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Fully autonomous vehicles in the EU: opportunity or threat?

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List of abbreviations

ACC	Adaptive Cruise Control
AI	Artificial Intelligence
AVs	Autonomous vehicles
CJEU	Court of Justice of the European Union
EPRS	European Parliamentary Research Service
EU	The European Union
GDPR	General Data Protection Regulation
MID	Motor Insurance Directive
MS	Member States
NHTSA	National Highway Traffic Safety Administration
PLD	Product Liability Directive
SAE	Society of Automotive Engineers
UNECE	United Nations Economic Commission for Europe

Keywords: artificial intelligence (AI), automation, autonomous vehicles (AVs), civil liability, motor insurance, product liability

I. Introduction

Background and motivation

Our society is currently facing accelerating trends in artificial intelligence, as almost half of the activities performed by humans could be automated with the help of innovative technologies that have been recently developed. According to the 2017 OECD/ITF study, AI (artificial intelligence) has received tremendous amount of attention and many scholars from the field of science and technology have emphasized that the employment of AI technology in our daily activities is no longer a concept of science fiction (Cohen & Cavoli, 2017). The research performed by Cohen & Cavoli outlines that the number of items with AI produced in 2015 is four times bigger as in 2003. Voice-powered digital personal assistants such as Siri or Cortana, civilian drones, social humanoid robots such as Sophia or autonomous systems such as the Google Car or Tesla's Autopilot, are just a few examples of entities with artificial intelligence that have been already developed and some of them are already available on the European market (Fosse & O'kane, 2018).

One of the most intriguing innovations is the introduction of driverless or fully autonomous vehicles (AVs). These types of vehicles promise to bring many new advantages such as economic and societal benefits once they enter the European market. According to the Victoria Transport Policy Institute, fully autonomous vehicles have an enormous potential for saving lives, decreasing traffic congestion in urban areas, increasing productivity or protecting the environment (Litman, 2018).

Based on the 2016 report of the World Economic Forum, the automotive industry is estimated to reach an economic value of US$ 0.67 trillion for vehicle manufacturers and $3.1 trillion representing societal benefits as a result of digital transformation until 2025 (World Economic Forum, 2016). Moreover, the introduction of fully AVs on the market will result in a significant reduction of car accidents, fuel and carbon emissions (European Commission, 2017). Nevertheless, the European Parliament Research Institute estimates that almost 1.2 million

human lives will be saved within the next decade if people replace their current vehicles with AVs (European Parliament, 2018).

Furthermore, the European Commission (2018) considers that automated vehicles represent a powerful sector of the economy of the European Union. 12.6 million persons have been hired in the automotive sector and as a result, the European Commission expects that this sector will bring €17 trillion in the European economy by the end of 2050. Furthermore, the Commission (2018) believes that autonomous vehicles would represent a new opportunity for Europe in order to solve "the challenges of congestion, transport emissions and road fatalities"[1].

However, with the mass rollout of these highly developed motor vehicles with artificial intelligence, a number of risks will be generated, requiring clear supervision and enforcement. According to the Commission's High-Level Expert Group on Artificial Intelligence (2018), the EU should "ensure to follow the road that maximises the benefits of AI while minimising its risks"[2]. In line with this proposal, it is clear that the EU wants to benefit from the use of AI, while safeguarding the citizens' fundamental rights and ensuring the protection of principles and values of the European Union (Heikkilä, 2018).

Likewise, the road transport sector has faced many regulatory changes at both international and European level (Pillath, 2016). For instance, at the international level there is the 1968 Vienna Convention on Road Traffic of the United Nations Economic Commission for Europe, which regulates standard traffic rules. In addition to this, there are another two UNECE Agreements from 1958 and 1998, which brought global technical regulations and several type-approvals for the construction of new vehicles. On the European level, regulators developed many acts concerning the production and use of motor vehicles. For instance, there are currently 532 Directives, 426 Regulations, 409 Decisions and 150 Acts adopted by bodies created by international agreements, which address issues such as civil liability, insurance, data protection,

[1] European Commission: On the road to automated mobility: An EU strategy for mobility of the future. https://ec.europa.eu/transport/sites/transport/files/3rd-mobility-pack/com20180283_en.pdf

[2] The EU Commission's High-Level Expert Group on Artificial Intelligence proposed on the 18th of December 2018 a draft report on Ethics guidelines for trustworthy AI, which is addressed to all relevant stakeholders developing, deploying or using AI. Source: https://ec.europa.eu/futurium/en/system/files/ged/ai_hleg_draft_ethics_guidelines_18_december.pdf

privacy, traffic rules, type-approval, consumer protection, safety standards concerning motor vehicles (EUR-Lex, 2018)[3].

Since AVs are entities with artificial intelligence, they will change the way we perceive liability, security, mobility, insurance or ownership (European Commission, 2018). In this regard, there is enough scientific evidence and significant demands from many stakeholders in the field, who would argue that the current EU regulatory framework for liability might not be sufficiently prepared to address all changes and risks associated with the introduction of AVs. This situation was first outlined in the 2015/2103(INL) draft report of the European Parliament, raising the question of whether machines with AI could be perceived as natural or legal persons, animals or objects. The reasons for asking such a question is related to the attribution of rights and duties, especially own liability for damages to third parties.

Besides, according to the January 2017 McKinsey Global Institute Report, the number of daily interactions between humans and AI systems have increased rapidly in the last years, while the EU legal framework has remained unchanged (Lucchetti, 2017). The reason why the EU legal framework is designed in such a general way is that it is meant to cover more situations and not specifically address each type of risk.

The advantages of fully automated vehicles

This section outlines the most important features of self-driving vehicles that are expected to be released from 2020. Many scholars support the replacement of manually operated vehicles by human drivers with self-driving vehicles, based on four main arguments (Cappelli, 2015).

First, self-driving vehicles will increase the efficiency of the current transport system, as they will minimize traffic. AVs will consume less energy and will decrease cars emissions in urbanized areas, enhancing therefore our environmental benefits (Andrew, 2017).

Second, driverless vehicles would reduce the number of road traffic accidents (Kiilunen, 2018). The saying related to firearms, “guns don't kill people, people kill people”, is valid for driverless

[3] The EU regulatory acts on motor vehicles can be retrieved from: https://eurlex.europa.eu/search.html?qid=1454600163434&text=%22motor%20vehicles%22&scope=EURLEX&type=quick&lang=en&DTS_SUBDOM=LEGISLATION

cars as well. According to Walker Smith (2013), humans are responsible for causing traffic accidents due to a various number of reasons including imprudent driving, human error, drugs and alcohol consumption, texting and so on. In addition, in many situations human drivers are required to make important decisions within seconds, such as steering either left or right in order to avoid an imminent collision. Thus, the software, which is equipped on the AVs, has run thousands of simulations and enables access to a huge database of driving incidents, so that the vehicle can choose the best way for avoiding any collision immediately (International Transport Forum, 2015). In addition, Teoh & Kidd (2017) believe that "self-driving vehicles are safer than conventional human-driven passenger vehicles", while both Tesla and Waymo announced a cooperation system among driverless cars, so that these vehicles can exchange data in real time, in order to reduce flow traffic (O'Kane, 2018).

Third, the introduction of driverless cars will ensure more mobility. Currently, elderly and impaired individuals do not benefit from the same opportunities related to car usage, but AVs enables them to move freely from one place to another, without the necessity of help from other individuals (Halsey, 2017).

Lastly, as driverless cars do not need a human driver by definition, enabling its users to have more freedom for other activities including reading newspapers, applying makeup, sleeping or using an electronic device (Cappelli, 2015).

Levels of automation

In order to develop proper regulation for fully automated vehicles in the EU, it is necessary to reach an agreement regarding the terminology used for these types of automated AI systems and the different types of categories. Current literature provides many levels of automation, leading to a lot of confusion. For instance, the difference in driving tasks between automated vehicles with level 3 of automation and automated vehicles with level 4 must be clearly understandable and distinguished by people.

Nowadays, there are more types of categories of automation, but this paper will make use of the categories identified by the International Society of Automotive Engineers (SAE)[4]. According to the 2014 SAE report[5], six levels of automation for vehicles have been identified, ranging from 0 to 5. The following image provided by SAE, outlines the levels of driving automation and clarifies which driving tasks need to be performed by the human operator and which can be completed by the machine itself, without any human intervention. The table presents operational driving tasks such as braking, steering, accelerating, keeping distance to the vehicle ahead, monitoring the driving environment, keeping and changing lanes, assistance in traffic jams and many others that come together with one of the mentioned tasks.

Summary of Levels of Driving Automation for On-Road Vehicles

This table summarizes SAE International's levels of *driving* automation for on-road vehicles. Information Report J3016 provides full definitions for these levels and for the italicized terms used therein. The levels are descriptive rather than normative and technical rather than legal. Elements indicate minimum rather than maximum capabilities for each level. "System" refers to the driver assistance system, combination of driver assistance systems, or *automated driving system*, as appropriate.

The table also shows how SAE's levels definitively correspond to those developed by the Germany Federal Highway Research Institute (BASt) and approximately correspond to those described by the US National Highway Traffic Safety Administration (NHTSA) in its "Preliminary Statement of Policy Concerning Automated Vehicles" of May 30, 2013.

Level	Name	Narrative definition	Execution of steering and acceleration/ deceleration	Monitoring of driving environment	Fallback performance of *dynamic driving task*	System capability (*driving modes*)	BASt level	NHTSA level
***Human driver* monitors the driving environment**								
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a	Driver only	0
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes	Assisted	1
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes	Partially automated	2
***Automated driving system* ("system") monitors the driving environment**								
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes	Highly automated	3
4	**High Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes	Fully automated	3/4
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**	-	

[6]

Source: http://cyberlaw.stanford.edu/blog/2013/12/sae-levels-driving-automation

[4] SAE International is a non-profit educational and scientific organization, which consists of over 90000 engineers and scientists who develop technical information on all types of vehicles, including AVs.

[5] The 2014 SAE report on 'Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems' can be accessed at: https://www.sae.org/standards/content/j3016_201401/

[6] The table summarizing the levels of automation has been developed by SAE International and can be retrieved from: http://cyberlaw.stanford.edu/loda

Level 0

At Level 0 Autonomy, the human driver performs all the tasks, such as steering, braking, accelerating, monitoring of the driving environment etc. The machine is not entitled to assist the driver in any situation. In other words, the machine has no autonomy, as the vehicle is manual.

Level 1

Level 1 Autonomy is actually the lowest level of autonomy. It allows the system to drive the vehicle in and out in parallel and bay parking spaces. The system is called 'park assist' because it assists the driver with the measurement of the parking place and after selecting the starting position of the parking, it performs optimum steering manoeuvres so that the vehicle can enter into small places without causing any damage to the vehicle. The driver controls the accelerator and the brakes, based on the driving environment and the vehicle performs the steering manoeuvres. Since the driver operates the accelerator and the brakes, he is always in charge over the vehicle.

In addition to the park assist, there is also the cruise control function, which falls into this category as well. The driver sets the vehicle at a certain speed that the system maintains until the driver presses the brake pedal or cancels the activity.

Level 2

Vehicles with this level of autonomy assist the driver with the control of the vehicle at lower speeds. This type of system is called 'Traffic Jam Assist' since the vehicle can autonomously follow the car in front at speeds not exceeding 30 km/h. This function is very useful while being stuck in a traffic jam on the highway for instance. The vehicle is able to steer, accelerate and brake based on the driving environment. Some scholars say that the 'traffic jam assist' is an extension of the Adaptive Cruise Control (ACC), a system which functions just like normal cruise control, but additionally, it can be set to maintain the given speed at a certain distance from the vehicle in front (Dyble, 2018).

Level 3

Vehicles falling into this category are also known as 'traffic jam chauffeurs', because they assist the driver in traffic jams by accelerating, braking and steering, but in comparison with the traffic jam assist, they can reach over 60 km/h on highways for instance, while also following the right

lane. In addition, vehicles with level 3 of autonomy are able to monitor the traffic environment. For instance, they can recognize vehicles driving slowly and can overtake them without any intervention from the human driver. However, the driver must respond quickly if the system requires his/her intervention. Having said that, the driver is still responsible for all driving activities.

Nevertheless, based on the results of the GEAR 2030 Discussion Paper[7], the EU Parliament mentions in its 2017 Final Report that current legislation is sufficient to overcome the use of motor vehicles with this level of automation (European Parliament, 2017).

Level 4

In addition to the vehicles equipped with level 3 of autonomy, a level 4 of autonomy will bring the highway pilot, which is expected to be deployed around 2020 and will offer automated driving up to 130 km/h, so that it can be used on all public roads including highways. The system can operate the vehicle, with functions such as steering, accelerating, braking, overtaking, keeping and changing lanes and so on. The intervention of a human driver is only needed for activating the system, which will then enable the vehicle to perform all driving tasks. Furthermore, the human is not required by the system to take over at any time during its use.

Level 5

Fully automated vehicles represent the final stage of automation when it comes to vehicles (level 5 autonomy). Fully automated vehicles can carry out independently all driving tasks without any assistance or guidance from the passengers. According to ERTRAC (2017), the need of autonomous driving is nowadays bigger than ever and therefore the introduction of fully automated vehicles is expected to happen in 2026-2030.

Although the Member States are currently working on their own jurisdictions, initiatives on the EU level for a harmonized package of legislation enabling a safe and secure introduction of vehicles with level 5 of autonomy across all Member States is necessary, a fact which was also emphasized in the 2016 Declaration of Amsterdam[8]. However, based on the outputs of the GEAR

[7] GEAR 2030 Discussion Paper: Roadmap on Highly Automated Vehicles. http://www.europarl.europa.eu/cmsdata/141562/GEAR%202030%20Final%20Report.pdf

[8] The Declaration of Amsterdam on 'Cooperation in the field of connected and automated driving' can be accessed under:

2030 Discussion Paper, the use of vehicles with level 5 of automation would require adjustments to "traffic rules, connectivity, driving license, liability framework, insurance, cybersecurity, privacy and data protection" (European Commission, 2016).

Conclusion

The five levels of automation allow shifting responsibilities and tasks from human to the machine. The picture[9] below released by the European Commission in its 2017 Final Report on 'Connected and Automated Driving' illustrates the key facts regarding the levels of automation.

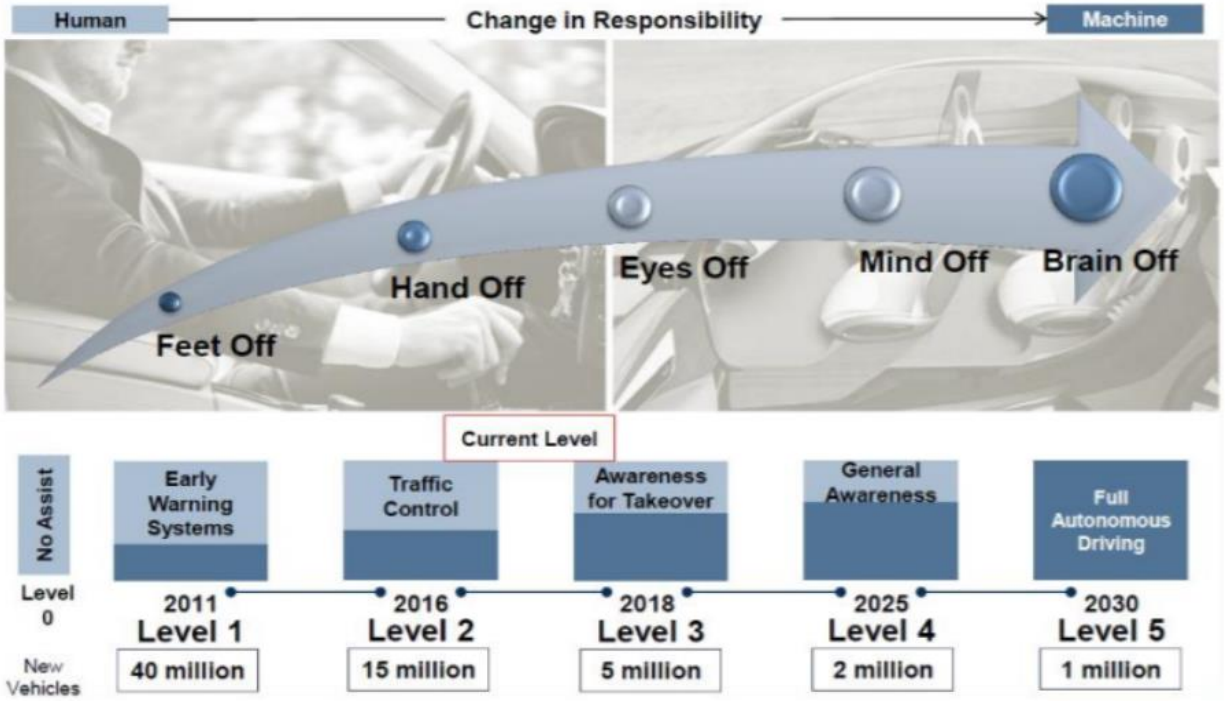


Figure 7: Emergence of semi- and full autonomous vehicles [149]

Source: European Commission (2017):
https://ec.europa.eu/docsroom/documents/24402/attachments/1/translations/en/renditions/native

Level 1 of automation allows the human driver to keep his feet off the pedals, while level 2 of automation allows him to take his hands of the wheel, as the machine can steer the direction of

https://www.bmvi.de/SharedDocs/DE/Anlage/DG/amsterdamer-erklaerung-declaration-of-amsterdam.pdf?__blob=publicationFile

[9] The picture used in this section is part of the European Commission's Final Report: Public Support Measures for Connected and Automated Driving released in May 2017. Source:
https://ec.europa.eu/docsroom/documents/24402/attachments/1/translations/en/renditions/native

the vehicle by itself. AVs with level 3 do not demand the driver to monitor the traffic environment, as the machine allows him to take his eyes off the road. Level 4 of automation means that a human driver is not necessary anymore, as the vehicle can interpret difficult situations and parameters alone. Finally, users and passengers of vehicles with level 5 of automation can enjoy a fully autonomous driving pleasure, as the machine can operate without the guidance of a 'driver'.

Scientific and social relevance

Based on the 2015 study[10] released by the OECD and the UK Transport Department, liability raises serious concerns for producers and designers of AVs, as there is a lot of uncertainty concerning civil liability. Apart from this, liability issues are addressed in the EU Commission's discussions[11] on the introduction of fully automated motor vehicles.

Based on these grounds, the main objective of this study is answering a novel question, as it focuses on the challenges that fully AVs will pose upon entering the market and the necessity of taking regulatory actions concerning the civil liability of AVs on the EU level. On the 5th of December 2018, the European Parliament released the report 2018/2089(INI)[12] in which under points 19 and 20 it is emphasized that the EU should harmonize the legislative system on liability for AVs, because "fully autonomous or highly automated vehicles will be commercially available in the coming years and that appropriate regulatory frameworks, ensuring their safe operation and providing for a clear regime governing liability, need to be in place as soon as possible in order to address the resulting changes, including interaction between autonomous vehicles and infrastructure and other users" (European Parliament, 2018). However, Eric Tjong Tjin Tai (2018) thinks that current legislation is sufficient to overcome the risks of AVs, without amending any EU Directives. He also believes that the EU can tackle the issues of civil liability with the already existing package of legislation, although there are some significant gaps concerning liability for algorithms that need to be adjusted (Tjong Tjin Tai, 2018).

[10] OECD Study on Automated and Autonomous Driving. Source: https://www.oecd-ilibrary.org/automated-and-autonomous-driving_5jlwvzdfk640.pdf?itemId=%2Fcontent%2Fpaper%2F5jlwvzdfk640-en&mimeType=pdf

[11] COM(2018) 283 final : https://ec.europa.eu/transport/sites/transport/files/3rd-mobility-pack/com20180283_en.pdf

[12] European Parliament's Report (2018/2089(INI)) on autonomous driving in European transport. Source: http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML+REPORT+A8-2018-0425+0+DOC+PDF+V0//EN

In line with the Commission's suggestion that it is more efficient to develop new regulation instead of prohibiting new technologies like autonomous vehicles (European Commission, 2017), this thesis will add relevant aspects to the current literature on fully AVs and the current EU liability system. In this regard, it is worth analysing the existing legal framework for motor vehicles from a liability point of view. The aim of this thesis is to analyse the existing rules on liability and insurance for AVs and conclude whether new regulatory actions are necessary, once fully autonomous vehicles will enter on EU public roads. Based on the analysis' results, the author will provide several ways of tackling legal issues emerging from the adoption and use of AVs.

Driverless vehicles that will be introduced on the European market at the beginning of 2020 will possess significant features, enabling them to be operated without a human driver (West, 2016). They are smart, easy to use and able to think and act accordingly in difficult driving situations. Scholars recognized the increase of social benefits and predicted the replacement of manual operated vehicles in the near future based on several aspects (Litman, 2018). AVs will reduce the number of traffic accidents, increase efficiency and mobility, use less energy and provide more freedom to the passengers (Taeihagh & Si Min Lim, 2018).

According to Heineke et. al (2017), our society is very attracted to technology nowadays, making vehicles with level four of autonomy and higher to be in high demand. Such vehicles come equipped with intelligent functions that enable them to perform many driving tasks. These tasks include accelerating, braking, steering, choosing the route, entering highways, changing lanes, overtaking slower vehicles and monitoring the driving environment, which makes the driving experience more interesting and pleasant. The European Commission (2017) encourages introducing fully AVs on the European market because they will bring many social benefits. The European Parliament demands adapting the existing legislative EU liability framework for motor vehicles, as mentioned in its motion for a resolution[13] on artificial intelligence to the Commission. Apart from ensuring more unity and improved consumers' rights, it would also produce economic added value of up to €148 billion (Evas, 2018).

[13] See MOTION FOR A EUROPEAN PARLIAMENT RESOLUTION on autonomous driving in European transport (2018/2089(INI)) Source: http://www.europarl.europa.eu/sides/getDoc.do?type=REPORT&reference=A8-2018-0425&language=EN

Nevertheless, since the European Union is stricter than the US concerning the rules for AV testing and technology in general, the purpose of the EU is to develop a satisfactory legislative framework for its citizens so that they can be protected from technological risks (Taeihagh & Si Min Lim, 2018). Nicola et. al (2018) mention that testing autonomous vehicles in some states of the US is authorized on public roads, while in Europe there are many obstacles preventing such testings. Although the 1968 Vienna Convention on Road Traffic[14] has already been amended, so that using automated driving technologies became legal, the amended 1968 Vienna convention[15] does not allow an autonomous vehicle to be driven without a driver and it demands a human driver that can be in charge of it in case of emergency (UNECE, 2013).

On the other hand, the EPRS emphasizes that this requirement is conflicting with this new kind of vehicles, as they do not need a driver. According to Pillath (2016), the EPRS proposed further amendments, so that the 1968 Vienna Convention on Road Traffic can be used as an instrument also for vehicles with level 5 of automation. ERTRAC (2017) highlights that governments of the EU member states are currently struggling to create a permanent regulatory framework for the use of AV at both the EU and national level.

Methodology

The current study aims to provide a qualitative assessment of the existing regulations concerning civil liability and insurance for motor vehicles in the European Union, as these will apply for autonomous vehicles too. Technical aspects of fully AVs are explored by analysing multiple academic documents, as well as various theories about the benefits that autonomous vehicles will bring with them once released on the European market. Since fully automated vehicles are anticipated to be introduced in 2020, the current research explores six theoretical scenarios involving the use of AVs. These scenarios are presented and analysed in order to reach conclusions concerning fully autonomous vehicles and further discussion on this topic.

[14] The 1968 Vienna Convention on Road Traffic can be accessed under : https://www.unece.org/fileadmin/DAM/trans/conventn/crt1968e.pdf

[15] Amendments to the 1968 Vienna Convention on Road Traffic: https://www.unece.org/fileadmin/DAM/trans/doc/2011/wp29gre/GRE-66-16e.pdf

The data collection method consists of observations, including readings such as scientific and newspaper articles of previous publications on four topics: *artificial intelligence*, *autonomous vehicles*, *product liability* and *traffic regulation*. In addition to this, legal and regulatory documents of the European Parliament, Commission and Council have been consulted, including reports, EU directives, working group documents, briefings and communications.

This thesis presents a systematic review of the two EU Directives: Product Liability Directive 85/374/EEC (PLD) and the Motor Insurance Directive 2009/103/EC (MID), but also a synthesis of primary research papers on autonomous vehicle regulation. The available literature on artificial intelligence and autonomous vehicles was studied and analysed in order to give an answer to the main research question of this study: **To what extent does the existing European legal framework for civil liability and insurance address the risks resulting from the introduction and use of fully autonomous vehicles and what kind of legislative policies can the EU develop in order to facilitate the adoption of fully autonomous vehicles on the European market?** In order to answer this research question, the author raises three sub-research questions, which are answered in separate chapters. Each chapter is meant to clarify a separate topic in order to provide a clear answer to the main research question.

Having said this, firstly, the main risks associated with the introduction of fully autonomous vehicles on EU public roads are identified. Therefore, the second chapter of this research paper answers the first sub-research question: **What are the main liability related risks resulting from the use of fully autonomous vehicles on EU public roads?** By raising this question, the reader is informed in detail about the features of fully autonomous cars and the possible risks resulting from the introduction of such vehicles. In order to emphasize these risks, situations in which vehicles are involved in road traffic accidents are presented, so that risks mentioned by scholars in their research papers can be applied to future real situations.

Secondly, the third chapter reveals the existing European legal framework concerning liability and insurance regulations for motor vehicles and answers the second sub-research question: **Does the existing European legal framework for motor vehicles protect the liability related risks resulting from the use of fully autonomous vehicles?** Outlining the EU legal system for motor vehicles is necessary in order to understand the nature of liability risks that fully autonomous vehicles pose. The qualitative analysis performed in this chapter represents a legislative analysis

of the existing EU civil liability and insurance framework for motor vehicles. The aim of this legislative analysis is to understand whether the risks identified in chapter two are sufficiently addressed by the current EU legal system. The central focus will be on the Product Liability Directive 85/374/EEC (PLD) and the Motor Insurance Directive 2009/103/EC (MID), as these two directives represent the main legal basis for addressing civil liability in the case of motor vehicles[16]. Nevertheless, national legislation of several Member States such as Germany, the Netherlands, Sweden, Belgium or France will be studied as well. The author aims to check, in situations when EU legislation may not be sufficient to address these risks, whether national legislation of the Member States completes this regulatory gap, so that victims of traffic accidents generated by the use of autonomous vehicles can be properly compensated.

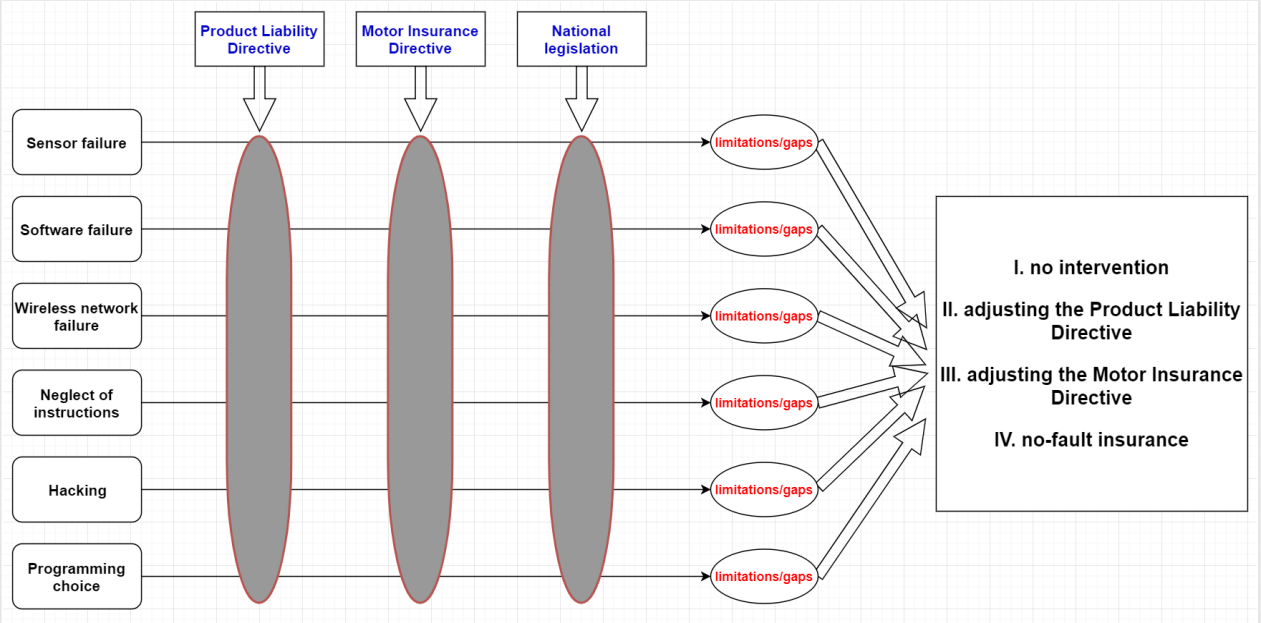
Lastly, the fourth chapter answers the last sub-research question: **What kind of legislative policies could the EU develop in order to enhance the introduction of fully autonomous vehicles?** The author will recommend three policy options. The first policy recommendation would represent no intervention from the regulator, the second policy option involves adjustments of the two EU directives (PLD and MID) and the third policy option introduces a no-fault insurance. This third policy option aims to provide equitable compensations for victims ''while keeping uncertainty about liability'' (Eastman, 2016). After these three policy options are outlined, the author presents a comparative policy assessment based on six criteria: *legal certainty*, *consumer protection*, *litigation costs*, *enhancing innovation*, *political acceptance* and *ease of regulatory change*. The author chooses these six criteria for the comparative policy assessment because these are considered the most relevant by many scholars from the field of technology, especially from the automotive industry (European Commission, 2018).

The comparative policy assessment highlights the pros and cons of these policy options and suggests which one is politically achievable for enabling a smooth introduction of AVs on the European market, while also guaranteeing EU citizens' rights and increasing their confidence in this new technology.

The following flow chart displays the analysis conducted in this research paper. On the left side, there are six scenarios. On top, the current EU regulatory framework and national rules for

[16] [16] See Report A8-0035/2019 of the European Parliament from 28.01.2019: http://www.europarl.europa.eu/doceo/document/A-8-2019-0035_EN.pdf

liability for motor vehicles are displayed, which are then applied for each of the six situations. The author applies this regulatory framework for the six selected cases, in order to check if there are possible limitations or regulatory gaps[17]. If any gaps that cannot be regulated with currently EU or national rules are found, the author proposes three policy options in order to overcome these challenges. The three suggested policy options are listed in the white box that can be found on the right of the diagram.



II. Risks of fully autonomous vehicles

Having looked at the advantages that autonomous vehicles bring and their levels of automation, this chapter considers the risks that fully autonomous vehicles pose. The following sections aim to underline the implications that these highly developed vehicles have if used on EU public roads. Some of the risks associated with AVs are very much alike with those of traditional cars, but in this chapter, particular risks that AVs raise will be presented. Since the nature of these risks is different, one of the major aspects for fully autonomous vehicles represents appropriate evaluation and mitigation.

[17] The limitations/gaps concerning to the use of AVs are highlighted with the red colour in the diagram.

Having said this, the current section of this paper aims to answer the first sub-research question: **What are the main liability related risks resulting from the use of fully autonomous vehicles on EU public roads?** Presently, the EU legislative system for motor vehicles is able to solve issues related to liability and insurance aspects, but if it were to apply for fully autonomous vehicles, it is essential to consider new risks as well. Lawyers from this field argue that current legislation can be interpreted in such a way that it can safeguard the uncertainties associated with AVs, but this still raises concerns, which are not clearly emphasized by current laws (Allen & Overy, 2017). According to the European Parliament (2018), if current legislation on liability were applied for autonomous cars, it would result in many discrepancies concerning liability between car producers and other stakeholders such as owners, public transport companies, lease companies etc. Not to mention that these risks could actually result in an increase of other administrative and legal matters because the industry of autonomous cars is still in its infancy, leading to a lot of around this topic.

Moreover, risks which cannot be covered by the PLD or the MID, are expected to generate more gaps in the EU legal framework once autonomous cars will be introduced (Parker et. al, 2017), because current PLD and MID were not supposed to regulate vehicles with AI that can take autonomous decisions, since they clearly differentiate themselves from conventional vehicles.

As an illustration, the European Parliamentary Research Service released a document[18] in February 2018 in which four main types of risks about liability concerns resulting from the introduction of AVs were outlined. The new types of risks are related to the software and network failures, cybercrime and lastly, the choice of programming. The European Parliament mentions that these four types of risks are not sufficiently addressed neither by the PLD nor by the MID. To this end, this study will only focus on these four categories of risks identified by the European Parliament, although the literature on AVs mentions many other types of concerns, including privacy and personal data.

[18] EPRS: A common EU approach to liability rules and insurance for connected and autonomous vehicles. http://www.europarl.europa.eu/RegData/etudes/STUD/2018/615635/EPRS_STU(2018)615635_EN.pdf

Software failure

The first type of risk concerning the introduction of AVs represents the failure of the operating software equipped on the vehicle. One of the main issues with the software is the nature of conditions under which the software producer, not necessarily the car producer, could be held liable and therefore cover the costs of damages to third parties. The other issue, it is not clear under which circumstances does the breakdown or the interruption of the software fall within the scope of the PLD, as a defective product. Until now, it is imprecise whether software can be regarded as product (de Almeida Lenardon, 2017), hence unsuitable to be subject to the PLD.

In addition, assuming that at a certain point, regulators will decide that software is a product, as the European Parliament intends, another issue appears. For instance, what are the necessary conditions for a software to be considered defective, being subject to the PLD and how can consumers prove that? Not to mention that from a legal position, it is unclear against which party should the owner of the vehicle claim liability. There is no clear provision that differentiates car producers from software producers when it comes to liability issues. If a defective software is equipped on a fully autonomous vehicle, then this vehicle will become defective as well. In this situation, in order to claim liability, it will be very difficult for the owner/user of the vehicle to distinguish between the software producer and car manufacturer. Based on the current legislation, all producers in the chain are held liable in case of an accident, but this needs to change in the future.

Network failure

This type of risk occurs in cases where the network fails to operate accordingly. Since fully autonomous vehicles cannot function without network access, another liability issue appears because it is not clear who should be responsible when the vehicle cannot communicate with the server and other traffic participants, obtaining useful data without which the car could not operate. Another question is of big importance in this situation: should the network provider be held liable for network problems, although the owner does not have a contract with the network company, but with the car producer?

The PLD applied for autonomous vehicles should establish if the network connection is considered a product and thus part of the vehicle, which would imply that car producers are also liable for network failure. If car producers guarantee that the vehicle will be connected at all times, regardless of the place of operation, then they will be also liable for network problems, according to the PLD.

In addition, the PLD stipulates that consumers must prove that the product was defective when the producer put it into circulation, which is already challenging enough for hardware products related to motor vehicles (Evas, 2018). For software products, this challenge is even bigger, because, in order to prove that a software or a network is faulty, a lot of expertise is required, not to mention the high level of uncertainty regarding software issues linked with the use of autonomous vehicles.

Furthermore, according to the MID, the amount of compensations for damages of third parties is set according to the national rules on liability of the Member States, which are extremely divergent across the EU (European Commission, 2018). As an example, Swedish rules on liability guarantee compensations for the damages of each person caused by a faulty network. On the opposite pole, within many of the EU Member States, there is no provision that guarantees equal protection for all individuals, including the operator of the vehicle.

Hacking and cybercrime

The third new risk that would emerge with the mass introduction of AVs is represented by hacking and cybercrime, as private data and privacy will be put at risk. Currently, the legislation of motor vehicles does not cover any aspect regarding this issue. Of course, this would not mean that privacy will not be regulated, in fact, the new GDPR[19], which entered into force in May 2018, has taken into consideration many types of new technological innovations, including AVs and therefore privacy and personal data of EU citizens are safeguarded.

[19] See Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679&from=EN

As the software and network failures mentioned in the previous sections, there is uncertainty regarding liability when AVs are hacked by third parties. Presently it is not clear who should bear the costs for such damages. This is another area that must be addressed with special attention because software can be hacked, resulting in the sharing of personal data to third parties, but also causing accidents on purpose. In this situation, who should bear the costs for these damages: the software producer or the car manufacturer? Bugs in the software are extremely difficult to be proven and this type of situation could remain unsolved for a long time.

On the other hand, since producers of autonomous vehicles have the power to control personal data of consumers through their products, they can be held liable according to the GDPR, but there are also some limitations[20]. In this situation, it must be proven that the producer of the AV did not take sufficient measures in order to protect personal data that was being hacked.

Lastly, it is the national courts that are entitled to conclude whether the owner, the keeper or the operator of the autonomous car is liable for damages (Kiilunen, 2018) as a consequence of his/her failure to install or update the existing software. According to the UK Parliament (2017), the decision of national courts vastly differs across the Member States and therefore it should be regulated at the EU level[21].

Programming failure

The last category of risks resulting from the introduction of AVs represents the so-called 'programming failure'. This type of risks refers to the way chosen for the program to operate the vehicles. This section aims to identify whether the car manufacturer can be held liable under the PLD for programming failures. The main question in this situation is whether the programming choice can be regarded as a design effect, so that it may constitute a defect of the product, and be therefore subject to PLD regulations. However, the current PLD is not so specifically developed in order to address this type of technological issues (European Parliament, 2018). According to Art. 7 (b) PLD, the car manufacturer is liable for injuries or damages caused by a failure of the software, network or programming; unless it can be proven that these were defective at the time

[20] See Article 23 of the GDPR. Source: https://gdpr-info.eu/art-23-gdpr/

[21] See the document provided by the House of Lords: Connected and Autonomous Vehicles: The future? Oral and written evidence. Source: https://www.parliament.uk/documents/lords-committees/science-technology/autonomous-vehicles/Autonomous-vehicles-evidence.pdf

the AV has left the factory. Other failures including software, network, and programming, resulting from the actions of third parties after the AV left the production line, are unfortunately not covered by the PLD. For instance, a bad reparation, hacking or a troublesome update of the software are not within the scope of the current PLD (Evas, 2018).

Conclusion

This chapter has outlined the most important risks associated with the use of fully autonomous vehicles that are to be introduced on the European market starting 2020. Based on the report on automated vehicles released by the European Parliament, the main categories of risks are related to software, networking and programming failures, but also to hacking and cybercrime activities. Other scholars emphasize that autonomous vehicles are indeed a serious threat unless sufficiently regulated, and bring these categories of risks into attention as well. As an example, few scholars refer to the topic of AVs as a 'social dilemma', as in their view, driverless vehicles will have a lot of potential, but would generate more risks and even amplify the current risks that traditional vehicles pose (Bonnefon et. al, 2016).

The following legislative analysis of the two directives mentioned above and other EU and national regulations that will be conducted in the next chapter will be based on these four categories of risks only, although there might also be other types of aspects that need to be taken into consideration.

III. EU Legal Framework for motor vehicles

Within the European Union, there are currently only two main EU legislative acts that can be applied to liability issues that can appear concerning motor vehicles, including autonomous cars. These are the Motor Insurance Directive (2009/103/EC) and the Product Liability Directive (85/374/EEC). In accordance with the Product Liability Directive, producers can be held accountable for injuries and damages resulting from the use of a defective product, as defined in Art. 1 of the PLD. The same EU Directive mentions in Art. 6 that "a product is defective when it

does not provide the safety which a person is entitled to expect"[22]. On the EU level, the framework regarding the liability of a manufacturer of defective products is harmonized, but there is only a limited EU framework for civil liability aiming to protect the victims involved in road traffic accidents caused by motor vehicles. This is because the rules for liability of the vehicle holder or the driver usually vary among the Member States. In the event of road traffic accidents, rules on liability, including insurance for third parties and the right to be compensated for their damages, are set by the Member States following the national rules.

The liability system in the EU is based on the concept of causality[23], in order to determine and assign liability (European Commission, 2018). This fact is significant because automated vehicles have particular levels of automation and the higher the level of automation, the more difficult it becomes to establish the precise cause of a road traffic accident, not to mention to prove that the accident occurred due to a specific defect of the automated vehicle. Having said this, this section aims to answer the second sub-research question: ''**Does the existing European legal framework for motor vehicles protect the risks resulting from the use of fully autonomous vehicles?**''.

As the two directives mentioned above serve for covering different areas and do not have the same degree of compliance on civil liability measures, the following two sections of this chapter provide a legislative analysis of the purposes of the two directives in order to understand more about the situations in which the two EU directives apply.

The Product Liability Directive 85/374/EEC (PLD)

The mentioned Directive provides a unified EU legal framework for liability of manufacturers of defective products, which is also applicable for fully autonomous vehicles. AVs are also a product that needs to meet the minimum requirements for safety, data protection, privacy etc. in order to be produced, sold and used on the territory of the European Union.

[22] Articles 1 and 6 referred in this section can be found in the COUNCIL DIRECTIVE of 25 July 1985 on the approximation of the laws, regulations and administrative provisions of the Member States concerning liability for defective products (85/374/EEC).
Source: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31985L0374&from=EN

[23] See Environmental Liability. Source: http://ec.europa.eu/environment/legal/liability/index.htm

According to the Court of Justice of the European Union (CJEU), the PLD establishes rules on the liability of producers and the rights that consumers are entitled to. Article 1 of the PLD[24] points out that the producer must compensate each consumer who bought a defective product. Regarding the rights of consumers, the PLD clearly establishes in Art. 4 that each consumer is entitled to reimbursement for the damages produced by the defective product, regardless of any possible limitations in the contractual clauses included by the producer, unless the injured party can prove the defect[25].

According to the current EU legislation, an AV that is involved in a road traffic accident is considered by definition as a malfunction of the system because it did not manage to avoid the collision with other vehicles or obstacles (Taeihagh, 2018). AVs are expected to monitor the driving environment without human intervention and take decisions faster and better than human drivers. Although AVs function based on software and algorithms, and are capable, at least in theory, to calculate all possible parameters so that an accident can be avoided, road traffic accidents will still happen. Therefore, in these kinds of situations, liability issues arise.

AVs involved in traffic accidents due to a defect software or hardware are subject to the PLD. Art. 1 of the Product Liability Directive 85/374/EEC mentions the following: "the producer shall be liable for damage caused by a defect in his product" (European Commission, 1985). The Directive establishes that a product released on the European market is defective unless it cannot meet the minimum safety requirements that it is expected to. AVs will fall into this category as well, as their users expect them to be safer than manually operated vehicles (DG MOVE, 2017), without being involved in accidents and causing injuries or damages due to the highly advanced software they are equipped with, which can analyse all driving circumstances in less time than humans could.

[24] Art. 1 of the Directive 85/374/EEC. Source: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31985L0374&from=GA

[25] Art. 4 of the PLD states that ''the injured person shall be required to prove the damage, the defect and the causal relationship between defect and damage''. This implies that injured parties shall be able to prove the defect of the autonomous vehicle, otherwise they cannot make use of the Directive and receive compensation. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31985L0374&from=EN

Furthermore, a defective product causes damages to third parties and especially in the case of AVs; such defects can lead to private property damages or serious injuries. Under Art. 9 of the PLD, 'damage' is defined as:

"(a) damage caused by death or by personal injuries;

(b) damage to, or destruction of, any item of property other than the defective product itself, with a lower threshold of 500 ECU, provided that the item of property :

(i) is of a type ordinarily intended for private use or consumption, and

(ii) was used by the injured person mainly for his own private use or consumption".

Based on the definition provided by Art. 9 (PLD), users of defective AVs that cause traffic accidents are entitled to liability claims from the producers.

In addition to this, Art. 3(*1*) of the PLD plays an important role, as the definition of '*producer*' is explained: '' ´Producer` means the manufacturer of a finished product, the producer of any raw material or the manufacturer of a component part and any person who, by putting his name, trade mark or other distinguishing feature on the product presents himself as its producer''. This implies that component part producers can be held liable as well and the car producer can escape liability.

The Motor Insurance Directive 2009/103/EC (MID)

In contrast with the PLD, the Motor Insurance Directive (MID) has relatively limited depth regarding an EU legal framework for motor vehicles. Regulations concerning civil liability for injuries, damages or even losses caused by road traffic accidents of motor vehicles are not supervised on the EU level, but by the Member States. Each member state has developed its own liability rules. For instance, in the Netherlands there are semi-strict liability rules on damages resulting from road traffic accidents involving motor vehicles (DG for Internal Policies, 2016), in comparison with France, which is very strict regarding liability in this situation (Parker et. al, 2017). On the opposite side, there is the UK, which has not adopted a strict liability procedure (European Parliament, 2018). However, the MID obliges all the motor vehicles which are registered in the EU to be covered by compulsory third party insurance. In other words, the

European Commission (2018) states that the Motor Insurance Directive is meant to ensure the smooth functioning of the EU Single Market[26], but it is the MS who are responsible for regulating claims and compensations for victims of accidents; therefore, there are different standards among the Member States.

Limitations and challenges of the EU legal framework

The aim of this section is to provide a clear outline of the current limitations and gaps on the EU level concerning the regular use of vehicles with level 5 autonomy on public roads of the Member States.

On the EU level, damages and injuries resulting from road traffic accidents in which motor vehicles are involved, are regulated by the two directives: PLD and MID. These two directives are reviewed regularly and in addition to this, the European Commission schedules public consultations[27] where various stakeholders can provide input about new risks and challenges of the existing EU liability framework. However, according to the European Commission's Review of Directive 2009/103/EC on motor insurance[28], most of the key stakeholders acknowledged that current directives are sufficient for addressing both the interests and responsibilities of the parties involved. To continue, the European Commission carried out another public consultation[29] within the same year regarding the PLD. As a result, a clear majority of 82.5% of the organizations that took part in the consultation believed that the PLD is sufficient for protecting the interests of both manufacturers and consumers (European Commission, 2017). On the other hand, the category of private individuals seemed to be less satisfied with the current PLD, as only 68% of the

[26] See the Commission's proposal COM(2018) 336 final.
http://www.europarl.europa.eu/RegData/docs_autres_institutions/commission_europeenne/com/2018/0336/COM_COM(2018)0336_EN.pdf

[27] See the public consultation on the rules on liability of the producer for damage caused by a defective product:
https://ec.europa.eu/growth/content/public-consultation-rules-liability-producer-damage-caused-defective-product-0_en

[28] See CONSULTATION DOCUMENT REFIT1 Review of Directive 2009/103/EC on motor insurance.
https://ec.europa.eu/info/sites/info/files/2017-motor-insurance-consultation-document_en.pdf

[29] See Brief factual summary on the results of the public consultation on the rules on producer liability for damage caused by a defective product
https://ec.europa.eu/docsroom/documents/23471/attachments/1/translations/en/renditions/native

respondents affirmed that the current PLD could sufficiently protect the rights and interests of producers and consumers.

Furthermore, representatives of the organizations and private individuals took into consideration that the introduction of autonomous vehicles on the EU market would directly affect the type of risks associated with motor vehicles (European Commission, 2017). Under the current EU liability system, there are only two types of risks concerning the use of motor vehicles. Firstly, a road traffic accident can be caused by a failure of the hardware (European Parliament 2018), which means that in this situation the producer of the defective product can be held liable. Secondly, it is the operator of the motor vehicle, i.e. the driver, which can be held liable based on national traffic legislation of the MS. According to the statistics[30] of the Directorate General for Mobility and Transport of the European Commission, the main causes for crashes are speeding, use of alcohol and drugs, but also the time of the day or the day of the week (DG MOVE, 2017). Although the driver is insured for the costs of damages and injuries based on the MID, he is always responsible for causing a road traffic accident.

However, with the mass release of fully AVs on the EU market, there will be no human drivers behind the wheel, and therefore there are new types of risks that could cause accidents. In addition, since autonomous vehicles are able to operate based on software that enables them to calculate distance, adapt speed, read and interpret traffic signs etc., there are several types of new risks that need to be immediately identified and included in the current legal framework on liability. As there are new types of risks that cannot be regulated by the current legislative framework (Taeihagh & Si Min Lim, 2018), it is wise to adjust and even propose new rules in order to face these new risks associated with the introduction of driverless cars. Thus, the next two sections of this chapter will outline the existing risks associated with motor vehicles accidents and the new type of risks that would result from the introduction of fully autonomous vehicles on EU roads. Finally, in order to regulate the new risks, it is possible that a shift will occur in liability, with the adjustment or introduction of new regulations to be applied in these situations.

[30] DG MOVE on characteristics of crashes: https://ec.europa.eu/transport/road_safety/specialist/knowledge/young/magnitude_and_nature_of_the_problem/characteristics_of_these_crashes_en

With the mass roll out of fully autonomous vehicles on the European market, an assessment of the existing regulatory framework on liability is absolutely necessary in order to decide who must be responsible in case of an accident. To this end, the aim of this section is to outline the current risks associated with motor vehicles accidents and determine whether the current legislative framework for motor vehicles is sufficient for regulating civil liability issues including fully autonomous vehicles. O'Toole (2014) states that AVs cannot be categorized as an upgrade to existing vehicles, but rather as a completely new product that is able to function based on sophisticated software, special hardware and various algorithms. Therefore, it is worth analysing whether the risks of using AVs on public roads are protected by the current PLD and MID.

The Product Liability Directive

The PLD aims to regulate the discrepancy of risks between manufacturers and consumers, which in this context are car manufacturers and clients who buy motor vehicles. However, the PLD seems to not address all types of risks and therefore the discrepancy of risks mentioned above may be compromised. As an example, there are three main types of risks, which currently the PLD does not sufficiently address.

First, the PLD aims to hold the producer of a defective product liable, but the term "defective" is broadly defined in Art. 6 of the PLD[31], thus making it difficult for authorities to decide whether a product is defective or not, especially in the case of fully autonomous cars. For the moment, the PLD covers only hardware issues, leaving the software issues as an area to be covered by future legislation. In this regard, because it is still unclear whether software can be regarded as a product, car manufacturers, importers, car dealers and component makers try to reduce their liability based on the current PLD.

Second, the injured parties involved in a road traffic accident will always bear the costs of the unknown risks that they encountered, because if such risks are not scientifically proven, as explained in Art. 4 of the PLD[32], the other parties, such as the car manufacturers, distributors and importers, cannot be held liable.

[31] Art. 6 of the PLD: "A product is defective when it does not provide the safety which a person is entitled to expect".

[32] Art. 4 of the PLD: "The injured person shall be required to prove the damage, the defect and the causal relationship between defect and damage".

Third, since autonomous vehicles are mostly based on new high-tech innovations, it will be very complicated for national courts of the MS to take decisions based on the current PLD and interpret which risks fall under the PLD and which do not.

Furthermore, under the current PLD, consumers must prove that a defective autonomous car was already faulty at the time it left the factory, as mentioned in Art.7 (b) of the PLD[33]; otherwise the PLD does not cover the risks of liability for car producers, component makers etc. This implies that the consumer must be aware of the minimum requirements for safety standards for new technologies, which in reality would result in the consumer being left with the defective autonomous car.

Finally, the current PLD provides only limited coverage of damages and injuries of third parties (Kiilunen, 2018) and when it comes to the driverless car itself, the PLD does not cover the car's damages at all. The actual Product Liability Directive only marginally protects producers and consumers of autonomous cars. The PLD seems to address a limited number of issues associated with the introduction of AVs and it provides a certain degree of uncertainty for the stakeholders in this industry (European Commission, 2017). In short, the current risks associated with the introduction of autonomous cars that are not addressed by the PLD include not only the inability of the consumer to prove that the product was defective at the time of purchase, but also limited coverage of the costs for private property damages[34] and the autonomous car itself, and the possibility of the producers to shift their liability due to unknown risks as it is a new technology.

The Motor Insurance Directive

The Motor Insurance Directive (MID) represents the second legal instrument of EU legislation for covering the damages and injuries because of a road traffic accident caused by a motor vehicle. Under the MID, all motor vehicles registered within the EU must hold a mandatory valid motor liability insurance so that in case of an accident, damages to third parties can be covered.

[33] Art. 7 (b) of the PLD: "The producer shall not be liable as a result of this Directive if he proves (…) (b) that, having regard to the circumstances, it is probable that the defect which caused the damage did not exist at the time when the product was put into circulation by him or that this defect came into being afterwards".

[34] Here is meant the threshold of 500 ECU as laid down in Art. 9 (b).

Since AVs are also motor vehicles, the MID can be applied and therefore all types of damages and injuries to persons and private properties others than the driver, will be covered by the insurer. In addition, on 24th of May 2018, the European Commission submitted a proposal[35] to amend the MID so that victims of road accidents caused by the use of motor vehicles will receive full compensations for their damages, even if the insurer declared insolvency. The amendment proposed by the Commission helps the authorities to fight uninsured driving and to enable the victims to receive fair compensation.

However, the MID does not regulate issues on civil liability, including the amount of compensations to third parties, as these are set by the Member States, as specified in Art. 3 of the MID. In this situation, national rules apply and these are different across the EU. At the moment, all national systems assume that the operator of the vehicle (driver) who is behind the wheel, is always in control (European Commission, 2017). Therefore, in case of accidents, national courts must establish the connection between the fault of the operator and the result of the accident, in order to determine the amount of compensations and the nature of the punishment for the operator (European Parliament, 2018). At this point, it is necessary to mention that the release of fully autonomous vehicles on the European market would directly imply that a software would replace the human operator of the vehicle (European Commission, 2018).

In addition, under the MID it is mandatory for users of motor vehicles to have valid liability insurance[36] that would cover the damages and injuries to third parties. The amount set according to Art. 9 of the MID is "EUR 1 000 000 per victim or EUR 5 000 000 per claim, whatever the number of victims and in the case of damage to property, EUR 1 000 000 per claim, whatever the number of victims". The driver who caused the accident and his vehicle are excluded. Thus, with the introduction of fully autonomous cars, the owner of the vehicle cannot be held liable for a possible accident. In this case, who should bear the responsibility for injuring the owner/driver? Since the current MID does not cover these types of damages/injuries, the question cannot be explicitly answered now.

[35] See the proposal COM(2018)336/976568 available at: https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2017-3714481_en#pe-2018-3261

[36] See Article 3 of the MID, concerning the compulsory insurance of vehicles.
Source: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0103&from=EN

To sum up, the Motor Insurance Directive should be reviewed, especially due to the introduction of fully autonomous vehicles, as several gaps have been identified within the legal framework. Besides, the current Product Liability Directive does also not address all the risks resulting from the use of vehicles with level 5 of autonomy. Releasing fully AVs on EU roads without an immediate revision of these two directives, would result in many risks for producers and consumers of such technology. The current EU legal framework on liability has to be adjusted in order to provide legal clarity for the automobile industry and its consumers.

Possible scenarios

Based on the types of risks[37] outlined by the European Commission in May 2018 and the European Parliament's report on autonomous and connected driving, but also on the literature available on driverless cars, there have been identified several possible scenarios related to legal issues on liability in case of accidents caused by fully autonomous vehicles. In order to elaborate on the usefulness and applicability of the PLD for autonomous vehicles, the following sections will present six types of situations. Below, each scenario will be briefly presented so that the reader can understand the problem at stake and afterwards, a legislative analysis of the two EU directives and rules of the MS concerning traffic liability will be outlined, so that legal gaps can be identified. The author presents the six scenarios in order to provide clear examples of ambiguous situations in which there is no clear solution based on current legislation.

Scenario 1: Sensor failure

The first scenario of this analysis represents a failure of sensors. This situation involves an operator of a fully autonomous vehicle who was injured due to a fault sensor, which could not fulfil its tasks properly and therefore did not recognize the right lane, causing the automated vehicle to drive against the upcoming traffic. It should be mentioned that the detection of the lane was not possible because of the faulty sensor and not due to bad road markings or bad weather conditions.

[37] The types of risks include cyber-attacks, hacking, safety, data privacy, liability, software and connection failures. The document can be retrieved from: https://ec.europa.eu/transport/sites/transport/files/3rd-mobility-pack/com20180283_en.pdf

Under the Product Liability Directive, the consumer, which in this case is the operator of the vehicle, is entitled to sue the car manufacturer or the hardware producer, assuming these are two distinctive parties. The operator shall be entitled to compensation for his injuries, unless he can prove that the sensor was malfunctioning. The reasons for a faulty sensor can vary and as an example, the author has identified some possible causes:

(i.) the sensor could have been defective at the moment it was put into circulation, after leaving the factory;
(ii.) a sensor may have been faultless, but wrongly installed and therefore became faulty;
(iii.) the producer may argue that the sensor became faulty due to normal wear and tear, only valid when the product exceeded the guarantee period;
(iv.) the sensor became faulty after a bad repair in the workshop after it left the factory;
(v.) the producer may argue that the defect in the sensor could have not been detected at the time it was put into circulation.

Based on these five possible causes for a faulty sensor, it is obvious that national courts are faced with difficult situations and their interpretations may vary a lot. In addition, damage to the malfunctioning autonomous vehicle cannot be covered following the Product Liability Directive. For the other types of damages such as property damage, under the PLD only damages exceeding 500€ are protected[38]. Nevertheless, in cases when the consumer (operator/holder of the autonomous vehicle) has obtained compensation from the car manufacturer, the latter can sue the hardware maker for reimbursement, assuming that these two are different parties, but this situation, again, depends on the national courts of the Member States, as mentioned in Art. 5 of the PLD.

In addition, scholars mention that it is still not clear who must bear responsibility for the personal injuries of the victim based on the liability for traffic accidents. When the user of the AV is injured, there is no provision that guarantees him protection. The only exception is Sweden, which proposed 'insurance against damage, and not liability' (Lohmann, 2016, p.339). This means that damages to the users of fully automated vehicles are covered by first party insurance

[38] See Art. 9 of the PLD and the European Commission Staff Working Document. Source: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018SC0157&from=EN

in the first place, and are not based on liability. Sweden's insurance model has also been proposed by Leenes et. al (2017) for all automated vehicles and is currently in discussion also in the United Kingdom, because users (drivers) of AVs can receive compensation for their injuries directly from the insurer of the motor vehicle, even in accidents when there is a single vehicle involved.

Furthermore, in countries that demand a risk-based liability on the holder, only pedestrians are protected. In countries such as France and Germany, this protection is also valid for passengers of the vehicle (Engelhard & de Bruin, 2017). In few MS such as Germany and the Netherlands, the owner of the vehicle is allowed to refrain from liability, unless he can prove that the accident was caused due to an external factor (Taeihagh & Si Min Lim, 2018). Thus, Engelhard & de Bruin (2017) mention that in other Member States such as Malta and the UK, injured persons cannot receive any compensation, unless they can prove a causal link between the faulty part (sensor) and the accident.

Scenario 2: Software failure

The second scenario deals with faulty software installed on the autonomous vehicles. Recently, national courts have been struggling with the controversy of whether software can be qualified as a product (Engelhard & de Bruin, 2017). Apart from this, a more interesting question is whether the sudden break or delay of the operating software will automatically mean that the software is faulty. The reason for asking this question is to clarify whether such delays or interruptions of the operating software that is equipped on AVs would affect a huge number of vehicles, pointing therefore software failure models produced within a specific period.

Clients of technology provided by AVs should expect weaknesses, delays, bugs or even breakdown of the software, the same as in the case of computers or smartphones. The most problematic aspect remains that bugs in the software cannot be detected at the time vehicles leave the factory so that they can immediately become updates. On the other hand, future operators could also claim that regardless the failure in the software, the vehicle itself is also defective, as it

could not prevent the interruption of the software and enter the well-known 'limp mode'[39]. Failure to enter limp mode can be regarded as a software failure too, but in this case, operators would address claims directly to the car manufacturer.

Assuming that software is considered a product, the PLD framework stipulates that the AV operator's right for compensation depends on the issues that caused the failure in the software. Issues with the software such as bugs or delays are covered under the PLD unless these issues could have been accurately identified before the vehicle left the factory. Based on the Commission's Report[40] from 2001, all other risks and damages that occur after the time of production remain uncovered under the PLD (Commission of the European Communities, 2001). The only way of receiving remuneration or coverage for damages and injuries generated by bugs or breakdowns of the operating system (software) will depend on national legislation on traffic liability. This means that for the moment, this right of receiving compensation differs extensively among the Member States.

Regarding the MID, this situation will be treated differently throughout the EU. In Member States with fault-based liability, the user or owner of the AV cannot be held liable, unless he was aware of this issue and could have avoided it. For instance, this is possible in the United Kingdom and Malta. The other Member States that demand a risk-based liability on the user (driver), the categories of victims are limited to pedestrians and for pedestrians and passengers in France and Germany, with the exception of Sweden. Of course, users or owner of AVs may use the external factor in courts, in order to escape from liability, but in practice, faults or defects of the motor vehicle are not included. However, it is still uncertain whether software failure can be categorized as such.

[39] 'Limp Mode' or 'Safe Mode' occurs when a computer or sensor of a vehicle is malfunctioning. In order to prevent a major mechanical issue or even an accident, the vehicle enters into limp mode and runs a secondary programming with limited performance so that the driver can continue driving the car up to the next workshop.

[40] Report from the Commission on the Application of Directive 85/374 on Liability for Defective Products. Source: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52000DC0893&from=EN

Scenario 3: Wireless network failure

Scenario 3 involves a more sensitive issue: failure of the wireless network. For this scenario, it is assumed that due to road maintenance, the route has been deviated. As the wireless network becomes suddenly unavailable and it cannot update the new route, the vehicle is following the initial route and crashes into road works. In this situation, apart from the operator and the producer of the vehicle and software, the wireless network provider becomes also a probably liable party. Evas (2018) assumes that it is very reasonable that car manufacturers will not be obliged to guarantee a nonstop wireless connection of the AVs with the main server and will not include this in the contract, being therefore not responsible for networks interruptions. Nevertheless, if they do and offer consumers a package where wireless network responsibility is guaranteed, responsibility for unavailable wireless connection will fall primarily with the car manufacturer.

If the producer in the contract does not guarantee being permanently connected to an available wireless network, the following question raises: Is the automated vehicle in this case defective? How can the producer prevent this situation? Should it have a back-up system that could allow the vehicle to drive further during interruptions of the wireless network or how can the user be informed beforehand? For situations when the wireless connection becomes unavailable, will the vehicle automatically slow down and park itself to a safe place until the wireless connection with the main server is again established? Failure to do so could be regarded by operators as a defect in the vehicle.

Domestic courts or even the CJEU will have to provide answers to the questions above. Although it is too soon and uncertain to discuss these decisions, it is expected that both car producers and the telecom providers will bear responsibility for network interruptions (Engelhard & de Bruin, 2017).

Moreover, in this scenario traffic liability may differ throughout the EU. Engelhard & de Bruin (2017) state that in Sweden, the law protects all traffic members to receive compensations from the motor insurance and the UK' Parliament proposed a similar initiative[41]. In the other Member

[41] Proposal for a Motor Insurance Directive amending Directive 2009/103/EC. Source: https://publications.parliament.uk/pa/cm201719/cmselect/cmeuleg/301-xxxiii/30107.htm

States, if the user is injured, he does not benefit from the same protection as the other traffic participants. Damages and injuries to other traffic participants can be compensated through risk-based liability. However, the owner of the AV may not be held liable in the Netherlands or Germany, if he invokes the external cause. He can mention in court that it was impossible to prevent the unavailability of the wireless connection and escape therefore from liability.

Scenario 4: Neglect of instructions

In the fourth scenario, the operator of the automated vehicle ignores the instructions provided by the car manufacturer as indicated in the user guide. So that we can speak about product liability in this case, the operator must demonstrate the failure of the vehicle (Parker, Shandro & Cullen, 2017). Apart from the facts presented above, an information defect should be taken into consideration as well. The information provided in the user manual shall be clear, concise and obvious. Engelhard & de Bruin (2017) mention that if the user manual can be proven to be unclear or ambiguous, then the product has ‘‘an information defect or a design defect’’. In this context, we can speak of a design defect unless the producer fails to equip the vehicle with a system, which gives the driver repeated warnings on the dashboard and through the steering wheel, and even takes control of the vehicle if the driver ignores the warnings or remains passive after a set period.

If the vehicle is defective, the producer can state in his defence that the user operated the vehicle in a wrong way, contrary to the instructions mentioned in the user guide. Art. 8(2) of the Product Liability Directive states that: ‘‘the liability of the producer may be reduced or disallowed when, having regard to all the circumstances, the damage is caused both by a defect in the product and by the fault of the injured person or any person for whom the injured person is responsible”. As a result, users who are ignoring the instructions can contribute to negligence and be therefore responsible for defectiveness, without any right to claim compensation from the producer.

Under the current traffic liability framework, in France and Sweden, the user of the AV can receive full compensation from the producer of the AV, although he has not clearly followed the instructions recommended. In all the other Member States, his right to receive compensations can be limited due to negligence concerning the instructions. However, if he can prove that another

traffic participant was liable for the incident, he can be entitled to some compensations, despite his negligence towards the instructions.

Scenario 5: Hacking

Another unpleasant scenario represents the hacking of the operating system equipped on the vehicle. Hacking and cybercrime are similar to the software and programming issues indicated above. As already mentioned by the European Parliament, the European Union does not provide a harmonized package of rules for civil liability yet, especially in the case of cybercrimes (Evas, 2018). Therefore, according to the DPD and GDPR, producers of fully autonomous vehicles that control personal data are responsible for the purposes for which they are using the data of their clients. However, there are some limitations and car manufacturers make themselves responsible unless they canot prevent personal data of their clients being hacked. Nevertheless, according to Parker, Shandro & Cullen (2017), hacking can occur also due to failure to installing new software updates. In this case, the issue whether the operator, or the holder or the keeper shall be responsible for damages as a result from not installing the latest software updates on the AV would be still decided by national laws of the Member States, which could outline different decisions.

Since the EU Commission enhances more autonomous and connected driving in its report on autonomous cars[42] from January 2017, it seems justifiable from users to expect issues related to hacking and cybercrime. Just like in the case of smartphones, AVs receive a lot of personal information from their users such as telephone numbers, addresses, locations etc. and therefore it is reasonable from users to expect more protection from car manufacturers.

Producers of AVs should include in their package regular updates as the technology used by the vehicle can be hacked. Users should be automatically notified when new updates are available, which could also include recalls. However, if producers fail to do so and the vehicle is being hacked, consumers can hold the car producer or the software developer liable. Otherwise, they must always install the latest updates that car manufacturers recommend.

[42] The report mentioned here has been published in the Digital Transformation Monitor and can be found at: https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Autonomous%20cars%20v1.pdf

Based on traffic liability laws, this type of risk will be treated just as in the case of the wireless network failure outlined in the third scenario.

Scenario 6: Programming failure

The last scenario focuses on defectiveness in the programming of the automated vehicle. It is assumed that the AV injured a number of pedestrians, as it tried to avoid a collision with a tree along the road. The main question in this situation is whether the car producer must bear responsibility for such an incident. Marchant & Lindor (2012) mention that in these situations, there is usually a design defect and the producers bear responsibility, as they are aware of these issues before producing the vehicles and operating software. Another important aspect is the choice of programming, as producers are aware of these road traffic incidents. Should they program the operating system of the vehicle so that it would avoid hitting pedestrians or the driver and his passengers instead of avoiding to hit other objects such as trees, houses, or other stationary vehicles?

Based on current traffic liability framework, pedestrians hit by the autonomous vehicle in this scenario are entitled to compensations for their injuries from the user or the owner of the motor vehicle. Again, the owner of the AV can escape liability in Germany and the Netherlands if he invokes an external cause for producing the accident.

Conclusion

The aim of this chapter was to provide an overview of the current EU legal framework on liability. The first section of this chapter introduced the Product Liability Directive, while the second section outlined the Motor Insurance Directive, as these two directives are the main instruments of the EU liability framework.

According to a compilation of scientific articles and other official documents released by EU authorities such as reports and plenary meetings of the European Parliament, the existing Product Liability Directive (PLD) and the Motor Insurance Directive (MID) framework do not explicitly address the four risks outlined in chapter II. The six scenarios presented situations in which current legislation is not sufficiently clear to cover all damages because of the use of a fully autonomous vehicle (Parker, Shandro & Cullen, 2017). The scenarios revealed that apart from

regulations on EU level, the other applicable rules on traffic liability differ among the Member States, which leads to different conclusions of national courts. For instance, the UK uses fault-based liability and offers victims direct compensations for their damages and injuries, while the other Member States adopt a risk-based regime. The situation in France and Belgium does not differ much, but the injured driver's right to receive compensation is limited. Both law systems are excluded in Germany and the Netherlands, as the possessor of the driverless vehicle can avoid liability invoking an external cause for the accident or the so-called 'Act of God' (Webb, 2017).

In addition, Member States that approach a risk-based law system prefer to use terms such as driver, owner, keeper, possessor and passenger. Thus, in case of accidents, only the passengers are entitled to compensations, whereas drivers do not receive any compensation for their injuries by risk-based liability. This implies that with the mass roll out of AVs, there will be different situations, depending on the owner of the vehicle and his country of residence.

Apart from this, fault-based law-systems are not compatible with fully autonomous vehicles (level 5 of automation), since these vehicles do not need a human driver and therefore human activity is excluded and no fault can be attributed in those Member States (France, Belgium, UK). In Germany and the Netherlands there is a similar situation, although they use a risk-based system, because fault-based elements are still being used, the use of fully autonomous vehicles will not be appropriately addressed by the current traffic liability system. Within the European Parliament there has been discussed in early 2017 the solution of attributing fault to the autonomous vehicle (Allen & Overy, 2015), but even in this case, it would still be difficult for victims to demonstrate a clear causal connection between the accident and the fault in the vehicle.

The legislative analysis revealed that without any specific intervention from the legislator, the present Product Liability Directive framework would generate a lot of confusion between both producers and consumers of AVs, if enforced to the four types of risks outlined in the previous chapter. Although in theory the PLD should resolve these kinds of risks, in practice, it would be extremely complicated if not even impossible to mitigate the damages to be covered by the PLD. According to Engelhard & Bruin (2018), unless revised, the current liability framework would diminish consumers' trust in fully automated vehicles. Besides, the current MID framework and

national traffic regulations of the Member States are limited, making it even harder to address current and new risks relating to AVs. Since there is not a harmonized package of traffic liability rules on the EU level, it means that EU citizens are protected differently in the EU, depending on each Member State (Evas, 2018).

To sum it all up, based on the findings of this chapter, the sub-research question '**Does the existing European legal framework for motor vehicles protect the risks resulting from the use of fully autonomous vehicles?'** can be answered in this manner: the current EU legislative framework is not able yet to address all the risks associated with the use of AVs. At the moment, not all types of risks identified above are protected based on the PLD and the MID. On these grounds, the current EU legislative framework on civil liability must be urgently reviewed, as the introduction of AVs on the European market under the current PLD and MID frameworks would generate even more types of risks. In addition, the European Road Transport Research Advisory Council (2017) suggests that it would be wiser to address all these new risks resulting from traffic accidents with a harmonized package of legislation at the EU level, so that differences in the decisions of national courts can be avoided. This way, every EU citizen can be entitled to equal reimbursement for damages generated by AVs driving on EU public roads, regardless of the Member State.

IV. EU Policies

Scenarios presented in the previous chapter outlined that the introduction of fully autonomous vehicles starting from 2020 in Europe would generate many risks. The EU legislative framework does not at all or only marginally cover some of these risks. In order to facilitate a safe, secure and sustainable introduction of these vehicles on EU roads as requested by the EU Commission[43], it is obvious that the EU must develop new legislative proposals. In this regard, the current chapter will answer the last sub-research question: **'What kind of legislative policies could the EU develop in order to enhance the introduction of fully autonomous vehicles?'**

[43] Communication from the EU Commission: On the road to automated mobility: An EU strategy for mobility of the future. https://ec.europa.eu/transport/sites/transport/files/3rd-mobility-pack/com20180283_en.pdf

Based on current literature and similar topics addressed by the EU over the years[44], the author suggests three legal solution models that the EU can adopt concerning the introduction of fully autonomous vehicles. The first policy option considered by the author involves no intervention in current legislation, while the second policy option stands out for adjusting existing EU Directives such as the Product Liability Directive or the Motor Insurance Directive. The third and last policy option highlights an insurance solution: no-fault insurance for fully autonomous vehicles.

1. No intervention

First policy option implies no change in current legislation. In this situation, the issues identified in the scenarios presented in the previous chapter would remain uncovered. As a result, the number of litigations between parties would rise, as it is expected that legal gaps of the current system to be filled by case law.

As there will be no adjustments to the PLD or the MID, from a procedural perspective, the legislator is not requested to take any actions (Evas, 2018). However, the identified legal gaps will not only remain uncovered, but they will also lead to a loss of trust among the consumers, confusions for national courts, different decisions across the EU and higher litigation costs (Delvaux, 2018).

2. Adjusting EU Directives

The second policy option contains adjustments to the already existing European Directives concerning the use of vehicles. As it was revealed in chapter 3, there are only two Directives that can be applied to fully AVs: The Product Liability Directive and the Motor Insurance Directive.

[44] A similar topic to AVs is the introduction of civilian drones. As the EU recognized drones as a big opportunity for the industry sector in Europe, it started revising the current legal framework so that its citizens can enjoy in full respect their fundamental rights. See the 2016 Warsaw Declaration at: https://ec.europa.eu/transport/sites/transport/files/drones-warsaw-declaration.pdf

Adjusting the Product Liability Directive 85/374/EEC

The current Product Liability Directive[45] is meant to "establish the principle of liability without fault applicable to European producers" (EUR-Lex, 2016).

In situations when AVs are proven defective, consumers can hold the producer liable for damages caused by the defective product, including negligence. However, the analysis outlined in chapter 3 revealed that Directive 85/374/EEC does not cover all risks related to fully AVs and therefore adjustments to the current PLD are requested by scholars such as Kiilunen (2018), Parker, Shandroo & Cullen (2017) and even EU institution such as the Commission[46] or Parliament[47].

Adjusting the PLD would bring overall more clarity to the distribution of risks between producers and clients. A clearer PLD would provide adjustments to the definition of the product, so that it can be clear what can be regarded as a product and what not. For instance, one of the current topics regarding the use of fully autonomous vehicles is whether software can be regarded as a product (Kim, 2018). In this situation, a clear definition of the term 'product' would be highly desired.

In addition, clear definitions of 'defect' would ease decisions of national courts. As an example, the scenario presented in chapter 3 when a fully automated vehicle chooses to hit a pedestrian so that it can avoid a frontal collision with a house. In this case it is clear that there was the software which was faulty and not the vehicle itself, therefore the car producer can claim liability from the software producer for a software defect, but without a clear definition of the term 'defect', judges were struggling with the issue of addressing full responsibility for the software producer (Reutiman, 2012). Besides, the amended directive should include software under the concept of a product, so that software issues can be regarded as defects under the PLD. Until now, no judicial court decided whether software can be regarded as product, process or service (Kim, 2018).

[45] Directive 85/374/EEC: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=LEGISSUM:l32012&from=EN

[46] Commission Staff Working Document from May 2018: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018SC0157&from=EN

[47] European Parliament's report: http://www.europarl.europa.eu/RegData/etudes/STUD/2018/615635/EPRS_STU(2018)615635_EN.pdf

Engelhard & de Bruin (2017) mention that it would make more sense to add in the PLD software breakdowns and other technological risks, which were not evident at the time of production. This way, consumers' rights can be better protected. The same scholars brought into attention that even if these technological risks will be included in the new PLD, in practice, the possibilities will remain limited, as product liability would compete, at least to some extent, with national liability rules for motor vehicles.

The discrepancy between national rules across the EU can be frustrating for AVs manufacturers because of the differences in the degree of liability risk. As discussed by the European Parliament (2018), in European countries with fault-based liability, their liability risk will be high, compared with Member States such as Sweden, Belgium or France, where the AVs producers will barely face any claims because of the very rigorous liability rules for motorized vehicles imposed on the owner of the AV.

According to the EPRS (2018), the European Commission did not show enough interest in its evaluation report of 2011 in order to amend the current PLD, so that new technological risks can be covered. However, the evaluation report from 2016 showed a significant desire and enough reasons to propose a new PLD, so that risks caused by the use of AVs can be protected.

To conclude, the major focus of this adjustment of the Product Liability Directive would be to provide fair reimbursement for the damages and injuries resulting from the use of fully autonomous vehicles. However, this policy option will not be easy to implement because directives are meant to be applied to more areas. For instance, the current PLD is designed to be applied to all defective products, which makes it difficult to adjust so that it can cover all risks associated with AVs, while also remaining flexible as it was designed at the beginning in 1985, to address risks resulting from the use of defective products. It is clear that there is enough room for improvement, but in order to provide more protection for consumers, there should be considered other compensation schemes as well.

Adjusting the Motor Insurance Directive 2009/103/EC

Revising the MID would bring in the first place more harmonization to national traffic liability regulations, but also enable the victims of accidents caused by AVs to be equally compensated for their damages across all Member States. Based on the analysis in chapter 3 and EU Parliament's report[48] on AVs, EU citizens receive distinctive coverage in particular Member States and therefore a common system of traffic liability rules would be highly desired. However, according to the European Parliament (2018), amending the current MID and adding new rules so that issues relating to the responsibility of the driver and remuneration of the victims can be solved, might be extremely burdensome.

Harmonizing national traffic liability rules and introducing risk based liability on possessors of AVs for the damages and injuries provoked by the use of their AVs may be challenging, especially in the case of the EU. Such intervention would require Member States to impose risk-based liability for all types of vehicles, including fully autonomous vehicles (level 4 and higher). However, many scholars have argued this option, that it would shift responsibility from the producer to the owner or keeper of the vehicle.

On the other hand, citizens from MS with rigorous traffic liability rules will be treated equally, if the MID is adjusted. In addition to this, victims from these countries would be prevented to claim compensation under the PLD, which is more difficult.

Thus, adjusting the MID would decrease consumers' confidence in autonomous vehicles, as they would bear more responsibility in case of traffic accidents, although due to the advanced technology, they are much less time or not at all in control of the AV, compared to conventional motor vehicles.

Nevertheless, in the UK and Malta there is a fault-based traffic liability system and therefore the personal conduct of the user (driver) will be out of the question for fully autonomous vehicles (de Bruin, 2017). Adjusting the MID would be very problematic for these Member States and may not be politically unattainable. Another reason why adjusting the MID may be politically unachievable is that the level of protection that traffic victims are entitled in particular Member

[48] European Parliament: A common EU approach to liability rules and insurance for connected and autonomous vehicles. http://www.europarl.europa.eu/RegData/etudes/STUD/2018/615635/EPRS_STU(2018)615635_EN.pdf

States such as the Netherlands, Sweden or Belgium is very high (Engelhard & de Bruin, 2018). Therefore, they will want to have the same level of protection, while the other Member States do not afford to guarantee or are not willing to offer the same conditions.

3. No-fault insurance

The third policy option could be a new EU instrument that would specifically address the risks resulting from the use of AVs. As the name already implies, this option presupposes new legislation and no-fault insurance, so that it can tailor the risks associated with AVs.

With this policy, the regulator would provide a clear framework so that it can cover all the risks and damages resulting from the use of AVs. The negative aspect is that it will be hard to implement and it could overlap with the existing PLD and MID.

According to Engelhard & de Bruin (2018), a no-fault insurance would be the most effective way of addressing risks about autonomous driving. The find this policy better than others because it can be developed so that it can cover all risks.

First, the owner, operator or vehicle/software producer of AVs could take out the no-fault insurance, so that none of them can be held liable in case of accidents, and damages to injured parties can be covered.

Second, the amount to be paid for such insurance can be based upon more factors such as annual mileage, country of residence, type of car and its age and another fixed amount to be paid by the car industry.

Third, Evas (2018) mentions that a no-fault insurance can be developed as compulsory private insurance that owners and operators of AVs can take out, so that entitlements to social security benefits of the damaged parties to be compensated. Although the owner, operator or producer of the autonomous vehicle can take out this type of insurance, none of them can be held liable in case of accidents, as a no-fault insurance does not rely on any culpability.

In addition, a no-fault insurance model will no longer require any decision from judicial courts, as there will not be conducted investigations of claims by the insurer. Of course, this would require a competitive insurance market for autonomous vehicles. In order to ensure that parties

are provided equal treatments regardless of the member state and avoid the fact that private markets may cause potential aberrations, public law regulation would be the most appropriate way of control in these situations. Nevertheless, litigation costs will decrease as there is no need for addressing before the court of law, but on the other side, the expenses for public regulation will rise.

As a final remark, given the fact that the industry of AVs is growing rapidly (Cappelli, 2015), additional no-fault insurance, apart from the entitlements to social security benefits of injured parties, would represent a flexible and tolerable solution. Thus, recognition and consent of the public and the car industry for these public regulations would need additional examination.

Comparative policy assessment

The following table summarizes the main criteria that need significant consideration concerning the proposed legislative policies for the enhancement of the introduction of fully autonomous vehicles in the European Union, based on a compilation of scientific articles and legal documents selected by the author. The second policy option (adjustment of EU Directives) has been split into two separate columns since the reform of the directives (PLD and MID) cannot be accorded the same values for each qualitative criterion. However, this should not be understood as two individual policy options.

Criteria	Policy Option 1 no intervention	Policy Option 2 PLD adjustment	Policy Option 2 MID adjustment	Policy Option 3 No-fault insurance
Legal certainty		+++	+++	++++
Consumer protection		++++	++++	++++
Lower litigation costs		+++	+++	++++
Enhancing innovation	+	+	++	+++
Political acceptance	+++	+		+

Ease of regulatory change	++++	+	++	+
	8	**13**	**14**	**17**

Legend: for each category will correspond a value, which ranges from 0 (zero) pluses to 4(four) pluses (++++).

The table summarizes the three policy options and uses six criteria for measuring the effectiveness, efficiency and political feasibility for future public policy interventions concerning fully AVs. For each criterion, there are given specific values in terms of pluses (+).

Policy option number 1 receives least of the points (8), although it scores best at two criteria (*political acceptance* AND *easy of regulatory change*). However, it receives least of the points because it cannot fill the gaps in current legislation concerning civil liability for fully autonomous vehicles. Nevertheless, a status-quo policy does not contribute to achieving EU objectives such as ensuring more mobility, decreasing car emissions or reducing the number of road traffic accidents.

Policy option number 2 receives many points (13 for the PLD, respectively 14 points for the MID), which suggests that current PLD and MID would need revision, since they can address many of the current gaps at the EU level. However, if the regulator decides to reform only the PLD and MID, not all the existing gaps related to the use of AVs identified in chapter three would be covered. Moreover, reforming only one of the two directives would result in consumers' dissatisfaction regarding the purchase of a fully automated vehicle. The reason behind this is that the consumer will pay for one risk twice, unless the risk is included in the purchasing price of the AV and at the same time in the motor insurance premium. To conclude, policy option 2 would increase *legal certainty* and *consumer protection*, but will not be able to solve all existing gaps, scoring therefore low for *political acceptance*.

As it can be seen, policy option number 3 (no-fault insurance) seems to receive more pluses (17) than the other two options, which means that no-fault insurance would be the best policy option for solving the risks related to fully AVs. Introducing no-fault insurance for fully automated vehicles means a new EU legislative framework that is able to cover all damages resulting from the use of AVs on EU public roads. New legislation at the EU level would be the most appropriate solution for addressing all existing risks. Based on the table from above, this policy

option scores best at three out of six criteria: *legal certainty*, *consumer protection* and *litigation costs*. However, this option requires a lot of *regulatory change* and *political acceptance*, as complete new EU legislation is desired.

As a conclusion, based on this comparative policy options, policy option number 3 (no-fault insurance) would resolve most of the risks resulting from the use of AVs. In addition to this, many scholars including Ilkova & Ilka (2017), Evas (2018) and Kiilunen (2018), but also European Institutions such as the Parliament or the Commission, suggest that a no-fault insurance would contribute more towards achieving EU objectives and ensuring legal certainty and consumer protection for users of AVs.

V. Conclusion

The present thesis focused on the introduction of fully autonomous vehicles in the EU and it analysed possible areas of concern. Fully AVs will change the way we perceive transportation today. Using, owning or selling AVs will generate new opportunities for business development and increase mobility. It is obvious that EU institutions, especially the European Commission, aim to seize the opportunities that fully autonomous vehicles create, while also considering new risks and challenges for our society.

Mitigating new risks concerning the use of motor vehicles including fully autonomous vehicles is presently regulated by two major EU Directives: the Product Liability Directive (85/374/EEC) and the Motor Insurance Directive (2009/103/EC). On the EU level, the risks posed by conventional motor vehicles are adequately regulated. The EU system could be able to deal with the mass rollout of driverless vehicles, at least in theory, although the analysis in chapter 3 suggested that there are some regulatory gaps and the same type of risk can be addressed differently across the EU. Besides, the analysis also outlines that if current rules were to be applied to AVs, it would result in a shift between consumers and producers of AVs concerning liability. The already existing gaps in legislation will not only remain unsolved, but they will generate even more risks while causing huge legal and administrative costs.

Based on the findings from the previous chapters, the existing EU legal framework for liability should be adjusted, so that the development of different risks and legal grey areas can be avoided. The author's intention is not to imply that the current EU legal system does not function well, but he emphasizes that it was never intended to cover liability issues that AVs raise, as these are technologically complex and clearly differentiate themselves from conventional motor vehicles that we see on public roads now.

The European Union has not amended its current legislative framework so that issues related to liability and insurance risks as a result of the use of fully autonomous vehicles can be regulated on the EU level. However, it is clear that the EU is continuously exploring solutions to these issues, especially for liability. Through the GEAR 2030 programme, which was launched in 2016 by the European Commission, the first attempts have been made by the EU in order to find solutions to AVs-related liability issues. In addition to this, the European Parliament suggested the Commission to develop a compulsory insurance scheme or to create a fund in order to reimburse victims of AV accidents.

Moreover, categories of risks have been identified, such as hacking & cybercrimes and failures related to the wireless network, sensors, software or programming choice of the AVs. Based on the reports of the Commission, expert groups including scholars and lawyers from the field of technology, but also on the opinions of the Parliament and Council, these categories of risks are only marginally protected by the existing Product Liability Directive (85/374/EEC) and Motor Insurance Directive (2009/103/EC).

Nevertheless, unless the existing PLD and MID are adjusted in order to overcome the risks enumerated above, the current regulatory framework for liability will generate even more uncertainties. The injured parties will support the costs of these scientifically unknown risks. Not to mention that for consumers it will be even harder to receive compensation for their damages, due to these unknown risks that AVs pose. This will result in low confidence in AVs on behalf of consumers and a delayed mass rollout of AVs, which is contrary to the EU position.

Intervention on the EU level is urgently desired as the development of AI is rapidly growing and it should ensure that three categories of issues are solved: first, the existing limitations and gaps in the liability framework should be resolved, especially the shift in liability between consumers

and producers of AVs; second, the necessity of adjusting the current PLD and MID, or introducing new regulations aimed to overcome new risks related to autonomous driving; and finally, the demand to develop new procedural rules in order to determine more easily who is liable for damages and injuries generated by AVs.

Based on current literature and available legislative documents, three main policy options are proposed: no intervention (policy option 1), adjusting the Product Liability Directive and Motor Insurance Directive (policy option 2) and the development of a no-fault insurance (policy option 3).

The last section of chapter four outlines a comparative policy assessment based on six qualitative criteria: legal certainty, consumer protection, litigation costs, enhancing innovation, political acceptance and ease of regulatory change. Based on this comparative policy assessment, policy option 3 (no-fault insurance) is desirable as it is the most likely policy option to cover all categories of current and new risks related to the use of fully autonomous vehicles.

Further research

Attributing legal personhood and liability: robots as electronic persons

This subject area seems to receive increasing attention from EU institutions as they have tremendous effects on road safety and driving experience. Based on the studies on artificial intelligence and the topics discussed by the members of the European Parliament, the author suggests another policy option: attributing legal personhood and liability to AVs. This idea has started based on the European Parliament's recommendation[49] from January 2017 for attributing a specific status for robots as "electronic persons" (Delvaux, 2017). These electronic persons would be granted specific rights and obligations, and even make decisions or interact with third parties, making them liable for their actions. Concerning the use of fully autonomous vehicles, there are some implications of this approach. Electronic personhood for AVs would imply rights

[49] See the Parliament's Report with recommendations to the Commission on Civil Law Rules on Robotics. Source: http://www.europarl.europa.eu/doceo/document/A-8-2017-0005_EN.pdf

and duties and be held accountable for their actions, including being sued and judged for criminal actions. Chopra & White (2011) highlight that legal persons are entitled to be politically active and once legal personality is granted to AVs, they will become subjects of law and will not be treated anymore as objects.

In addition, Cerka et al. (2017) mention that AI agents can be deemed subjects of law and could be legally liable for their actions, however, with limited considerations. However, Schlaepfer & Kruyne (2018) state that AI agents should not be granted legal personhood due to the inconsistency with the current purposes of the EU legal system. According to EURACTIV (2017), autonomous vehicles would require moral agents in order to be responsible for their actions.

As recently discussed by the European Parliament, AI should be granted more legal room for improvement (Delcker, 2018), as these kinds of vehicles can continuously develop themselves and exchange information in real time with other vehicles.

Therefore, the author considers that this option should be taken into consideration and researched further. As AVs are constantly equipped with new features that allow them to drive more safely and efficiently, allowing them legal personality can be considered a new option for solving the issue of liability. This would mean that vehicles would not require a moral person in the future.

To this end, the report 2015/2103(INL) of the European Parliament states that the Commission should consider all possible legal solutions, including legal status for robots with AI, granting them therefore the rank of electronic persons, having certain rights and duties including civil liability for damages to third parties. The idea behind this recommendation of the European Parliament is that entities with AI such as fully autonomous vehicles with level 5 of automation, have the capability of taking autonomous decisions and could be held responsible in the future for damages and injuries to third parties resulting from road traffic accidents. Although this recommendation seems science fiction at first glance, the reasons behind this thinking should be taken into consideration more closely, as these types of vehicles are now more technologically advanced than ever and therefore a future replacement of a human driver with software is no

longer a fantasy. As an example, the self-driving Waymo car[50], also known as the Google car is a fully autonomous vehicle that does not need a human driver behind the wheel and can perform each driving task that conventional cars do.

The option of attributing legal personhood to fully autonomous vehicles is very complex and difficult, as these agents with AI would require ‘‘a fundamental shift in legal thinking’’ (Chopra & White, 2011). If this point is ever reached in the future, humans and robots will share the same legal framework.

[50] The Waymo car started as a self-driving car project and was first produced by Google in 2009. After 9 years of testing this technology and more than 300 000 miles of driving on public streets, the Waymo company announced in early 2018 that together with Jaguar, they will build over 20 000 electric self-driving Jaguar I-PACEs.
Source: https://waymo.com/

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