
**Budapest University of Technology and Economics**
Faculty of Transportation Engineering and Vehicle Engineering

# Study about the Contradictions Between Self-Driving Autonomous Cars and Nowadays Legal Background

MSc Thesis

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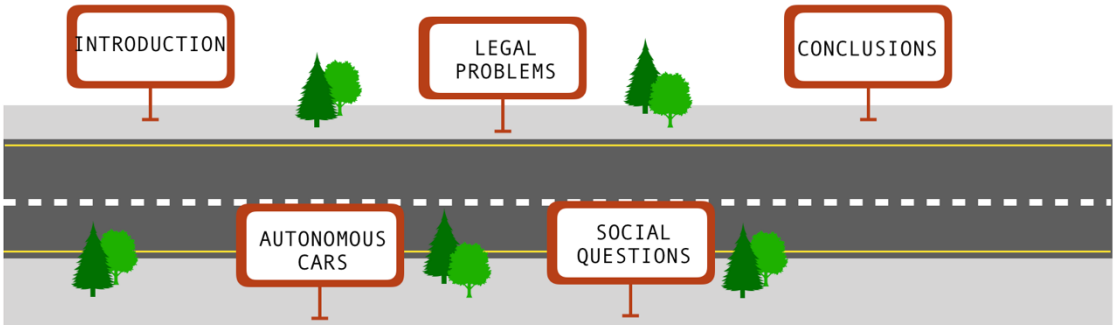


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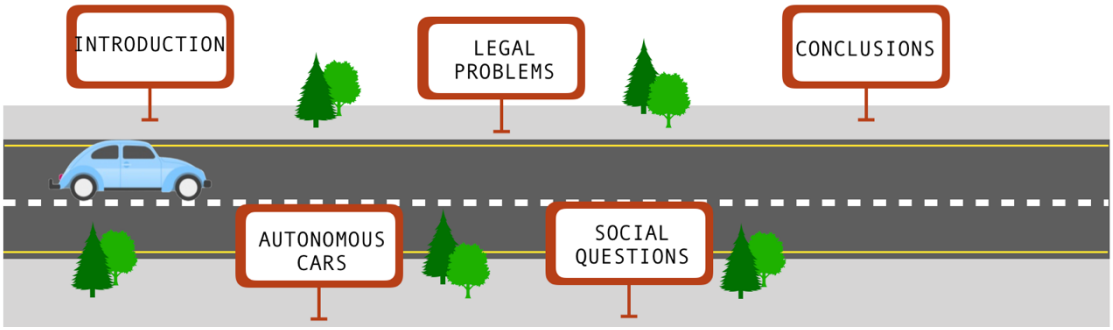



## Abstract

The autonomous or self-driving car is no longer a futurist idea. It exists and can perform in different scenarios successfully. That leads us to the following question: Is the world prepared? Along with this Thesis, technological challenges are going to be described, proving the existence of technologies that can bring the autonomous car to the market and the changes that will come with them. Moreover, the legal framework is considered as the key that can open the door to self-driving cars. Governments solutions about autonomous cars and the description of the reality performed by different countries show how this technology is on nowadays agenda. However, all this cannot be possible without the presence of the main part of industry and markets, clients. Their opinion is basic in order to understand what society thinks about this technology and how are they pushing institutions to take part in this automotive revolution.

# Introduction

Autonomous cars have existed since a long time ago. In 1925, the first car drove with no one controlling the steering wheel through a road in Manhattan, was a radio control system. Different approaches took place in 1969 through an essay written by John McCarthy were an 'autonomous chauffeur' was considered, starting to set the road for the next autonomous cars stakeholders.

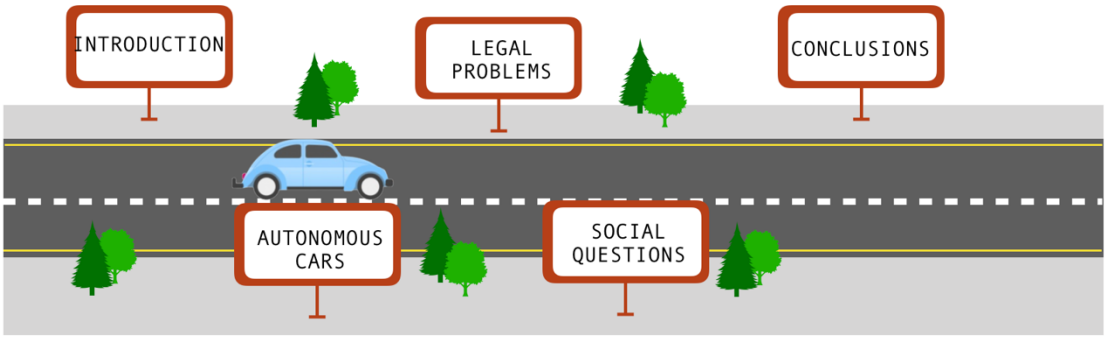
Since the moment of the appearance of autonomous cars in the modern times, lots of investigations have been done in order to study the possible changes they can bring to life, legal framework and technologic development. Documents about technology, economics or society that gave stakeholders information about how the whole industry was behaving.

Over time, technologic development has made possible the approach to the autonomous car on the road. Progress in electronics improved sensors and data transmission as well as cameras and computer communications. However, is not technology all that matters, companies founded and continue finding legal barriers that blocks and makes slow technological progress. The fact is the field this progress is taking place because transportation is a dangerous activity and is strictly regulated. Since the first automobiles where invented the governments have developed legal networks to regulate this important sector. In the 20th Century, international cooperation settled communal standards about transportation making regulations strong and solid. That is why when autonomous cars started to be able to be deployed on the road, they had to face with an established legal framework that made difficult autonomous cars to progress.

Seems like finally countries are starting to wake up and some of them are transforming old regulations to able autonomous cars to be tested on the road. Lots of investigation programs have been launched in different countries, an aspect that helps technical development go faster and attracts investment to the field. In Europe, North America and Asia different companies are investing lots of money in the autonomous car technology to make it possible and prove that the changes it might bring to the society are worth it.

Along the story, technological progress came before social awareness and is what is happening about autonomous vehicles right now. While the technology has been developed for around 15 years, people still not know much about it. Despite this, social acceptance is vital to accomplish the final objective of any technology, reach the market. The way transportation is seen, may bring problems when changing the mind about it. Also, the main problem is the confidence people have on technology and the hazards it may bring a difficult.

The research presented in this Thesis deals with the three main characters of autonomous cars technology story: technology, legal framework, and society. Answers questions about nowadays situations and makes more about the future development.




# 1 - About Autonomous Cars

The Autonomous cars era is about to come into the market. Are we aware of what are these vehicles about? Over the past years, several autonomous features have been implemented and the car may activate them itself, as an automatic transmission or door opening, although, the driving task is a bigger word. It can be a feature that improves safety and driving experience but there are many challenges to overcome.

Many driving tasks are a mechanic movement as activating the break or throttle pedals, even turn the steering wheel. However, driving includes paying attention to the surroundings. All the sings, pedestrians, other cars, any object on the road requires a short time reaction and a rational thinking. It is very important that the driver also make predictions about what can happen. When a pedestrian is about to cross a road, or a ball comes into the lane and you suppose that a child will follow it. All these tasks and many more, are easy to develop by a human brain, even though, a very sophisticated code has to be invented in order to lend the decision-making to the machine.

## 1.1 Self-Driving Cars Background

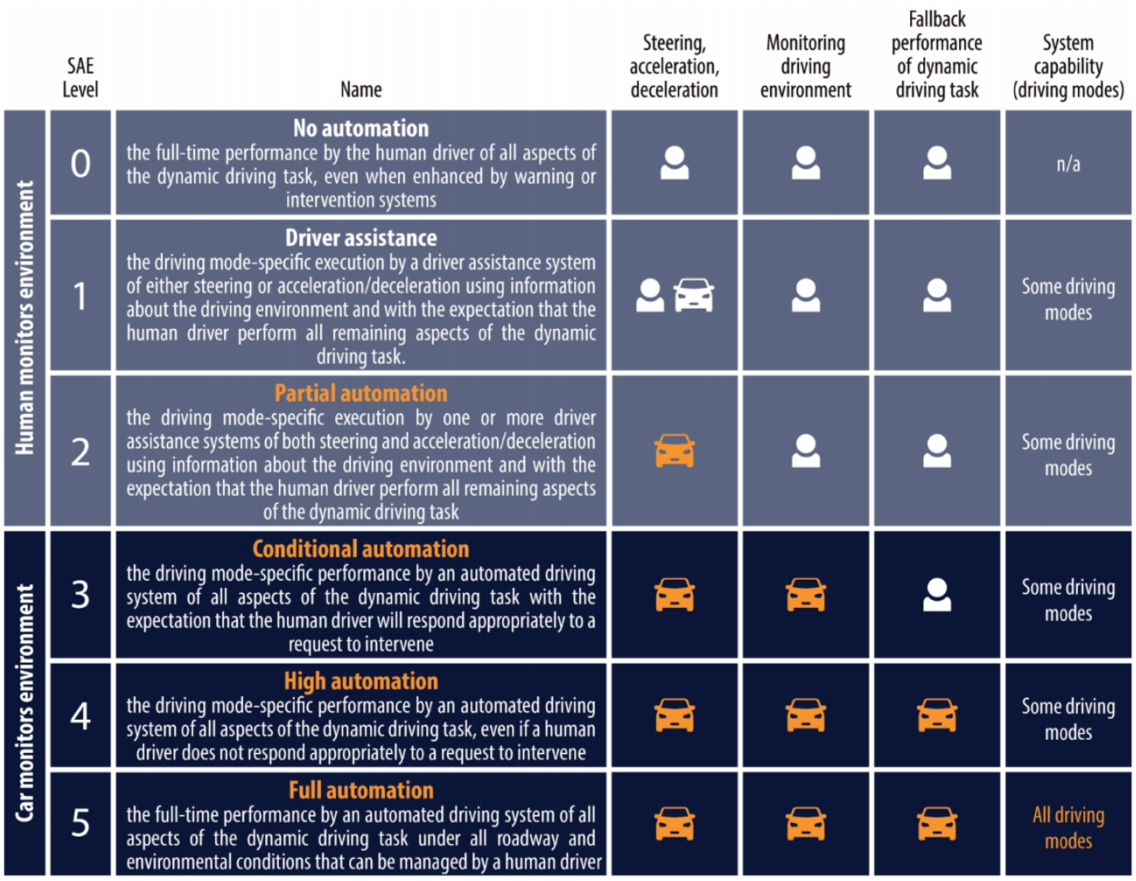
### 1.1.1 Automation Levels

It is important for the regulations and politic decisions for automated cars to create a standard about the levels of automation. Nowadays, there are several ways to classify them, but many companies and organizations agree with the International Society of Automotive Engineers (SAE) one. Was in 2014 when a report SAE made (SAE standard J3016), showed up six different levels of driving automation in order to ‘simplify communication and facilitate collaboration within technical and political domains’.

The six levels of automation determine the tasks developed by the human driver and the car itself (Figure 1). Each of them regards to a different behavior of the car and driver and have different characteristics. Functions like steering,

acceleration or deceleration are presented as classification and also some aspects of monitoring the surroundings or different driving modes.

*Figure 1: Levels of Automation*




Source: Susanne Pillath "Automated vehicles in the EU" EPRS 2016

**Classification of the six levels of automation[1]:**

Level 0: Automated system has no vehicle control but may issue warnings.

Level 1: Driver must be ready to take control at anytime. Automated system may include features such as ACC, parking assistance with automated steering, and lane keeping assistance (LKA) type II in any combination.

Level 2: The driver is obliged to detect objects and events and respond if the automated system fails to respond properly. The automated system executes accelerating, braking, and steering. The automated system can deactivate immediately on takeover by the driver.

Lever 3: Within known, limited environments (such as freeways), the driver can safely turn their attention away from driving tasks.

Level 4: The automated system can control the vehicle in all but a few environments such as severe weather. The driver must enable the automated system only when it is safe to do so. When enabled, driver attention is not required.

Level 5: Other than setting the destination and starting the system, no human intervention is required. The automatic system can drive to any location where it is legal to drive.

### 1.1.2 Change Potential

Self-driving cars or autonomous vehicles (AVs) will make passenger's time in a vehicle more productive; will reduce crashes, traffic congestion, energy usage and pollution. This new technology may also change the usage of land and even the ways to own a vehicle. Furthermore, sooner rather than later new markets will show up as well as financial openings.

Worldwide, according to the World Health Organization, 1.24 million people die annually due to highway accidents. It is estimated that traffic fatalities cost €212 billion each year and those accident injuries account for another €300 billion. This represents a total of €500 billion annually from highway fatalities and injuries[2].

According to a RAND study, "39 percent of the crash fatalities in 2011 involved alcohol use by one of the drivers." This is an area where autonomous vehicles almost certainly will produce major gains in terms of lives saved and injuries avoided[2].

The statics says that 90% of the accidents are caused by a human error. It is supposed that self-driving cars will not have the need of a human driver, that derivates in no human error, so road safety is expected to strongly improve road safety. An inform in 2015 written by GeekWire says that "the self-driving revolution is expected to be the greatest thing to happen to public health in the 21st century".

Self-driving technology will also reduce the cost of travel for the disabled population. They will be able to be used by people without driving license as minors without any other supervision. They will set more optimal routes based on the information they get from congestion roads and also will improve the highway experience setting speeds that remove traffic jams.

Another feature they can bring is the fact of parking on their own. There is a lot of space required for parking in the cities and the drivers like to park close to their destination point. When the city jobs come to the scene, there is a lot of land for the accommodate large number of cars. All the people that drive to their works need a place to park and this derivate in really crowded city centers. As a lot of lands has to be used for parking, economic activity decreases. There is an

example of Downtown Buffalo in New York, according to Shoup (2005), where says that half of its land is for parking areas.

At the point when AVs become a reality, they will bring huge changes to cities. Cars will be able to drive a worker to its place and then go too far away to the peripheral area of the city to park. With more space to build, downtowns will see its economic density increased. This also will bring a better life quality based on less noise, pollution and accidents.

When AVs appear on stage, cities will change dramatically. Downtowns, with parking space removed, will see an increase in the density of economic activity, causing productivity increase. Daytime parking will become more peripheral; it is possible that some locations of daytime and nighttime parking will coincide, allowing to take advantage of natural complementarity of the two types of parking and to reduce the total amount of urban land dedicated to parking. A research from Organization for Economic Cooperation and Development (OECD)found that 80% of current parking spaces will be unnecessary in the future, implying that this land can have different use[3].

It is said that as travel costs will be reduced (more efficient use of fuel or electricity) commuters may accept to live in further places to stay in better residences. The residential land may increase meanwhile the downtowns became less crowded.

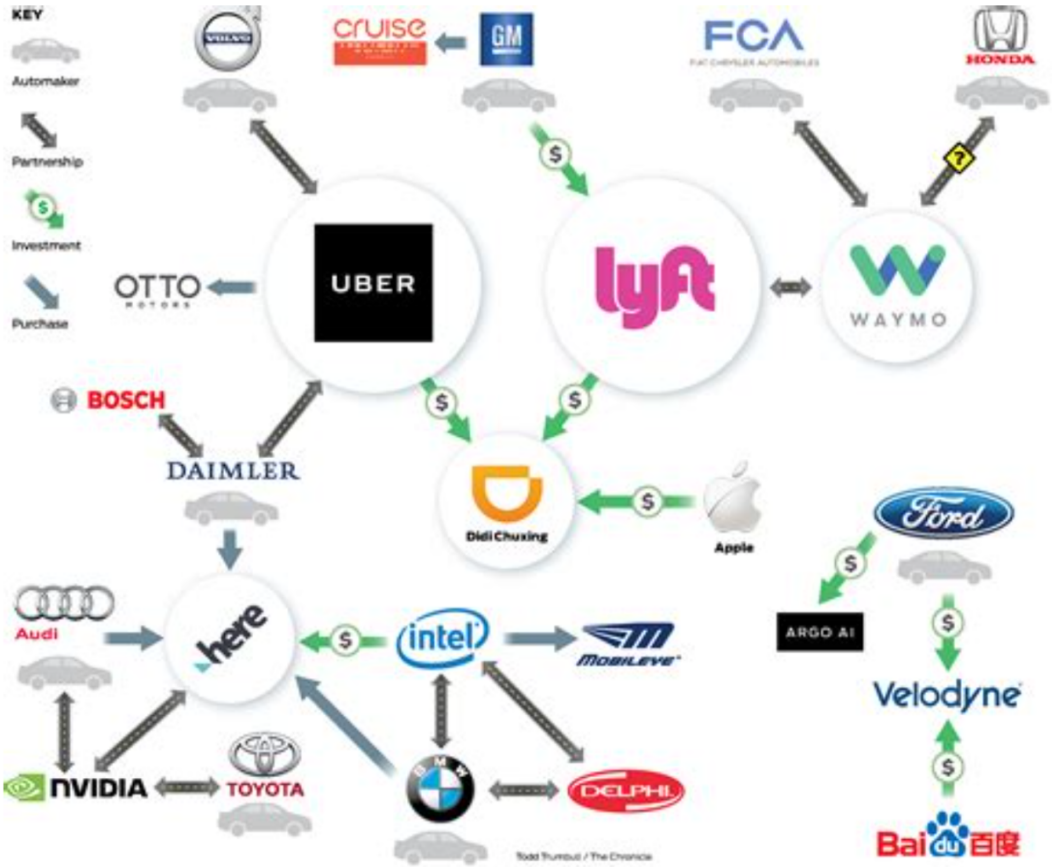
According to the more efficient usage of propulsion systems, the air quality will improve. It is known that the smog is also produced by cars so less pollution means less smog, so the diseases provoked by this issue, may decrease as well. It also will happen in traffic jams where the no efficient situation of accelerating and decelerate often, produces a lot of pollution. As AVs will adapt its speed in order to avoid them, the contamination levels will also go down in these areas.

Something linked to AVs is the usage of a Shared System of vehicles. It will be explained later although it means fewer vehicles on the roads avoiding a lot of emissions that come from the cars as carbon dioxide, sulfur dioxide, some volatile particles… and if the AVs revolution comes along with definitely established electrical vehicles, no need to worry about these emissions at all.

### 1.1.3 Companies Involved

The technology has progressed rapidly and is balanced for the business organization. A lot of companies worldwide are in the AV's race trying to be in the lead, with the aim to get better and sooner than the others.

*Figure 2: Companies Involved*




Source: Partner up! Self-driving car firms form tangled web of alliances. SFChronicle 2017

Google's AVs had driven more than 200,000 miles on public roads by October 2016 in USA (Google Self-Driving Car Project, 2016). More recently, nuTonomy, a software company, has launched the world's first self-driving taxi in Singapore (nuTonomy, 2016). Many car manufacturers, such as Volvo and Audi, are currently designing and testing their prototype AVs.

European auto companies ahead are Audi, BMW (in collaboration with Intel), Volkswagen, Daimler, Mercedes-Benz, and Volvo. The field these companies were good in its always been physical design. Even though, autonomous cars technology comes along a need of a good software and employees with skills in artificial intelligence and short-time data analytics.

Whereas, Japan and Korea governments and car manufacturers have not bet that hard on autonomous vehicles. Car manufacturers such as Honda, Hyundai, Kia, Nissan, and Toyota are the ones contributing the most. While in China,

Baidu has set a goal into transportation because of the chance to apply the handling experiences and fast learning capacity that the engine sector brought them, to another area.

### 1.1.4 Nowadays Situation

A lot of tests have been taken place around the world. Most of them in private areas where is easier to get permits. Programs like CATS, CityMobil/2 or SARTRE are a real possibility. The two first ones, called Cybercars, are vehicles with the obstacle-avoidance technology made for share environment with pedestrians, city vehicles and bicycles in areas with low affluence. The idea of this kind of vehicles has been currently implemented in different places as the transport of travelers in Heathrow airport (UK). These self-driving vehicles are completely driven by themselves even though at a low speed. Furthermore, there are pure Level 3 AV's testing in USA public roads in different states where the law has changed to allow this kind of tests.

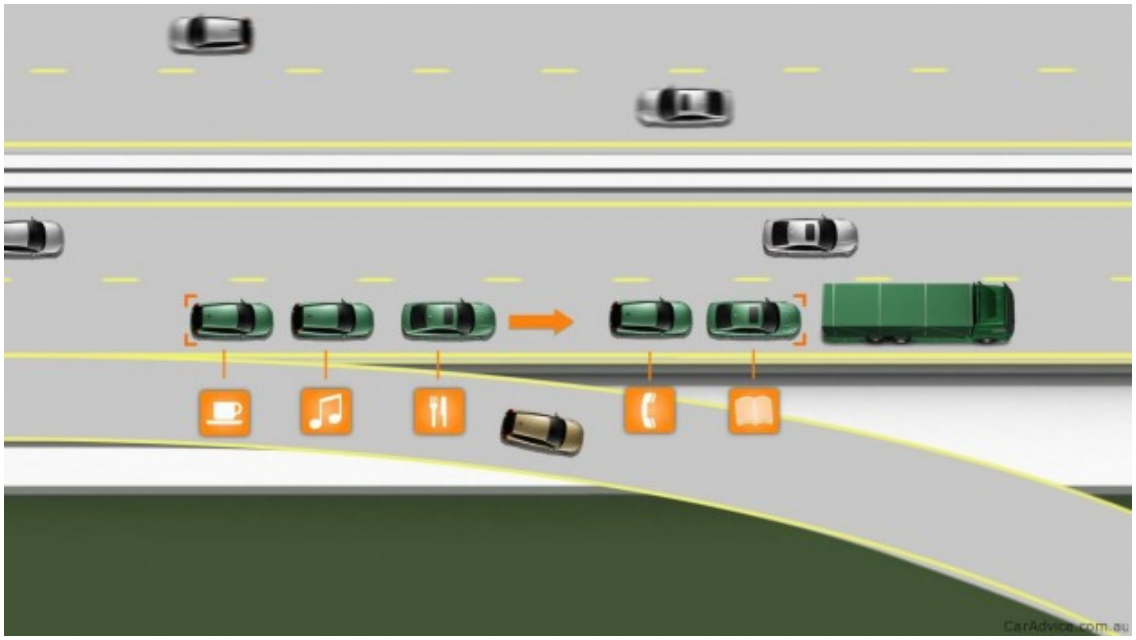
In order to explain the projects considered above, CATS (The City Automated Transport System) lasted from 2010 to 2014 involving the FP7 (a cooperation programme in transports founded by UE). The final goal was to consider how can driverless electric vehicles fit in some European cities, based on their currents activities. 11 teams in 5 countries took part in the project, involving Strasbourg, Romania, France, Ploiesti, and Laussane for their trials. The vehicles used were Navya ones, with a capacity of 8 passengers standing up. The two most extended trials took place in Strasbourg first and in Lausanne, Switzerland finally. In the second city, more precisely in EPFL campus, up to 1600 people used the transport in 16 days of vehicle task. Along the whole demonstration, there were 3 vehicles in action. Despite there was no driver, a person aware of the project was answering every question passengers made and also there was information collection from them, with a survey. The data obtained was really positive and showed up a great passenger's experience. There are also some negative aspects of this kind of driverless transport as the limited access for individuals with disabilities and the fact that is a similar transport as walking and cycling[4].

CityMobil2 was the follow-up of the CityMobil project (2006-2011). CityMobil had exhibited how self-driving vehicles could lead to distinctive transport ideas (almost automated car-share plans, CyberCars, BRT, and PRT), which can improve the sustainable aspect of urban mobility. Despite this, CityMobil had also featured several boundaries to the deployment of automated road vehicles: the implements on the legal framework. The main purpose of CityMobil2 was to remove the barriers identified by the CityMobil project. In CityMobil2 can be read "Concerning implementation, CityMobil2 aimed at removing the uncertainties hampering the procurement and implementation of automated road transport systems (ARTS)". The project brought together 12 cities (or city-type environments), each of which investigated where ARTS could deliver a beneficial transport service. The seven best cases were selected. In parallel, the project

procured two sets of automated road vehicle systems and put them to the cities for the 3 to 6-month demonstrators in the selected cities. Some of these plans have been working for a longer time and have demonstrated themselves to be work-efficient and safe. Although, it is hard to integrate them in urban zones since they require a totally dedicated and segregated infrastructure. Another good point comes at the point when the request is low or pick-up points are far apart because they are significantly more powerful than usual public transport systems[5].

Finally, SARTRE (Safe Road Trains for the Environment) is about a line of autonomous cars with a professional driver on the lead, guiding them. They communicate with the others via the wireless system and they incorporate radar sensors, cameras and laser guidance to keep a safe distance with each other and in the lane. They can pass each other the information about acceleration, deceleration even the steering systems. The interesting thing is that the systems SARTRE automated vehicles use are already in many cars so there is no need to develop a new technology. Furthermore, the existing roads will be able to be used by this kind of transport, so a complete modification of the highways system is not required. Some test took place in Spain several years ago completing a few kilometers. At the beginning, the project was founded by the European Commission but now a private company is following the research in order to move the project to the market. Considering all the advantages, just longer test to optimize the software and the protocols is needed. However, there is still so much legal work to do so this project is not on the roads yet.

*Figure 3: SARTRE*



Source: 'Successful vehicle platooning test by Volvo and SARTRE' CarAdvice 2011

## 1.2 Nowadays Technology

In the wide spectrum of proved automatic technologies in cars, there are two main types. The ones that are already implemented in common cars and the ones which are tested and will help to build the future autonomous car.

### 1.2.1 Implemented Technologies

Anybody who goes to buy a car nowadays is going to find several automated features in his brand-new vehicle. They have been implemented in order to help in driving assistance making driving easier, more comfortable and safer.

For example, ABS is one of the features that almost every car form the past 5 years have. Consist of regulating the brake force at the wheels when they are close to blocking. In trucks AEBS, the vehicle even initiates by itself, an emergency braking if an obstacle is recognized. Another feature is Adaptive Cruise Control (ACC). Just set a speed, and you will be able to move away your foot from the throttle. One smooth touch in the brake and will be disabled 6. Also, a good example is the parking assistance that works with an automated use of the steering wheel and the Lane keep assistance (LKA) which displays a warning if the car detects that you are out of the lane.

### 1.2.2 Vehicle sensing and vision technologies

According to an article by G. De La Torre (Driverless vehicle security, 2018), Light Detection and Ranging (LiDAR) is made out of a scanner, a specialized GPS, and a laser to give remote sensing using beats of light. These pulses are used to measure distances to generate 3D information of a particular landscape, which can become extremely precise when combined with airborne system information. Two types of LiDAR technologies have been developed, topographic LiDAR used to map land using infrared (IR) lasers and bathymetric LiDAR for underwater measurements using green light.

*Figure 4: LiDAR Sensor*

Source: 'Cómo funciona un coche autónomo' Autocasión 2016

*Figure 5: LiDAR 3D Map*

Source: 'How autonomous cars map London' Autocar 2016

The same article points out that stereo vision systems apply the principle of observing a scene from two (or more) viewpoints in order to rebuild a 3D scene using a complementary structured light source. CCD cameras are preferably used due to their low power consumption, low weight, small size, noise resiliency, accurate light measurement, and dynamic range. Stereo vision methods are classified into two different ones, active and passive, depending on the resources they use to reconstruct a 3D scenario. On one hand, active stereo methods utilize a complementary structured light source to re-construct 3D scenes while passive stereo vision methods use the unstructured light sources captured by the camera to reconstruct a 3D scene.

### 1.2.3 Vehicle location technologies

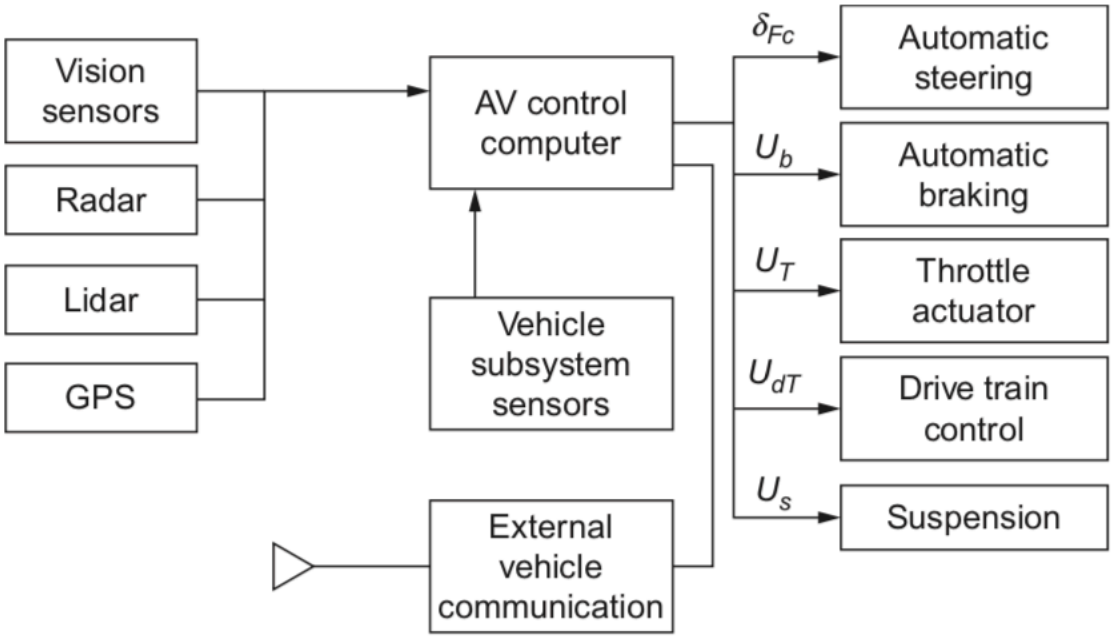
The main technology used in autonomous vehicles in order to determinate the position at any time is the Global Positioning System technology, GPS. It was invented during the war and is possibly one of the most used technologies nowadays. They are implemented in everyday devices as smartphones, transportation, trackers, watches. Working along 3D road maps, GPS will guide the self-driving cars.

### 1.2.4 Block Diagram

All the technology described above come to a unique system through the vehicle block diagram (Figure 6). This diagram shows up how the information is received by the sensors, radars, LiDAR and GPS and is transmitted through electronics to the mechanical outputs of a car. There is a computer who manages the incoming information and transform it into a message for the active systems which drive the car. Systems as the steering, pedals, suspension, transmission…

Every input has a different purpose. While the radar working along the vision sensors and the LiDAR monitoring the environment warns about any obstacle on the road, the GPS controls the situation and the planned route of the vehicle. This communication between both sides of the block diagram occurs at such speed that is capable the car to react to any situation in a ridiculous period of time.

*Figure 6: Representative autonomous vehicle block diagram*




Source: William B. Ribbens. "Autonomous Vehicles" 2017

## 1.3 Coming Technology

As technology is in constant development, in the world of AV's is happening too. There are several types of research documents which will help to bring levels 4 and 5 of automation to reality.

### 1.3.1 Communication Technologies

Self-driving and connected vehicles, communicating with one another (V2V technology) and with the road infrastructure (V2I technology), are a subject of extensive research nowadays and are expected to revolutionize the automotive industry in the near future. The major goal is to design a microscopic traffic simulation model for such vehicles, including a robust protocol for exchanging information. The question arises as to whether such communication system may efficiently improve travel quality while reducing the risk of collisions.

Autonomous cars scan the surrounding area to detect other vehicles and obstacles, but the range of such detection is relatively low and on-board computers have to interpret perceived data fast and correctly. With communication cars obtain detailed information about other vehicles' plans, routes and goals (however, sophisticated algorithm could make some suppositions) and can synchronize their drive, so communication between driverless cars might be an important improvement. The literature distinguishes a few types of vehicles' communication:

V2V (vehicle-to-vehicle) – vehicles can “talk” to each other.

V2I (vehicle-to-infrastructure) – vehicles can send information to the infrastructure

I2V (infrastructure-to-vehicle) – vehicles can receive information from the infrastructure

Cars equipped with devices enabling communication with other cars and with the infrastructure are named, in short, connected cars. V2V and V2I are jointly named V2X (vehicle-to-everything). V2X communication could be realized, for example, with a short-range communication system device (DSRC) or WiFi.

As G. De La Torre (Driverless vehicle security, 2018) writes in his article there are alternatives to DSRC as Visible Light Communication (VLC). This technology consists of using a visible spectrum of light to transmit information from an emissary to a receiver, both based on different points. This technology has been tested in case studies involving traffic lights and vehicles, furthermore, the technology has proved that is possible to stable communication at a range of up to 50 m. This system can be implemented in vehicles with front and back LED’s lights, changing the amplitude of the lights at a high frequency in order to modulate the data transmission holding its primary usage. Some tests have successfully accomplished the communication between vehicles in short distances, cause the main problem is to achieve a direct line of sight (LOS) in order to transmit the data.

An emerging technology for transmitting information between vehicles and the infrastructure (V2I) is VANET (Vehicular Ad Hoc Network). It combines different kinds of communication described before to make the flowing information possible.

Vehicular Ad Hoc Network (VANET) is an emergent technology capable of transmitting information between vehicles and the surrounding infrastructure through different communication types such as the ones described above. While different aspects of VANETs are being researched, there is a wide interest to start the deployment of this technology in the nearby future. There is a research with a VANET protocol strategy divided into 4 main stages that will progressively improve the vehicles communication 7. Stage 1: Mindfulness driving; empowers vehicles to become aware of each other and inform about road hazards. Stage 2: sensing driving; empowers vehicles to provide information captured by sensors equipped in the vehicle and utilize this data to have precise learning of their environment. Stage 3: called cooperative driving; permits vehicles to share expected future actions with other vehicles such as destinations and maneuvers. Stage 4: synchronized cooperative driving; refers to vehicles capable of driving autonomously under any situation, synchronizing trajectories and achieving optimal driving patterns.

### 1.3.2 3D Road Maps

In this section, it is pretended to explain how the data related to maps is going to be detected, distributed and improved. It is important to differentiate between the constant map of the surroundings that any AV with the help of the sensors and radars obtains and the road map that can be implemented in the vehicle system before starting to drive. The focus is going to be on the second aspect.

The 3D high definition maps are precise and can hold information about the lanes, different types of lines, barriers, signals, tunnels, and bridges… any road feature that influences the driving experience. This maps are more precise than GPS coordinates and can be updated at every moment. There are data memories that are placed in some surveying cars allowing to create 3D HD maps of any road the vehicles go on. The principal advantage of this feature complements the instant data collection from radars and sensors in order to differentiate sooner a hazard on the road. Any object on the road will be rapidly recognized and the named sensors would have to focus just on the other vehicles on the road.

Baidu, a company from China, has already implemented this kind of system in 150 surveying cars obtaining maps with 5 to 20 centimeters of accuracy along 6.7 million kilometers of highways and roads. Driverless cars will be able to improve their car guidance aspect[8].

## 1.4 Challenges and Future Research

### 1.4.1 Cybersecurity

Cybersecurity in autonomous cars is one of the main challenges to overcome. People needs to feel safe inside an autonomous car in order to start using it. It has to be a 100% of confidence about nothing can happen. However, nowadays there is a lot of work to do in order to test the electronic devices that provides information and its immunity in front of possible hazards.

The communication between vehicles (V2X) is the basis of a autonomous vehicle future, this kind of vehicles depend on it so the security in each environment they take part in, should be safe.

There are several security threats to cars connected between themselves as Petit and Shladover name in their study[9]. For example: jamming, hacking, data theft, blind cameras with potent lights or even manipulation of radars and sensors. In their research, they consider sending fake data as one of the main risks to have an accident.

In an Andy Greenberg article it is showed up that it is currently possible to remotely hack a vehicle. In his study a Jeep Cherokee was intervened taking control of the steering, radio, brakes and even the climate controls[10]. This case

demonstrates that experts need to consider vehicle security as an important fact when developing autonomous vehicle technology.

### 1.4.2 Future Systems

The future about to come, is full of opportunities. When the Level 4 and 5 of automation comes to life, highways and cities will have to evolve. Some investigations and simulations have been made. While platooning and full automated vehicles seems to occupy the major ways for transportation, shared autonomous vehicles (SA Vs) seem to be a reality in the cities.

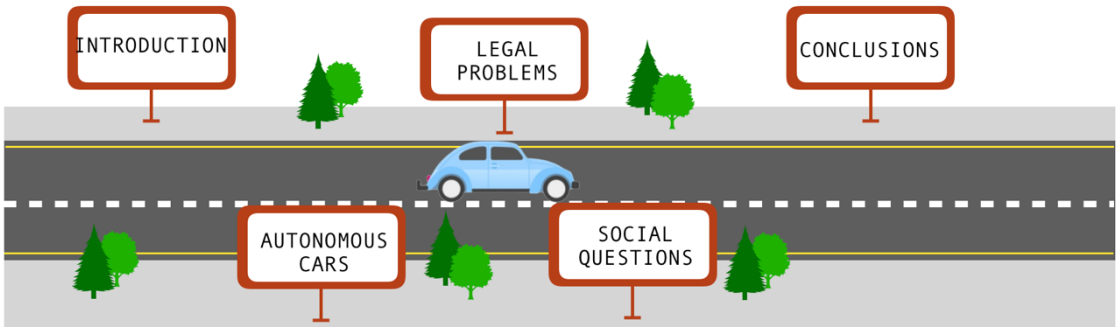
The platooning system (explained when SARTRE program), can open a wide future for highway transportation of trucks and personal cars. As the technology is almost in nowadays cars, the policy is the new barrier for this project. There are some researches about SA Vs that can show how this technology can be possible one day.

One of the most relevant studies is that developed by Fagnant and Kockelman (2014). They simulate SA Vs in Austin (Texas) using an agent-based model (MATSim). SA Vs are used by 2% of the total demand. The city is composed into traffic zones. Each traffic zone is characterized by a factor of attractiveness. All the trips are generated every 5 minutes a day using Poisson distributions. The model is then structured by following four major steps: (1) *SAV location and trip assignment*, which determines which available SA Vs are closest to the travelers in a waiting status (being more important the pople who have spent more time waiting), and then doling out an accesible SA Vs to those outings. The assignment is done according to a First-Come First Served (FCFS) order. A vehicle shall be assigned to a customer in an interval of 5min; otherwise the user is put in the waiting list and is considered as a priority in the next simulation. (2) *SAV fleet generation*, which defines the fleet size. In particular, the amount of SAV deployed depends on the next statement: when a user has been waiting more than 10 minutes and there is not any SAV available. (3) *SAV Movement* is characterized by a vehicle speed equal in a normal hour to 3 times the number of areas. Passengers boarding and alighting last 1min. The calculation of the vehicle position is registered every 5 minutes. (4) *SAV relocation*, aims to balance the vehicles distribution ahead of the demand[11].

Another interesting shared mobility alternative that can be on the market was made by L.M. Martinez and J.M. Viegas (2017). The idea consists of two different shared vehicles system (based on Lisbon characteristics). On the one hand, a self-driving shared taxi where several users can be on the same vehicle if the system accepts everyone's route as optimal. Some detours may be taken in order to make the trip effective. On the other hand, a shared self-driving bus where a route is booked and planned in advance. With this second system, the pickup place and the final destination one can be reached by short walks.

The model was launched with the idea to replace every vehicle on roadways, being this system the only one to be working on them. Other ways of mobility as walking, cycling or using tram and metro complete the transports system.

All this ideas and models for future transportation have a clear barrier, law. Policymakers should decide and analyze every proposal in order to change the transportation law and allow this system to be a reality. Decide if they are positive to economic and social progress as well as support the ones that can make the difference.




# 2 - Legal Problems of Autonomous Cars

As every new technology, there is a problem between the rules needed and technologies in constant development. Also, establish a legal framework without even have been displayed on the market not tested. Specifically, with autonomous cars, it is even more difficult as the legal framework is strong in the transportation field. Several challenges, as change the driving education and testing or decide how this technology is going to be tested, are ahead.

The regulation of road traffic is well determinate as a lot of users are exposed to risky situations when traveling. Automated cars should change the road security, even though, a deep change has to be made in the nowadays regulation. It is very important to create a standard and a common decision among the interested countries to standardize the technology and legal framework.

There are also some important aspects to overcome as the present statement present in the Vienna Convention on Road Traffic (1968) where it is said that a vehicle has to be driven always by a driver. Some theories about the driver definition are also on the run. Problems as the liability and the insurance can also decelerate the progress of the technology because if a self-driving car participates in an accident, the liability from the user can go to the manufacturer company.

These concepts and many more will be discussed below.

## 2.1 Viena and Geneva Convention

As is explained in the Susanne Pillath article made for EPRS (2016), the Vienna Convention on Road Traffic of 1968 is an “international treaty designed to facilitate international road traffic and to increase road safety by establishing standard traffic rules among the contracting parties”. After the signature, 73 countries ratified it at the moment. Even though all the EU members are signatories of the convention, UK and Spain have not ratified it. It is important to clarify that the USA is not a Vienna Convention signatory. They have just signed

the Geneva Convention on Road Traffic (1949). As this convention is less extensive about traffic regulation, it is easier for them to allow autonomous vehicles on the road. That is the main reason why the legal framework analysis is going to be focused in Europe and Asia.

Coming back with the Vienna Convention, the main concept described that can fight against the autonomous car technology is written down in the Article 8. Briefly says that a driver has to be always in total control of the car and being responsible for the way the vehicle participates in traffic.

**Article 8**

1. Every moving vehicle or combination of vehicles shall have a driver.
5. Every driver shall at all times be able to control his vehicle or to guide his animals.
6. A driver of a vehicle shall at all times minimize any activity other than driving.(…)

Some progress it is being done, in order to adapt the Vienna Convention to the nowadays situation. The WP.1, an organism responsible for the supervision of road-traffic conventions, approved an amendment in 2014 about the Article 8. It said '5bis. Vehicle systems which influence the way vehicles are driven shall be deemed to be in conformity with paragraph 5 of this Article and with paragraph 1 of Article 13, when they are in conformity with the conditions of construction, fitting and utilization according to international legal instruments concerning wheeled vehicles, equipment, and parts which can be fitted and/or be used on wheeled vehicles'. It also mentions '(…) when such systems can be overridden or switched off by the driver.' [12]. The mentioned amendment sets the possibility of having partially automated systems that can be activated or turned off by the driver, depending on the situation.

The amendment described above deals with the fact that the driver is always in control of the vehicle because is able to override the driver assistance systems. For example, not only the cruise control but the 'Autopilot' system is also a vehicle system that can be switched off. Even though, there are other systems like the automatic brake system that is not under the control of the driver. This kind of systems fits with Vienna Convention because helps the driver to keep control of the vehicle.

However, the amendment, as well as the Vienna Convention itself, may still incompatible with high levels of automation where no human interaction is required. It stills demanding a driver taking control of the car in any given situation.

According to the Nynke E. Vellinga article (2017), some countries have proposed the WP.1 to be more active in terms of autonomous vehicles regulation. Sweden and Belgium governments have proposed some amendments to articles of the Vienna Convention. This proposal started a discussion about how both conventions about traffic (Vienna and Geneva) ought to advance because of the progress of autonomous vehicles' technologies. It is

also mentioned that testing self-driving vehicles are allowed to be on the road with a human driver, according to the exemptions on Annex 5 where test cars can be deployed on the road in order to improve the existing technology and road safety.

As there is still a requirement of a driver taking control of any vehicle, some solutions have been suggested. They all try to modify or take advantage of the definition of 'driver' itself. There is no special mention of a 'human' driver so Bradshaw-Martin and Easton (2014) came up with the idea of a 'robo-pilot' of an autonomous car. It stands on the possibility of calling the software in charge of the vehicle, a driver. This affirmation contrasts with ethical and moral behaviors of the 'robo-pilot' as well as the liability of that 'driver' if it is involved in an accident. If there is included in the Article 8, that the driver can be or human or non-human, some other challenges would have to be faced. It is also said that a 'non-human' pilot can be similar to a human one if it is programmed to behave in the same ethical way as a standard vehicle user.

## 2.2 Self-driving Law

Self-driving cars are expected to be a safe transport, with a low number of accidents. Despite this, the problem is that they will not be perfect. The costs of traffic accidents are huge regarding victims and material damage. If accidents may occur, insurance and liability are topics to discuss and describe in order to adapt the current legal framework to the self-driving fleet. Nowadays, not many governments have adopted measures in this matter, therefore, some law complements need to be displayed.

### 2.2.1 Types of Liability

Different types of liability are extended explained in a research made by Bartolini, Tettamanti and Varga (2017) where main three types according to road traffic are suggested. The three types are the criminal, civil, administrative liability and product liability. These topics are discussed in the sections below.

The main problem of autonomous cars liability is that an extended framework has been built in the past. A complete and determinate regulation based on cars is adopted by every country and the existence of self-driving cars needs a complete renovation of all the implemented laws. It is not a problem to invent a new regulation, is about modifying the existing one, to adapt it in a self-driving car environment. As we have seen in Vienna Convention, the driver is who controls the machine. So, the liability regards on him or her. As driving is considered a dangerous activity, a strict regulation concerning manufacturing requirements, ownership of the vehicle, insurance… are topics to deal with.

#### 2.2.1.1 Civil Liability

The civil liability determines the way the damages suffered by an accident are restored. Civil liability is a complicated topic to manage because the circulation

of vehicles is unpredictable, expensive and with a lot of interest parts on it. Moreover, with the autonomous vehicles on the scene, can be even more complex to regulate. When there is damage done to people or other vehicles, the driver is responsible for what happens, so is the liable one. As there is not a human driver in high levels of automated vehicles, the liability has to be placed on another target. Anyone cannot be liable for anything, if the person was not in control of the machine, as any passenger in any other vehicle. However, negligence is considered when the driver is not in the right conditions to do it, so if a negligence case comes up to the scene with the autonomous car, the liability should lay on the owner or manufacturer because of something wrong in the manufacturing process or upkeep defects.

It is established a product liability for autonomous vehicles when the manufacturers topic is being discussed. It happens when there is a malfunction of a vehicle which causes an accident, or the software is not good enough to prevent it when it should. Therefore, the manufacturer will not be liable when there is an advice to the owner about self-driving malfunctions or risks that the owner wants to take. That will cause a problem about companies' insurance, it will be discussed it later.

In the tests to prove the autonomous technology, AI has been considered. Machines that learn from their past situations and remember them to act better in the future. This can bring several problems in detecting why the machine behaved in one way or another, because it may have learned it long ago. It should be like an airplane black box in order to identify the data analysis and decision-making process of the vehicle. If there is no possibility to detect the reason deep in the software, it may lead to a problem about the manufacturers' liability.

Regarding the actions someone in the vehicle has to attend to, some issues about liability are discussed. One of them is deciding and activating the planned course. If there is an accident it is going to happen because the passenger decided such destination. Another important feature is the manual control of autonomous cars (considering them with steering wheel and pedals). Nowadays an autonomous vehicle on the road must have them. When a dangerous situation occurs, the occupant should take control of the vehicle in order to avoid it. If there is enough time to react and avoid an accident, the liability will rely on the passenger. Even with high levels of automation, the passenger-driver has to control the vehicle in the situations it is required to. Therefore, if there is an accident and there was a malfunction on the automatic driving system which needed human driving on the steering wheel, he/she will be responsible for the damage done. Negligence may be called in these situations when some action could have been done. To sum up, there are two different situations where the passenger-driver or the manufacturer is liable for an accident. The first should be responsible if there was enough time to take control of the vehicle when it is needed. The second one, if the accident cannot be avoided by any driver.

All the discussed liability will have effects on the way insurance works nowadays. The law in most of the countries demands an insurance for every

single vehicle. Both topics have to be developed at the same time in order to combine them in the best way possible. It will be discussed in the next sections.

#### 2.2.1.2 Criminal Liability

Regarding (Cesare B., Tamás T. and István V. 2017), criminal liability refers to the act of acting with the intention to commit a crime. In terms of vehicles, causing an accident with a criminal purpose. According to the definition, there is an important aspect about who is involved in such accidents and its behavior. When talking about automatic vehicles, a change about the strict meaning of criminal liability has to be made. “Depending on the legal system, liability may reside on the legal person, on the natural persons who acted on its behalf, or both, but such liability criteria are not incompatible with the principle of personality of the crime”.

Law says that the legal responsibility for traffic accidents relies on the driver. Furthermore, as driving is considered a dangerous activity, criminal liability is stricter in this area. There is a possibility to avoid the liability in a traffic accident when the driver can prove he or she is not responsible for it. Therefore, as in high-level automated vehicles, there is no driver, there cannot be criminal liability set on a passenger.

There have been situations when the driver could not be held reliable of an accident. In the past, if the driver could not be criminally accountable, the car manufacturer was the criminal legal responsible for the accident. Nowadays it is possible to set the car manufacturer liable for an accident in legal terms, despite this, a car occupant can be also liable in particular situations. In other words, when there is no driver on an automatic car, but the passenger is not paying attention in order to avoid an accident, he or she could be held liable for the accident.

Two different questions can be made. The first one is about if the driver is allowed to be oblivious to the driving task when the automatic car is driving by itself. Therefore, does not have to be aware of the environment or if an accident may occur. The second one stands on the legal obligation to be paying attention to any event on the road at any time. Nowadays, as there has to be a person able to drive the vehicle in any situation, the second answer is the one active right now. There are not high-level automated cars on the road, so it may take time until the first answer becomes real. Thus, the automatic car occupant can be liable in criminal terms even if the car is autonomous.

Sometimes, although a car passenger is paying attention to the environment and everything happening around the vehicle, a car accident involving criminal actions cannot be avoided. Despite this, keeping the eyes on the road and trying to take control of the car when the situation requires it, can avoid the occupant to be held legally responsible for an accident. In any case, if the passenger is not controlling the surroundings, there is no way is going to avoid criminal liability.

There have been situations of autonomous car accidents when the autonomous system was driving the vehicle. One of them is the mortal accident involving a Tesla car, (2016). What has been investigating is if one DVD system was on by the time the accident occurs. In cases like this, the lack of attention by the person responsible for the car can rely on legal responsibility for what happened because of a negligence action.

According to the nowadays situation, as the technology is still not able to put high automated level vehicles on the road without any supervision, the criminal liability stays on the occupant if the action required to be made is not. In other words, the attention of the passenger is required in any situation, therefore a lack of it means that he or she will be liable of an accident because of not taking control of the car when was required. When the automated vehicles time definitely arrives, some changes in this matter can be made. Change as requiring fewer levels of attention of the car occupant and making car manufacturers more liable for this kind of accidents. Also, some changes can be made according to the action of taking control of the car when there is a system failure or a determinate situation to avoid. In these situations, a lack of warning by the automated system relies the liability on the car manufacturer and not taking control of the car does the same with the passenger.

#### 2.2.1.3 Product Liability

There are other types of liability that may be discussed. Product liability and traffic liability have such an impact when studying transports on the road, in special, autonomous cars. While traffic liability refers to the car owner and the damage it can be done to other drivers or objects on the road (similar to civil liability), product liability consists on the manufacturer crafting an item.

The product liability occurs when damage has been caused by a deformity in the product. The definition of deformity in a product says that it happens when the user did not experience the safety he or she expected to have. Regarding different aspects as possible defects on the product, the manufacturer has not declared, not as safe as the manufacturer said it would be or the time that has set in the market.

In the autonomous car industry, product liability is what can set manufacturers on the bullseye. Companies may be afraid of set new technologies on their cars or launching new products to the market which can make the transition to autonomous cars slower. The manufacturers will have to declare the hazards among autonomous technologies on their products and how safe they are going to be. Being too optimistic about this fact can make them legally responsible when a malfunction on their autonomous vehicle causes an accident. Moreover, prevention can cause the potential clients afraid of purchasing an autonomous car. In the next years, marketing departments will have to work hard in order to praise its products being sincere about which risks can clients take, so then they can avoid product liability.

As it is such a new concept of product liability, a standard has to be made. There is a need to set the path for the legal struggles that can happen when

accidents involving autonomous cars take place on the road. As product liability is close to safety topic, a comparison between conventional vehicles and autonomous vehicles is necessary. Nobody expects the autonomous vehicles to be less safe than human-driven ones, even though, at which point are they going to be considered safe? According to an article written by M. Schellekens (2015), society will at least assume that autonomous cars can be as safe as conventional cars. Despite this, it is hard to compare them as many differences show up. It is studied that some accidents caused by driven cars are those because of being drunk or falling asleep will not happen anymore. Even though, some other sort of accidents involving autonomous cars such as those caused by sensor limitations or malfunctions, may appear. There is another problem regarding the comparison between two human drivers, as it cannot be made, the one involving autonomous cars, neither. In the article mentioned before a proposal for a standard concerning 'as safe as a human-driven car', it is made. There are two statements. The first one consists on the safety statics between an autonomous car and a human driver, declaring the first ones should be safer, in a static study, than human drivers. This statement does not avoid the possibility that accidents may still happen, it just says that the number of victims on the road will not be worse with autonomous cars on them. It may not be what clients expect from the safety level being such a deep change in the system. The second one says that an autonomous car should be at least safer than the best human driver. The best human driver figure is difficult to describe, however the statement consists on mitigate the responsibility of an accident, because even the best human car driver would have not avoided it either. This second standard statement is more restrictive than the first one and can show a way for public to be trustworthy with the upcoming autonomous technologies.

### 2.2.2 Liability and Insurance

Nowadays, regarding the actual progress in legal and technical terms, we cannot think about autonomous vehicles without a human driver ready to take control of the vehicle at any time. However, the developments about to come can jeopardize the way liability and insurance is considered. Some legal gaps will appear and the commented risk of the manufacturer as liable for an accident can make this progress to be slow. Despite this, there are some companies like Volvo trying to prove themselves as trustworthy announcing that they will take full legal responsibility if an accident of one of their cars is caused when the autonomous mode is set.

There is an important point of view that has to be agreed in order to discuss insurance systems. A victim in an accident involving autonomous cars should not be worse than a victim in an accident caused by a conventional car. Thus, there is an insurance system that can help in the transition to autonomous vehicles. First-party insurance means a victim in an accident it is compensated just proving there where motor vehicles involved. So there is not really anything to prove, no matter if there was an autonomous vehicle or not. In other words, the system compensates a victim of an accident caused by any vehicle or even an own accident. There are several countries that have this kind of insurance program, although, it is not a mandatory one.

Regarding the insurance companies, it is hard to assume how are they going to act when autonomous technologies set on the road. There are a lot of risks about these vehicles as system failure or hacking, and others that may appear later. Considering the technology as new and unpredictable, the insurance companies will set high prices for their programs or even reject any insurance to this kind of vehicles. This is also a hazard in the progress of the autonomous car.

Progress has to be made in this field, as well as set a standard for insurance programs regarding autonomous vehicles. Governments around the world should ensure studies along insurance professionals in order to try to set which kind of risks a company may take. With the current state of the art, a car cannot be on the road without insurance, therefore, if the first high-level automated cars cannot have a insurance, the beginning can be hard. Another thing governments can provide is standards of security levels about autonomous cars. If the companies have to reach a high-security level, even if the technology launch takes long to happen, insurance companies would take less risk and accept to ensure autonomous cars.

Changes about manufacturers insurance may also occur. As it is said, there are situations where the manufacturer can hold liable for an accident involving an autonomous car. According to this, insurance for companies in this sector can turn more expensive even contract clauses will be added if the product insurance refers to a vehicle.

This being stated, I would like to throw some light on future autonomous cars insurance. If the technology reaches the security levels that are expected to happen, it will be easier. Stats studies say that autonomous vehicles will be safer than conventional ones, so insurance companies will find autonomous vehicles insurance cheaper than the conventional. There is a long way to walk on this issue, and the future steps will discover if the predicted statements are true.

### 2.2.3 Liability and Innovation

Innovation and liability, walk alongside. The progress in liability law can influence how fast manufacturers set autonomous cars, with a certain technology, on the road. If they are likely to be liable when a malfunction occurs, they will delay the deployment of this vehicles until the safety standards are high enough. Even though, liability law can be positive in a certain way as well. If there are exigent standards to accomplish clients may trust in the technology. Knowing the manufacturers are expected to be exigent in security terms, can make the public more comfortable about purchasing this kind of technology. There are gaps though, as the manufacturers can avoid liability in case of they can prove it was not possible to detect a defect after a traffic accident occurs, because the knowledge by the time it got on the road, was not enough.

When describing the human role in autonomous cars, it is important to clarify which level of automation the discussion is about. On the one hand, in partially automated cars, who is controlling the vehicle and driving it, is the human driver. There can be some situations when the control system is in charge, but the human driver should take control of it whenever he or she is needed to.

Regarding this, it is not likely that the manufacturer turns liable with partially automated cars. However, the role of the human driver is not an active role, which increases the risks of being distracted. When driving conventional cars, the continuous attention to the road keeps the driver aware of what happens around him or her. When the main task involves sitting down and supervising, the monotony and inactivity can make the task boring, which leads to doing it wrong. In order to deal with these situations, manufacturers should consider a way to make drivers aware at any time and create a system that can warn the human driver with enough time to him or her to react. Here is where the liability of the manufacturer can come into the scene if there is a standard regarding the interaction between the autonomous system and the human driver, situations where manufacturers hold liable in partial autonomous cars can happen. On the other hand, in full autonomous or self-driving cars, the driver is just a passenger on the vehicle. Every safety and control task depend on the system. As it is said before, several acts like setting the route and keep the car in a good condition may rely on the human passenger, but the driving task itself is about the driving system. Therefore, in this kind of situations, it is very likely that the manufacturers turn into the legal responsibilities.

According to these two different situations, something has to be said. The more automation level is implemented in the car, the more likely is the car manufacturer to hold liable for an accident. This statement brings the idea of how manufacturers are going to implement new technologies on the market. They may be cautious when an automated system is ready to be deployed. Delaying too long the known technology to the market, being afraid of liability law, may have a negative impact on the whole industry. It is also said, that this delay is a positive aspect because the implemented technology will be safe, as took a long time to make sure it will be. Safety levels are expected to increase, and if the accident rates decrease when autonomous cars exist, why do not wait a little longer.

### 2.2.4 Insurance as Solution

The previous sections determined a challenge about the exposure of manufacturers. The optimal balance should be between the overexposure because reaching this point the technology is going to be stopped by liability law, and underexposure because victims and the liability system has to still be effective. Insurance can clarify the position of the manufacturers in the autonomous car deployment.

First of all, with the current state, it is no certain knowledge about how insurers are going to react. In case the first autonomous cars are at least as safe as human drivers, from an economic point of view, will be worth it for the insurers. Despite this, until the autonomous cars become a reality, such stats are not known, so insurance companies may not decide whether is worth to ensure autonomous cars or not. This can turn into a cycle problem because without insurance, cars are not allowed to be on the road, and without the recollected data of their behavior, insurers may not take action. Considering this problem, we can find a solution in the progress deployment of new autonomous technologies on the road. As it is commented in the first sections, technologies

such as lane keeping, and cruising control are working nowadays, so the data progressive data recollection in order to clarify the future implication of insurers can be made. In other words, the step-by-step progress can be useful for static data recollection along technology progress.

There is another issue involving insurers and manufacturers. The way insurance is going to work with this sort of companies will have such an important influence. In an overexposure situation, manufacturers would hold likely liable for accidents, so insurance companies would be exigent with them in terms of prices and trustworthiness. It can build another barrier against the progress of the technology. If the situation turns into a manufacturer underexposure several problems can affect too. First of all, safety may not be guaranteed cause many companies can take advantage of the underexposure to not be as exigent with safety as required, regarding a minimum legal consequence. Also, the victims can be overexposed for not being able to complain in legal terms. This can happen to insurers too. If there is not the possibility for them to have a recourse against them, the whole definition of liability can be no longer effective.

Insurers will be an important character when their act gets required. Avoiding ensuring manufacturers below the standard and making affordable rates for the public in order to make the technology real for everyone.

### 2.2.5. Traffic Insurance

It can be understood as traffic insurance, the mandatory insurance regarding vehicles on the road. Each country has different requirements but most of them set obligations drivers to have to assume. There is one particular kind of insurance, discussed in the previous section, which is especially attractive for the autonomous vehicles industry. Such insurance is first-party insurance. It consists of the victim being compensated by the first party insurer. Therefore, when there is a collision between vehicles, the claim for the damage done, has to refer to the insurer of the vehicle you were traveling with. If right in the moment of the accident took place, the victim was not in any vehicle, the victim claims for the insurance of the causative.

Regarding the definition of this kind of insurance, pros and cons can be discussed. The main pro point is throwing liability away. The liability issue has not to be solved because of each one insurance cover the damage done by any of the people involved in an accident. As this has not to determinate, several economic costs about finding the legally responsible subject of the accident, are gone. According to this, the victims are compensated in an easier way and comprehensively. However, there are also some cons to considerate as the disappearance of liability law. There is any legal responsibility for what happens, which can lead to a less concern about these conflicts. If a negligence or an accident on the road has not a legal responsibility, next time drivers will take the same risks. In addition, as every victim is compensated by his or her own insurer, apart from being this kind of policy more expensive, a moral thought takes part because the victim covers the costs for others damage caused on them.

This being said, it can be declared that this system will work for automated vehicles' insurance. The problem of the human driver supervisor or not driver at all, is solved. However, it is important to analyze where this system is already working. Sweden has implemented this system long ago and holds the whole system of traffic insurance in combination with a stable social insurance that covers many of the costs of accidents. It's being said that this insurance system has to be even mandatory for the automated cars' owners. Even though, not every country has the same social insurance Sweden bears with. In addition, making the insurance expensive for car owners can have a negative effect on this market. There is some hope though, regarding the safety stats that will be accomplished by autonomous cars. If it is proved that autonomous cars are safer than conventional cars, insurers will launch cheaper policies.

There can be changes introduced by modifying the legal framework. On one hand, if no change is made, the same requirements as with conventional cars will have to be taken. This can rely on insurance companies the responsibility of choosing a standard to introduce new policies made for autonomous cars. On the other hand, if there are specific standards and requirements for automatic cars, the production of autonomous cars can be jeopardized. A slow progress would arise and the testing phase will deal with the worst part. An example of what a new legal framework can be, there is the introduction of a new driving license. As the driving role changes and also when high levels of automation can able young and elderly population to use this vehicle, a special license may appear. Such changes will come along with penal responsibilities when they are violated, so they can have a strong influence on the development of the autonomous vehicles.

## 2.3 International Governance

According to the article by S. Pillath for the EPRS (2016), "The United Nations Economic Commission for Europe (UNECE) is one of five UN regional commissions, administered by the UN Economic and Social Council". 56 countries from different continents as Europe, Asia, and North America take part in UNECE where they work together in order to cooperate in economic terms. Inside the UNECE, there is the ITC (Inland Transport Committee) which has the same purpose than the UNECE but about "the international movement of persons and goods by inland transport modes". The work made by this platform have reached more than 50 agreements and meetings that provided an international legal framework and a lot of regulations in order to deal with the development of international transport as rail, road, intermodal and water. Inside the ITC, there are two organisms working in road transport and whose research is important to consider in order to describe the automated driving situation. Those two ITC bodies are WP.1 and WP.29.

### 2.3.1 WP.1

The Global Forum for Road Traffic Safety is an international organism established in 1950 in order to prevent road accidents. Until 2017 the name of this organism was Working Party on Road Traffic Safety. The actual role of this body is to provide the conventions and international agreements an international and impartial opinion, supervising the decisions made by the different countries. All these actions, in the improvement of road safety field.

Another function of this permanent body is to participate and update the conventions on road traffic as the Geneva and Vienna ones.

### 2.3.2 WP.29

According to the definition established on the UNECE website: “The UNECE World Forum for Harmonization of Vehicle Regulations (WP.29) is a unique worldwide regulatory forum within the institutional framework of the UNECE Inland Transport Committee”

There is a main objective of WP.29 based on control and regulate the safety system that the new vehicles on the market include. They need to have implemented certain safety technologies able to provide safety for the vehicle driver, other drivers, on the road and also for the environment. As this technology has such an important impact on the economy is important to have this international organism.

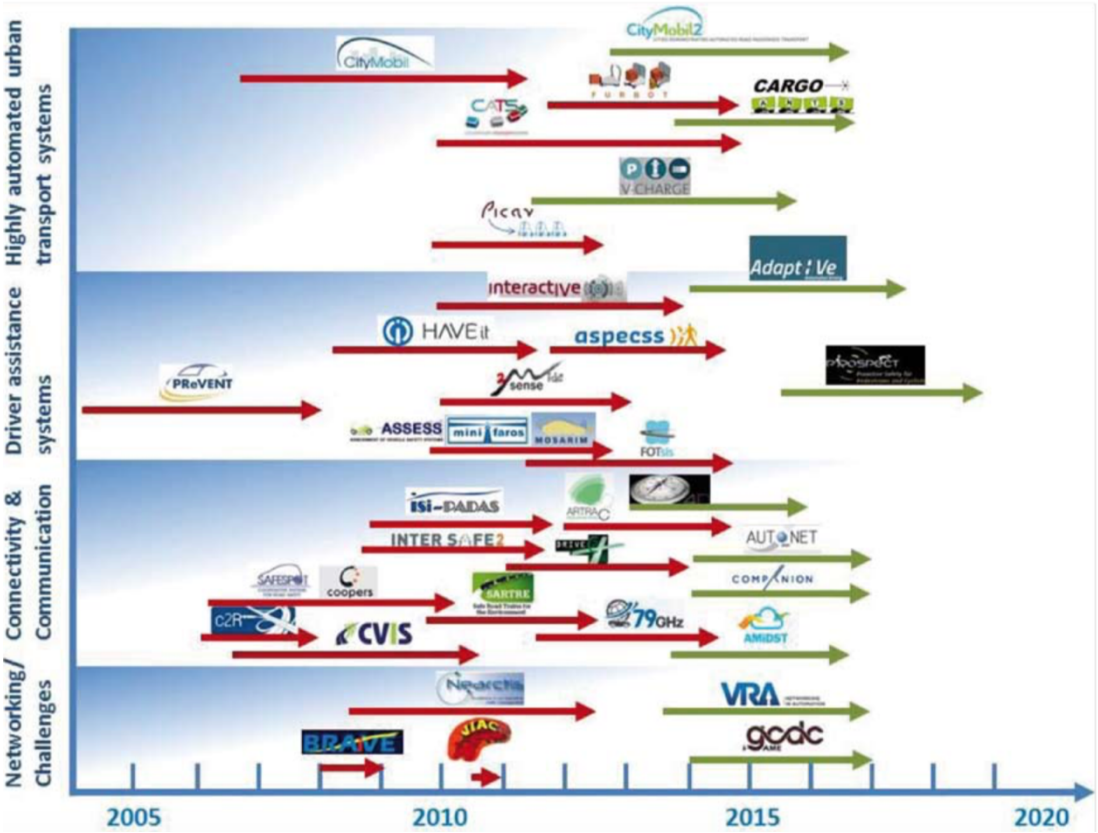
The technical requirement mentioned above were decided in different UNECE conventions where agreements were signed. One of them took place in 1958 were safety test and procedures were set. With the signature to this agreement, a whole compromise about production and approval of this kind of systems was acquired. There can be found 135 annexed regulations by Un and 54 contracting parties in this agreement. There is also another important agreement signed in 1998 by 35 contraction parties. In this second one, regulations on the construction of vehicles were set. Both agreements have to be applied in parallel, even though in the second one, the mutual recognition of approvals it is not provided.

It is expected that automatic systems and autonomous vehicles are soon part of the priority WP.29 agenda. There are a lot of regulations made for conventional vehicles that would need an amendment in order to be able to be applied to automated vehicles. This kind of international regulation has a lot of influence and power about the future development of the legal framework involving autonomous cars.

## 2.4 Europe

In the field of automated driving, the European Union has such an important activity involving several research and programs along European universities and companies. Most of them can be contemplated in Figure 7, where the EU has fully or partly invested in. There are different categories along 10 years of research. These are: Networking and Challenges, Connectivity and Communication, Driver Assistance Systems and highly automated urban transport systems[13].

*Figure 7: UE Projects*




Source: 'Automated Driving Roadmap' ERTRAC 2015

As it's being said, European Union is active about autonomous vehicles topic. The programs with positive results and the spreading of autonomous technology knowledge among the public, has increased the press interest and nowadays is a topic discussed. It is important to keep working on this matter because a whole transportation system change is ahead.

Moreover, there is another important challenge to beat. The technology challenge. This new incoming tech is based on high definition roadmaps, which will bear with the strict privacy framework exiting in Europe. Also, it is important to educate and teach young people and actual workers in IA technology. The competitiveness in the sector will depend on the knowledge in this filed, as the controlling system of an autonomous car with all the sensors is equipped with, are the main part of the technology. It is known that Europe is a good car

manufacturer, especially in structure and engines, bringing durable and viable cars. However, software and real-time data analysis will be the most important part of this upcoming era.

There is also another objective the European Union has to reach, agreements in the development of an extended legal framework. The previous one, made for conventional vehicles has to develop in order to fit with autonomous vehicles. Although it is important that every country adopts different laws according to this technology, all have to be faced towards the same direction. A harmonized regulatory framework according to safety, technology, and law, has to be created. As it's been said in many parts of this thesis, if the legal framework does not evolve along with technology, the whole automated vehicle's market can be jeopardized.

Social acceptance will be reached when a complete and structured law framework is created. Right now, the main concern involves high levels of automation where the driving law has to change in many ways. This will lead manufacturers, insurance companies, traffic authorities… to have a clear view about how the autonomous technology is going to behave in the future.

As it is said, a common strategy involving all the Member States is required. If the regulation progress is created by every country, a fragmented framework will be useless in order to promote progress. It is important to reach global solutions because this industry is such a powerful transportation system ahead. There is a need to agree on every legal progress because the main benefit of transportation is the international one. It is vital that an autonomous car can drive along all Europe without compromising its functions.

### 2.4.1 Main Issues

European stakeholders have to improve in precise but vital fields in order to be ahead in the autonomous vehicle technology race. The Darrel M. West article in 2016 shows up several ones, which will be discussed in this section.

#### 2.4.1.1 Technology Capabilities

There are some examples of European main companies on the lead about autonomous vehicles. Volvo has two systems that are the IntelliSafe Assist and Pilot Assist system, Audi includes in one of its cars a Dynamic mode where a lot of fo features related to the autonomous driving takes part. Then we have Mercedes-Benz with its Distronic Plus with Steering Assist and BMW also working on its own semi-autonomous vehicles. All of the use technology from other companies more specialized in sensors, cameras, chips… as Mobileye or Bosch.

Although, it is important to mention that Europe is not specialized in IA nor the technology is needed for autonomous vehicles. For example, lots of them purchase products from Mobileye, an Israeli company. The main topics are chips, sensors, high-definition cameras, data processing… and Europe should

make a better effort to educate the next generation in this kind of technology as it will describe the autonomous technology roadmap.

#### 2.4.1.2 Data Collection and Privacy Protection

New technologies and especially social media have threatened the way our personal information spreads on the internet. Because of this reason, restrictive regulations formulated by the European Union limit the data analysis and collection. One good example, named in the A. Kozak and M. Wieloch paper, are the fines Google has got to pay in several occasions as well as the company has been asked for copies of its data and some limits on the information collected have been placed. All these issues came up with the Street View data collection where citizens and roads are photographed. It is important to mention that Google got fined principally because of breaks into Wi-Fi lanes when collecting road data. Other protests aimed Google to blur all the faces and car plates of a determinate area. This being said, a question can be made, how this is going to affect the high-definition maps? As it is been said, this technology is very important for the autonomous vehicle technology, as helps them to drive safely on the roads.

Moreover, according to the internet access people has nowadays, according to the Darrell M. West (2016) research, the European Union General Data Protection Regulations placed limitations on the use of AI and machine learning. They were published in 2016 and included the prohibition of any decision made by an autonomous device which can affect EU citizens. It is easy to notice that an autonomous vehicle if is involved in an accident can affect in some certain way EU citizens. It is probably thought that this regulation is a way to protect citizens from machines, as people are afraid of them to learn and have a negative effect on humans. Even though, special definitions can be made in order to able EU manufacturers to research in this technology.

In other words, any regulation that prevents geo-mapping or IA learning is against the development of autonomous vehicles software. High-definition maps will bring the possibility to autonomous cars to circulate on common roadways and it is thought that the future autonomous car (specially which has high levels of automation) is going to be able to learn from its own mistakes, enhancing the experience and making the vehicles safer. If the European Union does not do anything to allow these technologies in autonomous cars, European manufacturers will be in trouble in order to develop the technology and be ahead of it.

#### 2.4.1.3 Product Liability in Europe

Since 1985 there is an organism in the European Union in charge for the regulation of the product liability, the Council Directive 85/374/EEC, which have provided laws, regulations and administrative decisions to the Member States concerning liability for defective products.

As it can be seen on the European Commission website, the European framework includes any product causing damage to the public o their property, where the product is defective. The manufacturers can escape from liability if they argue that there was not enough scientific progress to detect the malfunction and also if there was an announcement about the defect.

However, there is no specific regulation for motor vehicles involved in accidents, as with conventional vehicles liability was always going to be held on a driver, there was no need for it. With the autonomous vehicle technology, as the malfunction of the control system can involve a vehicle in an accident, regulation has to evolve.

The regulation of legal responsibility is different between the European countries. Most of the use causality as the way to hold liability. Despite this, several situations in which the liability is not clear can happen. In low levels of automation, if an autonomous vehicle cause an accident is difficult to determinate if the control system fault or the driver who was not paying enough attention. Comes up that some progress has to be made, in a harmonized way in order to regulate this whole autonomous vehicle framework.

### 2.4.2 Member States Initiatives

#### 2.4.2.1 European Parliament

There have been two important regulations discussed and voted in the European Parliament. Both aim to be conscious of new technologies in order to improve road safety and take advantage of economic progress in this matter. However, the exact references in both documents are short and are not the main issue of them.

In 2009, there was a voting in order to decide whether include several suggestions on the Intelligent Transport Systems Action Plan developed in 2008. These suggestions were made by the Committee on Regional Development and most of them exalted the benefits of ITS. On the several proposals, it was said that ITS can improve Europe's citizens live conditions, from all areas including urban ones. It had been said because it can improve safety, traffic efficiency, access to different areas, reduce pollution... It is also included in these suggestions to invest more on ITS in order to make the technology accessible and to take advantage of it, trying to involve all the Member States in order to create a common network[14].

There is also an interesting document voted in 2015 in order to implement the 2011 White Paper on Transport. As can be understood, the principal topic was transportation itself, without the special mention of autonomous vehicles. Despite this, several proposals to midterm accomplishment were launched. On the point 54, we can read the aim to invest in disruptive technologies as driverless cars. It is also heightened regarding safety, a greater application of driver assistance safety systems and also a proposal to introduce learning to obtain a new kind of driving license about new vehicle functions as driver

assistance systems. On the 44 section we can find the aim to "make better use of the opportunities offered by digital technologies, and to promote new transport services, as well as new business and distribution models, in order to foster growth, competitiveness, and jobs; stresses also the need to provide an enabling regulatory framework for pilot projects aimed at the deployment of intelligent automated transport in Europe" [15].

#### 2.4.2.2 United Kingdom

UK government see intelligent mobility as an opportunity to enhance its transport system, especially autonomous vehicles because they will reduce congestion and pollution, improve safety and the whole social, economic and environmental community will take advantage of it.

There is a council working in the UK in order to improve the communication and relations between the UK government and the automotive sector, as it can be seen on the UK Automotive Council website. It was established in 2009 and their activities are based in three different sectors: technology, supply chain and business and environment.

In a document published by this organism in 2013, there was a special mention to Intelligent Mobility which wanted to form part of the new Transport Systems Catapult. They aimed to create demonstrations programs in the UK expressing to bring this intelligent technology out from the laboratory right to reality[16].

A good example of innovation in the UK is the automatic pods in Heathrow's Terminal 5, a London airport, where ULTRA is driving passengers from this terminal to Greenwich. These driverless systems are placed in special structures, similar to railways for trains, and communicate these two areas with an eco-friendly transport[17].

Other advances have been completed in the UK as a regulatory review which can be useful to figurate a pathway to autonomous cars because in it is said there will not be barriers for autonomous cars to be tested on UK roads. Along with this declaration, a Code of Practice for the manufactures who want to test their own vehicles is also launched. In this code, such information as the driver knowledge about automatic systems is demanded. This will help also with platooning tests involving highways in England.

*Figure 8: Heathrow Pods*


Source: 'Where to? A History of Autonomous Vehicles' Computer History Museum 2014

#### 2.4.2.3 Netherlands

The Netherlands has been in touch with the autonomous vehicle technology for a long time. In 1998 a city of Netherlands called Rijnwoude experienced a demonstration of three fully autonomous cars in platooning mode driving around the trunk road N11. Three LeSabres drove 5.6 km as part of the PATH program developed by the University of Berkeley. That was just the most impressive demonstration of the event where a lot of European manufacturers showed up several automated systems[18].

According to the ERTRAC publication (2015), self-driving vehicles are being allowed on Dutch roads, working in cooperation with other countries and manufacturers, in order to bring this new technology right to the market. Also, a new legislation started to be effective in 2015. This legislation allowed Field Operational Tests on public roads in the whole country. FOT-Net is cofounded by the European Commission and their purpose is to launch the automatic technology on the roads in a secure way and with a continuous feedback in order to improve it. They especially test autonomous systems and cooperative systems[19].

As it is been said, Netherlands has a lot of programs and initiatives in order to cooperate and improve the autonomous vehicle technology. Another example is DAVI, Dutch Automated Vehicle Initiative, a public-private partnership with the

aim to bring autonomous vehicles to public roads. A lot of different projects are being held with the final goal to demonstrate they are safe in nowadays roads and can deal with the conventional vehicles[20].

#### 2.4.2.4 Germany

From 2013 the Federal Government of Germany established the "Automated Driving" Round Table. Aiming to find a common regulatory framework in order to introduce autonomous technologies on the road, this body allows the flow of ideas between autonomous vehicles stakeholders. Manufacturers, insurance companies, market experts and other collectives, exchange the ideas and experiences about this new paradigm. Twice a year, the Round Table is reunited in order to set which areas need to be taken into account[21].

There are also several 'test beds' in Germany. It was agreed to set the A9 motorway as one of them. Some other urban and rural roads are considered also to take part of this real laboratory network where autonomous cars can be tested along conventional vehicles, in a real traffic situation.

An important progress was made by the BMVI (The Federal Ministry of Transport and Digital Infrastructure) when in 2017 they launched an Act in order to amend the Road Traffic Act. It mentions fundamental rules about the situation of the driver with level 3 and 4 of automation in self-driving cars. According to the reason of the role change of the driver, in other words, from being an active driver to a passive one, supervising how the car is driven by the control system, it can be said that the attention of the driver may not be on the road all the time. Another basis of this act is that the driver is still at the driver's position, even though, when the system driving by itself commits a failure, the driver will not be held liable. With this act, providing some light to the future of the automated cars, Germany innovates in terms of traffic law.

and trial technologies for both automated and connected driving and intelligent infrastructure. The test bed is not a secluded testing area. Trials are carried out in real traffic situations, a laboratory under real-life conditions.

#### 2.4.2.5 France

There is a committee of experts in France called PFA (Automotive Industry and Mobilities) developing and consolidating the automotive sector in France. Brings solutions to manufacturers and public, enhancing the whole traffic industry around the country. There are also decision committees as the 'Automotive Research Council' (CRA) which is more specialized in autonomous cars. For example, one of the challenges of this collective is to implement ITS technologies in order to accomplish the 2020 objectives set by the European Union[22].

Along with this committee, the Nacional Council for Industry in France launched in 2013 the 'New Face for Industry Plan' where was included the autonomous technology as an important aspect of the future of traffic. With this

action plan, several objectives are set as develop relevant technologies or deploy more effort in the analysis of the future situation, as well as the aim to introduce the technology at the market.

It can be said that with this plan France will participate actively in automated vehicle test aiming to become a referent in terms of security, control, and safety.

This being said, stakeholders are participating in the development of this technology, but France has a long way to walk in order to be competitive with the other Member States that have activated different regulations about the autonomous vehicle.

#### 2.4.2.6 Sweden

It was in 2013 when Volvo announced the release of a new program called 'Drive Me'. The purpose of this program was to have on the roads in Gothenburg and surrounding areas a fleet of 100 self-driving cars used by normal clients. The aim was to collect a lot of data during the use of their cars and launch a semi-autonomous car by 2021 to the market. Apart from the Volvo Car Group, also the Swedish Transport Administration, the Swedish Transport Agency, Lindholmen Science Park and the City of Gothenburg is involved in this program that nowadays stays active. By the time it was announced it was a very ambitious project that was going to set Sweden ahead in terms of real autonomous cars testing. The area selected for Gothenburg included different kinds of motorways and roads which are normally with traffic jams problems. Thus, Volvo wanted to show how normal users feel with autonomous vehicles, their ability to share the road with conventional vehicles and also evidence the infrastructure limits that are present in the European roads framework.

A sad update was announced by the last months of 2017 when Volvo said that the Drive Me program suffered a detour due to a slow progress in certain areas. They also declared that progress on some technologies went faster than expected, as the sensor technology, while they found several unexpected problems with other issues. In order to describe the current state of the art, Volvo selected by the end of 2017 two different families in Gothenburg. A Volvo XC90 was provided to these families (new ones by the beginning of 2018) and a progress through the different levels of automation was described. As the families are feeling more confident the level of automation is going to be upgraded combined with teaching how to deal with the driverless car in such conditions. The new goal is to involve 100 cars during the next 3 years until the release of the Volvo autonomous car to the market by 2021[23].

Scania, a truck company of Sweden shows on their website the program of autonomous trucks they are already using in closed environments as work in mines or ports. It was released in 2016 and with an innovation agency of Sweden, Vinnova they have accomplished the objective of setting a technology which reduces pollution and improves safety. The trucks are able to complete a pre-designed route between different destinations, being able to control the surroundings. In the current state of the art, it is only in its test phase so is not

on the market but with this technology Scania wants to become a world leader in terms of sustainable transport solutions.

*Figure 9: Scania Tests*

Source: 'Scania lines up for platooning trials' Scania 2012

#### 2.4.2.6 Spain

There is an organism in Spain named M2F (Move to Future) which is the Spanish Technologic Platform for Automotive and Mobility. The aim of this organization is to impulse the development of the stakeholders taking part of the innovation chain in Spain, thus create an innovation culture and a common way to work in order to improve the competitiveness of the manufacturers enhancing investigation, development, and innovation. The automotive sector in Spain is very important as it takes the 10% of the investments in innovation (I+D)[24]. M2F includes several work groups in order to enhance safety, electricity efficiency, materials, urban mobility and investigation including ITS in all of these areas.

There is also a Forum similar to the European ERTRAC driven by M2F in order to coordinate all the different stakeholders in the transportation market. It was created in 2009, suggested by the Ministry of Science and Innovation, and involves some of the most important automotive manufacturers and also government members.

According to university innovations, several programs have been tested and launched in different Spanish cities. For example, the INSIA is a Madrid Polytechnic Institute of Investigation and has lead several projects about autonomous transportation. The ADAS program (Advanced System of Driving Assistance) involves technology to enhance safety and efficiency implementing

V2X communication systems, road maps, and sensors in order to test in two conventional Madrid roads cars with this technology. It took place in 2012 when 100km of public roads were driven by 7 fully autonomous vehicles[25].

In 2011 the SISCOGA program involving DGT (main Spanish traffic organism) and the Technologic Galicia Center of Automotive Technologies equipped 20 vehicles with control systems. The vehicles were deployed in a highway near Vigo and the aim was to collect data related to the environment perception of the informatics systems the cars were equipped with[26].

#### 2.4.2.8 Austria

There are several examples of Austria being ahead ITS technologies because the country has a large story founding programs in order to improve the mobility and showing this technology to the world. This can be demonstrated with programs like TESTFELD TELEMATIK and ECo-AT, which encourages the use of C-ITS around Europe enabling the test of automatic cars on the road. According to the ERTRAC publication in 2015, Austria also coordinated a program to improve road infrastructure (COOPERS) working on the research of V2I technologies.  the has been emphasizing the importance of a properly equipped infrastructure for more than eight years, with COOPERS (2006-2010 FP 7) as the cornerstone for fail-proof V2I communication. Organisms like ITS Vienna Region heightened the importance of getting data from the road transportation in order to enable new technologies on the road and improve the existent ones.

It is also declared in the ERTRAC document that there was finished a National Roadmap for automated driving by 2016, where a common framework was created for road tests in different environments as motorways or the first-last mile problem. The aim was to evidence the impact and benefits this technology can bring improving safety and efficiency in transportation.

## 2.5 Asia

Asia as an economic giant has also set autonomous technology as an important field to work on. Known for electronic development and the education of the population in some of its countries, China, South Korea and Japan are developing the future transportation technology. Important car manufacturers are based in these countries investing large amounts of money on innovation sectors. Companies have already made a move in order to approach Asia public to autonomous vehicles, regarding the traffic collapses problem that exists in the main cities along the continent. The public sector is also in the lead collaborating with the main firms and the developers of the necessary technology which will change our perspective.

### 2.5.1 China

As China is the biggest car market of the world and also a big producer of air pollution, with more than 200.000 victims for traffic accidents per year (According to WHO) automatic vehicles can improve life quality and can have a huge influence on the market development.

China may be an important actor on the autonomous vehicle progress. Regarding conventional vehicles, some technology as the engines were already created when Chinese manufacturers came into the scene. Despite this, the progress into the autonomous cars highlights the importance of a good software and electronic components and there is where China is good at, even close to Europe and US. Time will demonstrate if the knowledge in such technology can make China be on the lead.

Although, the main issue of China relies on the legal framework. A national standard has to be created and the ministries with competences in this topic, should agree in some law developments in order to allow test roads, cooperate with car firms, invest in infrastructure, promote the data recollection and solve the legal liability problem. Also, a greater job has to be made in order to make people conscientious about this disrupting technology about to come.

Baidu working on it and with a lot of investments in the technology itself, it is said that by 2020 there will be access to this technology.

#### 2.5.1.1 Government Regulation

Regarding ministries and departments, over 10 organisms have influence about autonomous vehicles in some way. From the Administration of Quality Supervision to the Ministry of Transport, through the Ministry of Public Security, among all of them, they hold jurisdiction over road mapping, liability, industry policy… A special committee reuniting all the stakeholders may help to coordinate all the organisms. Therefore, progress on the administration can be made, establishing a roadmap and giving visibility to the industry.

It is important for the progress being done to be carefully developed in order to ensure everyone requirements. On one hand, innovation progress is necessary but also security has to be ensured as well as data protection. The way Chinese policymakers develop the path to follow will help car manufacturers to create their own roadmap considering technology development and road testing.

It is also known that the government has to include automatic technology in a more important position because several invest has to be made in research and infrastructure. Manufacturers and all the industry involved needs the government to lead them, considering automatic vehicle technology important will bring the possibility to be ahead of this sector.

#### 2.5.1.2 Road Test and Map Development

It is known that road testing on normal roads, brings the possibility to collect true data, proves the behavior of an autonomous car on a normal road along conventional cars, and helps to improve the technology. As the Chinese rules state that the driver must keep both hands on the steering wheel at any time, an autonomous system cannot be deployed on the road. High level of automation cars needs a special regulation in order to be tested on public roads. Ideas as enabling a part of a normal road for tests can bring a harmless solution for, on one hand, improve the technology and on the other hand, do not overexpose conventional car drivers. It also can make public aware of what an autonomous vehicle is able to and the safety level it is able to accomplish.

Another important issue is road mapping. 3D high-definition maps allow autonomous cars to drive safely on the road, it is one of the main points in order to reach high levels of automation. Chinese legal framework set limits to the way this sort of data can be collected. A good example is the limitation depending on the territory and also the need to get a license for getting map information. Thus, a less restrictive regulation has to be set to develop highly accurate roadmaps and equilibrate China with other countries that have no limitations on this topic.

#### 2.5.1.3 Liability

Insurance is one of the main stakeholders in the autonomous technology industry. Issues of legal liability have to be developed in order to create a complete regulation. With the current state of the art, due to the wide variety of different road users, Chinese insurance companies work with personal liability. In other words, when an accident takes place, the legal responsibility relies on the person causing the accident.

As happens in most of the countries, there is not a precise solution when there is no driver at all, when the control of the vehicle relies on the automatic system. Thus, policymakers may include in the next year's rules that make possible the manufacturer to be held liable for an accident.

### 2.5.2 Japan

As an explanation for the nowadays situation in Japan, in 2016 the Japanese government released a 4-phase program where the automatic control of acceleration, braking and steering will be included. Starting from the first one, where just one of the three features can be activated to the last phase (by 2025-2030) where all three will have the possibility to be used without any driver on the vehicle.

There also permits to test autonomous vehicles on public highways, with a human driver on the steering wheel though. Nissan, Honda, and Toyota have already tested their own vehicles. All of the three companies have announced the release of different autonomous systems by 2020 but only Nissan have said that by 2020 fully autonomous cars will be able to drive the roads[27].

As Japan will be the host for the 2020 Olympics, they have set the objective to have level 3 of automation vehicles on the road. In order to accomplish this goal, the Commission for the Business of Autonomous Driving has been launched and promoted by the Ministry of Land, Infrastructure, Transport, and Tourism. This Commission will reunite a lot of stakeholders' experts. Progress on liability law, creating a standard, the need to create a new driving license or protecting the car against hack attacks are some of the main issues to consider by this organization[28].

There are also some limitations to driving test as the National Police Agency does not allow cars to be tested without steering wheel nor driver by now. Also, there is the aim to provide every autonomous car with a 'black box' in order to collect all the data in case of an accident.

This being said, the government has to invest on road infrastructure in order to collect data about traffic and accidents, so they can provide the autonomous cars with them, as well as the changing sign charts on the road. ITS are vital to open a path to autonomous vehicles on the road. According to an article by Angelo Young (2015), the government is taking part about investments because along the car manufacturers it is expected to invest around 10 billion yen to build test roads and participate in the research of better hardware systems. Also, there is the aim to create a standard about sensors or software systems to benefit the cooperation between car makers.

### 2.5.3 South Korea

The main Korean car manufacturers as Hyundai and Kia are on the lead in terms of investment and resource destined to such technology. As a senior engineer at the Hyundai Motor Group declared to a newspaper last year, it is thought that fully autonomous vehicles will be on the road by 2030[29]. Which can prove that Korean stakeholders are cautious about this incoming technology.

Despite this, some advances are being made in order to make visible the potential of the autonomous vehicle industry. In 2015, the Korean Government included the autonomous vehicle project on the number 13 of their top Industrial Projects that can bring economic benefits to the country. Thus, the government along, companies and experts from the industry will cooperate to develop this technology.

The project aims to include several companies even the medium size ones that can bring other points of view about the research. ITS solutions and software progress in order to develop the core of the autonomous vehicle technology is hoped to obtain. 295.5 billion KRW, around 223 millions of Euro are going to be invested in this project by the order of the Ministry of Trade, Industry, and Energy. This medium size Korean companies, working on the progress of the technology are expected to grow up and take part in the lead companies participating in the innovation[30].

In terms of vehicle test, recently a huge test bed opened its first section near Seoul. A complex of 320.000 square meters of a test city (K-City) wants to open

all the sections by the end of 2018. The budget for this project is around €8.17 million and was directed by The Ministry of Land, Infrastructure, and Transport in order to support the commercialization of Level 3 autonomous cars by 2020[31].

*Figure 10: K-City*


Source: 'South Korean Ministry of Land, Transport and Maritime Affairs'

### 2.5.4 Singapore

There is a clear organization in Singapore as the Land Transport Authority (LTA) is a committee under the Ministry of Transport. In terms of innovation, the LTA released 4 years ago an agreement with the Agency for Science, Technology, and Research (A*STAR) to set up a program called SAVI (Singapore Autonomous Vehicle Initiative)[32]. The aim of the partnership was to set the autonomous vehicle technology on the Government agenda providing cooperation between the stakeholders and creating a common strategy to develop the technology. The research and development of the SAVI include some examples as solving the last/ first-mile problem or explore new ways of urban mobility.

From 2015 autonomous cars are being tested on public roads, selecting a determinate area to do so. Vehicles tested in this area has to count with third-party insurance and show the precise documentation in terms of safety and also ensure that a human driver can take control of the vehicle in any situation[33].

Moreover, by 2014 a Committee called CARTS was created by the Ministry of Transportation. 17 professionals in the industry will lead the research and

development of the autonomous technology heightening the importance of developing also the infrastructure and the business models around it[34].

## 2.6 Future Driving Law

In the previous main sections, it has been explained what challenges the Driving Law has to overcome worldwide. Policymakers and governments have to agree with companies in setting a standard about technology, liability, insurance, and law in order to let the innovation grow by itself. Despite this, there are two interesting topics about the future understanding of driving law such as the introduction of a robot driver (commented briefly above), to make driverless cars legal under the Vienna Convention Umbrella. The other idea is the moral choice between AV and CV when the first ones turn up way more secure than the conventional ones.

### 2.6.1 The Interpretation of 'Driver'

As described at the Vienna and Geneva Conventions and the main regulations of the countries mentioned, not only fully autonomous vehicles are not expected to be released soon but also a human driver has to be on the steering wheel at any moment. It is mentioned on the Vienna Convention Article 8 and also on the progress made about road testing, there has to be always a professional at the steering wheel supervising the autonomous car behavior. Progress is being made in order to not decelerate the technology development, although the definition of driver changes the whole spectrum.

With partial autonomous cars the human driver is most of the time an observer, even if keeps the hands on the steering wheel and supervises all that happens, in a strict definition of the word, the automatic controller is driving the vehicle. If a control system can perform every action a human driver can do, it is automatically understood as a driver? On a paper written by Nynke E. Vellinga in 2017, indicates that the Dutch law demands that a car must stop when an official security member says to do so, therefore, the autonomous system should be aware of such actions.

What happens if the concept of the driver is changed and a robot can be understood as a driver? Who is liable for an accident if a robot-pilot is involved? Legal responsibility of machines is not considered yet, as well as fully autonomous cars. Despite this, this sort of questions should begin to be made, in order to anticipate the law to the technologic progress.

### 2.6.2 Self-Driving Cars and Ethics

An interesting idea about the future of the autonomous car on the road is developed by R. Sparrow and M. Howard in an article published in 2017. The main statement announces the progress of the autonomous car on the market. In a hypothetical situation where they can be sold, until they get safer than

conventional cars, should be unethical to sell them regarding the increment on traffic accidents victims. But what happens if it is demonstrated with collected data that automatic cars are safer than humans, therefore, it should be illegal to drive a conventional car because it would not be the safest option on the road.

It is important to declare that this possible future can take place when fully automated cars are a reality, because the same thought cannot be expressed with partial-autonomous cars. As they can be driven in certain situations and the human driver is still necessary, the complete idea cannot be placed with such technology. In the progress from the semi-autonomous car to the fully autonomous cars, there can be several situations to deal with. The more functions a car deal with itself, the less practice the driver has. Thus, when the road conditions change, and the human driver has to take control of the car, a loss of the skills can have devastating consequences.

In legal terms, also the semi-autonomous cars can be involved in problems. For example, when a car equipped with all the necessary autonomous systems to drive by itself, it is controlled by a human driver and, the human driver causes an accident, the victims can legally assert that the driver was negligent in terms of not letting the autonomous system drive. Human errors that an autonomous car can avoid, can bring several problems. This idea, in long-term thinking, can generate enough legal pressure to make illegal to take control of an autonomous vehicle when the system does not ask for it. Also, even the Governments can come into the scene to demand the manufacturers of conventional vehicles to stop production due to the insert of a negligence product into the market.

When autonomous cars are fully autonomous, levels of automation 4 and 5 several situations as kids, disabled people even pets can become passengers of this vehicles. The activities inside a car can be from reading and sleeping to drinking and having fun while the machine takes control of the vehicle and accomplish the demanded route. In this case, no control of the car by a driver is going to be taken, the act of driving will not be a human obligation. If it is demonstrated with this level of automation that a lot of lives can be saved, even if they are not perfect, they will be ethical. One issue is that the kind of accidents may change from a negligence of the driver to a system failure. Accidents involving autonomous vehicles will be avoided with a driver on the steering wheel, so a whole change of mind should happen.

The prohibition of human drivers on cars is not conceived nowadays. Making an effort, even if the regulation is placed to ensure a positive accidents reduction, can bring several problems. First of all, keeping people away from the act of driving can make them more insecure as the control does not rely on them. Also, as many people feel the car as a part of themselves while driving, vehicles will not be longer an important good to put money on. As the transportation may rely on pressing one button and arrive at the destination, the market may change.

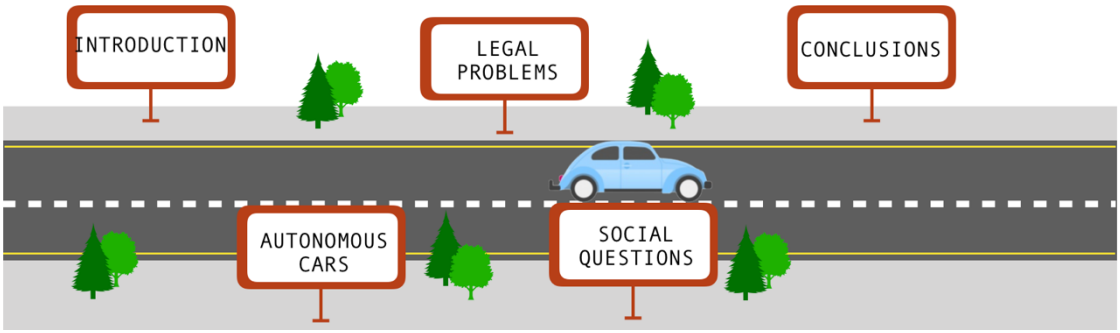
By the time the autonomous vehicles turn safer than conventional ones, a lot of private initiatives will show up in order to invest in this technology. A deeper

progress and the statics on their side, will insurance companies to make cheaper policies and even hire agencies will find cheaper to hire an autonomous car. By the time they become viable, the whole industry may reject cars with steering wheel and pedals just for the reason they will become more expensive. If the option of an autonomous car even it is still legal to drive one, can cope with the market.

One of the main challenges to bring level 4 and 5 of automation to the market is dealing with human reactions and decisions we make in an automatic way. Every sudden event can be solved easily by a human driver because of the experience, the formation and the control they have of the car. It is important for a fully autonomous car to be as fast and logical as a human driver. Other problem shows up when autonomous vehicles share the road with the unpredictable car drivers. If in an intersection, human drivers are continuously going through even if they are not allowed to do so, the autonomous vehicle, in order to avoid an accident, will let all the human-driven vehicles to go on. A problem shows up when human drivers want to benefice themselves of this issue, for example when they are arriving late to work. Passengers in autonomous vehicles can get bothered by this kind of situations making public opinion go down.

In order to accomplish the transition from conventional vehicles to autonomous vehicles, a mixed fleet will be on the road. Cars allowing human control will be along fully autonomous car and this can cause several problems. Legal policymakers should consider this issue making harder to take the control of the steering wheel in a stable situation in order to evolve to a driverless vehicle's future.

A lot of challenges are ahead, but this kind of situations have to consider because a completely different future can happen with autonomous vehicles. A lot of economic and social challenges have to be proposed and discussed and the cognitive science can have an important role in order to develop machines that think as human drivers.




# 3 - Social Questions About Autonomous Cars

As it's been explained in the previous chapters, autonomous cars are about to shake up the near future. Is the society ready for the changes to come? Will be buyers of autonomous cars? Will people trust in technology? These questions will be discussed in the next contents, taking information from different polls in several countries. In the table 1 can be seen the surveys that are going to be discussed below.

*Table 1: Surveys Used for the Research*

| Author | Year | Country | NºRespondents | Respondents Nationality |
|---|---|---|---|---|
| **Schoettle and Sivak** | 2014 | US | 1.533 | American, Australian and British |
| **Mazda (Ipsos MORI)** | 2017 | Germany | 11.008 | 11 European markets |
| **Intel (Intuit Research )** | 2016 | Not especified | 1.250 | Australian, Japanese, Taiwanese, Korean, Singaporean |
| **Rakuten AIP** | 2017 | Japan | 1.500 | Chinese, Indian, Japanese, Singaporean, American |
| **April Morning Poll** | 2018 | US | 2.202 | American |
| **Sivak and Schoettle** | 2016 | US | 618 | American |
| **L.M. Hulse** | 2017 | UK | 916 | British |
| **M. Kyriakidis** | 2015 | Netherlands | 4.886 | International |
| **CARAVAN** | 2017 | US | 1.015 | American |
| **Eva Fraedrich** | 2018 | Germany | 24 | German professionals |
| **Rico Krueger** | 2016 | Australia | 435 | Australian |

## 3.1 Self-Driving cars in Nowadays Society

Asking for a survey about autonomous cars on the road nowadays is such an imagination exercise. The technology is being tested and it seems that the public has a close contact with the autonomous cars these days, despite this, the surveys about this topic have to be considered in a cautious way. Most of them engage a few amounts of people and the questions made to seem uncertain. However, lots of them are going to be analyzed through the next sections trying to extract a general opinion coming mainly from Europe, Asia, and the US.

It is also important to say that nowadays society covers from people who have experienced the worst times of a World War, to people that have grown with an electronic device on their hands. As is going to be reflected on the surveys, young people are more open for a change than elderly people and is also going to be described how the culture of each continent understand the act of driving. In other words, if driving means just travel from A to B or if includes the experience and the importance of the vehicle.

The first survey to talk about is the one made by Schoettle and Sivak (2014) in which 1533 people older than 18 years from the USA, UK and Australia participated in. In 2014, the 34% of the total said that before the survey, they had heard nothing about autonomous cars nor self-diving vehicles. Starting from this point, for that 34% the rest of the survey depends on which information appears in order to answer the next questions. Despite this, more than the 50% of the respondents said that the general opinion about this technology is very or somewhat positive. About the benefits autonomous cars can bring, the US main 'very likely' opinion was for the improvement of the emergency responses to crashes while in the UK was for better fuel economy and Australian respondents most likely event was fewer crashes.

After this general overview, regarding Europe population, the survey launched by Mazda in 2017, says that the 66% of drivers would like to drive a conventional vehicle even if the autonomous car were on the market. The percentage is even higher in Germany or UK where the 71% said that. The country more likely to choose a self-driving car, Italy, with a 41% of acceptance. Using the survey as a base, European population does not even want the self-driving cars to be a reality as just the 33% of the drivers 'welcome the advent of self-driving cars'. It is important to say that the percentage did not change between the group of age from 18 to 44 years old. Trying to understand this strong rejection of autonomous cars, the question about the driving experience and the fact of a car as an extension of the personality throws some light to the topic. The average of 36% understand the act of driving and the car as an extension of their personality and is curious how the 54% of the engaged, said that have gone driving eventually just for fun. It is important to say that the Mazda survey comes along with a program called 'The pleasure of driving' and they used the results as a marketing weapon.

The Intel survey analyzing some countries of Asia and Australia shows a wide awareness about autonomous cars because the 83% can declare that they exist. Despite this, they do not seem optimistic about when the autonomous vehicles will be available. There is not any specification on the question about the level of automation, so based on the answer which says that in 5.8 years they will be available (average of the total answers), it is assumed that they consider the fully autonomous cars. Responding the question of purchasing a brand new autonomous car if the possibility on the market exists, the 51% of the respondents said yes, being stronger in Taiwan with an 83% of affirmation and the lowest in Australia with a 24%. There was another question to those ones willing to purchase an autonomous car where an intention of a moderate automation was revealed. Just the 22% of the ones who would buy an autonomous car would like to have a fully autonomous car. Among the reasons given by the respondents, the two main choices were a cleaner environment (purchasing hybrid or electric autonomous cars) and the possibility to spend the commuting time doing other activities.

On another survey made by Rakuten China, Japan, Singapore, India and US population were analyzed. As many car manufacturers have announced the introduction to the market of autonomous vehicles by 2020, the question made was to consider the interest in purchasing a fully driverless car. While the 'Yes' was the preferred choice in China and India (69% and 63%) the country with more 'No' was the US with a 52% of the respondents in that country. In order to consider why would be beneficial to the Indian and Japanese population to purchase an autonomous car. Among the ones answering 'Yes' the main reasons of interest were the 'New experience' and making driving easier while the non-interested ones chose the price and the lack of security as main reasons for not to buy an autonomous car. Japan population also showed to this survey a strong opposition to driverless cars saying that the 49% would not buy one. Among the reasons of not to purchase an autonomous car, there is the no need to have one, safety concerns and the lack of driving experience.

The 2018 April Morning Poll survey spreads some interesting information about how aware people are about autonomous cars and its technology in America. 2202 adults participated being the 48,27% males and the 46% between 18 and 44 years old. The total stats declare that the 18% of adults have heard a lot about autonomous vehicles and the 51% have heard some recently. That makes a big percentage of people aware these days. Regarding this information, only the 8% of the adults, state that they have a very favorable view of these cars while a 31% is not too favorable. As in previous surveys, males show up more optimistic about autonomous cars than females. Another important point is safety, where the 30% states that the autonomous cars are much less safe than cars driven by humans. Answering the question of 'Driving an autonomous car' the general opinion says no (38%) saying that maybe in a future (35%) they will.

About the Sivak and Schoettle survey on 2016 made in the US, preferences about conventional vehicles or autonomous ones were studied. The 46% of the respondents chose a no autonomous car and just the 16% preferred a fully autonomous one. There was gender analysis in this survey that evidenced the female as likely to be worried about car automation. Just the 12% chose fully autonomous cars in contrast with the 19% of the male. This difference is even bigger with the question about being concerned if the only vehicles to purchase were fully autonomous, where the 43% of the female said 'Very concerned' while the 31% of the male said the same. A curious question where the steering wheel and pedals were considered in a fully autonomous car, the 94% of the respondents said that they would like to have control devices as the ones mentioned, even if the vehicle is fully automatic.

These different surveys evidence that Asia population is less concerned about the uncertainty autonomous cars can bring. Also, an effective mentality allows them to choose a more efficient and safe way to travel, being confident about the technology. Even the Europe and US population have heard about autonomous cars, they do not feel close to the idea of purchasing an autonomous vehicle and the reason can be from the experience of driving to the fact that the control does not longer depend fully on the driver.

## 3.2 Population Concerns

Disinformation comes along with ignorance about a subject. If the autonomous cars are not known and their safety rates are not published in mass media, the population will be scared about it. Some of the social concerns published in the surveys will be analyzed.

According to the general results of the L.M. Hulse survey in 2017, the 24% expressed uncertainty about the road safety and the capabilities of the autonomous vehicle. There are two options with the 19% of the participants. Both are nothing to fear and feeling uncertain about virus hacking in road safety. Regarding genders, males are way more confident about the attitude towards the risk than the females, 28% expressed that is there nothing to fear in contrast with the 11% of the female population. There were also different kind of participants regarding their role in the transportation chain. While the non-drivers are confident with the autonomous cars or feeling uncertain about hacking and road safety, the drivers are more cautious saying that they trust in the technology, but something can go wrong.

In the 2014 survey, where participants from U.S., U.K., and Australia took part, there were main concerns about some issues. The three countries agreed with the most concerning issues, which were "Safety consequences of equipment failure or system failure" and "Self-driving vehicles getting confused by unexpected situations". In general, the most selected option in every issue by the U.S. was "Very concerned" while in U.K. and Australia the majority chose

"Moderately concerned" for almost all the issues. Is interesting to highlight the influence of security about hacking, the 34% of the total said, "Very Concerned" and a bit less (32%) showed up as very concerned about "Self-driving vehicles not driving as well as human drivers in general".

There were also some questions about possible public scenarios when the Level 4 come to reality. The most concerns for the three countries were "Riding in a vehicle with no driver controls available" and "Commercial vehicles such as heavy trucks or semi-trailer trucks that are completely self-driving". In these scenarios the level of concern is similar, and the less concerning topics were "Self-driving vehicles moving by themselves from one location to another while unoccupied" (39,2% Very Concerned) and "Taxis that are completely self-driving" (42,9% Very Concerned).

In an international questionnaire made by M. Kyriakidis in 2015, the main concern of the respondents about fully automated vehicles is the software hacking and misuse, followed by safety and legal uses. Privacy was the least chosen opinion. Also, people did not show any problem with sending information to different organisms, tax authorities was the less chosen though. Is interesting to analyze the answer to the question about the enjoyability of driving a car. The most chosen option says that drive autonomous cars would be enjoyable when the most chosen for partially autonomous cars was the next one, 'agree on a little'. This would say that after conventional vehicles, regarding this survey, people would rather prefer fully autonomous vehicles.

There is a survey made in China by Xian Xu in 2018 considering insurance aspects for autonomous cars. In order to analyze the background information, the 44% chose that AVs' will increase the risk in a substantial or small way. After this, respondents, even having the 42% a positive view about autonomous cars risks, the 48% decided that would increase the coverage of their insurance policy if their car was upgraded to be an autonomous one. Considering insurance premiums, the majority thinks that they will be lower for autonomous cars and it will be the main reason to purchase them. Despite this, the 31% does not agree with this saying that the premiums will be the same for both kinds of cars. It is interesting to evaluate how people perceive the risk of autonomous cars even when the stats say the opposite thing. It can be said that people do not trust machines in such tasks where the human life is at such risk.

On the Intel survey, there is a variety opinion about autonomous cars concerns. The data collected shows a major concern for females and non-drivers. The main concern among the respondents with the 79% of agreement relies on the legislation, choosing "Safety standards for driverless cars are not yet in place". Next concerns talk about the software of the driverless car and the spontaneous situations, saying that they will not be prepared for situations they were not programmed before. The hackers hazard is occupying the third position of the concern rankings and is one of the most named ones regarding all the surveys. Also, some issues as the liability in case of accident or the glitches in the technology make people worry. A feeling that is also in this survey is the fact

that autonomous driving will remove the fun of driving, being a strong statement among the drivers.

Regarding the 2016 survey where participants were only from U.S. people still being very concerned about not having pedals or a steering wheel in a partial or completely self-driving car. Some topics as the way to transmit the route or how to receive notifications were discussed, but the concern about driving partial or total autonomous cars still high. Despite this, respondents show less worried about partial autonomous cars, the 16,5% is not concerned at all if the only purchasable vehicles where partial autonomous ones. The half of the respondents are between the sightly or moderate concern, in contrast with fully autonomous cars where the 37% shows very concerned if it was the only kind of vehicle on the market. People stay worried about fully autonomous cars because they prefer it with the steering wheel and pedals even if the level of automation is the highest possible.

It is interesting to heighten the position of American population against the idea of even sharing the road with autonomous cars. The law in the US is different from the one ruling Europe and Asia, thus, autonomous vehicles are widely tested in the US. Despite this, in a survey realized by CARAVAN in 2018, the 64% said that they will be very concerned if they ever share the road with autonomous cars. There is a lot of work left to do, starting from the manufacturers and the publication of optimistic data to the governments spreading the autonomous car technology.

There is an important fact about any new technology if clients do not want it, it is not going to evolve. Car testings should become more realistic and the data collected published in order to evidence that is a safe technology and can save a lot of lives, time, and Earth health. Governments have to collaborate with stakeholders and set standards of legislation and regulation to develop legal issues along technological ones. Excluding Asia, in none of the surveys analyzed, the response was positive about autonomous cars. Right now, people do not want to purchase the technology and if it is going to be ready by 2020 as many manufacturers have announced, a better marketing job has to be done.

## 3.3 Self-driving Public Transportation Vehicles

A driverless shuttle bus worked in Finland in the 2015 summer, in the City of Vantaa. A total of 19,021 passengers traveled by 3,962 km autonomous buses on a specific route. The sample of 197 informants was analyzed regarding safety, security and also how emergencies are managed compared to the conventional bus. According to the results, the subjective traffic safety of the passengers in the driverless shuttle bus seemed to be good. 37% of passengers answered that the traffic safety of the driverless shuttle bus is better or much better than that of a conventional bus. 36% answered that the traffic safety is the same. 27% of

informants assessed the traffic safety of the driverless shuttle bus to be much worse or worse than a conventional bus.

According to the passengers' subjective assessments, in-vehicle security of the driverless shuttle bus is a challenge. 64% of passengers answered that the security of the driverless shuttle bus is worse or much worse than that of a conventional bus. 28% answered that security is the same. Only 8% of informants assessed the security of the driverless shuttle bus to be better or much better than a conventional bus. The emergency management of the driverless shuttle bus was also a challenge for passengers. 54% of them answered that the emergency management of the driverless shuttle bus was worse or much worse than a conventional bus in the case of fire, vehicle failure etc. Only 8% of informants assessed the emergency management of the driverless shuttle bus to be better or much better than that of a conventional bus. 38% answered that emergency management is the same.

In order to analyze differences between women (122) and men (75), men assessed their experiences of in-vehicle security, traffic safety and emergency management overall better than those of women. There was a significant difference between women and men when they evaluated the sense of in-vehicle security. There is also analyzed if there are assessment differences between age groups. The informants assessed their user experiences in a relatively similar way. There were no significant differences between age groups when analyzing informants' perceptions of the topics discussed.

This was a simple first-of-its-kind research with a small sample and limited results. The research focused on passengers' subjective perceptions of traffic safety, in-vehicle security and emergency management when they traveled by the driverless shuttle bus. The findings provide information for public transport operators designing appropriate multi-modal transport services with autonomous vehicles. Shared autonomous vehicles can make streets less noisy and less vehicle-centric. They empower pedestrians and cyclists because autonomous vehicles are more sensitive to other road users than human-driven vehicles. Incremental walking and cycling also contribute to better public health.

The analysis pointed out that passengers' sense of traffic safety in the bus was relatively good. Thus, the integration of driverless shuttle buses into the transport system will be presumably easy from the point of view of traffic safety. However, the maximum speed of the driverless shuttle bus was 13 km/h which is lower than a speed of a human-driven shuttle bus. This might implicate that passenger's perceptions of better traffic safety may not be as significant result as it would be if the speed was equivalent to human-driven buses. The challenge is, according to the data, that passengers experience lack of security on board. This finding is remarkable because the passengers were not on board alone. A member of the research group was on board with them. Moreover, the results come from Finland, which is the safest destination globally according to World Economic Forum.

Autonomous technology can strongly have influence in new city systems for transportation. Another good example, apart from the autonomous bus, is the SAV technology (Shared Autonomous Vehicles). The way they work is explained in the first sections of this thesis. The most reasonable thing to happen is that a company own a fleet of autonomous cars with the sharing tech and public can have access to them via membership or from a smart device. Shared technology points out the importance of make more efficient travels and also fix the first-last mile problem. They are not going to affect the taxi business because the function is not the same. While the taxi is for personal use and for short periods of time along cities normally, car sharing can be used for commuting, go to the school or the workplace.

A survey from Eva Fraedrich in 2018 stressed the fact of shared vehicles as a tool to improve the cities. The survey was made for 24 professionals in the city transportation system field. Most of them from the 'Association of German Cities' expert commission on transport'. Among the different positions each respondent has, most of them are from the municipal transport planning. They were asked first, about which plans every municipality is working on and then, how different autonomous vehicles can help to that improvement of the cities. The different answers to the first question showed up the aim to reduce motor transportation, improvement of the transportation system and also reduce noise and air pollution. Other answers to improve safety issues and road capabilities were the least chosen. Shared vehicles were considered positive in terms of achieving the city future plans, half of the respondents pointed out that they can help to improve the mentioned ideas.

Discussed the positive and utile function of SAVs, it is important to analyze the opinion of the public about this topic. Will people use this system? It is understood as an option for those who do not have access to a private transport, therefore it is going to be considered in terms of the opinion about the technology. In an Australian survey of 2016, the 82% of the respondents held a driving license and owned a car, and they had an explanation before answering the survey and a hypothetical case of prices and time about different SAV's options. More specifically, with more people or not. The results pointed out a willingness to use SAV in the future, especially including the dynamic ridesharing.

Considering autonomous taxis as another option regarding cities mobility, they are less likely to be a main concern in the future. Autonomous cars main reasons to appear are safety, enhancing the driving experience and reduce pollution. As a taxi is driven commonly on the city, and the activities being a passenger are similar to those driving a fully autonomous car can experience, not a strong effort is going to be made. In addition, taxi companies employ such an enormous amount of people between drivers and office operators.

Despite this, common opinion reflected on the Intel survey showed up that Taiwan people are the less scared about using autonomous taxi services. Another time, Australian population seem the most concerned with just a 30%

of probably use of the technology. Regarding the tests Uber made in the US until the fatal crash that happened on March of 2018[35], it can be said that some progress is being made in this field. It is important to say that UBER had not a developed technology as Waymo or other car manufacturer leaders. In a New York time article, some struggling with Uber technology was pointed out[36]. While Waymo could drive even 5600 miles before having to take control of the steering wheel, Ubers' record was 13 miles. Taught drivers supervising Ubers' driverless cars had to take control of the steering wheel at every difficult situation that was presented. It opens a discussion about public opinion. The Uber crash was spread (as it obvious) on the media and the focus was set on autonomous vehicles. Such events jeopardize the opinion of the potential clients and it is important to be sure about such risky technology before launching it.

Human error is not presented in other transport systems as a deep hazard to safety. Trains, boats or airplanes have already implemented several autonomous features even though they still need human interaction for their correct functionality. One of the reasons to make this kind of transports fully autonomous could be the absence of human presence, regarding a cheaper maintenance of the transport. If economic resources have to be used in order to turn the technology into reality, having the low expected benefit, it is easy to understand why the technology of this transport systems is not spread worldwide. Regarding public opinion about these alternative ways of transport, the survey made by Rakuten pointed out the choose of autonomous vehicles as the autonomous transport choice to ride. The autonomous car choice was followed by the autonomous train, it can be explained regarding the lack of interaction with the surroundings that a train has. People may feel comfortable about this technology considering it safe, at least, safer than autonomous airplanes or boats.

## 3.4 The Society of Tomorrow

Any prediction about what is going to happen with autonomous vehicles technology can be similar to the prediction on 'Back to the Future' films, completely uncertain. Car manufacturers are announcing several automation features within the next few years, but the real change will come when level 5 of automation is reached. Until that moment, the public will be optimistic about purchasing partially autonomous cars, car accidents may start decreasing by then, however, the question involves the generation is going to face the real change by the time no steering wheel nor driver is needed anymore.

Regarding the current state of the art, with the common knowledge about autonomous cars and the confidence feeling of driving your own car, public seem distant from the next future advances in the named field. Autonomous vehicles are seen as potential weapons for hackers and a danger for road users and are not popular among the population of the countries such technology can

bring changes. Despite this, it is remarkable the fact that publications about autonomous technology are increasing and also the topic is moving from the specialized media to the mass media

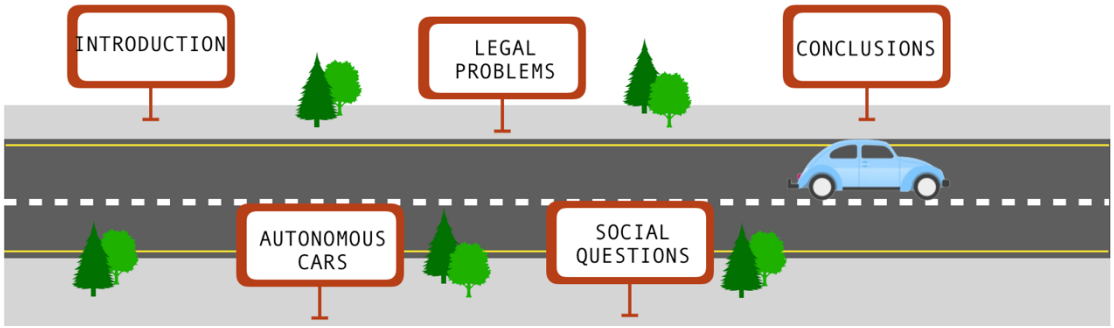
Are the different generations react to the autonomous car technology in the same way? That is not probably going to happen. The called 'Millenial' generation has seen the internet being common worldwide, the invention of smartphones, and the wearable tech flooding the scene every day. As cars exist nowadays, maybe the change to autonomous cars is not as disruptive as expected and that is probably the reason why is not considered an impressive change, regarding the time until high automation level turns into a reality. Despite this, the rough part of the evolution from a way of transport to the autonomous car one is starting. Once it has started and young people try the technology, if it is harmless as it should be and can improve the quality of life of the public, it is going to be the chosen option. The problem is that even if the self-driving car would be available today, the young people nor the old one would buy it. Therefore, there is still a lot of work to do. What happens with the 60's generation? In a few years, adults between 40 and 60 years old will be the ones with more incomes to purchase this technology. Are they convinced of its benefits? Probably if you are not a fan of technology, you are not. And this spot of the market is going to decide whether the autonomous cars turn in a rentable solution for manufacturers or not.

Talking about manufacturers, the power of the technology is on their hands and the influence they can have above the public is vital. They are the developers of the technology and the responsible ones when talking about testing. It is also important that the economic benefit interest stays under the safety one. The test part of autonomous vehicles is going to determine whether they can behave well in a real situation or not, making people aware of how safe they are. A lot of manufacturers are investing large quantities of money in this technology and it is important for them to cooperate. The market competitiveness is also useful in order to be motivated about developing a new technology that can make your company ahead and have strong benefits. As it is said before, the fast progress has to come along calm because a bad public opinion and your cars are never going to see the sunlight. Making public demonstrations can also have an influence on the public and experiences along marketing campaigns when the time to bring the technology to the market is approaching, can have an impact on the public opinion. Another challenge comes with the price the autonomous cars are going to cost. If people seem in doubt about purchasing the technology, an expensive price is not going to help.

The government has an important role to variate the way the technology is going to evolve. Regulations, laws, fares, taxes, subventions, agreements… They have to mix with responsible developers and market experts to benefit the common good with this technology. The first step about regulation is to permit road testing, considering the development of the partial autonomous cars by now, Vienna and Geneva conventions are not an imminent problem to deal with.

It is still going to be a driver on the steering wheel at the moment, so insurance regulations and solutions to manufacturers are the challenges to beat by the Governments. If the Government and the experts collaborating show an optimistic attitude towards autonomous cars, the public will follow. It has been mentioned the progress being done by several countries that points out some progress in this field.

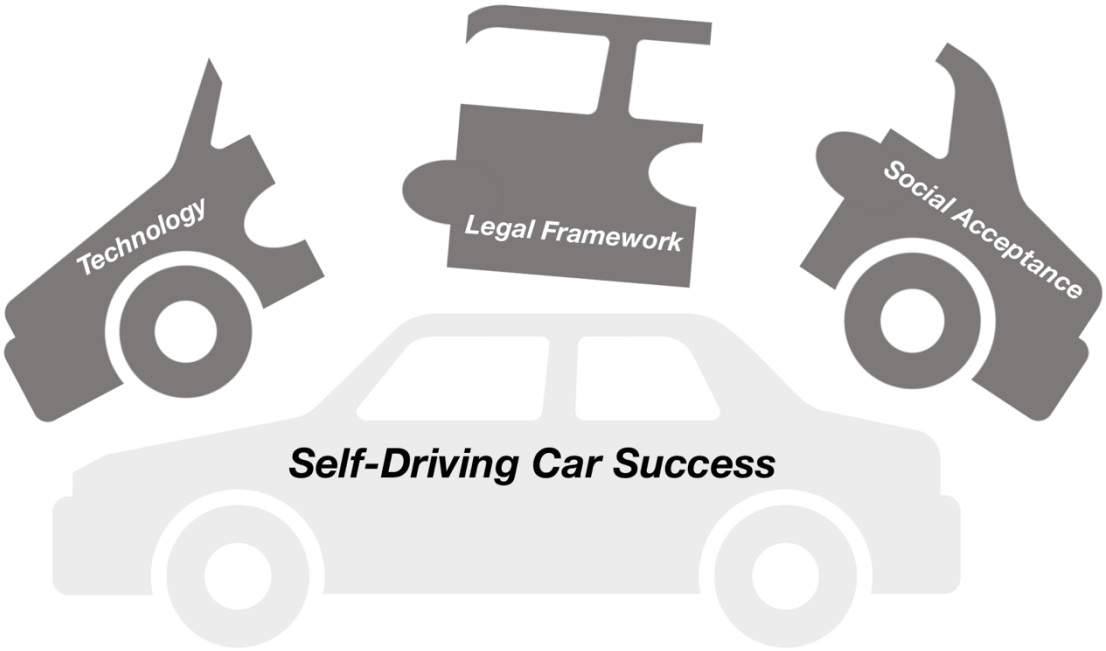
Last but not least, the way the society of tomorrow is going to face autonomous car technology also depends on mass media. It is known the strong influence media has on the population and a positive opinion about autonomous cars can help the public to join the progress. When Uber accident occurred, assessments against the whole technology were made. Such event made mass media sharks smell the blood of money coming, posting the new to provoke a conflict. If it was redacted with the information about other autonomous cars progress and evidencing that Uber was not in the lead, it would set the focus on Uber, not the whole autonomous car market. This is just an example of how mass media can influence the mainstream opinion, but it can be also beneficial to autonomous cars if publications about the technology advances are made.




## 4 - Conclusions

The way Self-Driving car are going to evolve, depends on three important parameters: technology progress, legal framework and social acceptance.

*Figure 11: Different Needs for Self-driving Autonomous Cars Success*




High level of automation will become a reality in a very next future. The necessary technology is not developed yet, and the social and legal barriers the technology has to bear with, are too high to be able to be climbed for the moment. The fact is that high level of automation autonomous cars is the key to the whole transportation change. Features like the self-parking, the communication between vehicles to avoid traffic jams, eradication of accidents, no need for insurance policies, city adaptation to the technology, elderly and young public purchasing the technology… Depends on the level 5 generation.

With the partial automation almost accomplished, next step is based on the conditional automation (Level 3), where the car is going to be able to drive by

itself in certain situations with a human driver on the steering wheel, taking control of it when needed. Regarding the current state of the art, this level of automation is possible to be accomplished because the need of a human driver bears with almost all legal issues, insurance can still work as it works nowadays and having the driver as the backup for any problem the technology may have made it 'safe'. The discussion with this level of automation can be based on the time the human driver has to take control of the vehicle and the way the vehicle is going to communicate with the driver in case it is needed. Also, issues about system malfunction and hacking have to be solved when these vehicles come into the scene.

Presented this level of automation, which benefits can bring? It can be pointed out the avoidance of certain accidents, which ones? The driver still has to be sober and paying attention to the surroundings so the accidents because of distractions and alcohol problems, cannot be eradicated with this system. Moreover, thinking about critical situations taking place right before an accident, it is likely to think that the car will ask for the human driver reaction when they happen. This level of automation can disengage the driver attention to the road in easy and long journeys because they will likely behave weirdly in daily city situations where the driving experience involves so many human errors and acts far from the corrects ones. Are the clients going to pay for such benefits? It is also said that having this software on the vehicle involves an overexposure about data privacy and the electronics on the car themselves.

Here is where the contradiction shows up. The 5 level automated cars, with a human-like behavior imposed by the software and the self-learning, can improve life quality and change the way transportation works. However, to accomplish the level 5 of automation, the progress has to come slowly, with lower levels of automation that can bring fewer benefits to the public but can collect vital data for software developers and car manufacturers. Also, this slow evolution helps the governments to take solid decisions about the regulation and can draw a path for insurance companies, increasing public awareness and optimistic point of view. The way this technology gets slowly on the market has to be almost perfect though, any malfunction, car accident, hacking case, whatever, and the mass media will throw autonomous car technology to the dogs. It happened with Uber, even it is said that were not a reflection of the real technology progress, the accident made them stop the tests on public roads which add more time to developing the technology.

It is important to mention how much work left to do the Governments have. It has been shown in the countries subsections, that most of them are collaborating with brands and experts' committees in order to progress together in all the areas involved. Despite this, precise autonomous cars regulations have to be made. As a new technology but an old transport system, almost every legislation made until now has to be adapted or changed. And the challenges this technology has to deal with are very different from the one a conventional vehicle has. There is a need to regulate the ethics involved in autonomous car

> software, build strong legal walls against hackers, solve the difficult field of liability… Some of the issues to deal with are currently on its way, however, almost most of the European Governments have not accessed to open public test beds on public roads for autonomous cars. And still, have strong regulations about road mapping and data traffic that set some limits the technology is ready to solve.

The process has to be similar to raising a child. The government would be the instructor and the car manufacturers the child itself, having the public acceptance as the child environment. Governments have to look for them but also give them certain freedom as they can make progress on the technology without any barrier. The governments have to set the boundaries and supervise how manufacturers develop the technology but showing them a clear pathway. If this process is done in a good way, the public will automatically accept the autonomous car technology as it is and will take profit of it.

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