RFID technologies could simplify arguments in regard to liability when a self-driving vehicle causes an accident, as there would be a significantly smaller chance of complete system failures as the RFID transmitters could be passive, relying on the readers for power.

Insurance, law and liability as a collective will have unquestionable effects on the development of self-driving vehicles as changes in legislation will need to take place before large scale manufacturing can begin, and this is likely to be a drawn-out process in which members of the automotive industry will need to effectively communicate with lawyers and other professionals to establish clear guidelines, particularly in relation to where liability will lie in an accident caused by a self-driving vehicle.

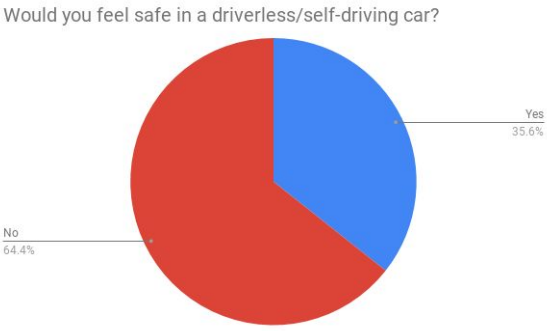
4. Lack of information and transparency:

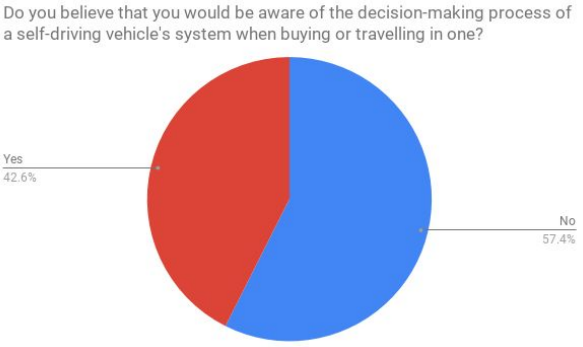
Currently, there is a general lack of information and transparency in relation to the development, successes and failures of self-driving vehicles. This is most likely due to manufacturers and technology creators trying to protect their findings until they have been implemented in order to prevent them becoming openly available to competitors in the field.

It seems that members of the public are generally uninformed about the possible advantages of these new types of vehicles, as 45.5% of people that completed the questionnaire believed that road accidents would be more likely to occur with driverless cars, although they are in fact expected to prevent up to 90% of road traffic accidents on our roads every year[14]. At present, there are over 30,000 deaths on US roads every year (nearly 100 per day) and this figure is thought to be increasing[15]. The widespread introduction of autonomous vehicles could reduce over a million deaths annually on the world's roads, and this would be a significant minimisation in the death toll.



Unsurprisingly, the majority of respondents (64.4%) said that they would not feel safe in a driverless/self-driving car and this is most likely due to the lack of information about their development and the technologies that are being created. This lies close to the results of a survey conducted in March 2018 when 3 out of 4 US drivers stated that they were afraid of riding in self-driving cars[16], drawing attention to the lack of communication about the successes and potential of these vehicles. In addition to this, members of the public have varying expectations in regard to the transparency of the programming of these systems as 57.4% of respondents did not believe that they would be aware of the decision-making processes of a self-driving vehicle's system when either buying or travelling in one. This highlights the need for more information to be made available in order to increase the confidence in these new technologies.



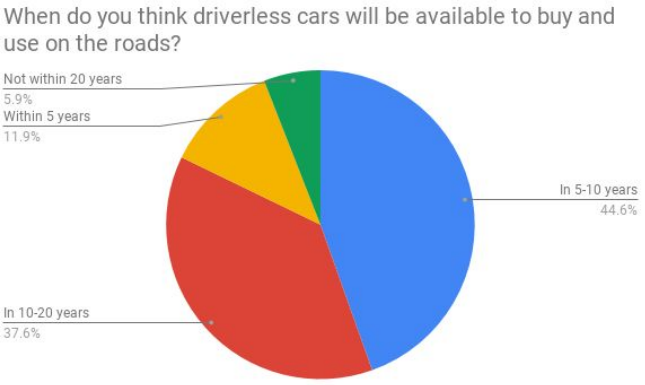


It is important to consider risk heuristics and algorithm aversion when evaluating transparency, as the novelty of autonomous vehicles will result in overreactions to accidents, risking the slowing or stopping of the adoption of such vehicles, unless the public are are

[14] "We're only just starting to understand the side-effects of driverless cars." 4 Aug. 2015, http://theconversation.com/were-only-just-starting-to-understand-the-side-effects-of-driverless-cars-45342
[15] "After fatality, autonomous car development may speed up." 7 Aug. 2016, http://theconversation.com/after-fatality-autonomous-car-development-may-speed-up-63488
[16] "Death by Driverless Car: Who's to blame when ... - Trusted Reviews." 20 Mar. 2018, https://www.trustedreviews.com/news/driverless-car-deaths-insurance-blame-uber-tesla-2945865

prepared for the inevitable and receive open communications of algorithmic improvements. Moreover, pervasive media coverage of crashes involving or due to self-driving vehicles could intensify fears and this relates to the availability heuristic, where risks are subjectively greater when they easily come to mind, as well the affective heuristic, in which risks are seen to be greater when they arouse an intense emotional reaction[17]. This could have a considerable effect on the development of these vehicles as their rate of advancement would decrease if members of the public were unwilling to adopt the new technologies being used. However, it has been suggested that serious accidents caused by self-driving vehicles would not always result in a slowing of development as they could instead spark a potential for improvement and effectively highlight areas of weakness within the systems.

Furthermore, the general public are unaware of when driverless cars are likely to become available to buy and use on the roads, with 44.6% of respondents to the questionnaire expecting this to be in 5-10 years, and 37.6% believing that it would be in 10-20 years time. Although no one truly knows when these will become available for public use, these results suggest that most people do not believe that we currently have the technology to begin large-scale production of autonomous vehicles, despite plans for them to begin testing on UK roads in 2019[18].



In summary, the apparent lack of information and transparency about self-driving cars and the technologies being used will have a serious effect on the development of these vehicles, although this will be one of the simplest hindrances to eliminate if the general public are provided with a greater understanding of the principles upon which self-driving vehicles are based.

[17] "Psychological roadblocks to the adoption of self-driving vehicles" 2017, http://rdcu.be/vKrb
[18] "Self-driving cars could be the answer to congested roads." 21 Nov. 2014, http://theconversation.com/self-driving-cars-could-be-the-answer-to-congested-roads-33438

5. Case studies:

Two of the main companies currently making significant advancements in the development of their self-driving vehicles are Google (or Waymo) and BMW.

Google began creating their first autonomous vehicle in 2009 and they have continued working towards their original aims of making public roads safer[19]. In 2012, Toyota Prius cars using this technology were able to drive more than 300,000 miles of freeways autonomously and as a result of this success, more focus was put into navigating complex city streets[20]. In 2015, Google's Firefly car became the world's first fully self-driving vehicle on public roads. The Firefly had no steering wheel, pedals or driver,and comprising of custom sensors and computers to control steering and braking. In 2016, this project was rebranded as Waymo, a new self-driving technology company, and they have since introduced fully autonomous minivans. These vehicles are undergoing continuous testing on US roads with no one in the driver's seat.

New self-driving software implemented into Waymo's vehicles operates in three main stages; perception, behaviour prediction and planning. This allows the vehicle to identify and interpret the actions of objects around it, and hence lessening the potential of unethical programming, as the system is able to make its own decisions based on each particular scenario. However, software of this level requires a greater level of security to minimise the effect of system failures or attacks. To ensure the reliability of their self-driving software, Waymo have created redundant systems for major safety-critical components, including braking, steering and collision avoidance, as well as a secondary computer system which runs in the background in case the first system fails.[21]

Waymo have made significant attempts to reduce the effect of factors such as ethical programming and cyber security on the development of their self-driving vehicles, through extensive testing and simulations in order to produce a dependable system which could be used to make this technology safer and save thousands of lives currently lost due to road traffic accidents on the world's roads.

The development of Waymo's fleet of self-driving vehicles was a long process, requiring in-depth research and analysis of test performances by specialist teams. During this evolution, factors such as ethical programming and cyber security were thoroughly investigated and at times hindered progress. Formerly Google's self-driving car project, Waymo have a significant advantage in terms of ensuring cyber security and data integrity as this is a task which their teams will already have experience and information readily available. In addition to this, having links to a large company, Waymo will be able to consider the most suitable approach to programming these new vehicles in order to make it possible for the car's systems to interpret data it receives on a huga scale. Since 2009, Google and now Waymo have faced difficulties of varying degrees in relation to the ethical programming and cyber security of their vehicles, and although this has affected their development, it has not prevented it.

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[19] "Google's self-driving car: How does it work and when ... - The Guardian." 28 May. 2014, https://www.theguardian.com/technology/2014/may/28/google-self-driving-car-how-does-it-work

[20] "Boys and their toys: a crash course in driverless cars - The Conversation." 19 Jul. 2011, http://theconversation.com/boys-and-their-toys-a-crash-course-in-driverless-cars-2319

[21] "Waymo." https://waymo.com/

Similarly, the car manufacturers BMW have begun creating their own driverless car, and in doing this they have set out a clear path to autonomous driving. Experts at BMW have detailed five levels of increasing automation that they will use to base their systems upon. Level 1 is described as driver assistance, where systems support the driver but do take control of the vehicle, and full automation is reached at level 5 where the vehicles manages all driving functions and anyone within the vehicle is seen as a passenger. Engineers are currently in the process of testing levels three, four and five, however all BMW models have the use of level 1 automation included and many of these also extend to level 2.

Under BMW's proposed full automation (level 5), passengers within the vehicle will not need to own a driving license and the car will perform all tasks unaided by the passengers. During its early stages, such vehicles will only drive at comparatively low speeds in highly populated areas to allow the vehicle to process information gathered through its sensors.[22]

Factors such as ethical programming and cyber security have been thoroughly investigated by teams at BMW in order to produce prototype vehicles that are able to deal with changing scenarios. It will be vital that these strategies are implemented gradually to evaluate the effects of any potential beaches in cyber security.

[22] "Autonomous driving – 5 steps to the self-driving car - BMW.com." https://www.bmw.com/en/automotive-life/autonomous-driving.html

Conclusion:

Minor factors:

Numerous factors will have an effect on the development of self-driving to varying extents, including less prominent factors such as heuristics and employment. Risk heuristics are important to consider as these relate to the way in which members of the public will react to self-driving vehicles, and ultimately this could prevent the adoption of the vehicles if the availability and affective heuristics are no considered in sufficient detail. In addition to this, media coverage of developmental failures within the automotive industry could lead to a lack of trust in these new systems, therefore highlighting the need for the media to fairly portray both the successes and inevitable failures within the process of creating fully self-driving cars. Similarly, it is essential that statistics are not misleading to readers as over the past 15 years in Britain, more than 800,000 people have lost their jobs due to technology, however advancements in technology have also created 3.5 million new jobs[23]. This is particularly relevant as the widespread introduction of driverless vehicles is anticipated to first be in the transport of people and good, significantly reducing the need for lorry and taxi drivers, however this will also require more people to maintain the systems being used. Therefore, seemingly minor factors such as heuristics and employment will still somewhat affect the development of self-driving vehicles.

Ethics:

Ethics is another factor which is predicted to significantly impact the development of these vehicles. The basis of self-driving vehicles is the technology which upholds them, and for this to be finalised, there are several moral questions which must be answered in order to create a set of ethics to be implemented within them, such as those in Germany. Until clear guidelines have been established, the programs needed to run these autonomous vehicles cannot be completed, and this will greatly hold back their development. However, there is unlikely to be simple answer to the moral dilemma surroundings the ethics of these vehicles, as the general public are undecided on their expectations of the type of approach that should be put into action. Furthermore, regardless of the decisions reached in relation to ethics, there will inevitably some groups of people who are unsatisfied, and any public protests as a result of this could further impact the development of such cars. Overall, ethics will have a serious impact on the development of self-driving vehicles, and this will become increasingly so the longer that ethical questions remain unanswered.

Cyber security and connectivity:

Cyber security will undoubtedly have an affect on the development of autonomous vehicles, and this is likely to be a complex issue to solve. Due to the nature of these vehicles and an understandable need for connectivity, they will be susceptible to malicious attacks and technology like this could be devastating if these unlawful attempts were successful. As connectivity becomes typical in these cars, any threat to one autonomous system will quickly become a threat to thousands of connected and networked systems, and this could cause large scale traffic jams or accidents. Moreover, the vast amounts of data required to allow optimal performance from self-driving cars will need to be safely transferred between systems, and this will need to ensure that the possibility of interceptions of data are minimal. In summary, cyber security will affect the development of autonomous cars, as the systems will need to be

[23] "Guy Martin vs the Robot Car - Channel 4." 26 Nov. 2017, https://www.channel4.com/programmes/guy-martin-vs-the-robot-car

rigorously tested before implementation is possible, and this will be a huge part of the ongoing development and attempts to improve such vehicles.

Insurance, law and liability:

Insurance, law and liability are factors which will collectively impact the development of self-driving vehicles. In order to reduce this impact, it is likely that new laws will need to be passed and clear guidelines will need to be set so that all users are aware of where liability lies if a self-driving car was to cause an accident on public roads. These factors will affect development due to limitations that they place on testing as current laws need to be abided by when testing takes place on UK roads. However, insurance, law and liability will have a greater influence over when these vehicles can be produced for sale and use. If these problems are resolved in the near future, then such vehicles will be able to be available to businesses and then members of the public in turn. Therefore, insurance, law and liability will have a more serious effect on the introduction of self-driving vehicles to public roads than to the development of self-driving vehicles.

Lack of information and transparency:

A lack of information and transparency in regard to self-driving cars will significantly affect the development of such vehicles, as the public are unaware of the many benefits that they could bring. This issue can be addressed easily by providing members of the public with sufficient information in regard to the current developments, successes and failures of self-driving cars. If different parties involved in the development of these autonomous vehicles were to do this, then it can be anticipated that the public will be more comfortable with the transition to autonomous cars. A lack of information and transparency will hinder the development of these vehicles and manufacturers will not want to put large amounts of money into projects that are unlikely to be successful. However, these factors are also more likely to affect the prevalent adoption of these projects due to a lack of understanding from people. For this reason, a lack of information and transparency will have a lesser effect on the develop of self-driving vehicles compared to the effect on the adoption of them.

Overall conclusion:

There are many factors which will affect the development of self-driving vehicles to varying extents. The ethics and cyber security surrounding these cars will have a comparatively larger effect on development than insurance, law and liability, and a lack of information and transparency. Overall, ethics will have a significant effect on the development of self-driving vehicles along with cyber security to a certain extent.