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Autonomous Vehicles

Regulation in Germany and the US and its impact on the German car industry

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Description and Abstract

Abstract

Autonomous driving is emerging fast in our society, and thus, we are observing more and more car models using autonomous or automated features to support the driver and to create a more safe and relaxed driving experience. But with all the advantages of relieving the driver, who is responsible if the vehicle is involved in a crash?

After explaining what are autonomous vehicles, and highlighting what problems and opportunities they are generating, the civil liability in Germany, especially under the new amended Road Traffic Act, and in the US will be presented and subsequently analysed. This paper is going to compare further civil regulation by means of different approaches within the legal systems of Germany and the US and will conclude with an overview on the impact on Germany's car producing economy and how its investment flows are influenced by the recent law concerning this evolutionary technology in mobility.

Research question

How is Germany legally prepared to remain as one of the leading automotive industry business locations considering the evolutionary development in autonomous driving vehicles? A comparison between German and US civil law on autonomous vehicles.

Specifically, this work questions the different risk management of Germany and the USA based on the comparison between the civil liability systems and regulations concerning autonomous vehicles of the USA and Germany. The amendment of 2017 in the German Road Traffic Act is examined in order to investigate if Germany is legally prepared for the self-driving car evolution in their economy, industry, society and legal system. Finally, the competitiveness of Germany in terms of the regulation and its impact on the German car industry is investigated.

Keywords

Autonomous vehicles, self-driving cars, driver-less cars, Vienna agreement on road traffic, traffic law liability, product liability, data protection, algorithmic bias, automotive industry, German car business location

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Table of abbreviations/glossary

AI ....Artificial intelligence
AV ....Autonomous vehicle
BGB ....Bürgerliches Gesetzbuch/German Civil Code
BMW ....Bayerische Motoren Werke Aktiengesellschaft
Delaware-Effect ....Race to the bottom and natural selection on the most attractive law by having different state methods in one country, a reason for disharmony of law in one closed system.
ECPA ....Electronic Communications Privacy Act
FCA ....Federal Communications Act
GB ....Gigabyte
GDP ....Gross domestic product
GDPR ....European General Data Protection Regulation
GG ....Grundgesetz/German Constitution
HGB ....Handelsgesetzbuch/German Commercial Law
KPMG ....Klynveld Peat Marwick Goerdeler co-operative
MaaS ....Mobility as a service
NHTSA ....National Highway Traffic Safety Administration
OEM ....Original Equipment Manufacturer
ProdHaftG ....Produkthaftungsgestz/Product Liability Act
StVG ....Straßenverkehrsgesetz/Road Traffic Act
StVZO ....Straßenverkehrszulassungsordnung/Road Traffic Licensing Act
UN ECE ....United Nations Economic Commission for Europe
Upfitter ....A person or undertaking, which attaches hard- or software based on a usual car but is different from the car producer.
US DOT ....Federal Department for Transportation of the United States of America
V2I ....Vehicle to item communication
V2V ....Vehicle to vehicle communication
VW ....Volkswagen Aktiengesellschaft
ZF ....ZF Friedrichshafen Aktiengesellschaft

Introduction

Humans across the world and centuries had visions of autonomic mobility systems. They saw people inside a vehicle just as a passenger and no longer as an operator of that vehicle. Since the autonomous vehicle is able to get people or goods safely from one spot to another, humans can spend their time on other things than operating the transportation devices. Humans can enjoy the journey. Even Leonardo da Vinci, back in 1500, planned and sketched an autonomous vehicle which should be automatically pushed forward by force of a spring. This has been the very plain, but for this time very revolutionary idea of autonomous mobility. Setting this into contrast to riding horses, which were the most common kind to overcome distances at those times, da Vinci was a great visionary and ahead of its time.

Significance

This thesis is filling a gap in not only investigating different liability approaches regarding an accident with an autonomous car of Germany and the USA rather more linking all regulation concerning autonomous driving with current economic developments in the German car industry. In contrast to the most literature, this paper is looking into the future application of autonomous vehicles and thereby predicting the usage of those cars in daily-life.

Background

Numbers show that most of the German and US consumers would like to have the opportunity using the autonomous vehicle technology of driverless cars, especially for improvement in terms of an overall smoother, stress-free and more comfortable driving practice.[1] Thus, society identifies big paybacks for the traffic flow due to autonomous technology for cars. Vehicles deciding on the driving process independently and based on the code can prevent accidents due to their unbiased, rational judgement of a situation and subsequent prompt execution. Such actions are taken by the machine within milliseconds, whereas, the human needs except for the perception and thinking time also a few seconds of reaction to take action in the way he has decided on. Self-driving cars can prevent hundreds of fatal and car body damage accidents. In scanning more surrounding at the same time and acting quicker than a human, the actions undertaken by the autonomous vehicle are more precisely and can save many lives. Since most of the accidents are caused by human failure, this can be eliminated by deploying the new mobility technology in daily life.[2]

People all over the world can benefit from the AVs, also due to their ability to drive more predictive, balanced, and well-tempered. By those features and characteristics, AVs drive more efficient on resources and most environmentally friendly.[3] Due to the fluent driving style in which autonomous cars are operating, the traffic as a whole can be reduced and harmonised by a high number of those cars deployed in the streetscape.

[1] (Statista, 2018), (Fuß, September 2017)
[2] (Griesser, 2019)
[3] (Chao, 2018)

Beyond facilitating and relaxing the city traffic issues, the vehicles do have great potential in suburban and rural areas. Certainly, the significant number of commuters can benefit of driverless vehicle technology.

Instead of the time-consuming searching for a suitable parking lot or wasting much money for parking tickets, the commuter once arrived at work, can send the car back home. The commuter is also able to let the AV take care of other tasks such as picking up groceries, or laundries or the car can be linked to a car-sharing service platform. In the last case, while one works, one can also let the car work by offering other people a lift.

Despite the suburban matters, self-driving cars have a capability to provide elderly and disabled persons, who are not able to drive by themselves, with freedom and independence. Afterwards, they are not anymore, relying on subsidised transport organisations on a municipal level. The authorities can save money. Consequently, the rural area becomes more attractive also for the elderly to stay.[4] The elderly persons can benefit from independent mobility accessible by AVs in case one is no longer able to see properly or to handle the impressions and stress conveyed by traffic. Beyond that, elderly people are capable of going on longer day trips or self-determined rides which they avoided before, due to the high strains. They are no longer relying on public transport schedules and availabilities. AVs transporting elderly can avoid accidents which would have occurred otherwise due to the disabilities of that part of society. The AV generates an overall better quality of life in those areas. Having said this, the migration into the cities and thereby linked overcrowded urban can probably be reduced. Another noteworthy fact is that AVs can reduce the number of misdemeanours due to their configurations not to drive faster than allowed or only to park where it is determined.[5] According to a survey, 86% of the decision makers in the German car industry believe in that new technology and predict a high prevalence rate and a big potential business market for self-driving cars.[6] Thus, the AV will play an important role in one’s prospective life.

Problems

Among all the benefits this invention can provide to society, people look sceptically on the risks related to that technological progress on the streets. The most significant reason people worry about is safety. [7] Although people see opportunities in autonomous driving to reach safer traffic transactions in avoiding accidents, at the same time, they doubt the safety of self-driving vehicles. Mainly, their argument is linked to the algorithmic bias problem, which consists of the decision process in case code has to decide which person will die or injured or which good will get damaged in an unavoidable situation.[8] For example, a car is only able to avoid a crash with a pedestrian; the car has to dodge and crash into a parked vehicle on the edge of the roadway. In that parked vehicles could sit two children waiting for their mother.

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[4] (Roland Berger, 2018)
[5] (Friedhoff & Kirchbeck, 2018)
[6] (Wilkens, 2019)
[7] (Vitale, et al., 2017)
[8] (MIT Technology Review, 2015)

At this time, the AV is also not able to foresee, which damage is preferable, but the code-driven vehicle has to decide. This is an ethical problem, so-called algorithmic bias since the algorithms are following a predefined tendency.

Apart from the ethical issue, why are generations so fascinated by autonomous driving, and why do societies have problems with that innovation?

Since AVs are not stand-alone inventions, rather interacting with a vast number of different factors, even humans have problems to manage how the innovators and proponents of autonomous driving can overcome these doubts in daily life? To increase trust and, thereby, to foster this economic branch of AV manufacturers and developers, it must be clear for the people who are bearing the specific risks and what kind of risks do exist when it comes to self-driving vehicles in daily life. People question the invention first because they are used to standard driver-operated cars. A transition from something society is used to for an extended period of hundred years is always asking the people to get out of their thinking comfort zone.

Secondly, the society is used to the legal system in which one lives and how one deals with car accidents. This familiarity excludes new inventions at first sight because people do not know how to deal with them legally. Most people know about their legal system and how to cope with a car accident. This expectation is disturbed by autonomous vehicles and generates anxiety and worry for the people. Since, a car crash is mainly concerning legal assets, such as money, health, or life, people strive for legal certainty and financial security in case of a crash. Thus, the awareness of how to handle a car crash involving up to a Level 4 vehicle with a driver on-board is higher in society. The society is experienced in managing driver operated car accidents.

Thirdly, if an accident happens, there is a human which the society or a least the victim can blame for. Damaged by a computer-operated car is strange and very dissatisfactory for the victim in the first moment.

On the other side, the industry knows about their liability and how to minimise it. Economy and society are grown up in this system of human drivers and behaviour linked liability. However, what all disruptive technologies have in common, they require a change in thinking, habits, and in the system to be adopted by the people. The author will illustrate significant fields of ventures related to the law and regulation and how those particular legal uncertain features influence the economic strength and opportunities for the German car industry as well as for the society.

Specifically, this work exemplifies the different risk management of Germany and the USA based on the comparison between the civil liability systems of the USA and Germany in order to investigate if Germany is legally prepared for the AV evolution in its economy, industry, society and legal system. Furthermore, the author illustrates how deep Germany’s economy is tied to the car industry.

It will be questioned if Germany laid a foundation to remain as a leading automotive industry location by preparing a legal environment for autonomous vehicles and the big amount of business potential related to them; especially, if Germany can stay competitive in the race for research and development investments related to that entire AV ecosystem. The following chapters are not looking into the liability system for not fully autonomous driving vehicles. Thus, the work focusses on self-driving cars, fully autonomous vehicles of the highest level of full autonomy, because this will be the future.

The paper is not assessing criminal liability. Traditionally, criminal law is interconnected to individual behaviour as a base of punishability and culpability. As this work is investigating liability in a car crash with an autonomous, driver-less car, the individual behaviour of a driver or operator is not anymore existent. Subsequently, the base for criminal liability as known has vanished. The only link can be seen in the responsibility of a company which created a wrongful system. Although this field bears many questions, the criminal liability for a company does not exist in Germany. Thus, the legal base is missing.[9]

For new inventions, it is often the case, that regulation simply does not exist since they are too novel. For self-driving transportation devices, in many countries, no specific regulation is established, or the regulation is brand new. There are no cases, no judicial expertise or experience, and legal uncertainty. This tension causes many problems in the question who bears the risk of autonomous vehicles if they are involved in a car crash, hit a pedestrian, or do not work correctly and causes damages.[10] Thereby, the different US and German civil liability system will be examined. Besides the product and traffic law liability on autonomous vehicles, this paper investigates safety and further regulation on autonomous vehicles as well.

Due to former cases and enough real-life experience[11] involving car crashes caused by mechanical malfunctions or drivers, those issues of car crashes are not going to be assessed. The main subject matter will be consisting of a fully autonomous driverless vehicle having a malfunction in its software. Beyond that, the software malfunction is only caused by a defect code or its application, not by a hacking attack or any other factors outside of the sphere of responsibility for car manufacturers and their suppliers.

Methodology

As this thesis is divided into two different sections, the first part of this thesis is assessing law, cases, and secondary literature on those resources in a doctrinal research technique. The analysis of the two different legal systems is mainly based on a comparison of intention, purpose, and impact of the law. The second part of this paper is dominated by an assessment of the current development of the car industry, and for this part of the research consulted current news, reports, and surveys.

[9] (Warmuth, 2019)
[10] (Ebert, 2016)
[11] (HG.org Legal Resources, 2019) (Indemnity caused by a defect engine, 2009) (Indemnity caused by a driver error, 2017)

Literature Review

Law

The comparison between US and German product and traffic law liability regarding car accidents with autonomous vehicles is the first part of the paper. The legal conditions concerning such vehicle crashes are important in the face of three fatal crashes in the US in 2016 and 2018. Since those accidents were not caused by autonomous vehicles rather by automated cars, the ultimate question of the civil liability in the case of an incident with a self-driving car raises. That is one reason to investigate the issue in Germany by comparing it to the United States of America. There can be a lot of literature found on the civil liability of both jurisdictions. However, this thesis focuses only on the scope of application for autonomous vehicles.

The overview of civil accountability regarding traffic and product liability in the US and Germany of *Maurer, Gerdes, Lenz,* and *Winner* of 2015 is useful to estimate the situation, but this book is not assessing the new amendment in the German Road Traffic Act released in 2017. This is also the issue of the second main oeuvre in that field of *Oppermann* and *Stender-Vorwachs* in 2017 who also investigated the proposed amendment before it was published. Consequently, an assessment and comparison of the amendment setting it in a connection to autonomous vehicles are currently missing.

Apart from that, the assessment of *Mueller* leads to the result that the law is still leaving many questions unanswered. He concludes that the legislature established a new law which is contradicting itself by requesting a driver, although the law speaks about autonomous vehicles. Additionally, he emphasises that the amendment requests the driver to stay prepared to take over control any time while granting the driver the freedom to pay attention to something else while operating in the autonomous mode. He claims the impracticability of the provision.

Impact of the law on the German economy

There is only one recent report from *KPMG* on how the law is interacting with the automotive business and how Germany is prepared for autonomous vehicles and their industry. This report ranks Germany on the 6th place among 25 countries around the world. It concludes Germany's legal situation as appropriate for now, but expandable.

Another report of the *German Federal Ministry for Economy and Energy* stated in 2018 that the investments of German companies are on an all-time high, and German enterprises are described as an engine for investments and jobs in the US. Specifically, this official report refers to the above average involvement of German car producers in the US, and the high job rate German businesses generate in Michigan and California in this sector.

Chapters overview

First, in chapter 1, the general technical base will be explained. The definitions of several technical approaches and concepts will be determined to prepare the reader for the analysis.

To identify which system of regulation is more appropriate to keep pace with the innovation process, this diction will reveal the German and US jurisdiction on autonomous driving vehicles in chapter 2 by means of the existing regulation and efforts to foster legislative changes and amendments. By doing so, the holistic approach will be examined, focusing on the different civil liability systems. The author illustrates what kind of liabilities are used to solve car accident accountability issues now and which are in what way applicable for Level 5 vehicles.

Besides, the civil liability considering self-driving vehicles in a car crash, it will be determined what kind of administrative rules the two countries developed in order to promote this growing industry. For that, the work shows the legislation in three different fields. First, the security rules for AVs, second, arrangements for testing routes and lastly data protection provisions are investigated. In order not to overextend the reader, these laws will be examined on a federal level and in the US on a state level of three exemplarily chosen states, which are California, Arizona, and Michigan. All three states possess a secure connection either to modern technology business locations or to the car industry sector.

In chapter 3, the existing law will be analysed, and political, social, and economic consequences in Germany will be determined with the support of comparing it to the US system. After the regulatory assessment of self-driving vehicles involved in car crashes and further regulative efforts to adopt autonomous vehicles of Germany and the US, both systems and their outcomes will be compared to each other in terms of their social and economic compatibility. The comparison shows if Germany is prepared to mitigate the problems industry and society have with the innovation of AVs. Next will be discussed why the two different legal approaches boost or slow down the development of autonomous vehicles and the car industry.

Afterwards, it will be illustrated how Germany and the US try to adjust their legal systems to the necessities of the market and what value Germany can get out of that emerging industry in terms of their own economic growth in the future.

By reason of an unavoidable expanding of autonomous vehicles in the future, seen by a race of the big car manufacturers across the world, it will also be recognised which regulation method is the most appropriate for the emerging and quick development of that technology in the future. Primarily, this thesis will examine the latest investment policy of the car manufacturers and in what direction this money is going by determining the future hot-spots of research and development on mobility ecosystems.

Finally, chapter 4 illustrates to what extent the car business is essential for the entire German economy. Afterwards, it will be exemplified how the investments for research and development of autonomous vehicle technology is impacted by law and regulatory framework and how Germany is prepared to remain competitive in that industry which is leaving the currently known traffic landscape shifting into future mobility concepts. It will give a brief compilation of what authorities of Germany can improve on their regulation in order to keep pace with the technological advancements and social needs on this topic.

1. Autonomous vehicle technology

1.1. Autonomous driving

Da Vinci dreamed about a self-driving cart. He was not wrong by his vision as a first step to forego horses as the main propulsion of means of transportation, which were for centuries the only way to get to a destination faster than walking. However, people still want to avoid using humans in the transportation process. The vehicle of the future should be able to drive without a human involved as an operator. Since the automobile was developed, people tried to make them drive automatically. At the world exhibition in 1939, GM cooperated with the inventor Norman Bel Geddes and presented an automobile which should operate by radio communication and electromagnetically fields. Instead of the driver, only these physician methods could conduct the car for a short section.[12]

1.1.1. Milestones in the development of autonomous driving

In 1945, Ralph Teetor created a driving assisting system which we use still today. He developed the speed and cruise control for vehicles and obtained a patent on this invention in 1950.[13]

The EU was fostering a project group in 1987 called Research Funding Organization EUREKA. It invested in the project "Prometheus", programs for a European Traffic of Highest Efficiency and Unprecedented Safety, with the final goal to facilitate the traffic and to reduce car accidents and the number of people dying in car crashes. Here the first time, a transputer was used, and data were collected, so, the machine could learn from previous experience. This vehicle could drive autonomous, but a driver was always available to prevent accidents. The models showed driving on free tracks, driving in convoy, lane change and automatic overtaking over 1000km on highways.[14]

The first DARPA (Defence Advanced Research Projects Agency as a division of the US Department of Defence) challenge was invented in 2004. The winner would have received $ 1 Million if the vehicle could have reached the destination via its autonomous mode. The challenge consists of a route of 80 km distance through a desert. No vehicle reached the destination. There was no winner of $ 1 Million because most of the 15 starting vehicles crashed, caught fire or got off the track.

In 2007 another DARPA challenge event was taking place, but, this time, it was in an urban environment, and 53 different teams participated in the competition with their autonomous robotic cars.[15] The Tartan Racing Team of the Carnegie Mellon University, Pittsburgh, Pennsylvania won the price of $ 2 Million by utilising a robotised Chevrolet Tahoe.[16]

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[12] (Potor, 2017)
[13] (United States Patent and Trademark Office, 1950)
[14] (Vieweg, 2015)
[15] (Flora, 2012)
[16] (Carnegie Mellon University, 2007)

Afterwards, the evolution of autonomous driving shifted from research to trade competition. Most of the car producers wanted to make the technology suitable for real-life cars to enter mass production.

First, this would lower the costs and second, to fresh up their image to illustrate; they are not only operating as a mechanical, stiff car producing company but rather, as a modern, flexible high-tech service company.

In the end, people with visions far away from their real possibilities drove the development of autonomous vehicles forward, with the consequence that these vehicles could go in our current practice. As often seen in the development of inventions, competition, curiosity and challenges set by visionaries' act as the main driver to obtain the AV on our streets.

1.1.2. Different approaches to autonomous driving

When thinking about autonomous vehicles, one may picture car, which can drive on its own to destinations to pick up our food or laundry, or which can transport us comfortable to our annual family meeting in our hometown.

However, the special terms in automation in driving technology were often mixed up, and the users did not clearly distinguish them. Though, there are large technical differences between the individual technological approaches.[17]

1.1.3. What is autonomous driving technically, what is an AV?

Indeed, autonomous vehicles (AV) fulfil the picture we drew above. An autonomous vehicle has the ability of making, even in changing environments and while moving, decisions based on the input of the different "senses" such as radar, lidar, GPS, cameras and real-time news via the internet. Taken into account that autonomy is an important part of this approach, only the single vehicle is in focus by that method. Autonomous driving is, therefore, about individual vehicles independently acting and independently making driving decisions without interacting in systemic traffic flow or necessary human interference.[18]

1.1.4. What is automated driving?

Automated driving means the execution of processes and procedures without human intervention. Thus, automated vehicles can drive by their own, also without a human controller. However, the term is narrower. To automate a process or procedure can be, for instance, the cruising pilot or lane assistant. Consequently, our society already has automated cars with such assistant systems.

[17] (Weber, 2019)
[18] (Kuhn, 2018)

Sometimes a distinction is made here between fully automated driving and the different stages of automation on the different processes which support the human driver.[19] By speaking about automated vehicles, one should be aware of fully automated or partly automated cars. An automated car can be an autonomous driving car but can also be a car with supporting assistant systems for a human driver.

1.1.5. Connected and cooperative driving

For connected driving, every single road user is equipped with a digital communication possibility to stay in contact with the other road users. In that way, automated and non-automated vehicles are automatically able to exchange information with each other as well with the infrastructure surrounding them, such as traffic lights, temporary or permanent traffic signs or predicted traffic situations to prevent traffic jams. Nevertheless, connected driving still focuses on the processes, goals and destinations of the single vehicles and items. Thus, connected driving is one step further than just autonomous driving, but still has a too narrow view on the traffic as a whole.

Cooperative driving is more about driving individual vehicles and road users cooperatively in traffic. By reaching an improvement of the overall traffic flow, cooperative driving means that every single road user coordinates their individual micro-goals and their execution while communicating with the other road users in a more global approach.[20]

1.1.6. Automated traffic

That is the end level scientists and society is aiming for. It can also be described as intelligent mobility by using collected mobility data, artificial intelligence procedures and predictions. Automated traffic will facilitate the entire driving experiences and will have a deep impact on the real-life driving experience because automated traffic is not just about automating individual road users, but about automating traffic as a complete system-in-system. According to this, traffic automation not only includes vehicle automation and their autonomy to make driving decisions but also the automation of traffic regulation and infrastructure. By this means, the traffic as a whole system can impact the system of the individual autonomous transport devices, by steadily reviewing, shifting and adjusting the small individual decisions on the macro level.[21] Finally, the autonomous vehicle is only the first of many interim steps to obtain an automated traffic infrastructure and an intelligent mobility scheme, which will be the next global emerging technology, on which many countries work on.[22]

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[19] (Kuhn, 2018)
[20] (Murtha, 2015)
[21] (Bundesministerium für Verkehr und digitale Infratsruktur, 2019)
[22] (Red Chalk Group, LLC, 2019)

1.2. Levels of autonomous vehicles - how to get to an AV?

The global community of autonomous driving involved parties agreed on five different levels as interim steps on reaching the ultimate autonomous driving technology for individual cars.[23]

The different levels describe what elements of the driver can be missed while the driving process, for example, the eyes, the hands, the head or the driver as a whole. Most car producers adopt this scheme to develop their technology of autonomous vehicles. In order to drive autonomously, AVs collect around four thousand GB per day.[24]

1.2.1. Level 1: Assisted driving

The driver is constantly controlling the car and must constantly keep an eye on the traffic. The driver is liable for all traffic violations and car crashes, resulting in damages. Individual assistance systems like the speed control or the lane keeping system, support the driver with specific single responsibilities while driving the vehicle.[25] Such support processes are a standard in all vehicles produced today. They helped to avoid accidents, for instance, if the driver gets tired and impend to lose control over the lane or speed. However, the eyes and the hands of the driver were still necessary to drive the car properly.

1.2.2. Level 2: Partially automated driving

At this point, only a few vehicles have arrived so far. In certain situations, the car is able to drive autonomously straight ahead, keep the car inside the lanes, even if the marks are temporary. The vehicle regulates the distance to the vehicle in front and applies to the legal minimum distances between cars. The vehicle takes over completely in traffic jams by stop and go situations or in certain circumstances, such as on highway ride or parking space.

However, there are limitations due to bad weather. The car relies on the sensors, so, if they are dirty or affected by snow or rain, the car is not able to assist properly, or the supporting systems fail. If the system requests for the drivers’ attention and the driver doesn’t intervene, the car initiates a safety program, which consists of starting the hazard warning lights, slowing down and going to the right side of the street to stop on the breakdown lane. If the driver is not responding to the system, the emergency call centre is called automatically, and the location of the car is sent to the emergency personnel.

The entire process is only assisting the driver, which has to be ready to interfere at any time. In the end, the driver can do some small tasks besides driving like drinking and is able to control the car only with one hand on the steering wheel, but still, the eyes and hands are necessary for driving the car.[26]

[23] (SAE International, 2018)
[24] (Doll, 2019)
[25] (Allgemeiner Deutscher Automobilclub, 2018)
[26] (Dahlmann, 2019)

Right now, those features are available in Tesla models with the feature "Autopilot" [27] or in a Mercedes Benz E-Class with the "Drive Pilot".[28] Both already reached Level 2 in 2016. This level is the most common and legally permitted technology on our streets today. Thus, passengers can get familiar with that level of automated driving.

1.2.3. Level 3: Conditional automation or highly automated driving

The system can assume full control of the vehicle in certain circumstances on the road, by meaning that the driver can disengage from the driving process for a longer period of time, especially driving on highways with proper traffic signs and marked lanes.[29] The highly automated vehicle can dodge or break automatically if obstacles appear on a motorway. For this environment, the car is able to drive without the support of the drivers' hands on the wheel and, they can even take their eyes off the road.

However, the drivers still must be poised to take over the process if the drivers want to change one decision of the car or the system requests that the driver has to interfere. For Level 3, the new Audi A8 is a proper example of a highly automated vehicle. The car is able to take over completely the driving process in a traffic jam. Thus, the driver can pay attention to something else.[30]

1.2.4. Level 4: Fully automated driving

The driver becomes a passenger and is no longer involved in the driving process in specific circumstances, like a highway, parking garage or outside cities. The Level 4 car is able to drive certain routes completely independently and is able to drive those passages without passengers. Those are allowed to spend their time on other things, like sleeping or reading. In advance, the system recognises its limits, and when the specific circumstance the system can manage is ending, so the driver has sufficient time to take over the control again.

At this level, the technical systems perform all the driving tasks automatically; the car can cover longer distances without intervention. The car could, therefore, drive onto the highway, even into the traffic at high speed, follow the lane, flash, overtake, brake if necessary, change the lane and finally leave the highway again.[31] Finally, Level 4 is almost autonomous driving, but the technology is not applicable in every kind of circumstances and situations. Thus, the driver has still to be there to take over control when the vehicles reach their limits.

Level 3 and 4 are highly convenient when reached and can tremendously facilitate the driving process, and also those levels are already capable of preventing many accidents while abolishing human interaction in certain circumstances.

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[27] (Tesla, 2019)
[28] (Daimler AG, 2019)
[29] (BMW AG, 2019)
[30] (Allgemeiner Deutscher Automobilclub, 2019)
[31] (Dahlmann, 2019) (BMW AG, 2019) (Allgemeiner Deutscher Automobilclub, 2018)

Having said this, the biggest disadvantage of vehicles with Level 3 or 4 is that the autonomous working part is limited and the driver has to take over in case the system fails or requests that. This situation of transferring not only the operational control furthermore the responsibility back to the driver bears many risks and high error susceptibility. By again taking over the control requested by the system, the driver is probably not able to react or to grasp the entire traffic condition fast enough to avoid mistakes because he paid his attention to something else or even worse is sleeping and totally not able to take over the system. The BMW i4 is one prototype containing Level 4 technology.[32]

1.2.5. Level 5: Autonomous driving

At that level, autonomous driving and Da Vinci's and the previously outlined vision becomes real. Humans are no longer the operator or driver because driving is now the responsibility of the transportation device. The vehicle can decide in every situation and circumstance how to behave in traffic and can interact with other road users on its own.[33] A steering wheel, gas and brake pedal are not anymore necessary. The vehicle replaces the driver.[34]

The vehicle is equipped with GPS systems and the internet, which provides access to all real-time data related to traffic circumstances and directions on navigation or weather. Additionally, it is equipped with radar, sensors and cameras to observe and scan the setting the vehicle is moving in. The car can adjust its driving style and its reaction situational to the current driving process. Thus, it identifies curves and slows down, or it recognises a dangerous situation during a passing manoeuvre and goes back to its former position.

However, the vehicle is working autonomously, by meaning it is independent. The decisions of the car are driven by individual codes and are not connected to other parties involved in traffic. Even the car is able to perform in all circumstances to obstacles, or other parties involved in the traffic; the AV is not interacting with other participants, rather it is acting on an independent base.[35]

Most of the big high-end car producer and developer such as Mercedes, BMW, Volvo, Tesla, GM and Audi, however, also the big mobility service companies like Uber, Waymo and Apple try to develop already Level 5 fully autonomous vehicle systems currently[36] as a further step to autonomous mobility ecosystems, what is the final target.[37] The autonomous vehicles have the advantage not being reliant to an operator as a human who can take over the driving process in case the system requests that or the automation is not sophisticated enough to mitigate the complexness of the traffic situation.

[32] (BMW Group, 2019)
[33] (Volvo Car Corporation, 2019)
[34] (Dornier Consulting International GmbH, 2017)
[35] (Allgemeiner Deutscher Automobilclub, 2018) (Dahlmann, 2019) (BMW AG, 2019)
[36] (National Highway & Traffic Safety Administration, 2019)
[37] (IMO - Institut zur Modernisierung von Wirtschafts- und Beschäftigungsstrukturen GmbH, 2019) (Dahlmann, 2019) (Korosec, 2018)

So, autonomous vehicles are just the beginning of autonomous traffic and driving systems. In the end, the AV has to be seen as one isolated part in the whole innovative infrastructure process, researchers, manufacturers and countries are reaching out for. Embedded in a wider field of new technological, digital and connected inventions in the mobility sector, the Level 5 system is the one which is called autonomous vehicle. Today, there are only a few vehicles which can perfectly reach this level; however, developers work hard on the technique and test the first driverless cars of Waymo in the US.[38] In 2018, Waymo went public with a self-driving car transport service, called Waymo One.[39]

This is the level of autonomous driving the author uses as the subject matter for this thesis.

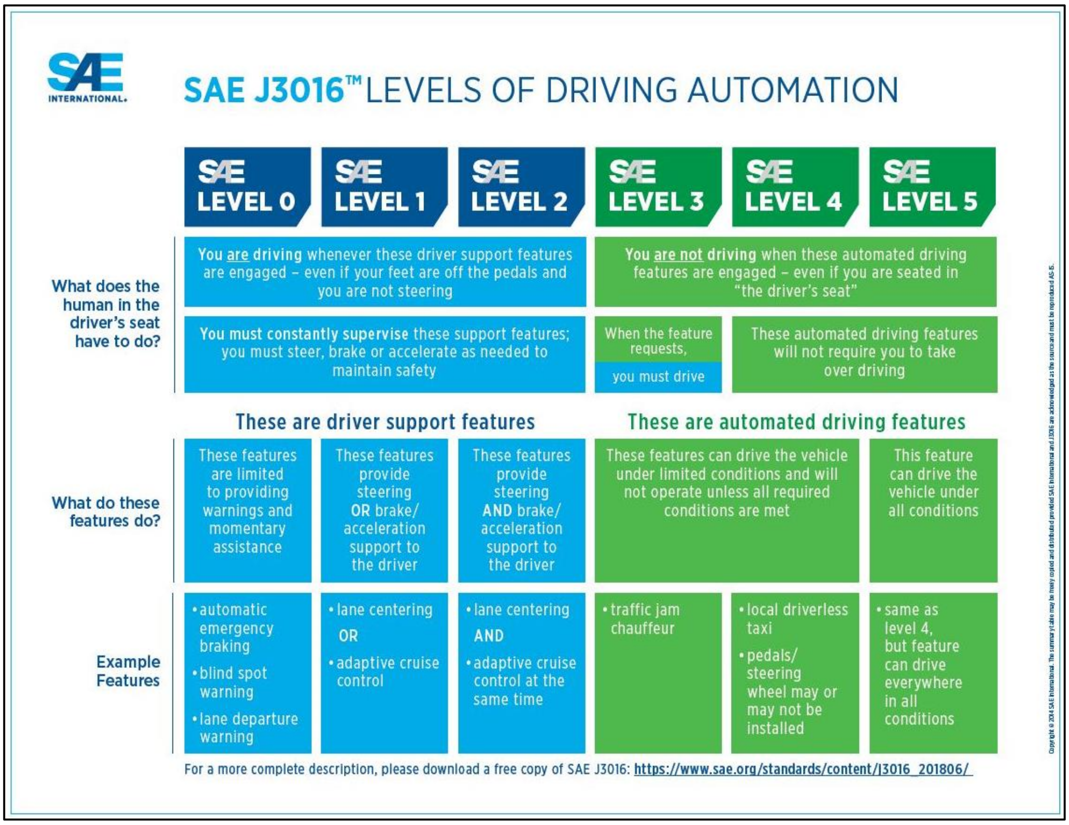

Figure 1: Different levels of automated and autonomous driving systems.[40]

1.3. New infrastructure concepts

Taken into account all the changes which can have a huge impact on our living quality and circumstances, authorities have to consider long-term goals in maintaining, improving and develop traffic roads. In order to increase the vast opportunities self-driving cars, provide can us with, not only the legislative but also the infrastructural investments have to adjust. The main of those new mobility developments will be introduced in the following to provide you with an idea of what the future is keeping ready for us.

[38] (Waymo LLC, 2018)
[39] (Waymo LLC, 2018)
[40] (Shuttleworth, 2019)

1.3.1. V2V and V2I communication

As a result of increasing autonomous mobility concepts, not only the isolated vehicle rather more the infrastructure as a whole will make changes to a more connected system. This development includes, e.g. traffic lights which function more systematically in a flow to harmonise and reconcile the traffic flow. Autonomous vehicles will be connected to each other, which is called V2V (vehicle to vehicle) technology. However, the self-driving cars will also communicate and stay connected with the infrastructure items such as traffic signs, traffic lights, parking spaces or dangerous zones in front of schools or constructions. This surrounding communication is called V2I (vehicle to item) technology.[41] It will be necessary to implement this technology into the streetscape to improve the orientation and recognition of other road users and obstacles. Human beings use significant points or buildings as a mark to orientate where and how far away from items they are, even when they move. That's how orientation works in the human brain. To copy this procedure, the AI in the self-driving car has to reproduce the same as human do. The AV is now able to use orientation marks, such as the traffic light, to calculate distance, speed or crashes. However, the system does only recognise in advance programmed or stored schemes. To improve that, the autonomous vehicle should not be seen as isolated, rather more as a communicator with the surrounding to recognise everything properly, by its own emitted definition.[42] By incorporating step by step new infrastructural elements, the transportation becomes then even more efficient. For example, traffic lights which communicate with the traffic, to indicate when the red light will be on or off.[43] In order to increase the safety level of driving and to knock out the human factor of the process, the AV needs orientation points which tell the car, what their function is. In doing so, the car does not only copy the human system; it is smarter since its capability of acting faster and rational in any event of danger.

1.3.2. Platooning

Most of the time, this technique, founded on autonomous driving technology, is applied to trucks in the freight traffic. The method enables every truck which is following one leading truck, to operate driverless, eco-friendly and with a high level of safety. The leading truck nowadays still is operated by a driver. The following trucks drive in the perfect distance behind the first one and can save fuel and a driving person and thereby reduce the costs tremendously of the transportation of goods. Interestingly, the name originates of the term platoon because the convoy imitates the function and features of a platoon with one leader. The high level of safety is generated due to the distance and breaking assistance of every vehicle and their interconnected systems. Every other vehicle which can connect with that system can be part of the platoon. Thus, the driver car turns into a car in which a driver is no longer necessary.[44]

[41] (Gora & Rüb, 2016)
[42] (ZDF- public TV channel, 2017)
[43] (Lemmer, 2015) (Technische Universität Braunschweig, 2013)
[44] (Pluta, 2015)

1.3.3. Telematics

To make sure that those technologies are globally harmonised, the telematics technology[45] tries to translate the collected data of the vehicles into one worldwide recognised language and to facilitate thereby the communication between the vehicles of different manufacturers and ensuring a constant and reliable possibility for the vehicle for communicating with its surrounding anywhere and at any time.[46]

1.4. Summary

As of the new extensive and wide-ranging development of all matters approaching mobility, environment, cityscape redesign, helping elderly people and traffic, the regulation on autonomous vehicles has to take this into account. If an authority permits AVs on the street, the mostly public held and financed infrastructure should be developed as well to keep pace with the transportation technology and to perfect all the advantages of self-driving vehicles. Regulators should also be aware of the unavoidable tendency of the young generation to decide for environmental-friendly shared mobility services.[47]

1.4.1. Tension between technical innovation and law

Now, learned about autonomous driving, how it works, and what tremendous changes go hand in hand with the autonomous driving evolution, the question is why is such a positive innovation causing problems?

The autonomous driving would not only relieve the driver of a vehicle but can also make better or more precise driving decisions. Code waives emotions like fear, panic or willingness of taking risks of a human driver and uses only the strict accuracy of calculated actions in the event of an accident or imminent danger.

In the end, scientists and researchers try to achieve not only a substitute for a human being (driver). Moreover, they reach out to facilitate the entire traffic system and make it safer for all users. For this reason, the responsibility for driving decisions shifts apart from the former driver towards the code which operates the system now.

Meanwhile, the progress of the autonomous innovations provides some huge legal issues to regulators. Since the driver changes into a passenger, who is no longer responsible for the driving process, who else is? Thus, society faces not only liability issues but also numerous different opportunities and open questions on AVs.

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[45] The term Telematics consists of a range of different features, options and devices that are brought together by the principle, to merge data and communication and to use the results for improving mobility concepts in every manner.
[46] (Telematics.com, 2017)
[47] (Dr. Behrendt, et al., 2015)

2. International regulation and law in Germany and the US on autonomous vehicles

After analysing the legal systems of the US and Germany, the chances and possibilities, opportunities and dangers of autonomous driving will be briefly outlined in terms of the entire German society and industry, the traffic infrastructure and the participants in the AV development. Since the regulation has an impact on technology and vice versa, the AV generates new problems and chances which influence the regulation process and regulation of that new technology, on the other hand, has an impact on the scope of these problems and chances. Later, this reciprocal effect will be examined in this paper. First of all, the legal environment will be illustrated.

2.1. International United Nation treaties on traffic

There are many multinational treaties and conventions which were set up by the United Nations to bring all the different national legal approaches on mobility and transportation in line. The agreements are effective for the entire European Union and then also called treaties of the United Nations Economic Commission for Europe (UNECE).[48] Two of them are very important, referring to autonomous vehicles and the legislative possibilities of Germany in changing provisions solving liability questions on self-driving cars. Since these agreements were signed, and the regulation was adopted to national law in many countries for a long time, those countries also want to stick to them. Consequently, their national law is such deeply interwoven with that treaties, that the first step for a change is starting on this international level in order to elaborate on the own national regulations.

2.1.1. The Vienna convention on road traffic

The convention of Vienna of 1968 is a multilateral, international, UN-recognised and initiated agreement on standards concerning road traffic. Its origin lies in the ultimate intention of harmonising road traffic rules, technical road standards and traffic signs, in order to facilitate mobility around the world.[49] Though a lot of countries signed this convention, it is in many countries not ratified and, in that way, not fully applied. It is ratified in 78 countries. But some countries denied signing the agreement to remain independent and to stay free so that they can take their own judicial decision on road and traffic rules. The United States of America did not sign the road traffic convention and is not bound to it.[50] In contrast, Germany is.

2.1.2. The convention and autonomous vehicles

Although the convention was established in 1968, it is steadily assessed and for technological development amended and complemented.

[48] (UNECE, 2019)
[49] (Bundestag/ German Parliament, 1977)
[50] (Franz, 2016)

So, it also happened in 2016 when the agreement was amended by a new provision. This modification was initiated by Belgium, France, Italy and Germany to adopt new types of vehicle technology in the UN treaty. Since March 23rd in 2016, Article 8, which defines the necessity and capabilities of a driver, the convention is amended by a new subtitle number 5bis. Germany adopted this new provision and implemented it into their national legislation according to Art. 59 (2) Grundgesetz (GG)[51]:

> *"**Article 8 - Drivers***
>
> *1. Every moving vehicle or combination of vehicles shall have a driver.*
>
> *2. It is recommended that domestic legislation should provide that pack, draught or saddle animals, and, except in such special areas as may be marked at the entry, cattle, singly or in herds, or flocks shall have a driver.*
>
> *3. Every driver shall possess the necessary physical and mental ability and be in a fit physical and mental condition to drive.*
>
> *4. Every driver of a power-driven vehicle shall possess the knowledge and skill necessary for driving the vehicle; however, this requirement shall not be a bar to driving practice by learner-drivers in conformity with domestic legislation.*
>
> *5. Every driver shall at all times be able to control his vehicle or to guide his animals."* [52]

According to the imaginations in the '60s, a driver was intended. This version was amended in 2016 by a new subtitle 5bis which refers to autonomous systems as "*systems which influence the way vehicles are driven"* and recognise also existing assisting systems the first time internationally as permitted.

> *"**Amendment of Article 8:***
>
> *A new paragraph (i.e., paragraph 5bis) is to be inserted into Article 8. Paragraph 5bis shall read as follows:*
>
> *5bis. Vehicle systems which influence the way vehicles are driven shall be deemed to be in conformity with paragraph 5 of this Article and with paragraph 1 of Article 13, when they are in conformity with the conditions of construction, fitting and utilization according to international legal instruments concerning wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles.*[53]
>
> *Vehicle systems which influence the way vehicles are driven and are not in conformity with the aforementioned conditions of construction, fitting and utilization, shall be deemed to be in conformity with paragraph 5 of this Article and with paragraph 1 of Article 13, when such systems can be overridden or switched off by the driver."* [54]

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[51] Grundgesetz/ Basic Law, (Bundesrepublik Deutschland / Federal State of Germany, 1949)
[52] (Bundestag / German Parliament, 2016)
[53] (United Nations, 1958)
[54] (Bundestag / German Parliament, 2016)

The member countries, including Germany, are bound on the legislation of this contract. Before the initiative to change Article 8 of the convention, autonomous systems in mobility were not mentioned there. Now, changing Article 8, vehicle systems which influence the way vehicles are driven are allowed to incorporate in vehicles using public roads. This amendment is significant for the recognition of modern remote and digital systems and technologies installed and integrated into usual mechanical cars on which this convention was initially based on.

2.1.3. Agreement concerning the establishing of global technical regulations for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles of 1958 (Geneva agreement)

This international agreement is about harmonisation on technical standards of moving vehicles and all the parts incorporated in them. In order to ensure minimum safety and harmonised standards, a lot of countries around the world signed this agreement. Germany signed and adopted this agreement as well as the Vienna convention.

Although the US did not sign the Vienna convention, that agreement on technical standardisation was signed by the US in 1998 but only after the type-approval of cars was amended by the self-certification system which exists in the US.[55] Though the USA did not ratify it, the states voluntarily try to comply with it. But the agreement is still not bounding the US authorities.

The Vienna convention is referring to the agreement concerning the establishment of global technical regulations for wheeled vehicles in the new amended subtitle in which the autonomous systems are included. The Vienna convention on road traffic states that the autonomous systems incorporated in a moving vehicle which comply with the agreement concerning the establishment of global technical regulation for wheeled vehicles fell under article 5 of the Vienna convention. Thus, those systems are legally recognised and allowed to assist and support the driver in a car.

Nonetheless, that agreement does not include or mention autonomous vehicles or any kind of automated driving technologies in particular. It just states the absolute minimum condition on wheeled vehicles, such as breaks, steering wheel, safety belt or headlamps.[56] Especially No. 79 of the agreement is hindering AVs, because this section is explicitly excluding, prohibiting autonomous steering systems, despite the ones on a closed parking lot.[57] Those systems, nevertheless, are crucial for driverless cars.

[55] (Verband der Atomobilindustrie (VDA), 2016)
[56] (Vienna Agreement on Road Traffic annex 5, 2013) (Wikipedia, 2019)
[57] (Wissenschaftliche Dienste Deutscher Bundestag/ Scientific commission of the German Parliament, 2018)

2.2. Law in Germany

After learned about international regulation and how this is impacting German law processes, the probable liability in the German jurisdiction will be investigated. Starting with standard product liability and further assessing liability under the old and amended Road Traffic Act and completing German legislation with three different legal implications on autonomous vehicles: Data protection, testing routes and safety regulation, the law in Germany will be illustrated.

2.2.1. Standard liability in a car crash in Germany

This section is referring to the liability question of self-driving cars of Level 5 in Germany which were involved in an accident during their ride first under product liability law and second under the old traffic law of 2017. Next, the author will investigate why Germany identified a need to amend the traffic liability act and how the liability has changed by this.

2.2.1.1. Liability according to the Product Liability Act/Produkthaftungsgesetz (ProdHaftG)

The liability is regulated in § 1 ProdHaftG. § 1 is referring to some other sections in the law system to define terms or to describe the scope of the damage to pay for the specific injuries. [58] In more than 99% of car crashes, product liability is not applicable, because of disastrous driver decisions, weather complications or wrongful behaviour of pedestrians and not by product defects. Currently, only less than 1% can be led back to product defects, what the manufacturer has to take responsibility for and not the drivers because of a lack of maintenance or service measure.[59] Consequently, product liability in Germany does not play a significant role in the question of an accident liability today.

However, to have the full burden of accountability for driving decisions as a driver of an autonomous vehicle seems inequitable. According to the shift of the role of a driver in fully autonomous vehicles towards the one of a simple user or single beneficiaries of the technology, why should that passenger be held liable for a mistake the machine does, and the passenger did not have an impact on? The car manufacturers might refill the gap the driver leaves behind. Thus, not only the legal environment for the users of AVs but also the one for car producers like Daimler, BMW or VW and insurance companies will change by implementing Level 5 AVs in daily life in Germany. This alteration is also influencing the application of product liability for car accidents in a large sense.

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[58] (Prof. Dr. Dr. h.c. LL.M. (UCLA) Oppermann, Apl. Prof. Dr. Stender-Vorwachs, & Prof. Dr. LL.M. Beck, 2017)
[59] (Statistisches Bundesamt, 2017)

Let's have a closer look at the current scheme under § 1 ProdHaftG.[60]

Causal facts for the liability

The law is applicable to all new moveable product inventions, §§ 2, 16, 19 ProdHaftG if they have a defect which causes the death or injuries of a person or damage to property (above € 500) which means not the defective product itself.[61] The burden of proof for the further mentioned requirements bear the claimant and any exculpations have to be proved by the defendant, § 1 (4) ProdHaftG.

Product

The damage has to be caused by a product defect, §§ 2, 3 ProdHaftG.

First, the defective part must be seen as a product by § 2 of the product act. A product is given when the defect is on an item which is movable, even if it is incorporated in a bigger machine system, but can be taken out or the system as a whole is mobile. The law system is only applicable if this product has been introduced to the public.

An autonomous vehicle, all of its parts incorporated in the system even the nonphysical software and data of Level 5 vehicles is seen as a product by the prevailing opinion[62], and in a statement of the European Parliament on the Directive 85/374/EEC - liability for defective products[63], thus, the law is applicable to all fully AVs.

Defect

To know what a product defect is, § 3 is defining this more specifically. For the definition, the so-called safety-relevant error term applies. The product is built defect if it does not guarantee the safety standard what the traffic regulation considers necessary in advance of releasing the product and when the consumer as an innocent bystander cannot expect such a defect.[64]

There are huge obstacles to overcome before a car manufacturer gets the certificate of the authorities that the vehicle is fulfilling all required technical, safety or environmental standards. Only after that approval of one role model car, the manufacturer starts mass-production of this specific type of car.[65] Thus, the scope of the application of product liability would be very small. In all cases, without a clear, physical product defect, the manufacturer can rely on the serial certificate. Nonetheless, the approval and the European Directive on what it is based is until now not considering highly partially or fully autonomous vehicles and their systems as an element of a car.[66]

[60] (Deutscher Bundestag/ German Parliament)
[61] (Federal Ministry of Justice and Consumer Protection and the Federal Office of Justice, 2017)
[62] (Meyer & Harland, 2007)
[63] (European Parliament, 1989)
[64] (Oechsler, 2017)
[65] (Official Journal of the European Union , 2018)
[66] (European Parliament, 2007)

So now, the process is about getting the approval to build the exact same model again. Nevertheless, this scheme does not take into account, the flexibility of digital systems which drives partially and fully automatic technology, and especially does not consider artificial intelligence (AI) systems which are meant to change steadily by learning with new input. Since the certification is just for the starting product, consequently, car manufacturers would need a constantly renewed approval on the software development on every car. Another option could be to shift from the assessment of the type of the car to an assessment of the whole integrated digital system and to test if this system can deliver the by then changed requirements, such as data-protection or a remote steadily self-evaluation of the system with resulting in an alarm to the driver and the manufacturer if the system detects a malfunction.[67]

However, if the AV was approved by the authorities with a certain kind of AI and this software is learning wrongfully, thereby, acting and reacting improperly and causing an accident, that kind of even flexible software is than defect and in the end a product defect as a subject to § 3 of the product liability act.

Causality

Additionally, the defect must be causal to the damage which occurred by that accident. So, the software malfunction has to be the direct cause of the accident instead of driver overriding decisions or misbehaviour of other road users.

Probable defendant

According to § 4 ProdHaftG the producer, the one who is branding the defective product, the importer or the supplier is liable and can be the defendant. In the case of numerous defendants, they are liable as joint and several debtors, § 6 ProdHaftG.

Damage

A damage has to be existent, which was caused by the injury of property, an injured or dead person. The damage for objects is calculated by the difference hypothesis, § 249 Bürgerliches Gesetzbuch (BGB) [68]. Therefore, the damage is the result of the value of the injured property before the accident minus the one afterwards, nevertheless, the damage has to exceed € 500, § 11 ProdHaftG. Every property damage under € 500 is seen as a deductible.

The damage for injuries is calculated according to medical and pain and suffering compensation. Additionally, the person can claim compensation for the incapacity to work, § 8 ProdHaftG. The damage for dead persons is like the one for injuries on a person, not fix but depending on every single case but should compensate the costs of the dead person (funeral, etc.) and balance its loss, §§ 7, 9 ProdHaftG. This is usually covered by insurance. For AV product liability, there are no big changes to expect.

[67] (Prof. Dr. Eisenkopf, et al., 2017)
[68] (Deutscher Bundestag/ German Parliament)

Possible exemptions and exculpations of the producer

Conferring to § 1 (2) No. 1 to 5 ProdHaftG, there are 5 regulated exemptions for the manufacturer to exculpate. Those cases, in particular, are consisting of:

> *"The producer's liability obligation is excluded if*
>
> *1. he did not put the product into circulation,*
>
> *2. under the circumstances it can be assumed that the defect which caused the damage did not exist at the time when the producer brings the product into circulation,*
>
> *3. the product was neither manufactured by him for sale or any other form of distribution for economical purpose nor manufactured or distributed by him in the course of his business,*
>
> *4. the defect is due to compliance of the product with mandatory regulations at the time when the producer put the product into circulation or*
>
> *5. the state of scientific and technical knowledge at the time when the producer brought the product to market was not such as to enable the defect to be discovered*." [69]

Significantly, no. 5 is excluding the liability of a car manufacturer if the defect could not be discovered due to the state of scientific and technical knowledge at that time when the producer put the product at the market. Taken into account, that the evolution of autonomous driving is fast developing and a self-driving car of one year is seen as working on an old-fashioned system while the next year the state of the scientific and technical knowledge is much more sophisticated and advanced than when the "old" car was introduced. Though, also considering, that cars have a longer utilisation time than one year, rather more than 40% are 10 years and older, accidents with cars can also happen after 5, 8, or 13 years of their initial launch to market and it is not mandatory to use a cutting edge car.[70]

The exemption for the producer is very broad and not exactly determined. For this reason, it is not easy to explain drivers, they are held liable for the damages caused by their autonomous driving cars, while the manufacturer can escape this accountability in simple proving, that the car is an old one and no longer state of the art. This interplay is more harming the promotion of AVs than creating an atmosphere which can be seen as fair-minded.[71] Especially when it is not mandatory to drive a car, what is always state of the art.

[69] (Bundesministerium der Justiz und Verbraucherschutz / Federal Ministery of justice and consumer protection, 2017)
[70] (Kraftfahrtbundesamt, 2019)
[71] (Verbraucherzentrale Bundesverband e.V., 2017)

2.2.1.2. Liability according to the German Road Traffic Act/Straßenverkehrsgesetz (StVG)[72]

As the author has figured out, product liability can be seen as an appropriate device to clear up accidents and their scope of liabilities of the parties involved. However, nowadays, almost 100% of car crashes in Germany are solved and regulated by the Road Traffic Act (StVG).[73] Having said this, it is worth to have a closer look on that liability.

The German liability of car crashes and the responsibility of the persons involved is always based on the concept of the car holder or car driver, §§ 7, 18 StVG. Both parties can be held liable jointly and severally beside the mandatory third-party liability insurance of the car keeper, which is a mandatory condition to have for an official authorisation of the car for the vehicle keeper.[74]

2.2.1.2.1. § 7 StVG - Liability of the car keeper

In Germany, the liability is distinguished by whether you are a driver or keeper of the car.

§ 7 StVG holds the official responsible person for the car, the vehicle keeper, which is not mandatory the owner of the car defined by civil law liable in any occurrence the car caused damages while taking part in moving traffic. This is a strict liability regardless of individual behaviour causing damage. A car is seen as any machine-driven vehicle on land which does not depend on rails, § 1 (2) StVG.

Car keeper

A car keeper is a person who takes care of the car in terms of periodical services appointments with the garage and is the policy holder of the mandatory car insurance, both on its own costs. Mostly the car keeper is also the owner, but not necessarily. Although the § 7 StVG does basically apply to autonomous vehicles, problems with the current regulation occur by diverging from any of those principles. Especially, the ownership- or car keeper-accountability is challenged by new models of sharing.

Keeping this in mind, the question about the car keeper arises, when the AV is not kept by a single person, rather by a sharing community which set up a private sharing system for them or a commercial sharing platform, which owns a fleet of self-driving cars used by numerous members. The community can be seen as a private corporation; however, this would mean every member can be held liable with their own private assets[75], analogous to § 128 Handelsgesetzbuch (HGB).[76]

[72] (Bundesministerium für Justiz und für Verbraucherschutz - Straßenverkehrsgesetz, 2019)
[73] (Prof. Dr. Dr. h.c. LL.M. (UCLA) Oppermann, Apl. Prof. Dr. Stender-Vorwachs, & Prof. Dr. LL.M. Beck, 2017)
[74] (Gesamtschuldnerische Haftung von Fahrer, Halter und Haftpflichtversicherung bei einem Verkehrsunfall, 1989)
[75] (jura-basic, 2018)
[76] Commercial Code (Bundesministerium der Justiz und für Verbraucherschutz / Federal Ministery of Justice and for Consumer Protection - Commercial Code, 2017)

Considering the increasing sharing economy and platforms of the initial product developers, the car keeper may switch to be equal to the manufacturer, which is providing a huge AV fleet, as Tesla announced.[77] In that way, the community model would be unattractive very quick. To avoid such uncontrolled responsibility, the authorities are requested to regulate these issues in advance.

Damage of a legally protected right

According to § 7 StVG, a damage means either an injured or dead person or a damage of property. That can happen in a car crash involving an AV.

Using a vehicle in moving traffic

The car has been in the operation mode while the infringement happened, to be covered under the liability of § 7 StVG. Though it must not be moving; it has to take part in the operating traffic, for example in a parking lot or during a break while unloading goods. With AVs, the proof of if the vehicle was in operation will be easy to asses technically, thanks to the saved data.

But it will be an ethical question if such data can be used at court, who does have access to this data (only the involved participants, the manufacturer or the authorities) and what are the consequences in the judicial system if the proof can be seen by pushing the button. Those concerns should also be covered by new legislation on autonomous systems in traffic and mobility.

Causality

The damage must be caused by the vehicle. Thereby, it is not necessary that the damage was caused by only this car, also in the case that various cars were involved in the accident, at least a partial responsibility should have been stated referring to that specific damage. Here again, the question of the facilitated proof rises when it comes to the stored data and a policy to use them in court.

No act of God/inevitable event

Force majeure means outsourced or by outsiders' elemental forces of nature or by actions of third party's person induced and after human insight and experience unforeseen events which could not be prevented under use of tolerable economic means or by extreme care or harmless and which were not be accepted because of their frequency.[78]

Considering Level 5 vehicles, a system failure or hack could be probably seen as an act of god, due to its unforeseen and for the car keeper unavoidable event. Although the system error or executing defect happens in a field which is not part of the legal risk sphere of the car keeper, it cannot be seen as force majeure in any case.

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[77] (Boudette, 2019)
[78] (Bundestag/ German Parliament (14th legislative period), 2001)

Since the system, even as intervehicle or linked with other systems, e.g. the producers' system, is a part of the car itself and thus, not an outside event.

2.2.1.2.2. § 18 StVG - Liability of the driver

After investigating the liability of the car keeper, the discussion of the accountability of the car driver is shorter due to many parallels in the liability system. There are only a few differences concerning the liability assessment scheme. First, the liability is not strict rather linked to the driver and the individual behaviour of the driver. In German road traffic legislation, the driver is the one who controls the car during the driving operation. In addition, the driver's liability is only given, when the one of the car keepers is applicable under the Road Traffic Act, § 18 (1) 1 StVG.[79]

However, this is not a big problem because strict liability is easier to affirm. The link to the behaviour of the driver, which is most highly uncertain and has to be proved by the parties is in accidents involving self-driving vehicles missing.

Though, there is one material difference between the liability of the vehicle keeper, which is linked to the simple risk of having an automobile publicly accessible and used in public areas. As this strict liability is tied to the vehicle keeping risk, the risk cannot be transferred to a driver of a car. Significantly, the legal accountability of the driver is, in any case, tied to his/her behaviour and actions.[80] Presumed, the driver is replaced by an autonomous Level 5 performing vehicle system, the liability of the driver is not applicable any more. The human driver has vanished and is no longer a key element of a transportation setting. Although the human driver turns into a user, the system which replaces the demanded conductor is now the producer who released the code integrated into the car: This system is the new key driver.

2.2.1.3. New traffic regulation in Germany § 1 a-c StVG

The amendment § 1 a-c Straßenverkehrsgesetz in the German Road Traffic Act was amended in 2017, June 16th, by the German parliament.[81] Thus, the amendment is two years old and is able to demonstrate if it already had an impact on the legal certainty and the development of autonomous vehicles in the society and industry. Firstly, the new three sections will be illustrated and explained. Later, the design and reasons for the new legislation will be shown.

Conclusive, the author will comment the efforts on the legislative change and if those are appropriate to mitigate the aforementioned legal uncertainty on autonomous vehicle responsibilities in accidents and if the German car industry and technical development in that field are favoured by the amendment.

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[79] (Bundesministerium für Justiz und für Verbraucherschutz - Straßenverkehrsgesetz, 2019)
[80] (Gasser, 2015)
[81] (Deutscher Bundestag/German Parliament -Lesung StVG, 2017)

The amendment

§ 1 a to § 1 c StVG amend the § 1 StVG which is describing the features and conditions which are requested for vehicles to be recognised as such and to get the official approval as a traffic participant on public roads in the streetscape.

Due to the fact that this Road Traffic Act was established in 1909, newly created in 2003 and only modified by European regulation changes on the type approval process, the Road Traffic Act is influenced by a very antiquated way of thinking. To overcome this old-fashion piece of law, the German parliament put great effort in the procedure to amend the act and bring it up-to-date.

> **The result is § 1 a - c of the Road Traffic Act:**
>
> *"§ 1a Motor vehicles with highly or fully automated driving function*
>
> *(1) The operation of a motor vehicle by means of a highly or fully automated driving function is permissible provided the function is used for its intended purpose.*
>
> *(2) Motor vehicles with highly or fully automated driving function within the meaning of this Act are those which have technical equipment which*
>
> *1. is able to perform, after activation, the driving task - including longitudinal and lateral control - for the respective motor vehicle (vehicle control),*
>
> *2. is able to comply with the traffic regulations applicable to the vehicle driving task during highly automated or fully automated driving,*
>
> *3. can be manually overridden or deactivated by the driver at any time,*
>
> *4. is able to recognize the necessity of manual vehicle control by the driver,*
>
> *5. is able to visually, acoustically, tactilely or otherwise perceivably notify the vehicle driver of the requirement to pass vehicle control to the driver with sufficient reserve of time ahead of passing control, and*
>
> *6. notifies of use that is contrary to the system description. The manufacturer of such a motor vehicle must declare in the system description that the vehicle complies with the requirements of sentence (1).*
>
> *(3) The preceding paragraphs shall only be applied to those vehicles which are approved in accordance with § 1 (1), which comply with the requirements of paragraph (2) sentence 1 and whose highly or fully automated driving functions 1. are described in international regulations applicable in the territorial extent of this Act and comply with them or 2. have received a type-approval pursuant to Article 20 of Directive 2007/46/EC of the European Parliament and of the Council of 5 September 2007 establishing a framework for the approval of motor vehicles and their trailers and of systems, components and separate technical units intended for such vehicles (Framework Directive) (OJ L 263, 9.10.2007, p. 1).*
>
> *(4) Driver is also the one who activates a highly or fully automated driving function referred to in paragraph (2) and uses such a function for vehicle control, even if he does not control the vehicle by himself within the context of the intended use of this function.*

§ 1b Rights and responsibilities of the driver when using highly or fully automated driving functions

(1) The driver of the vehicle may turn away his attention from the traffic and the vehicle control when the vehicle is controlled by means of highly or fully automated driving functions according to § 1a; he must remain sufficiently responsive that he can fulfil his duty under paragraph (2) at any time.

(2) The driver is obliged to take over the vehicle control immediately, 1. when the highly or fully automated system asks him to do so or 2. if he recognizes or, on the basis of obvious circumstances, realizes that the prerequisites for the intended use of the highly or fully automated driving functions no longer exist.

§ 1c Evaluation

The Federal Ministry of Transport and Digital Infrastructure will evaluate the application of the regulations in Article I. of the law of 2017, June 16th (Federal Law Gazette I p. 1648) after the end of the year 2019 on a scientific basis. The Federal Government informs the German Bundestag about the results of the evaluation." [82]

Design of the new legislation

The amendment refers in § 1 a directly in the heading but also in subsection (1) to highly and fully automated driving systems, which include AVs capable of Level 3 and 4. However, surprisingly, the law demands and expects expressis verbis in § 1 a (2) No. 3 StVG that a driver has to be on board and always stay ready to control the car. Although, Level 4 is no longer requiring a driver for specific circumstances like on highways, and the driver turns into a passenger according to the international recognised Level 4 standards[83], this Level 4 freedom cannot be executed under a law which always requires the readiness of a driver to took over the driving process any time.[84]

By doing so, § 1 a is taking up the automation progress in the mobility environment. The paragraph considers and allows every Level 3 and 4 car which has a type-approval and complies to all international technical standards stated in the Geneva agreement to participate in the road traffic in Germany. Autonomous driving cars of Level 5 are not mentioned in the new law.

After § 1 a describes the condition of the automated car, § 1 b sheds light on the role of the vehicle operator. The driver is allowed to put his/her attention to anything else during the time frame the car operates the driving process on its own. Nevertheless, the operating person has to stay ready anytime to take the driving process over when the vehicles request that or the driver has to realise that a situation occurred in what the system is not anymore capable of acting properly. So, the not desired human vigilance during the ride is fundamentally assumed by that regulation. This section does exclude the role of a driver turning into a passenger.

[82] (Czarnecki, 2017) (Bundesministerium für Justiz und für Verbraucherschutz - Straßenverkehrsgesetz, 2019)
[83] (SAE International, 2014)
[84] (FORUM - Wissen, das ankommt., 2017)

Finally, § 1 c was amended in the Road Traffic Act. This section of a legal obligation to evaluate this amendment after a certain period of time, here after 2019 terminated, incorporated and enacted in the law is not often to find in the German legal environment. It is a new method of the German legislature to ensure regulation has to be assessed and reviewed in order to stay up-to-date and to comply with state of the art in terms of the tremendous and fast progress in research and development in various technologies.[85]

2.2.2. Further regulation promoting autonomous vehicles in Germany

Data protection

Today, data is an important and valuable asset for a business.[86] Companies can use data for their own marketing strategies, to find out about their target groups' satisfaction, to improve the product and safety[87], but these data can also be sold or misused.

However, apart from the classical telecommunication or digital companies, from which such data collection is more likely to be expected, the car manufacturers also get on their way to build up mass-data. The big manufacturers focus their attention not anymore on engine, design and performance; they become owner of a big server-capacity, processing data of their clients about the movement profiles, preferences or driving styles, related fuel consumption or how many people were transported by the vehicle.[88]

To take control about data use and to return back the control of the data to the persons from whom the data originates, in Europe, the new European General Order on data protection entered into force in May 2018.

According to the European General Data Protection Regulation (GDPR) which says in Art. 2 No. 1 GDPR, the data, collected by the car manufacturers is subject to that protective regulation, as the data is suitable to identify a specific person, the client (personal data, Art. 4 (1) GDPR).

> *"This Regulation applies to the processing of personal data wholly or partly by automated means and to the processing other than by automated means of personal data which form part of a filing system or are intended to form part of a filing system."* [89]

Therefore, not only the business world is shifting their attention to this issue as an asset for their balance sheet, but also authorities are taking this concern into account, and they also have this topic on their sheet when it comes to regulation on AVs.

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[85] (Bundesministerium der Justiz und für Verbraucherschutz, 2018)
[86] (ADAC- Allgemeiner Deutscher Automobilclub, 2018)
[87] (Krompier, 2017)
[88] (Kowalski, 2018)
[89] (European Parliament, 2016)

Testing routes

A significantly high number of various testing routes popped up in Germany for testing new mobility technology in 2018.[90] In order to get a permission for testing any car which does yet not comply with security requirements on public roads or to achieve a waiver of the usual car type approval process for that certain testing area, the authorities in charge can provide the applicants with an exceptional permission, according § 70 StVZO/Road Traffic Licensing Act. Such exemptions are fixed tied to an area which is specified in advance by the authorities. [91] The waiver conditions that the car meets all requested security standards and a human driver can take over control any time, according to § 1 b Road Traffic Act. The car is driving only based on this waiver and cannot achieve a type-approval and registration.

Additionally, the waiver is meant to be first for just one vehicle. Applicants need one waiver for every single car. Moreover, § 70 (1) No. 2, 3 of the Road Traffic Licensing Act pertains only a waiver from this Act and refers to the permission to take part in public traffic on public roads. Restricting the application of new technology in cars, all other regulations have to be followed by the cars holding a waiver.

Security regulation in Germany

Mostly, Germany's regulation on security requirements of autonomous vehicles depends on the Geneva convention, which states what kind of details the vehicle has to be equipped with. Based on that the EU agreed on European Directives such as the Directive 2007/46/EC (approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles) in order to harmonise and set up a certain quality standard.[92] These directives serve for the type approval, which every car has to pass as well. Although Germany made big progress in pushing forward the change in the Vienna convention, the Geneva convention still remains the same. Thus, the German legislator cannot deploy big changes in national law on security requirements, specifically for autonomous vehicles. As the Geneva convention No. 79 demands only non-autonomous steering systems.

However, § 1 a to c generate a big step in German traffic law. It is maybe not enough to keep the German car industry competitive in the global market. The USA, especially the car technology hot-spots such as California invented new legislation in 2014 on AVs with a driver and on the driverless cars either for testing or public deployment in 2018.[93] In order to get a better overview of how competitive German law is in terms of autonomous vehicles and creating legal certainty for that emerging technology, the next chapter presents the US legal framework on AVs.

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[90] (Die Deutsche Versicherer, 2017)
[91] (Bundesministerium der Justiz und für Verbraucherschutz, 2019)
[92] (European Parliament, 2018)
[93] (State of California- Department for Motor Vehicles, 2019)

2.3. Law in the United States of America

Contrarily to the German system, where the legal scheme related to liability is characterised only by federal law, in the US, liability and regular framework on a car crash is provided by state law[94]. Only in terms of the product manufacturer liability, methods across the states are summarised on a federal level in order to harmonise them for the whole country.[95] Though this summary on product liability is not binding, the general court practice follows it. Further, the standard liability, according to traffic law, is also established and solved by every single state because those have a different kind of specifications and provisions on drivers' standards.[96] To govern safety standards, on the federal level, the National Highway Traffic Safety Administration (NHTSA) and at the state level, the particular departments of transportation are in charge. In the following, the reader will find the distribution on the two different, federal and state level responsibilities in the legislative system of the United States of America:[97]

"NHTSA's responsibilities	***State's responsibilities***
Setting Federal Motor Vehicle Safety Standards (FMVSSs) for new motor vehicles and motor vehicle equipment (with which manufacturers must certify compliance before they sell their vehicles)	*Licensing human drivers and registering motor vehicles in their jurisdictions*
Enforcing compliance with FMVSSs	*Enacting and enforcing traffic laws and regulations*
Investigating and managing the recall and remedy of noncompliance and safety-related motor vehicle defects nationwide	*Conducting safety inspections, where states choose to do so*
Communicating with and educating the public about motor vehicle safety issues	*Regulating motor vehicle insurance and liability"*

Table 1: Illustrating the allocation of responsibilities for traffic law in the USA.[98]

Subsequently, the US authority cannot easily regulate autonomous vehicles on a federal level in case of considering this tort liability as applicable for AVs involved in car crashes. Nonetheless, many states have different concepts to cope with liability issues and provide various approaches. Furthermore, the federal authorities in charge such as the Federal Department of Transportation (US DOT) or the National Highway Traffic Safety Administration show no intensive efforts to change the lack of federal regulation on liability in the future.

[94] (Logan & Mayer, 2010)
[95] (The American Law Institute, 2015)
[96] (Talley, 2019)
[97] (NHTSA, 2017)
[98] (NHTSA, 2017)

By letting all the different mindsets, policies and concepts of the states compete with each other, the US usually does find the solution which will prevail while it is adopted quickly by various states which are afterwards beneficiary for both, the society and the economy like it happened in Delaware in terms of company law.[99]

2.3.1. US product liability and autonomous vehicles

In the United States, even the tort law on product liability is the responsibility of every state; thus, the researchers and car producers of AV technology deal with 50 different approaches. In case product liability is applicable while most of the states tried to mitigate this in adopting the Restatement of the Law, Third: Torts-Products Liability (ALI, 1998), a collection summarising and systemising the product liability law, there are still significant differences of product liability.[100]

Strict liability

This special kind of liability, in the US, is a hybrid between tort and contract law. Basically, the manufacturers are accountable for the damages caused by the product sold and thereby, it is distributed to the public market.[101] In recent years all states refer to the summary of the ALI which distinguishes three different types of defects. Additionally, product liability is a strict liability regime, not referring to intentions or driving behaviour. The liability persists only between the manufacturer and the product user. [102]

Defect

Product liability seems to be one suitable approach to find the right person in charge of a defect at the self-driving vehicle. Regardless of various legal definitions on those defects causing liability, the most important one in this paper is, which one does apply if the software fails and is there one case in which the autonomous system failure is subject under. For every other error occurring at an AV and related to the physical, tangible car, we already know such cases and how to deal with them. Thus, the main novel question is, in what way can a car manufacturer be held liable for a software malfunction, subsequently leading to a car accident.[103]

Furthermore, there are three different broadly recognised forms of a product fail which might cause liability: manufacturing defect, design defect, or inadequate instructions or warnings, according to § 2 of the Restatement of the Law, Third: Torts-Products Liability.[104] The manufacturing defect refers mainly to physical parts, whereas the inadequate instructions or warnings mostly focus on the professional usage of a product, which is only relevant if the AV operator took action in the driving process.

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[99] (Delaware Government, 2019), (Cary, 1974)
[100] (Oluwatola, et al., 2016)
[101] (Geistfeld, 2017)
[102] (Cornell Law School- Legal Information Institute, 2019)
[103] (Geistfeld, 2017)
[104] (The American Law Institute, 2015)

Assumed, the operator fulfils only the role of a passenger during the ride, as intended by Level 5 technology due to the probable missing steering wheel, the software is the leading new element which can cause an accident by a malfunction.

The design defect remains as the one seeming suitable for a software bug. Nonetheless, the literal definition of a design defect is as such a defect

> *"...is inherent, as it exists before the product is manufactured. While the item might serve its purpose well, it can be unreasonably dangerous to use due to a design flaw. In 47 states, the plaintiff has the burden of proof to prove the existence of a design defect. In Alaska, California, and Hawaii however, the defendant must justify the product's design to show why there was no defect."* [105]

According to the definition, the law distinguishes between the singular item and the entire product. Hence, the software is included in the design defect as one part of the whole product autonomous vehicle. The autonomous system operating the car existed before the car was completed and sold on the market. So, the software is inherent and an integral part of the end product. Though the law assumes a first a smooth conduct, even if the flaw does not appear, the product has a design defect due to the inherent danger of that single harmful item. Once, the digital system does not comply with the specified instructions and this failure results in a car crash. The design defect is undisputable given.

Investigating the law in the most states the product-user as a plaintiff has to prove the defect unless the liability is not a strict one rather more connected to negligence or recklessness,[106] whereas circumstantial evidence is often sufficient to shift the burden of proof to the defendant.[107] Taken into account, that the user of the AV has no possibilities of influencing the vehicle and this itself is good in shape due to periodical service and complies with the required standards, the operating software will be easily seen as the cause of that accident.

Causation of the injury

The defect has to be the cause of the inflicted damage. As the software of an AV has an error and is driving unassimilated, so that, an accident was entailed by this malfunction, the causation can be affirmed.

Exculpation

After founding the defect and its correlation with the damage, the producer might be exculpated. Exculpations, the producer, can prove are defined in two cumulative ways, first by consumer expectation (1) and cost-benefit theory (2).[108]

[105] (Cornell Law School- Legal Information Institute, 2019)
[106] (Cornell Law School- Legal Information Institute, 2019)
[107] (Walter, 1969)
[108] (Villasenor, 2014)

(1) *“A product is defective in design or formulation when it is more dangerous than an ordinary consumer would expect when used in an intended or reasonably foreseeable manner. Moreover, the question of what an ordinary consumer expects in terms of the risks posed by the product is generally one for the trier of fact.”* [109]

(2) The cost-benefit (risk-utility) test tries to weigh the benefits, or utility, of the specific design against the costs, or risks, accompanying it. The factors that courts use in doing a cost-benefit analysis and getting results on that theory to determine whether a design has a defect vary by state jurisdiction.[110]

The liability based on consumer protection (1) is, however, very unmanageable for the producers due to the high or not realistic expectations consumers may have. This approach is, therefore, not fashionable anymore in courts.[111] Nonetheless, the second theory (2) is very debatable in its application on autonomous vehicles. Notably, the software providing the ride instead of a human driver, eliminate and avoid a high percentage of accidents and serves for a good purpose, from which many, if not thousands of potential traffic victims benefit. Weighing this benefit against a decreasing number of car crashes that still exist, the cost-benefit factor for the software will be in favour of the manufacturer generating both the software and the benefit.[112] Regardless of this issue, the software error is in spite of that considered as a subject to product liability due to a design defect according to the cost-benefit theory on product liability. Literally, a software bug is a design defect. However, it might not have hard and costly consequences for the producer due to the exculpation possibility.[113]

2.3.2. Standard liability in a car crash on state law level according to traffic law

However, both systems, the German and the US, have in common, that traffic law regardless its application in different states in distinct manners, the traffic law and its liability consequences are tied to the driver and the behaviour of the driver, for instance to negligence.[114] In some states, the liability is connected only to the driver, not the owner. The plaintiff has to prove all points such as duty, breach, causation, and harm of the driver, which caused the accident by his/her behaviour.[115] For that reason, the liability in car accidents, which is regulated by the states’ Road Traffic Acts will be no longer covering self-driving cars due to the absence of a driver.

Furthermore, a few states make use of a third liability system within their traffic law. They are using strict liability organising traffic law liability. This concept requires an ultrahazardous behaviour of the perpetrator of the accident and that the causer knew about this particular dangerous behaviour. This is also connected to the driver, who will vanish.

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[109] (DONEGAL MUTUAL INSURANCE v. WHITE CONSOLIDATED INDUSTRIES INC, 2006)
[110] (Jensen J. B., 2018), (Oluwatola, et al., 2016)
[111] (HISRICH v. VOLVO CARS OF NORTH AMERICA INC, 2000)
[112] (Oluwatola, et al., 2016)
[113] (Oluwatola, et al., 2016)
[114] (HG.org Legal Ressources, 2019)
[115] (HG.org Legal Ressources, 2019)

Some states use the “non-fault” system in traffic car accident claims, which consists that the victim is compensated by its own insurance until a certain amount is reached. Only beyond that amount, the action is permitted, and the often highly costly and challenging investigation on the fault starts in court. Having said that, the question on the fault of whom is still rising when the certain limit is reached.[116] Moreover, some states link their traffic law accountability to the owner but only in the cases, for example, the driver is a family member, employee or has a permission of the owner. However, affirming that the owner was different from the driver, those regulations establish liability then only with the misconduct of the particular driver. Thus, only the owner, not the driver, is liable in the case the driver would have been.[117]

2.3.3. Further federal regulation promoting autonomous vehicles in the United States of America

Data protection

Also, the US is aware of the collection of private data by the industry. Therefore, the federal legislature enacted and amended data protection law on a continuous base. The Drivers’ Privacy Protection Act is one of three possible Acts which could cover the management of data collected by the self-driving vehicle. The other two probable suitable Acts are named the Electronic Communications Privacy Act (ECPA) and the Federal Communications Act (FCA).

Firstly, the Driver Privacy Protection Act applies only for the State Department of motor vehicles and its employees.[118]

Secondly, the ECPA consists mainly of a prohibition of interception of communication in any unlawful way. 18 US Code § 2511 (2) specifically refers to electronic communication services and not to the production industry. Apart from this, the Act's scope is clearly covering only communication between two consumers and its interception and not to pure information collected by the company. The producer has to ensure that the data is protected from third-party interference.[119]

Thirdly, the Federal Communication Act is addressed to telecommunication carriers in order to protect the customer-information they collect. The classification if a car producer can be seen as a telecommunication carrier is still open, but the law initially intended to allocate to telephone provider or operator.[120]

Although that sector-specific data protection exists on a federal level, the states can provide their residents with additional law, but state law for data protection is rudimentary and rare.[121]

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[116] (Oluwatola, et al., 2016)
[117] (Nolo, 2015)
[118] (U.S. Government , 2012)
[119] (U.S. Government, 2012)
[120] (U.S. Government, 2012)
[121] (Colbert, 2018)

Security regulation

The NHTSA and US DOT try to mitigate the problem of finding the appropriate security rules and standards for the emerging autonomous mobility technology. Instead of establishing law, the NHTSA provided a voluntary guiding policy on safety characteristics for autonomous vehicles in 2016 in collaboration with the DOT.[122] Much more, the NHTSA, simultaneously in that way, announced a 4 billion program *"to accelerate the development and adoption of safe vehicle automation through real-world pilot projects,"* [123] The National Highway Traffic Safety Administration made the application process for car manufacturers testing and developing AVs faster and declared to be more open to waivers[124] in order to foster the technological progress.[125] The main function the NHTSA and DOT serve in this situation is to clarify and harmonise the safety features of autonomous vehicles on a federal level with the papers "Automated Driving Systems- A vision for safety" [126] and "Automated Vehicles 3.0 - Preparing for the future of transportation." [127]

In section one of the first official paper, the NHTSA determines what kind of safety standards should be taken into account of the companies creating self-driving cars. Despite the NHTSA and DOT approach the autonomous vehicle topic by publishing guidelines or recommendations, they are not generating binding liability law and their purpose is not to reach a final federal regulation on that. Accordingly, in section 2 of the guideline, the NHTSA emphasises the assistance role of the federal authorities in the topic of liability or further issues.[128] In doing so, the federal US regulators keep the space open and get out of the way for the states, for the competition between the states to find the most suitable regulative answers.

2.3.4. State law promoting AVs

This paper is going to show an exemplary way of how regulation triggered by AVs in some states is developing. For that reason, California, Arizona and Michigan were picked.

After having learned about the liability issue concerning autonomous vehicles, the US states California, Arizona and Michigan already have gone one step further. In order to beckon the rising industry, build around AV technology and also to satisfy, retain and extend the existing tech hot-spots and the car industry in their states, California with the Silicon Valley, Arizona located next to it and Michigan as an old car business location are willing to build also administrative and legal infrastructure. All three states recognised their pioneer function and how important legal certainty and protection is for new upscaling and increasing businesses.

[122] (NHTSA, 2017)
[123] (National HIghway Traffic Safety Administration, 2016)
[124] (Cornell Law School, 2015)
[125] (U.S. Department of Transportation, 2018)
[126] (Eastman, 2016)
[127] (U.S. Department of Transportation, 2018)
[128] (NHTSA, 2017)

2.3.4.1. California

At least since Facebook, Apple, Google and Amazon, the State of California is well-known as the place to be when it comes to technological and important digital inventions. Most of not only the biggest and most successful rather more the most valuable IT- and high-tech companies are headquartered in California.[129] To survive in that race of new invention, disruptive IT ideas, building new ecosystems and digitalisation of everything, California provides its industry with very active, flexible and cutting-edge legislation processes which are mostly come into existence by an active collaboration of the legislators and the economy.[130]

Because California wants to provide the new technology with a regular framework to prosper in, California was one of the first states which enacted regulation on autonomous vehicles in 2012.[131]

The law required the manufacturers to comply with certain safety aspects set up by the NHTSA and to give notice to the local department of transportation before they are allowed to use autonomous vehicles for testing purpose. This was with a person who possesses the proper class of license for the type of vehicle being operated and seated in the driver's seat to monitor the process.[132]

Between 2016 and 2018 the state adjusted, amended and reviewed its legislation on autonomous vehicles 6 times. One bill in 2017 encourages the Department of Transportation in California while maintaining and improving road infrastructure also to invest in devices which already have the ability to communicate via V2I technology with the autonomous vehicles, Road Maintenance and Rehabilitation Program 2030 (d).[133] In the same year, division 16.6. Autonomous Vehicles [38755] of the California Vehicle Code came into force. This new section allows cars without a driver on public roads for testing purpose while it ensures that the operator, who must not be seated in the car, has to fulfil some security features such as continual monitoring the AV or be provided with the possibility to take over control of the AV any time.[134]

The latest bill of 2018 allows San Francisco to set up a tax upon autonomous vehicles which provide mobility as a service (MaaS), not as a private car.[135]

Testing routes

As mentioned above, California allowed by law the testing of autonomous vehicles with a driver matching certain features in the entire state in 2012.

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[129] (Prof. Dr. Elbert, Müller, & Persch, 2009)
[130] (Legislative Technology & Innovation Caucus, 2019)
[131] (National Conference of State Legislatures, 2012)
[132] (Senate of California, 2012)
[133] (Senate of California, 2017)
[134] (The State of California, 2017)
[135] (CCH Tax Group, 2019)

In 2016, California amended its regulation with the Section 38755 of the Vehicle Code, relating to autonomous vehicles and permits thereby specified testing routes for driverless cars without a steering wheel or brake pedals driving not faster than around 56 km/h.[136]

Data protection

The California State Assembly and State Senate agreed in 2018 on a data protection act (California Online Privacy Protection Act, CalOPPA)[137] to equip residents of California with the rights to know about what data is collected from them and whether these were sold or disclosed to whom. Moreover, the act protects the residents against selling and disclosing data whilst the companies concerned have to give the residents the right to say no on this by providing a No-button on their websites. This law applies to profit companies which surpass either $ 25 million gross revenue, or possess data of more than 50.000 residents or earns more than 50% of its annual revenue by selling data.[138] The act will enter into force on 2020, January 1st.[139]

2.3.4.2. Arizona

Arizona has no regulation on autonomous vehicles, however, reacted on the emerging mobility technology issue in a more direct way. The Governor of Arizona released an official Executive Order on autonomous vehicles which consist of testing procedures for driverless autonomous vehicles on public roads, in September 2015.[140] Three years later, the Governor adjusted this executive order by another one, which mainly focused on autonomous driving systems and their compliance with federal and state safety standards. Beyond this, the order facilitates the entire testing procedure in expanding the application of driverless autonomous vehicles from certain areas to the whole state, demanding to give notice from the tester to the Arizona Department of Transportation and instructing traffic enforcement authorities how to face issues with AVs in case of emergency.[141]

Testing routes

There is no particular regulation on fixed testing routes, instead of the state is the testing route.

Data protection

The State of Arizona has a state data protection regulation which enforces companies owning, maintaining or licenses unencrypted personal data to notify the victims in case of a security breach in the companies' systems, according to Section 1. Title 18, chapter 5, article 4. Data security breaches.[142] Thus, a car manufacturer is only affected by this data protection law if the car company gets hacked, and the data is released to a third party. In doing so, the data has to be protected by a security system, which is immune against unauthorised and unlawful access of third parties.

[136] (Senate of California, 2016)
[137] (Colbert, 2018)
[138] (Californias for Privacy, 2019)
[139] (Senate of California, 2018)
[140] (Governor of the State of Arizona, 2015)
[141] (Governor of the State of Arizona, 2018)
[142] (State of Arizona House of Represantatives , 2018)

Consequently, the collection of data of autonomous vehicle users is not regulated; only the way this data has to be stored is. Except for this, there is no more state legislation on data protection.[143]

2.3.4.3. Michigan

At 2016, December 9th, the Senate of the State of Michigan amended their legislation on AVs. Before in 2012, the state allowed self-driving cars only for testing purpose, however, with the new amendment, the authorities permit the establishment of on-demand automated motor vehicle networks running on public roads of the states. According to the act, those are driverless operating vehicles which can be used similar to a taxi as a transportation device to connect passengers and AVs. The enterprise setting up this network can be a car producer or any Upfitter, which is an OEM of software equipping cars with automated driving systems.[144]

Testing routes

In Ann Arbor close to Detroit, the University of Michigan build a test area for autonomous driving already in 2014.[145] This is still used, but the attractiveness of the public roads is pulling the car manufacturers to them since it is allowed to conduct driverless cars in public.

Data protection

Similar to Arizona, as well, Michigan does not possess a specific data protection regulation. Its only law in this field is concentrating on the breach of a security system of any company and giving notice of data loss to the consumers.[146]

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[143] (Arizona Attorney General Mark Brnovich, 2019)
[144] (Senate of the State of Michigan, 2016)
[145] (Eckl-Dorna, 2014)
[146] (CSR, 2019)

3. Analysis of the law

3.1. Conclusion on international UN treaties

Taking the progress in international regulation into account, Germany tries a lot to keep pace with the technological development in the area of autonomous driving and to ensure legal certainty in that field. Moreover, Germany was one of the initiating parties for the amendment in the Vienna convention of 1968 in 2014. With the change and adjustment, a broader acceptance of driver assistance systems and subsequently autonomous mobility technology is expected. So, Germany, among other European countries, strove very early for a new regulation on autonomous vehicles. However, changing the international treaties was just the first step on the path to pave the way for Level 5 fully autonomous driverless cars. Since Article 8 was just amended for autonomous systems that assist the driver, the core of Article 8, that *"Every driver shall at all times be able to control his vehicle…"* [147] remains in force. Subsequently, implementation of new national legislation addressed to Level 5 autonomous vehicles is again bound to the international treaties Germany has signed and ratified.

Even considering Article 54 No. 5 of the convention which did allow countries, before ratification, to declare reservations relating to this convention, Germany cannot bypass this treaty.[148] Because Germany ratified the convention in 1977, autonomous driving was not predictable, and thus, no reservation could be declared. However, Germany passed the amendment through the UN decision process but did not open up the convention as far as it is necessary for legal recognition of AVs. Disappointingly, Germany had the resources, the intention and willingness to keep pace with the technical development, but went not as far as it was necessary in for example complimenting Article 8 in a manner, that a driver can be replaced by an autonomous system in a moving vehicle so far it is complying to the technical standards as stated in the Geneva agreement.

By changing Article 8 of the Vienna convention on road traffic, Germany took the first step to change also its national legislation. In doing so, Germany tries to implement not only legal certainty about new technics in vehicles and the responsibilities if they are involved in car accidents, but also tries to rise social acceptance, to foster economic sectors and technical research and development in those emerging mobility technologies solutions.[149]

Conclusively, the amendment does imply a significant shift towards regulation on autonomous assistance systems, nonetheless, does not permit a lot of manoeuvrability for the pending and soon developing technical progress and development. In the end, the change is covering the latest technical development but is not considering prospective progress or addressing issues in the future. Level 5 AV technology and mobility ecosystems related to that are not covered in the Vienna agreement.

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[147] Article 8 No. 5 Vienna convention of 1968
[148] (Schweizerische Eidgenossenschaft- Der Bundesrat, 2018)
[149] (Deutscher Bundestag (18. Wahlperiode) / German Parliament, 2016)

3.2. Analysis of national liability regulation - Germany

3.2.1. Conclusion on the German Product Liability Act

Thus, looking forward to a broader scope of application of product liability provisions in order to search regulative solutions for autonomous driving technologies involved in car accidents, the law now is not mature and fully-developed for the emerging technology. It lacks a clear statement of accountability of autonomous and artificial intelligence systems. On the one hand, the exculpation in § 1 (2) No. 5 ProdHaftG is hindering the potential clients of self-driving cars since they have to bear the risk. On the other hand, the car producers are pushed by this lacking liability so far to develop the technology and to bring it to market. Working on this concept and adjusting the law by explicitly excluding autonomous systems in No. 5 could help to solve the imbalance. Eventually, the product liability act has not only downsides.

One big advantage of this particular liability is that it cannot be excluded by the producer in charge in any kind of explanation, declaration, contracts or in general terms, § 14 ProdHaftG. So, if the exemptions mentioned in § 1 (2) does not apply, the manufacturer principally is held liable in any case. With the flexibility of that law, many cases of liability questions in accidents involving autonomous vehicles which have a defect can be covered by the product liability act. Furthermore, the act is based on a European Directive. Thus, all the European countries which have implemented the act in a similar manner as Germany, have good coverage of AV defect damages cases. Because the regulation is not an invention, rather a well-known liability system out of the 1990s with often used provisions, the legal certainty is thereby fostered taking a glance of emerging AV technologies in the future. With the sophisticated damage system and the clear structure for the burden of proof, this law is also suitable for further developments on emerging transport opportunities.

However, using product liability shifts the liability entirely from the driver to the producers and tech-developers, which can impact not only the insurance industry, rather more the attitude of the driver not to react or override autonomously taken decisions in order to escape the liability intentionally. According to this, the statistic in increasing safety on road traffic would have to consider this also. So, the mix of machine acting and human surveillance would even ideally extend the safety on road traffic but would miss the purpose of self-driving cars facilitating riding experience.

Using more autonomous vehicles on our streets, the connection of liability and a human is losing significance. The unavoidable shift of the responsibility from individual behaviour to broader accountability of the producer is supported by the development of the technology and increased redundancy of a human operator in a driving process. So, the product liability system will gain more importance and should be appropriate for approaching future transportation technologies. Altogether, the Product Liability Act is not hindering the emerging technologies. It is rather more facilitating social acceptance and technological development by creating legal certainty.

3.2.2. Conclusion on old traffic law liability for the vehicle keeper

The legislation on car keeper liability can be transferred to autonomous vehicles without bigger problems. The regulation is capable of covering new cases of the ownership/vehicle keeper problem or the accountability of them for systemic defects. However, the authorities can also now use the chance to change the legislative decisions taken in former times and adjust them to modern ideas by rethinking the car keeper accountability in sharing community using platforms in which ownership is a less significant focal point. The German regulation could shift their focus away from the consumer of the mobility more in the direction to the producer of the devices.

It is a challenge and a question for the regulator also, to decide acts who will be responsible and seen as a car keeper in new legislative to adjust the current legislation. Basically, to find an answer if there will be any car keeper link in the future. By opting for a new law which endeavours to find an appropriate solution, the legislator can customise the new autonomous vehicle liability act for their purposes and ethical determination then.

By illustrating the tension between the gradually low influence the car keeper actually has on the vehicle's system and the full accountability for system failures, the current legislation might not be appropriate to promote AVs in Germany. The current provision focuses on the victims of a car crash and the best way to protect those in advance in deciding for liability of the car keeper without actually no capability to avoid the accident cause, system failures.[150]

Conclusively, the responsibility of the car keeper would not change totally, nevertheless, the car keeper could choose what driver he/she wanted to trust in riding the car, now with a Level 5 AV, the car keeper can only decide what kind of system he/she is trusting in to ride the car. So, the choice is shifting from a personal, sometimes pleasant or necessary decision to a more technical, lifestyle, or ecosystem preference.[151]

3.2.3. Conclusion on old traffic law liability of the driver

Under § 7 of the Road Traffic Act, this accountability is solely related to drivers' behaviour. In eliminating the liability of the driver due to AV technology, Germany will lose the most applied liability provision concerning car accidents. This will not request a shift in the legal practice, in court, lawyer profession or legal education only but more importantly, this change will produce a huge problem for the acceptance of the society.

To find a balance between the interests of the "driver" then passenger or even not anymore on board, who don't want to be held liable for a machine failure, the car producer and its strict product liability and the society who wants to be compensated when experiencing injuries and losses caused by a self-driving car.

[150] (Ass. jur. Singler, 2017)
[151] (Gasser, 2015) (Woisetschlaeger, 2015)

3.2.4. Comment on the amendment in the German Road Traffic Act

According to § 1 a StVG, the first step towards including new mobility systems in German traffic law is accomplished. As a big supporter of this step, the beforehand efforts to change the UN regulation of the Vienna agreement paid off. This international approach paved the way for national legislation on automated driving technologies. By implementing the highly and fully automated, so Level 3 and 4 vehicle systems in the traffic law, a lot of research on this topic and ambitions of the German car industry are facilitated and enhanced.

In contrast to accelerating Level 3 and 4 vehicles by the regulator, the relevant car industry is already mainly trying to overcome problems between highly or fully automated cars and drivers which have to interact in case the system fails. This transfer between driver and system is highly risky. Due to the risk transfer[152], car manufacturers are reaching out for the Level 5 AV and the linked infrastructure for those highly data-driven and connected cars. Hence, Level 3 and 4 cars are not anymore the ultimate goal, the new technical challenge for car producers is already creating fully autonomous vehicles which are safer than the risk transfer requiring Level 3 and 4 models.[153] Consequently, the law made for emerging technologies goes beyond the former existing regulation while it is rapidly outpaced by new engineering approaches and opportunities. The amendment takes a brief current snapshot of what is going on in the automobile development but is not cutting-edge, although it is just 2 years old.

Furthermore, the law does not yet comply with the international SAE level standard in which a Level 4 vehicle is described as one that can operate autonomously in certain circumstances, so, without a driver. Nonetheless, § 1 a (4) first presumes a driver, not a passenger on board and § 1 b (1) especially set up the duties the driver has to fulfil, in case the car is not acting properly. This inconsistency on Level 4 cars with, on the one hand, having an international harmonised driver transforming into a passenger and, on the other hand, taking for granted the driver is any time able to take over operation is a huge contradiction in the law itself.[154]

Even though § 1 b (1) allows the operator to pay attention to something else while the system is operating automated, the law is not consistent within itself because using digital facilities such as mobile phones or laptops is still strictly prohibited and will get punished by the police, §§ 23, 49 (1) No.22 StVO.[155] Moreover, the driver is allowed to pay attention to something else but has to stay prepared to take over control at any time. This is practically not possible. According to a study, a human at least needs 15 seconds to realise and estimate the traffic scene properly when the driver was not paying attention to it before.[156]

[152] (Oluwatola, et al., 2016)
[153] (Villasenor, 2014)
[154] (Wissenschaftliche Dienste Deutscher Bundestag/ Scientific commission of the German Parliament, 2018)
[155] (Bundesministerium der Justiz und für Verbracherschutz -StVO, 2017)
[156] (Mueller, 2018)

Additionally, the § 1 a-c are lacking information on Level 5 AVs. The amended Road Traffic Act presumes in (4) a driver or operating person is still existing, and from time to time is leading, monitoring or checking upon on the driving process. To let an autonomous car, operate without a driver is unlawful, therefore. A fully autonomous driving vehicle of the recognised Level 5 is also not considered in the Vienna agreement as a car what is allowed to operate on public roads, irrelevant of its capability, features or potential. Consequently, the new Road Traffic Act is bound to this agreement.[157]

Even though the German legislature put a lot of efforts in the process to receive a legal approach in terms of promoting AV technology, the German legislature seems too short-sighted in the legal change. While keeping an eye on the importance and significance of the car industry on German wealth, economy, employment, investment and export rate, the legislature may have gone beyond the nearby cases. Hence, the legislation procedure would have a good deal more remunerate if the entire process would have started with the goal of allowing autonomous vehicles immediately and not only automated vehicles on public roads.

3.2.5. Conclusion on German product and traffic law liability

The strict liability of a car producer by § 1 of the product liability act and of the vehicle keeper by § 7 of the Road Traffic Act bear some tensions in them due to the conflict of interests. The product liability can be simply circumvented by the producer, and the car keeper concept does no longer fit to the change in society towards a sharing community with a platform rather than an ownership thinking. The shift as in many other businesses observed is away from a product selling towards a service selling. Selling cars as a service is called MaaS: Mobility as a Service.[158] Those problems leave the manufacturers, potential users of the autonomous vehicles and the society as the one worrying about the safety and compensation in car accident cases in a legally very uncertain and volatile situation.

One method to provide a bigger amount of certainty for the involved participants could be a jointly and severally strict liability of the car keeper and the producer. Simultaneously, encouraging the car keeper maintaining and the producer improving the autonomous vehicle steadily.

Unavoidably, product liability will increasingly become the centre of attention if the sharing concept is running rampant in society.

Subsequently, with the sharing economy, a completely new ecosystem and perception of ownership will be built, and the German law principles relying on and determined by the ownership thinking does not work anymore in an effective way. Certainly, the companies may be owning the platform or taking care of the communication would then be liable.

[157] (Wissenschaftliche Dienste Deutscher Bundestag/ Scientific commission of the German Parliament, 2018)
[158] (Colbert, 2018)

Nevertheless, if the platform owner just facilitates peer to peer interaction and some individuals own a car, but share it with the entire community, why should the platform take the risk of being liable for the trip of their clients. Once the ownership disappears and is maybe substituted by a usership, it will be more likely to hold the producer liable and not anymore, the one using the product. Due to the fact that the user of an AV is actually not acting with the product rather than consuming it.

Henceforth, not only the importance of the ownership link of German traffic liability but also the accountability of the acting person is shrinking due to the decreasing acts the user has to undertake during a ride on self-driving cars.

As a consequence, the German legal landscape as we know and practice it is shifting towards a higher application of product liability in car accident compensation. Instead of solving only 0,1% of the cases by means of product liability in car crashes and 99,9% by means of the Road Traffic Act, an increasing number of cases will occur and require a different approach, when technology is emerging into the daily-life using experience of societies and the driving is more and more frequently outsourced to machines.

Since law is always used to organise interests and to prioritise some goals over others, the emerging technology of autonomous mobility and transportation systems requests the legislature to fulfil its duties in doing so. [159] According to the demonstrated tensions, the German legislature has to decide how German liability on AVs will look like and what interest will be encouraged by the new law which entered into force in 2017.

3.2.6. Conclusion on further regulation in Germany promoting AVs

Comment on data protection

Despite the GDPR in Europe. the main question who exactly owns the data is still pending. The data collected by the car and gathered by the producers' servers can imply very detailed information about the car and its users. Taken this matter into account, a car manufacturer, for instance, collects data of two different drivers:

The first driver is driving very calm and does not need a lot of fuel, in the car always at least 3 people. The second one has a risky driving style, is always gaining speed and slows down abruptly and in that car is riding only the driver.

All this information is an inference of the tire pressure monitoring sensor, which can collect data on speed and breaking sections and which is able to deliver precise changes of the weight of the car and when someone with what weight is entering the vehicle.[160] According to the movement profile of the drivers, also data is collected about their home or working addresses. The question arises, who is the owner of that information?[161]

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[159] (Pötsch, 2009), (Hobbes, 1651)
[160] (Jensen, Gruschka, & Lüssem, 2016)
[161] (Doll, 2019)

The GDPR is not answering these concerns. However, the European data regulation establishes a framework in which such data used by companies in a commercial way have to be anonymised. Although this protection, car manufacturers are allowed to collect and use the data, or even sell the data.

By doing so, retailers or insurance company can get deep insights into the preferences, living style or personal characteristics of the drivers of a particular car producer but cannot connect this to an individual person. Consequently, the data buyer can personalise their marketing strategy and adjust and limit it to their targets only. Additionally, the insurance company is set in a position that allows it to raise the insurance fee of a driver driving a certain brand. Even that driver was not obliged to disclose such information to the insurance enterprise.

On the other hand, these databases enable the entire traffic system to be connected and to create a more preferable driving experience and assistance, facilitating everyday life and also to improve products and car technology. Thus, the collection of personal data can be seen as an opportunity, as well as a threat to societies.

For this reason, ownership, processing and control of data streams and information flow is an important question for the companies, authorities and the society as a whole. Consequently, the issue around the protection of this data becomes more and more important for people in the digital age. Since smart home products like an intelligent fridge, which is generating the content of itself via an app on your phone and virtual assistants such as Amazon’s “Alexa” are urging even in people’s homes, concerns on the use, access and protection of all the collected data are increasing significantly.

As this paper mentions previously in chapter 2, Europe has a European and national adopted data regulation, which picks up the data protection problem in a very complete and holistic manner since 2018. Nonetheless, the topic is still pending because many car producers can bypass the regulation in collecting data in making them anonymous. The question is still remaining if this data is not more the property of every customer or user rather than the free database of the car manufacturers.

Although the European GDPR is strengthening consumers rights, it can be bypassed by the cleverness of the generating companies in anonymising it. However, the car producers do collect the data, maybe, even without any confirmation and knowing of the user or buyer.

Another big problem consisting of the data regulation is the enforcement. In case industry fails to comply with the regulation, it is difficult for the authorities to find out due to a lack of efficient surveillance and subsequently, the enforcement is often missing because of the missing transparency.

Concluding this, the ethical dilemma and the personal data question are both influencing the regulation process of AVs because these topics are concerning the entire society, not only in a positive manner.

Testing routes

The existing testing routes for autonomous vehicles offer a broad range of different routes of various degrees of difficulties all over Germany. Unless, there are plenty of research institutes, universities, software companies and car manufacturers involved in those testing processes, the testing routes are only established for automated cars which do need a driver. Even though the § 70 StVZO waiver enables the applicants to bring test vehicles with a type-approval for testing purpose on the road, the remaining regulation has to be fulfilled, for example, the requirement of the constant presence of a driver seated in the drivers' seat. A driverless car on public streets is not allowed under the current legislation.[162]

The greatest disadvantage of this procedure is the lack of transparency. It is not clearly published what kind of certificates, forms or fees are necessary to be fulfilled for a prospective applicant. Even worse, the § 70 StVZO is written in an abstruse legal language for laymen and only in German. Thus, this waiver offers a possibility which is hard to reach for not companies which do not have a vast experience in the German legal environment around car production. So, fresh and young start-ups maybe from the digital software-developer business branch have a clear disadvantage in that procedure. In essence, they are excluded from that waiver.

Safety regulation

Germany can only regulate the security requirements to autonomous vehicles slightly. Since Germany is limited by the international UNECE Vienna and Geneva agreements and by the European Directives formulating the conditions in order to achieve a type approval, the national legislature can only change and adjust the security specifications for AVs by initiating the whole international procedure as happened in 2014 in order to change legislation in 2017. This practice takes definitely too long and represents a big disadvantage of the German regulator in comparison to the US.

To remain competitive with the world and especially with the two big automotive industries US and China, which are both not part of the UNECE agreements, the German authorities should start initiating new provisions in those treaties which are more open and not tied to certain technologies. The multilateral contracts have their origin in the middle of the 20th century and do not consider new mobility services or approaches. Thus, Germany should try to adopt those emerging issues in the treaties.

It will find reception and encouragement in other countries as they like to stay up-to-date as well. But for most countries subject of those agreements, the automotive sector has not that significant impact in their economy like it has in Germany. This is an urgent reason for Germany to act on this issue. As a side effect of staying competitive Germany will additionally generate and remain with a strong automotive industry supporting the German economy overall. To have a flexible adoptable regulation on invention disrupting the car producing branch is crucial for Germany.

[162] (Bezirksregierung Düsseldorf/ Düsseldorf District Government, 2017)

3.3. Analysis of national liability regulation - USA

3.3.1. Conclusion on US product liability

With the exculpation provided by the cost-benefit theory, one company can escape liability easily. This holistic economical method is single-sided. In preventing car producers from liability with an invention which is beneficiary for the society, the industry loses the incentive of making better, improved and safer products. Having said this, authorities should take action to close this gap of legal uncertainty in product liability applying to autonomous driving vehicles as a profit for the entire society. Bypassing a pure economic judgement of the design defect and thereby, undermining the liability of car manufacturers and compensation of victims, is the task for authorities now, to pave the way for legal certainty on AV technology in short term view as well as on the long run.

Subsequently, the strict liability approach is suitable for AVs. In addition, this type is frequently used and well known. It will not disrupt the legal system and not take the legal practitioners by storm. Finally, using product liability generates a lucid degree of certainty for both society and the economy.

3.3.2. Conclusion on US traffic liability

The traffic law scheme which is based on negligence will not be a successful model for liability of drivers of autonomous vehicles. The method is tied to the behaviour and reactions of the driver. In respect thereof, the role of the driver will vanish with the implementation of AV mobility in our infrastructure and the necessary behaviour and reaction disappear. Thus, states using the negligence approach have to react in order to modify their traffic liability if the states want this law still in operation for autonomous vehicles. It might be a good concept to deal with for the transition on public roads of human conducted and driver-less cars.

States, which implemented the strict liability in traffic law liability, may also succeed with their method. This technique holds only drivers liable which behave ultrahazardous and must acknowledge that. By using this regulation, an early version of an AV which might not be yet fully proficient can be seen as an ultrahazardous behaviour of the operator and subsequently, in a car accident the driver can be held liable under traffic law.[163] This is efficient but, not very free-market economy oriented. Then, it will be hard to find any consumer or market.

Reflecting the second “non-fault”-system used in states, this idea is probably a good one in equally compensating as well as distributing indemnification payments. According to the fact, that there will be no driver in AVs necessary, this system may bear a good approach to regulate traffic law liability in case of accidents involving self-driving cars which cause damages and costs up to a certain amount or maybe even to an open amount.

[163] (Jensen J. B., 2018) (Oluwatola, et al., 2016)

Certainly, in the case of an accident, the compensation of every victim will be paid by their own insurances. Consequently, the third person liability insurance for cars will be replaced by one which covers every personal damage or injury of the victims, similar to the case involving an accident with a bike and a pedestrian. In the event of an accident involving pedestrians or cyclists, so no cars, the damage is currently not covered by a special insurance. The personal liability insurance of every person is covering the losses. Thus, a mandatory car insurance changes into a mandatory third person insurance. This could be a probable solution for a short-term period; even though everyone has to pay insurance, regardless of owning a car or not.

However, there will be no incentive in terms of regulated payments for the car manufacturers to build safer self-driving cars if the victims' insurances are going to cover the damages. Looking out for a long-term solution, the car industry should either contribute to this system, or the product liability will change and replace traffic liability. A possible scenario could consist of a contribution of the car producers with payments on a certain rate per each accident as a manifestation of the operational risk they bring to the market in simply make the AV available to the market. Another method could be the traffic liability will be replaced by the product liability[164], which can then, to not lose out of sight the producers, be combined with factors which can reduce the payment of the producer due to faulty behaviour of a participant involved in the accident.

Altogether, due to the diverse systems, methods and ideas in the US the traffic liability in the states, the United States of America are well-equipped in adopting AV in their systems with the product liability.

3.3.3. Conclusion on further federal regulation of the US promoting AVs

Data protection

Due to a lack of federal regulation on data protection, the data collected by the vehicles are not protected in any manner. The existing law is sector-specific organised. Except the constitutional privacy US citizen can claim being violated by the car manufacturers in using and selling the data, there is no link for data privacy and autonomous driving.

However, the data privacy was never protected a lot in the US on a federal level before. Consequently, the likeliness of such claims is very low.

Safety regulation

First, the regulation in the US is broader because the US didn't ratify the Vienna agreement on road traffic.[165] The NHTSA and DOT are not bound to the multilateral agreement, only to the national legislative bodies. So, the federal authorities can determine flexible what security specifications Level 5 cars have to match or not. Even if, the federal level sets up some guidelines, in the US it is mainly up to the single state to establish requirements for AVs on public roads and if the state would like to prohibit or permit them.

[164] (Logue, 2018)
[165] (Sokolov, 2015)

Although the greater independence equips the regulators in the US with more flexibility, the difference between the single states can contradict the prosperity of self-driving technology. As every state requires different features to be fulfilled, the car developer tries to match them, but cannot launch the cars in the neighbour state. To mitigate this problem, the NHTSA or the US DOT is trying to agree on one harmonised minimum-security regulation with all states. Then, these provisions are bounding for every manufacturer and developer in the process of the autonomous vehicle.

Because of the steady progress of the mobility concepts, it is hard to predict, what further issues exactly AVs will create. Thus, the problem for the guidelines regardless of federal or state level is, the technology is that much new, so the regulator cannot imagine what the technology is capable of until now and what should necessarily be content of the regulation.

On the other hand, letting the states compete on the appropriate law of AVs can lead to the best suitable result which is desired by the industry and the consumers or users of the product. The best example here for, is the company law in Delaware, which was distilled as the most successful by many different tries and approaches of various states, also called Delaware-Effect.[166]

3.3.4. State regulation promoting AVs

As done in chapter 2, the further regulation of the USA will be investigated with the model states of California, Arizona and Michigan.

3.3.4.1. California

While the California state tries hard to promote investments and to pave the way for new developments and their application in the real-life market by setting up the regulatory framework and steadily improving them, in other countries external investments are seen critically.

Many companies chose to be located in California not only due to the concentrated competence, rather more due to the better opportunity to find investors, and due to an easier launch of a product on the market. In joining different forces out of various sectors in the state, for instance, legislation, administration, industry and education, California increases their knowledge and competence significantly on cutting-edge needs.[167] The main reason for California to do so is to remain as one of the leading and the most popular high-tech locations in the world, in order to simultaneously generate jobs and welfare for the entire society.

One big advantage of Californian law is, allowing driverless automated driving technologies of Level 5 on their roads and providing this in a simple application procedure.[168]

[166] (Bonnevier-Dudzik, 2001)
[167] (Legislative Technology & Innovation Caucus, 2019)
[168] (Californian Department of Motor Vehicles, 2018)

California is providing an easy and understandable checklist for companies and institutions striving for a driverless testing permit.

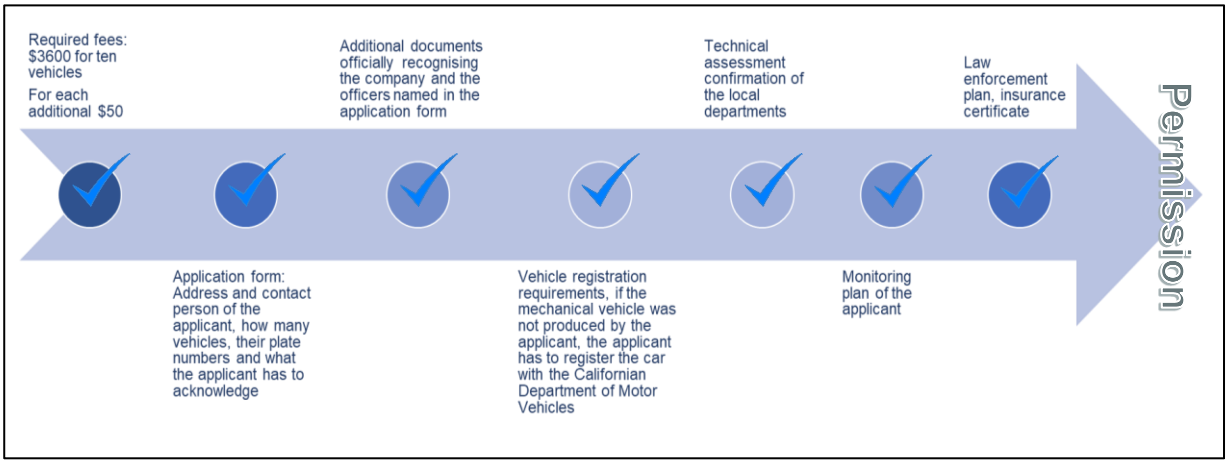

Figure 2: Administrative approval process for driverless cars in California.

California wants to foster competition between the different companies, regardless of whether they are well-known car producers, a residential or small start-up digital software companies which try to enter the automotive industry. Especially for those small emerging industries, California facilitates the entering of the market in limiting the data protection regulation. Due to the great effort, the entity has to spend on complying to this law, it is a big cost factor and can become an obstacle in the development of a new business. Knowing that data privacy is a huge issue for both the consumer and the companies, the Californian authorities exclude small firms which do not exceed the determined limits of revenue and data amount. Thereby an easy start is possible.

Consequently, California is establishing a very balanced regulative regime on autonomous vehicles. The law picks up many points which give certainty to the industry and the consumers. Despite the fact that the liability act is still missing special provisions related to AVs, California is the only state mitigating the data issue. By steadily amending the law as California does, the state is always executing the input of the industry and the needs of the people.

3.3.4.2. Arizona

Whereas California decided to solve the AV problem by passing a law, Arizona dealt completely different in releasing two Executive Orders of the Governor. The one in 2015 included the issue of self-driving technology and stated clearly the support of the state and all its administrative organs to promote that progress.

Arizona, located next to California, the big tech-venture-capital-money hot-spot is always in a tight-spot to entice away investments of big companies from California. While competing with California, the Executive Order of the Governor is a quick way of establishing rules which adopt new problems, because a long legislative procedure is not necessary and the strains of endless discussions are neutralised.

By releasing the Executive Order, which allowed driverless cars, Arizona made a cutting-edge law in 2015 and attracted many companies in that sector to try their research and development result on the streets of Arizona first.[169] This is a reason why Arizona permits driverless cars also in a very simple application procedure. The application process requires similar information and forms as it is required in California. The process is published on the website of the department for transportation and accessible for every interested party. One big advantage of Arizona is that this state is allowing driverless cars not only for testing purpose but as well for the usual operation of AVs on public roads.[170] This promotes Arizona specifically as a very attractive business location for AV developers. By making the entire state a testing route, research and development on autonomous technology in Arizona are growing. For instance, the subsidiary of Google's Waymo launched its first driverless car on the roads of Arizona's capital, Phoenix.[171]

However, Arizona is missing efficient data protection measures which deal with the sensitive data collected by self-driving car providers.

3.3.4.3. Michigan

As the home state of General Motors in Chicago, Michigan was always addicted to and relied very much on the automotive sector. It is not a surprise that this state started enacting legislation which regulates dealing with autonomous cars technology and automated driving systems very early. By establishing a regulatory framework to operate on-demand autonomous car services as MaaS,[172] the state fosters radically the business location Michigan.

Those efforts already paid off, looking at the $ 13.6 million generating 100 to 400 jobs investment Waymo is going to place in Michigan by setting up a new factory and lab for fully autonomous vehicles.[173]

[169] (Wu, 2017)
[170] (Arizona Department of Transportation, 2015)
[171] (Automotive News, 2018)
[172] (Tasker, 2018), (Reynolds, Orr, Goetz, & Berliner, 2016)
[173] (White & Khan, 2019)

4. Impact of autonomous vehicles and their law in Germany

Finally, in this 4th chapter will be outlaid why it is that central for Germany to adopt new laws for the upcoming mobility technologies. This invention bears risks and chances for German society, which will be illustrated first. Before answering the main question, the author demonstrates additional factors, which influence and accompany the legislative procedures and discussions in the German parliament and in German society. Afterwards, the massive importance of the automotive sector in Germany will be figured out and if the German economy already detects a change in that business due to the new regulation of 2017. In the end, the thesis sums up if Germany is legally prepared to stay competitive in the world as an attractive business location for the auto industry.

4.1. Algorithmic bias - correct ethical decisions

On the one hand, AVs are determined to save lives, but if there are fatal accidents who are ethically responsible for those inhuman digital decisions. Hence, one big question hanging like a sword of Damocles over the revolutionary invention of autonomous vehicles. They are driven by codes, to provide rational and neutral decisions and reactions within milliseconds as a consequence of their sensory perception, thus, to free up the humans' attention on the driving processes. Although, the AV is driving smoother and will avoid stupid, human or overrating driving behaviour in order to reach the destination safely the autonomous vehicles will face unavoidable collisions also, which will then be covered and executed by the code as well. This is in ethical circles, also called the trolley problem.[174] Originally, the trolley problem establishes an ethical case in which a person has to decide on which rail a trolley should go. Thereby, the decision-maker is aware that on the one rail are two people or a young person and on the other track is only one or an old person. This example is used to illustrate utilitarian choices.

Nonetheless, it should not remain unattended, that also the code which grants these neutral orders is always produced and written by human beings. Hence, a predetermined ethical dilemma cannot be avoided by this work and causes numerous questions and problems referring to dramatic life-changing decisions made by humans and executed by codes.[175] More precisely, the ethical dilemma consists of the decisions humans incorporate in the code of AVs.

For example, an autonomous vehicle is driving through a city setting. Lefthand there are oncoming motor vehicles. Righthand cars are parked along the street. Suddenly, a pedestrian is walking into the lane of the vehicle. Three plausible possible scenarios can be coded now to execute a final decision:[176]

[174] (Nature- International journal of science, 2018) (Wiggers, 2018)
[175] (Li, Zhang, Wang, Li, & Liao, 2018)
[176] (Li, Zhang, Wang, Li, & Liao, 2018)

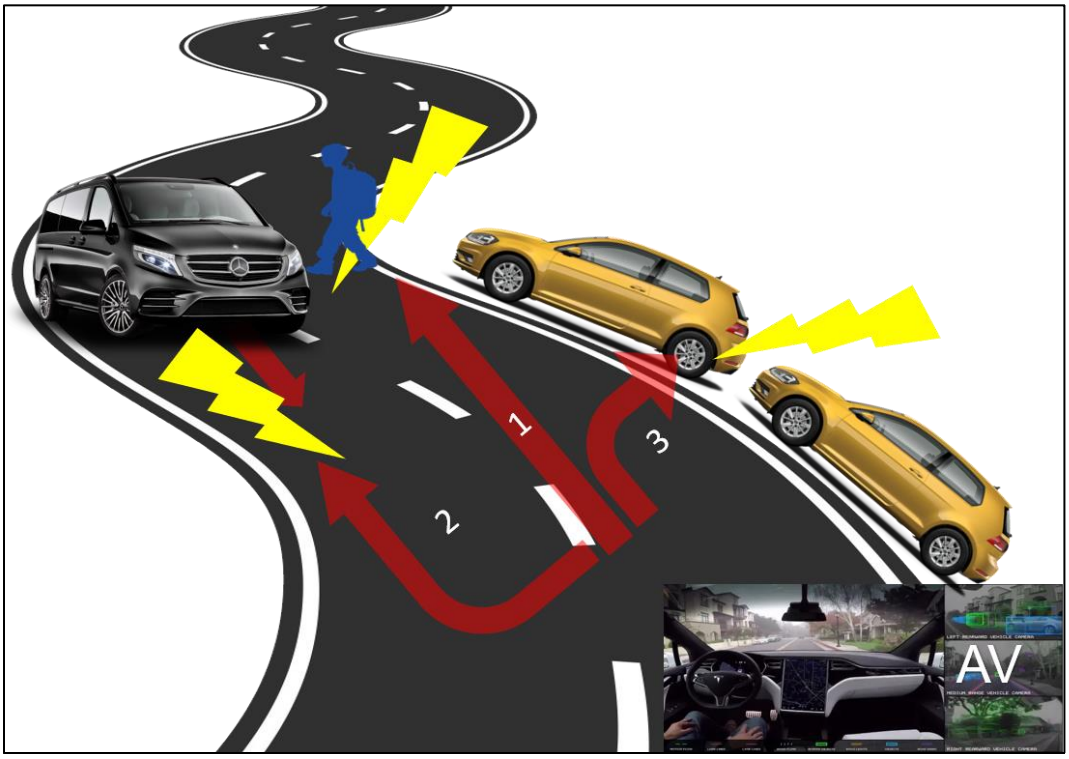

Figure 3: Example of ethical dilemma related to decision-making process of AVs.

(1) The car can try to slow down, but calculates, that even with an emergency braking, it will not stop in front of the pedestrian, rather it will crash into the pedestrian who will die because of the accident. The occupants of the AV will survive on account of a much less severe collision. The consequence will be one dead person. Though, the autonomous mode identifies two other options.

(2) The second one, the car can slow down and direct to the left into the oncoming traffic. The AV will hit another car, and both occupants will get badly hurt or die as well. The consequence can be at least two dead persons, assuming one in each car.

(3) The third alternative way the autonomous vehicle identifies is that the AV is driving to the right and hits the parking cars, yet the collision will most probably end fatally for the cars' occupants due to the hard hit. The consequence will be at least one dead person, assuming there is only one person in the AV.

Certainly, option two (2) will not be executed through the code, because thereby at least two people will die. But still, the decision about whether alternative choice one (1) or three (3) will occur, is up to the software developer who is coding the autonomous system.[177] Thus, this person decides by coding the vehicle software, how the car should react in such a future case.[178] Now, this case above is a simple one, with just three possibilities. This case can be imagined in advance. Although it is a simple case, the decision the coder has to program is a fatal one for one of the participants in that incident. Consequently, the software developer has to be very mindful, vigilant and responsible in coding such emergency schemes before they actually ever have occurred.

[177] (Webb K. , 2016)
[178] (Prof. Dr. Dr. di Fabio, et al., 2017)

While this dilemma is about a temporally beforehand decision process, another problem appears when the AV is set in a situation which was not imagined and coded by the developer. Consequently, that dilemma, the AV acting without a pre-set valued decision process, is one that can be mitigated by artificial and learning intelligence of the software. Thereby, artificial intelligence can be able to recognise similar cases and find a solution for those unimagined emergencies, even if they were not 100% learned before.

Although, a human driver in a non-autonomous car also has the responsibility of a fatal crash, the ethical dilemma now is more precisely, that this responsibility is shifting away from the driver, who is probably in a better condition to evaluate and judge the situation rather than a coder in advance of the decision point ever could have to be.[179]

Furthermore, the AI is limited to the input it got for learning. Like an inexperienced kid, an artificial intelligence network cannot deal with unknown only similar circumstances. One solution of the lacking input experience for the AI is to gather more data from all autonomous vehicles which already operate on the streets. For the research and development departments of the big AV developers, this is the main target at the moment.[180]

The only approach that is able to narrow down the decision to a certain extent is utilitarian thinking, which decides in favour of the most valuable person for society. But who determines what the car considers as valuable enough to survive? The car even can be programmed as a racist, just recognising people with bright skin as humanoids and people with dark skin as passing by the object.[181] Under this impact, a young person goes before an old one, a pregnant woman goes before a woman, or a healthy active person goes before a sick one. However, this approach tries to mitigate the issue; it cannot deliver a sufficient solution which is desired by society. Additionally, the next question arises on which category of people goes before another category and what happens if both possible decisions would let die a healthy young man.[182]

Finally, the ethical dilemma arises mainly on the issue of the decision process of the developer without being involved in an actual situation. This person is responsible for deciding which person will die or survive according to the code order. Until now, there is no perfect ethical solution to mitigate this problem.

Many authorities, Ethic Boards and software developing companies follow up with this dilemma, which is influencing the regulation process in many countries as well.[183] Above and beyond, this decision should be taken by clear legislation on this topic, so the coder is legally secured in his coding task.

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179 (Beck, 2017), (Prof. Dr. Dr. Hilgendorf, 2017)
180 (Kirchbeck, 2018) (Hawkins, 2019)
181 (Huang, 2018)
182 (Hao & MIT, 2018)
183 (Prof. Dr. Dr. h.c. Julian Nida-Rümelin, 2017)

4.1.1. Infrastructure development involving autonomous vehicles

By encouraging the AV technology through the official safeguarding of a regulatory framework, higher social acceptance because of the environmental components or clever marketing campaigns of the providers, the market share of these autonomous vehicles will increase.

So, a significant number of AVs driving on the streets will also affect the development of the streetscape and shape, plans for prospective roads, residual areas or even current road constructions.

4.1.2. Deployment of AVs

The infrastructure will change and adjust to the new invention. The next section divides the prospective changes and impacts on the infrastructure in the urban and rural section because both benefit differently of the technological advances. Hence, both must manage the deployment of AVs in a way to foster the features which are most beneficial for them and to minimise the disadvantages related explicitly to the dissimilar characteristics and distinctiveness.

4.1.3. Urban

Due to the new mobility possibilities, urban areas are able to perform a conversion. In most cities, agglomerations, metropoles or megacities, a significant number of people commute from the suburban or surrounding regions into these hotspots for work or social life. Now, the problem of commuting by car means these cars are used to get into the city and to get out of it. In the meantime, the car is not used and needs a safe and proper place to wait for driving back. Those parking spaces are mostly created near the desired destination of the driver, so the remaining distance can be covered by foot. These are challenging the cities in providing parking space next to the destination while lacking space throughout the whole area.

The autonomous vehicles can serve only as a transportation element in these big areas. The AV can transport the passengers to their jobs, friends' house or every desired destination. Then, the passenger leaves the car, go for work or leisure activity, and the AV is searching for a parking lot by its own maybe nearby but also farther away from the passenger's destination. The AV can be called for the way back home to the point where the passenger would like to get picked up.[184]

Furthermore, the parking lots do not have to be built for humans with the related building regulation to protect humans' health because the AV is driving autonomously to the assigned spot. As a consequence, less space is used by those parking lots, and the space utilisation is more efficient.[185] A substantial quantity of open-air parking possibilities and parking garages will vanish in the cities and free up the streets for a different using concept such as bike lanes, green spaces or to help to solve the housing shortage.

[184] (Zakharenko, 2016)
[185] (Heinrichs Deutsches Luft- und Raumfahrtzentrum, 2015)

A big opportunity for urban areas to decrease traffic problems and parking space in order to organise the cities in a greener and cleaner manner, the autonomous vehicles can be used not only by one person, rather bears enormous capacity for shared mobility.

Thus, autonomous vehicles provide great chances and changes for urban areas beside a better, safer, easier and more sustainable traffic flow while generating opportunities for cities designed with more the people in mind.

4.1.4. Rural

Completely different challenges are waiting in rural areas to be faced by autonomous driving vehicles. In rural regions, most of the people struggle with less infrastructure, remote places or far-off destinations which are necessary to manage daily life such as shopping centres, medical care or administrative service centres. In integrating AVs in rural areas, many of these issues can be solved or reduced. Elderly people not any more able to drive are not any more forced to leave their home towards junctions just because they live more infrastructural isolated in the countryside.

Another very useful application of AVs in rural areas is to focus on families and their needs. In Germany, at least 25% of private households own more than one car. Additionally, people in rural areas are more relying on cars than people in cities due to offered alternative mobility systems.[186] In order to reduce the necessity of more than one car in families, self-driving cars can face the problems families have to struggle with such as different routes to job, nursery or shopping centre.

Since AVs enable people to send cars to different destinations without being present, autonomous vehicles can bring and pick up kids, elderly people or the shopping which the family ordered last night while the parents are working.[187] This multifunctional feature is a big advantage for rural areas in which the daily life infrastructure is always tied to overcome greater distances.

Considering, Germany’s rural areas are very big and empty due to a continuing trend of rural-urban migration in comparison to other European countries, the deployment of self-driving cars would facilitate daily-life difficulties and would cope with obstacles for the growing elderly generation while simultaneously ease up on the increasing urge for urbanisation due to centralisation of infrastructure, people and business.[188]
The AV becomes more than a vehicle it converts into a mobility facility which improves quality of life. To let people, benefit from these opportunities while providing a safe streetscape, Germany has to establish a legal environment which includes autonomous vehicles.

[186] (Umwelt Bundesamt, 2018)
[187] (Chmielewski, 2018)
[188] (Zech, 2018)

4.2. Chances, risks and changes for the different participants in the AV setting

This chapter illustrates what different participants will most probably have to expect by the autonomous driving technology development and how they will be interfered by the invention. Thereby, the author does not only refer to the simple regulatory impacts but also to economic or social roles which are going to change from traditional ones into new missions, responsibilities and tasks for the participants.

4.2.1. Drivers

The driver in a self-driving vehicle is no longer necessarily be titled as a driver, because of the invention the driver turns into a passenger of the vehicle. Thus, the occupant loses the tasks of driving he/she changes the role completely. Nowadays, the car stands as a status symbol for most people. It is important how many or what kind of car one household can afford. Most people in the US and in Germany own their cars and are responsible for the state of the vehicles and their maintenance. In Germany, around 550 cars were count for every 1.000 inhabitants (>55%).[189] In the US, even more than 800 cars come on every 1.000 inhabitants (>80%).[190]

However, imagining the world in which the AV is assuming tasks like taking the kids to school or getting the laundry and groceries back home autonomously, the itself will lose importance for the people and will be more and more seen as a technical transportation device to overcome distances rather than as a status symbol which everyone has to own. While using one autonomous vehicle of a platform fleet like Uber or Lyft for the kids and the household, another AV can be used to collect people in the suburban, transporting them to their working place or desired destination in the cities only. Smart traffic grids which combine all the requests, destinations and number of people who would like to be transported, the platform can calculate the most suitable and shortest way to connect all the needs. By that processes, the fleet of AVs will be used economically in the most efficient and environmentally in the eco-friendliest manner.

Nevertheless, with a lot of positive changes through the AV creations, the most negative one is that self-driving cars like other technical inventions replace peoples' jobs such as taxi-drivers or couriers. Also, public transport can be facilitated by replacing the driver with AV technology. As a result, the personnel costs can be reduced as a saving. The chance for professionals working in those fields is to mitigate the risk of losing jobs in previously shifting the focus on maintenance of AVs. This is a challenge for the professionals as much as for the authorities which have to mitigate the risk of jobless people by AVs via implementing skills in their educational system which cannot be substituted by digital technologies. However, this fact is not only a challenge based on autonomous driving achievements, what is enhancing this progress, but it is a challenge facing authorities since digital technology and robotic facilitate daily life.

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189 (The European Commission, 2018)
190 (Statista- The statistics portal, 2019)

Conclusively, when the driver turns into a user, the owner role is less important, and the service role of the manufacturer, operator or provider of autonomous vehicle platforms and fleets become more seminal than now. Furthermore, switching from a driver into a user claims fresh and new skills from the people to get a job and submit a significant economic contribution to society.

4.2.2. Car manufacturers

As the driver does, so the manufacturers will follow them in finding a new role different like producing and selling goods. The big companies worldwide already started to transform their company model away from a rigid and stiff industrial structure towards a more flexible and especially a digital one. For instance, the car producer Volvo is cooperating with the transport platform provider Uber in a joint venture to stay competitive in the transportation branch of the future.[191] Each company invest $ 150 Million in this joint-venture in which firstly both companies pool their resources and know-how on autonomous driving technology. Moreover, the joint venture will lead to an expanded research and development spot for both companies to develop the Volvo XC 90 AV which will later be integrated into the Uber business network to provide transportation services without a driver necessary. This steady conversion will lead the manufacturers to a more service-oriented platform company culture and will consequently result in longer-lasting client relationships than it is used to be today for car producers what just sell their products.

According to the data collection issue mentioned before, car manufacturers are able to gather data from the autonomous driving vehicles of them. Consequently, they have to change their business concept by focusing on server technology and data security also. In order not only to possess but also to store, analyse and assess the collected data, the car producers are shifting to become more digital within themselves. Thus, using the data efficient and result-orientated to improve technical weaknesses or running processes, requests willingness and preparedness of the manufacturers to change their self-conception.

4.2.3. Insurance companies

Today each owner of a car is obliged to take out a third-party liability insurance policy in almost every country of the world. At least in Germany (§ 1 PflVG)[192] and in the most states of the United States of America[193] holding a third person liability insurance as a car owner is mandatorily requested from the competent authority.

Now, by changing the role of the driver into just a passenger of the car, and by transforming the car owner into just a user of transportation services offered by platforms, the legal base of mandatory insurance for car owners is vanishing.

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[191] (Reuters, 2016)
[192] (Bundesministerium der Justiz und für Verrbraucherschutz, 2017)
[193] (Araujo, 2019)

So, also the main business of car insurance companies is shifting away from the single car owner, maybe towards service companies owning autonomous driving car fleets. By doing so, the contact point of ownership still exists for the insurance companies. However, their client base will be much smaller. However, the evolution of autonomous cars will decrease the number of accidents significantly.[194] Instead of a lot of car body damage accidents, which will be almost complete disappear, the number of fatal car crashes will also be considerably less. Hence, the insurance industry in traffic law liability will decrease.

For this, the sector of product liability insurance necessity will grow. Whereas the insurance companies will lose a broad client base of traffic policy holders, they will save costs as well, which the industry uses to spend on tedious processes and disputes in courts. In deploying AVs with data collecting systems, a full investigation of the crash can be done quicker and fewer resources wasting.

As demonstrated, self-driving vehicles bear enormous potential for society as a whole. The greatest benefit of the AVs is the increasing safety of transportation in eradicating human emotional driven errors by replacing those with computed applications for the decision-making process and its dispassionate execution.[195] Germany is one of the leading car manufacturing and development countries in the world, thereby to be also the main location where autonomous mobility systems, which are popular and demanded in the future, is highly essential for the German economy. A significant high part of the economic and social welfare is related to an export trade in the automotive sector.

4.3. Germany as one of the big automotive industry locations in the world

Now learned about the reasons why autonomous vehicles and suitable regulation on them are a must have in Germany’s society, this subtitle emphasises the importance of car production for the German economic standing. To remain an important nation in terms of cars and manufacturing industry, particularly the new generation of cars may have an influence on the German economy in the future.

Across countries and cultures, the German economy is seen as characterised by and one of the leading automobile industries.[196] With large car producers as Daimler, BMW, VW, Audi and Porsche calling Germany as their origin and home country, not only the pure car producers rather more the automotive supplier industry is also located and often incorporated in Germany. Those suppliers are for example ZF, Bosch, Continental or Thyssenkrupp. These firms are also called OEMs, which build several products but do not bring them to the public retail market rather only to the wholesaler market for car manufacturers.[197] Altogether, these companies build a backbone of the German economy and are able to generate a huge impact on the economic growth or down-sizing and welfare in Germany.

194 (Griesser, 2019)
195 (Chmielewski, 2018)
196 (Sullivan, 2018)
197 (Software-Express, 2019)

4.3.1. The German economy and the automotive industry - currently inextricably linked

Moreover, the automotive industry is the employer number one in Germany, and growth and development in this specific segment do also influence the whole job security and prosperity of numerous German people and families.

Simplified, the German economy is highly relying on the automotive sector in many circumstances. Hence, German society is depending on steady growth, progress and investment in this industry. The investment does not mean monetary but legal framework, education and political certainty as the investment; the government can provide the industry and society with.

Figures show how deep the automobile industry is tied to the German economy, society and the German self-conception as a leading engineering and export country. Hereunder, the next two figures prove the car industries' standing is by a reason.

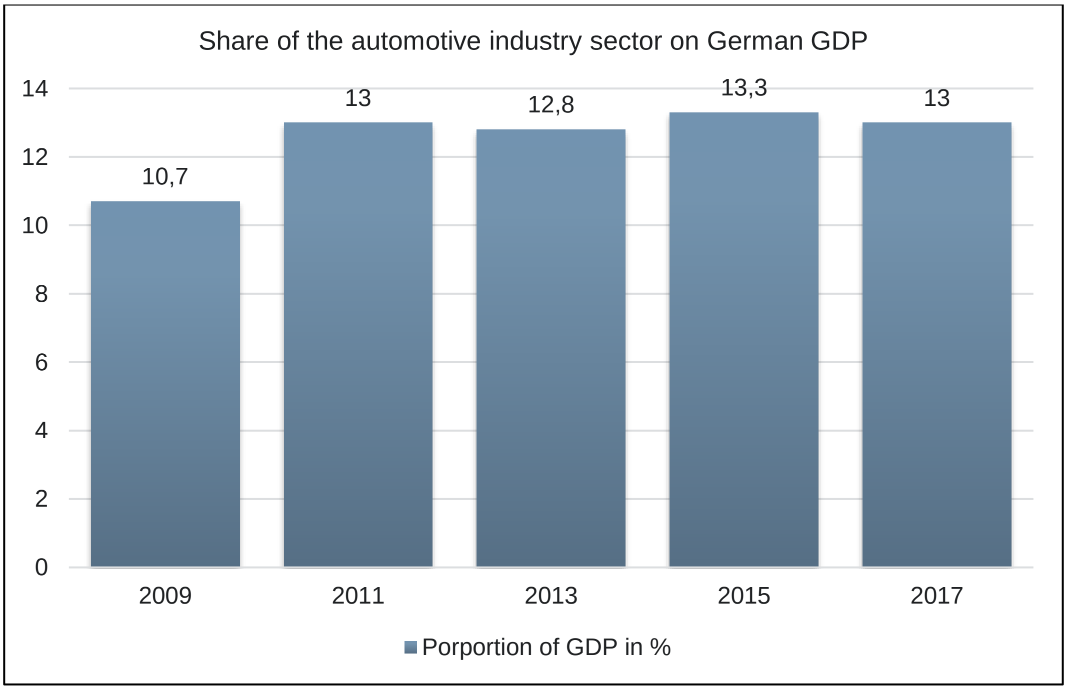

Figure 4: Share of the automotive industry sector [in %] on the whole German GDP from 2009 to 2017.[198]

[198] (Dörnfelder, 2019)

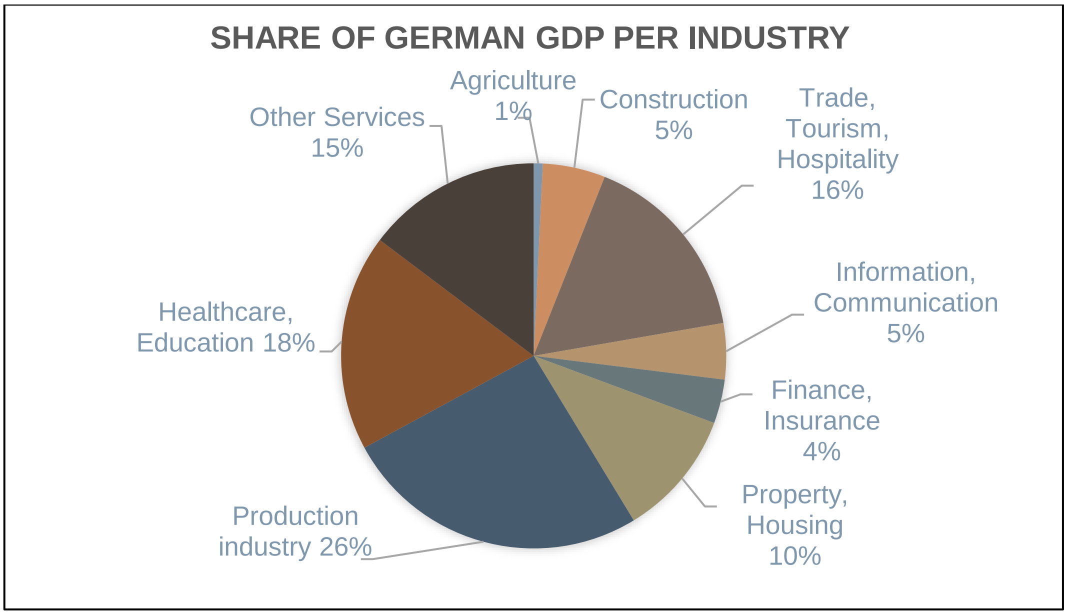

Figure 5: Distribution of economic sectors [in %] of German GDP in 2018.[199]

Figures 4 and 5 illustrating the importance of the automotive industry and all the attached suppliers for Germany due to its 13% portion on the overall GDP. The production industry, shown in Figure 3, which includes besides all the engineering industry such as mechanical engineering, aircraft, ship and machine construction also the automotive industry, had a 26% share on the total German GDP back in 2018. Assuming the segment of the automotive industry stays relatively stable beyond 2017 also in 2018 and there are no indications for the opposite, automotive industry accounts for a share of 50% of all engineering activities in the production industry in the German national economy. Some experts already consider not only big financial institutions such as Deutsche Bank but also the big car manufacturers like VW and Daimler as systemically relevant for the German national economy.[200]

Moreover, German society is at least impacted by the high employment rate in the automotive industry, according to Figure 4 below. Furthermore, many Germans identify themselves with the big car industry as a part of a high-quality carnation, which is also promoted by a lot of presence of the big car manufacturers in social life. As best examples could the sports sponsoring activities of Daimler in Tennis, Football, Formula One, E-Sports events and various other activities be seen.[201]

[199] (Institut der Deutschen Wirtschaft, 2019)
[200] (Seiwert, 2017)
[201] (Daimler AG, 2018)

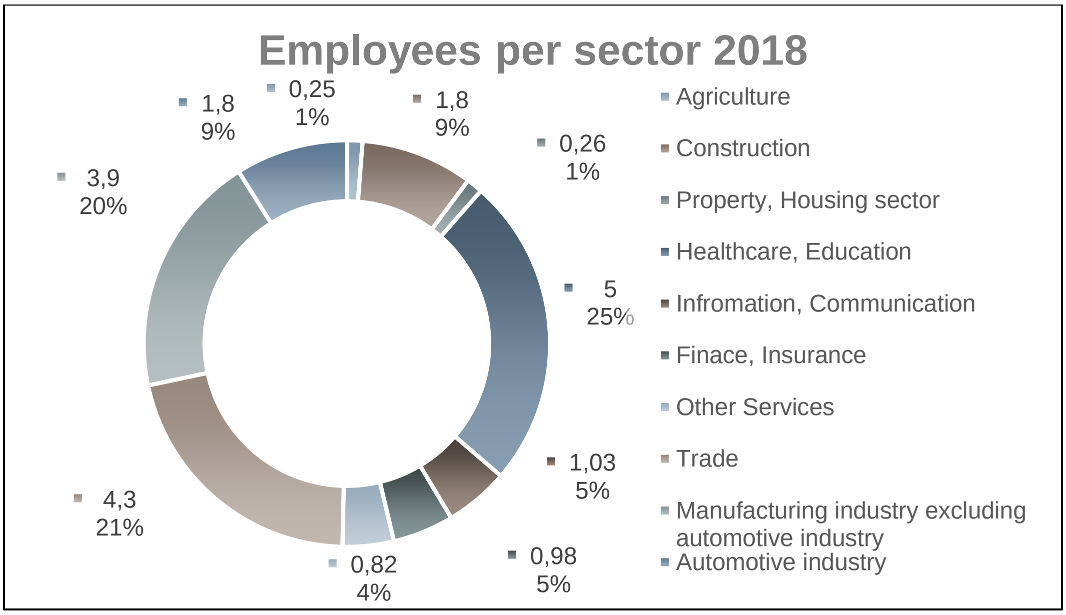

Figure 6: Share of employees [in M and %] related to the economic sector of all social insurance employed people in Germany in 2018.[202]

Although Germany is known for the 19th century's automobile invention and nowadays state of the art car manufacturing, it is also known to be very traditional and safety-conscious.[203]
Many governments of countries all around the world identified the automotive industry and especially the mobility inventions of this economic branch as an industry full of potential and business opportunities. The market is steadily growing due to the human demand for transportation. Foreign countries already support the automobile development subsidising and specifically promote automation in mobility systems.

Taken into account, that the autonomous vehicle evolution is linked with the emerging digital sharing platform approaches what have the capability of directing the upcoming commercial business world by establishing new mobility concepts, which has already been successfully tested in many parts of the world, Germany and its corresponding automotive industry has to keep pace within this global competition in the AV market. By doing so, Germany has to take action on issues raised by self-driving cars and their impacts on the daily life procedure.

4.3.2. Why law correlates with technology and economy?

According to a theory which describes the correlation between law and technology with the economy as its intermediary quite exact, the law can promote technology through regulating its economic value: *"New knowledge (inventions) arises only in the process of communication. this involves transaction costs. If the law creates the legal prerequisites for economic exploitation, it is a source of added value."* [204]

[202] (Statistisches Bundesamt/ German Federal Statistical Office Employer rate, 2018) (Selwert & Recclus, 2017)
[203] (TMF Group, 2019)
[204] (Schmidtchen & Leder, 1990)

As a matter of fact, in 2017 Germany already invested in their legal framework in order to ensure the safety of every person involved in road traffic and provide legal certainty to the car industry in stating what kind of technology is officially recognised. Amending the law by inserting § 1 a-c StVG into the Road Traffic Act generates significant progress in the field of regulation on autonomous vehicles. Furthermore, the German authorities try to mitigate a lack of trust of the potential users in the AV technology by providing legal certainty by clarifying the civil liability problem.[205]

In not including fully autonomous vehicles rather excluding Level 5 cars in the new legislation, it can be seen as a statement or signal to the world. According to this, Germany should be careful in not appearing dismissive of the autonomous vehicle system research and development and car producing industry. The technological progress will proceed in other countries if they provide better conditions to that specific industry. Thus, by establishing a legal framework whereas, giving possibilities and welcoming but regulating the emerging mobility technology, Germany might stay competitive with the US which already generated such an industry-friendly climate with their well-advanced and ambitious rules embracing and promoting autonomous vehicles in some states.

Questionable remains the fact if Germany is undertaking these measures in a way which keeps Germany as competitive as other countries across the globe. Besides the global competition on the car manufacturer market, Germany also has to defend its reputation as not only a current but also a future automotive research location consisting of and attracting new genius engineering potential top performers in order to develop cutting-edge technologies related to mobility. By doing so, this industry sector has the potential to draw new foreign and internal investors into the country, of which the entire society can benefit from. Hence, investing in appropriate regulation means investing in research and development, which has indispensable needs for new regulation. Because without regulation, legal certainty is missing. Consequently, a market and end consumer for the autonomous vehicle would be hard to find. So, by not establishing legal certainty and a market, the research will be done somewhere else, where the researched product (AV) in the end can be sold.

4.3.3. Already detected offshoring

The firms with the highest level of AV development are US companies, Waymo as No.1, followed by Cruise and Zoox.[206] For instance, Daimler and Bosch, two big and important automotive companies, collaborate on driverless Level 5 autonomous vehicles research and development at the Silicon Valley.[207] By investing a lot of money in those research programs, the likeliness that the companies are more attracted by a legal environment which permits AVs on public roads for research or private purpose and laying the foundation for a potential market for selling the product is much more higher than to invest in a research program in a country which does not tolerate the product legally.

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[205] (Prof. Dr. Eisenkopf, et al., 2017)
[206] (Webb & Ryan, 2019)
[207] (Daimler AG, 2019)

The companies pay more attention to place their investment in a legal environment which is already constructed around the research, instead of investing in research and afterwards fighting for the right to use and sell the product. Consequently, the major research departments and subsequent investments for autonomous driving vehicles up to Level 5 are located and done in California, USA and not in Germany.[208] The question that remains is if Germany still lacks regulation for autonomous vehicles and what impact does it have on the German business climate.

Bosch recently announced a big investment in California in order to position their research and development team working with Daimler on autonomous vehicles in an improved way.[209] Because the technology is promoted by the governments, also know-how gathers in their states. The traditional German car producers already are trying to keep up with the progress and try to stay competitive by their own strategy. Therefore, many of those big companies are reaching out for new places to invest in and to build their new bases. Daimler is investing the huge amount of half a billion Euro in an acquisition of a company specialised in autonomous driving called Torc Robotics, incorporated in Virginia. This company is located in the United States of America, not in Germany.[210]

Furthermore, Volkswagen invests almost two billion Euro in a joint venture with Ford and their autonomous vehicle division in the US.[211] As the number of autonomous vehicle businesses is increasing besides the traditional car manufacturers, a lot of different start-ups are hitting the market with their ideas. As of November 2018, in California alone, there were 56 companies that had a permission to drive with an AV.[212] And this number is expected to increase like it did the last four years. 86% of decision-makers in the German car industry believe in the tremendous commercial potential of autonomous mobility. Thus, they will also act in order to keep pace with the rest of the world.[213]

Conclusively, looking into the future, the investment strategy of the big car producers which shape Germany's economic growth and welfare shifts towards the prospective technology and where it is already highest developed due to a riskier, but broader legislation. This is also confirmed in two reports[214] which analyse the investments of German companies, specifically out of the car producing sector. Here both agree on a higher involvement during the last few years of German businesses in Michigan and California. Numbers show that 81% of the German big car producers and suppliers are planning to increase their foreign investment budget.[215]

[208] (Vetter, 2019) (Mayr & Schmieder, 2019)
[209] (Daimler AG, 2019), (Bosch, 2018)
[210] (Deutsche Presse Agentur, 2019)
[211] (Webb & Ryan, 2019)
[212] (Driverless-car market watch, 2018)
[213] (Wilkens, 2019)
[214] (Deutsche Industrie- und Handelskammer /German Chamber of Industry and Commerce, 2019) (Bundesministerium für Wirtschaft und Energie/ Federal Ministry of Economy and Energy, 2018)
[215] (Deutsche Industrie- und Handelskammer /German Chamber of Industry and Commerce, 2019)

4.3.4. How is Germany prepared to stay competitive?

Compared to some states of the United States of America, Germany is not as good prepared as these states are. Even Germany tried to develop its legal system on automated cars. They acted to short-sighted in terms of the amendment of the Vienna agreement. By excluding autonomous vehicles and autonomous transportation systems in the Vienna agreement, Germany is bound to this exclusion in its national law.

As Germany missed this chance in 2014 and did not include autonomous vehicles in the initiated amendment, it will take time until Germany can initiate a new amendment again which can be broader worded in order to leave it open to every national legislature to decide on including or excluding law for autonomous vehicles.

What’s more, the US legal system also is not close to a perfect legal framework answering the demand for legal certainty. However, the picked states send a signal to the developers, the researchers, the industry and to those full of brilliant ideas, that they are welcome to experiment with and enhance the new technology in order to find the best solutions for the society. Thereby, the US economy can take more benefits from legal promotion, whereas several different companies already set the focus on the US in their current and prospective investment strategy. Thus, knowing about the car industry importance in Germany, the law has to be improved and reviewed in terms of allowing Level 5 cars on public roads in order to stay competitive in a globalised world.[216]

In the end, Germany did well and leave its society a great margin for automated vehicles. Moreover, the German legislature emphasises with the fact the law puts focus on safety first. The German Road Traffic Act prioritises safety before venture. The strict driver on-board the vehicle rule is based on the thought to prevent accidents under any circumstances. That might be a weakness for the German economy. However, it can be a strength for every single road traffic participant, at least for the time period when AVs are not yet fully developed. In contrast, the German society and especially the rural areas are deprived of the benefits of autonomous vehicle sharing or taxi fleets what are already announced to hit streets by next year in the US.

[216] (KPMG International, 2019)

5. Conclusion

This thesis discusses the legal situation, regulatory framework and their impact on the German economy of autonomous vehicles, which are internationally classified in Level 5. A fully autonomous self-driving vehicle as described in Level 5 of the International Society of Automotive Engineers does not need a driver, steering wheel, brake or gas pedal anymore.

This paper illustrates the law and regulation concerning this kind of cars by international agreements on traffic rules as well as the German and US federal and state legislation. The focus is explicitly taken on the different civil liability approaches for road users involved in a car accident with such kind of autonomous cars in these two countries. Additionally, the administrative regulation governing self-driving cars is discussed.

Subsequently, the law is analysed by comparing the different methods of regulating this new technology. Also, the development of the law regarding driverless cars and their industry consideration is compared to each other. The US system provides significant bigger scope for dealing with the new technology. By releasing law from state to state in a different manner and with a different approach, the United States of America is widely positioned in terms of rules and provisions covering the research, testing, use and implementation of autonomous vehicles in the streetscape. Mainly, this arises out of the great independence the US posses in their legislative procedures. In contrast to Germany, the United States is not hinging on international treaties or standards, neither on federal nor state-level legislation.

Comparing both systems of liability, the US is prepared a bit better for car accidents involving autonomous vehicles, due to the more frequently applied product liability in that kind of cases. Germany’s judicial system does not have a lot of relevant experience on product liability used in accident events. Despite that, Germany has a better and more appropriate traffic law liability. This is because the German traffic law is regulated on a federal level, and Germany’s law is more flexible regarding the vehicle owner and car keeper roles. The liability is always a strict liability, which is not the case in many states of the US, where the liability is mainly linked to the negligence of the driver. This practice is not suitable for autonomous vehicles since the driver will be replaced by the vehicle itself and become a user. Consequently, a liability system based on drivers’ individual behaviour cannot be applied anymore regarding a driver-less car.

One big difference between the two countries is the structure of the legislature roles. While in the US, big problems occur among the different state-level requirements and standards on autonomous vehicles, Germany is covering all issues respecting this new mobility concept centralised. Germany published an amended Road Traffic Act in 2017 regarding automated mobility systems. Taking into account that a driver is always personally required as an additional operator in such a new vehicle, Germany does not allow driver-less car, thus, fully autonomous driving on public roads.

This is not facilitating the liability under the Road Traffic Act because the question about responsibility during the transition from the autonomous system to the operator again in Level 3 and Level 4 cars will raise the same problems of proving fault or negligence in court as it was before. At least, through the amendment automated vehicles classified up to Level 4 are officially recognised and allowed in Germany.

That being said, Germany is more inhibited with regard to its legislative process, due to its membership in the international traffic agreement, called the Vienna convention on road traffic. This treaty does not include autonomous vehicles, so Germany's traffic law does not. In initiating an amendment of the global agreement in 2014, Germany did not go far enough and did not consider fully autonomous, instead only automated driving. Being depending on that international law, Germany is not capable of changing its national law quickly, like the US are. Conclusively, Germany's traffic law is more sophisticated and suitable for vehicles up to Level 4, comparing it to US law. However, in terms of Level 5 vehicles, the US is better prepared because first, they allow them on their public roads, the federal level provides them with a unique compilation of safety standards, and many states are promoting AVs in releasing appropriate regulation for them. The US product liability is well developed, also for car accidents and the US are much more flexible than Germany can be in setting up new regulation on emerging technologies surrounding AVs.

However, both countries have a considerable impact on their national car industry with their extending regulation on the general usage of AVs. Since Germany does not permit driver-less autonomous vehicle technology on public roads, not even for a testing purpose, but most states in the US do, therefore the US simultaneously laid a foundation for a potential market for autonomous vehicles. By setting up a law which is promoting self-driving cars, a lot of research and development of the traditionally in Germany headquartered car producers is now offshoring towards those technology embracing jurisdictions.

By leaving out the fully autonomous vehicle in the traffic law amendment in 2017, Germany has to be careful, not to lose its economical highly important industry of car manufacturers and their suppliers. In the end, the modification of the Vienna convention was too short-sighted, and Germany should initiate another broader formulated and more open scope offering provision, this time including developing autonomous mobility concepts. Doing so, Germany can also adjust its own national law to keep pace with the emerging autonomous vehicle inventions business and technology in order to remain competitive as one of the leading car industry business locations in the world.

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