The Autonomous Vehicle:

End of the Road, or the Beginning of a New Era?

ROMAIN ANSELMETTI

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Abstract

The Autonomous Vehicle is about to enter the mass-market. The question is not about when it will happen but in which conditions, under which form or who will be the first car manufacturer to release an efficient and reliable final product.

By now, the equation has not been solved, due to the high price of the technologies needed, the lack of solutions to provide a reliable network, and the necessity to change conventions established a long time ago in terms of responsibility of the driver.

Depending on who is talking, the Autonomous vehicle is not only an evolution of a previous product, which is able to evaluate and to progressively transform into something different that we could call a self-driven car. This innovation is one step further and is challenging everything that was established until now in terms of objective criteria expected from a car. This is why some are calling this a disruptive innovation, or even a revolution, in the sense that it has the power to totally change the way we are interacting with our everyday transportation system.

To enter into the market, this technology, this product, will have to overcome some challenges, on the technological side but also on the psychological side of his future clients.

Therefore, this thesis research analyses why this innovation could be the future of the Automotive industry, where it is coming from, what are the challenges it will have to overcome, which will be the impacts, and the different possible scenarios.

Keywords:

Autonomous Vehicles, Innovation, Sharing Economy, Strategy, Business Model
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Foreword

First and foremost I would like to express my profound gratitude and my sincerest appreciation to my supervisor, Andrés Ramirez Portilla, who did an amazing job guiding me, recommending me through the writing process of this thesis paper. His critical feedbacks helped me understand the meaning of a scientific paper and I did my best to fulfill his requirements. He supported me when I was hesitating and it permitted me to improve the final results. For this, thanks a lot Andrés.

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In addition, I am thankful for the time and insights that our interviews – Christophe Aufrère and Eric Nang-Tchee – shared with me.

At last I would like to thank my friends and family, for supporting me through every steps and decisions I had to take.

Romain ANSELMETTI

Paris, May 2016
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Definitions and Abreviations

Before starting, we should define the different terms and expressions that will be mentioned in this study.

- **Creativity** is the ability to bring something new to existence (Storr, 1994). Steve Jobs also said “Creativity is connecting things”.

- **Innovation** is translating an idea or invention into a good or service that creates value (Tidd, Pavitt & Bessant, 2001)

- **Technology** is the application of scientific knowledge for practical purposes, especially in industry.

- **Innovation diffusion** refers to the theory that every market has groups of customers who differ in their readiness and willingness to adopt a new product (Rogers & Shoemaker, 1962)

- **Disruptive innovation** is the process of innovating in a different direction of the mainstream business, to go out of the boundaries while losing closeness with customers (Christensen, 2013)

- **Sustainability** is the continued development or growth, without significant deterioration of the environment and depletion of natural resources on which human well-being depend

- **Ethics** are a system of moral principles and a branch of philosophy which defines what is good for individuals and society

Will be used as Abbreviations:

- **AV**: Autonomous Vehicles
- **EV**: Electric Vehicles
- **OEM**: Original Equipment Manufacturer
- **NHTSA**: National Highway Traffic Safety Administration
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1. Introduction

1.1 Background

Since the first mass-produced vehicle, the Ford T from 1908, a large number of evolutions changed the characteristics of the mass-market vehicles. In those years, having a car was a luxury. Nowadays, it became mainstream, and the automotive industry is following several trends that are daily shaping it into something better – improving, for example, safety, efficiency, connectivity. Among these trends, there is one trend which stands out as having the potential to be a game changer for urban traffic systems (Wyman, 2001): the Autonomous Vehicle (AV) Technology. A technology that every main actor is trying to develop as fast as possible, in order to build cars that will, in a more or less distant future, be able to drive themselves (Boston Consulting Group, 2015).

To do so, the AVs use a set of radars, cameras, GPS, motion and ultrasonic location sensors, accelerators, and of course computers to manage the data, the operations and the decision taking. An AV is a vehicle capable of sensing its environment and navigating without any human input. The AV thus have control systems capable of analyzing all this data to go from a point A to a point B while distinguishing the different cars on the road and while managing the unexpected to happen.

The technology is everyday improving and step-by-step, the customers will get used to its benefits. The first indicators are the options available while buying a new premium car: indeed, driver assistance systems are starting to become mainstream on the market. Auto-parking, lane warning, intelligent cruise control, emergency braking, are technologies that are started to get generalized, still in option but without any hesitation in serial in a few years. At first sight, we could think that these driver assistance systems will evolve gradually into fully AVs, but that’s one of the misconceptions associated with AVs. The approach and the development of assistance systems that operate for a few seconds has nothing to do with the development of a technology that allows a system to make a car drive itself continuously for minutes or hours.

Nevertheless, the technology is on its way to the mass-market and there is no longer a debate about if it will happen - but when and how it will happen and who will the main players be. Who will be the first city in the world fully equipped with AVs, or who will be the first Original Equipment Manufacturer (OEM) to put up on the market the first reliable AV.
Then, some strategic questions have to be answered by the traditional players of the automotive industry: of course OEMs have an important role to play, but the suppliers have a heavier weight we could think on a first thought, and technology providers like Google for example entered the game. The patriarchs of the industry (Volkswagen group, General Motors, Toyota…) are getting “tickled” by new-comers like Tesla, most advanced OEM in the development of AV and electric cars. Moreover, they are integrating vertically, developing their own self-driving system and providing their own batteries.

Indeed all these questions are relevant to be studied and answered, however in order to contribute at least to some extent in understanding this phenomena, it is necessary to focus on investigating one idea. This research focus of this thesis is explained in detail in the next section.

1.2 Purpose

The aim of the study is to contribute an analytical framework of the dark side of innovation, technology diffusion, technical change in mature industries, related to the specific case study of the AV technology. The objective is to provide arguments to state the fact that some technological innovation has different aspects which have direct effects on employment, industry, environment, people behavior, and that the Autonomous Vehicle technology is one of them. In the end, the objective is to challenge the decisions taken by the leader automotive groups and to make a state of the art of this innovation. Obviously, AVs have a lot of positive attributes, and they will be mentioned in this study, the objective being to demonstrate that those innovations also have some negative aspects that can’t be avoided.

The purpose of this report is then to provide an analysis of potential benefits and disadvantages that the Autonomous Vehicle (AV) technology could provide to the final customer and, most generally, to the global automotive industry. A particular attention is paid to the question of sustainability and ethics in the specific context of the introduction in the market of the AV.

This report should be able to answer to the question: What is the Autonomous Vehicle technology, should it be considered as a disruptive innovation, and what impact will it have on the society and the automotive industry?
In this study will mainly be considered the automotive industry including individual cars, which could be driven by someone owning a driver license. Unfortunately, the innovations and technologies mentioned in this study are for the moment mostly dedicated to developed and developing countries, due to the fact that the infrastructure and solutions are not yet available in undeveloped countries. Figures from the CIA’s World Factbook explained by The Telegraph (2016) show that some countries have less than 100 kilometers of roads referenced for example.

The study conducted is mostly based on qualitative data, the information coming from the interviews conducted in relation to this paper and what could be found in specialized Medias, press and on the internet. Some quantitative data have been extracted from surveys made by professional interviewers for the creation of reports from market and technical analysis. Those reports could be found on the internet and will be mentioned as references when specific data will be extracted from any of them.

The study mainly focuses on experience based on the European automotive market, and relies on data from the European, Asia and US market. All the forecasts and expectations are only under the responsibility of the research firms that conducted the surveys associated.
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2. Literature Review

2.1 Concepts of creativity and innovation

The concept of the AV is an innovation that could be compared to any other innovation concept: Adeney (1994) mentions the example of the knife to prove his point about the dark side of every new technology on the market. He mentions the fact that “a car may be used to rush a sick child to the hospital, or it may be used as a weapon to run over an enemy”. This example of double standards is a relevant argument to prove that an innovation is not either black or white: we need to contrast the attributes of an innovation in order to define its positive or negative aspects.

McLaren (1993), also mentions the dark side of creativity, meaning “the harm that scientific and technological creativity can do.

As a matter of fact, “Science cannot claim moral neutrality, much less moral indifference” (Snow, 1961). When an innovative technology arrives on the market, especially when this innovation is coming from a large industrial group, it has only one final purpose: create benefits. Whatever the way it is presented, the communication strategy that the company/group chose to apply, when an entity decides to invest money in the development of a technology, of a product, of a process, especially an innovative one, the objective is to create value that could deliver profits then benefits.

In the meantime, creativity is well-received by the global customer market. Creativity and Innovation are correlated to efficiency and effectiveness, Tsanoff (1949) goes even further and says “What is this creative power of mind? Excellence so transcendent cannot be due to merely human powers; some divine principle speaks in the sage or see of poet”. Plato (1952) even mentions it as a “devine influence”.

As mentioned by McLaren (1993), the “concern for the negative impact of a new technology is not a new phenomenon”. The industrial revolution that occurred during the 18th and 19th century that was made possible by the creativity of industrialists, was pointed by literary figures such as Coleridge or Victor Hugo for its devastating effects on domestic life among the poor and working classes.

Some may say that it was the price to pay for the world to grow and to develop. This may be true for the society, even if some facts could prove the other way around. But for a company, innovation is central, we should even say necessary. Abernathy (1978) was able to make the conclusive argument that “companies may change themselves to foster innovation as they grow and prosper”. Indeed, innovating is a way of staying successful in a very competitive marketplace, in the sense that if competitor A releases a disruptive innovation valued by the customers, competitor B could lose market shares and, without providing an alternative, get bankrupted.
2.2 Contrasts and impact of innovation

Every innovation has a technical, technological side, but relies on an economical side, without which it couldn’t work. Indeed, “rapid technological economic growth is an effective way to create wealth, such growth primarily benefits a small elite” (Adeney, 1994). That means that some innovations are not improving everybody’s life but only a defined group of individuals, and that it increases the gap between the different segments of society. “Technology often seems to benefit the few at the expense of the many”.

Some innovations have good sides but include the risk of having devastating bad sides – there is no better example than the nuclear power technology. This technology permits millions people to have access to electricity, but its civil use includes the possibilities that we all know, not to mention the disaster that occurred in Fukushima in 2011 or, even worse, Tchernobyl in 1986.

An innovation also have an impact on our everyday’s way of behaving with other people for example, even if we are convinced of the importance of this new product in improving our day by day routine. How many times did we hear from the persons that are not really into new technologies, when a new product entered the market, that they will continue to live their lives without it and that they don’t want to be part of it? The smartphone is a really good way to illustrate this fact. With yearly sales of 1433 million in 2015, this is a good example of an innovation that took a lot of space in our lives. Did it improve our life? Obviously yes, since we can now have access to a whole world of information, culture, directly in our pocket. Did it increase our knowledge, our will to culture ourselves, read books or encyclopedia? Probably not, because even driven with good intentions, innovation and new technologies can sometimes become a distraction and the humankind is able to find a way to turn a genius invention into something worthless, or at least use it a different way that it was meant to be used at first glance.
2.3 Control and limits of innovation

Then comes the question of the control of innovation, and its limits. First, not every organization has the capacity to invest in large scale technologies. Only large companies or governmental institutions have the resources needed to invest in expensive Research and Development. The difference is that governmental institutions are public institutions, which must follow international or regional rules, while on the other hand, companies’ innovations are in private hands. Capitalism claims it is safer, while Socialism prefers to see such power monopolized by the state (Ardenay, 1994). When companies start to have the investment capacity of large institutions, boundaries and rules should be established. But how a governmental organization could be able to have the level of expertise of a company which is pioneer in a specific topic? Does even companies have control on the innovation they create? Adeney (1994, p. 23) claims that “The power of technology must pass from the control of tiny institutional elites”. As a matter of fact, institutions that control technology are motivated by power, profit, and to do so they are looking for competitive bias, new ideas, and new products. In order to stay competitive on a specific market, some companies must do choices, take decisions, and under, they could do mistakes and take the wrong path. Volkswagen group, to gain competition for the most efficient diesel mid-engine, took the responsibility to include an adaptive software in the on-board computer that could adapt to test procedures, while competitors took the decision to invest in expensive hardware solutions. Unfortunately detected by NHTSA (National Highway Traffic Safety Administration) modules, this software could cost Volkswagen more than $34 billion according to the last estimations from Forbes (2015).

This is one more proof, if needed, that within a competitive industry, taking risks is central and even for a large group like Volkswagen, evaluating the consequences of a decision and managing the risk is central. In the worst case scenario, Volkswagen could lose customer faith, and then the sales volume could go down, carrying with it the production volumes… which directly impact employment. We will address later the topic of employment in the negative aspects of innovation.
3. Methodology

3.1 Research and methodological approach

The aim of this report is to challenge the outputs of the AV technology, and even focused on the dark side of this innovation, it is very important to specify that the objective is not to prove a point which would make this technology look bad for the humankind, environment, and industry. Nevertheless, after mentioning the positive aspects of this innovation, the purpose will be to clarify the situation on several topics related to this novelty, and to replace into its context the popularity, passion, craze that it aroused.

Thus, the objective will not be to state the “good” and “bad” attributes of the AV, but more to detail with precision the positive outputs of the technology, the problems it will solve, the difference it will make in our lives, while challenging it with all the problematics it will have to solve, and the ones that will not be solvable.

The figure 1 is a graphical representation of the conceptual framework which could be used to explore a field in the context of a disruptive innovation within a mature industry. The AV could be described this way, and the aim of this research was to challenge the outputs outlined in this figure.

![Figure 1: Conceptual framework of the fields explored](image-url)
The data gathered in this paper is coming from several sources, from the main players and actors, both from the company side, governmental authorities, analysts, and customers. The path followed for the exploitation and analyzing of these data was to stay as raw as possible, in order to maintain an objective and relevant judgement to conclude. As mentioned earlier, the study is mainly based on qualitative data, the information coming from the interviews conducted in relation to this paper and what could be found in specialized Medias, press and on the internet. Some quantitative data have been extracted from surveys made by professional interviewers for the creation of reports from market and technical analysts.

Therefore, the study reasoning is mainly inductive, in the fact that from qualitative data are deducted specific observations allowing to make broad generalizations. Indeed, the conclusions don’t stand as a ‘truth’ but the objective was to get closer and closer to it without ascertain with complete certainty. The inductive reasoning has its place in the scientific method according to Bradford (2015); scientists “use it to form hypothesis and theories”.

3.2 Interviews

In order to provide detailed and personalized information, in relation with the fact that for example companies are only communicating while using saleable and marketable arguments, 2 interviews were conducted. Those interviews allowed to take in consideration some problematics that are sometimes not addressed by the regular articles because too specific or irrelevant. These interviews provided strict and precise information from different perspectives, improving the knowledge and understand of the challenges from the marketing view, software development view, infrastructure and regulations view. The 2 individuals interviewed were all from the industry but occupied significantly different positions, which happened to be truly interesting because they were not always sharing their point of view regarding the direction this technology was going, and which impacts it would have in the future. It is relevant to remind that their points of views are of course subjective and driven by their environment.

The first interview was with Christophe Aufrère, Chief Technical Officer within Faurecia Automotive Company, the largest French tier-1 supplier and the seventh worldwide, involved in the development of lightweight solutions, automotive seating, interior systems and Emission Control technologies. Faurecia is directly involved in the decision process and is a source of proposals for all the OEMs they are working with, all around the world.

The second interview was with Eric Nang-Tchee, Engineering Technical manager within FAAR Industry, a small French Company providing expertise in the development and production of embedded electronic control systems for vehicles such as engine, transmission, body control, electric vehicle supervision and so on. Since a few years now, they are involved in the development of turnkey contracts for short series AV, with a fast innovation and decision taking opportunities due to their small size compared with larger structures.

Please refer to Appendix (chapter 6) where the main questions answered are listed.
4. Findings

In this chapter, combined knowledge from the theoretical framework, the case study and the interviews will be analyzed in order to create a state of the art of the technology involved in the development of the Autonomous car.

It makes common sense to say that the purpose of innovation is to solve a problem. The AV happens to answer to a lot of problems and is providing efficient solutions to the society.

The societal benefits of autonomous driving are easily identifiable – decreased traffic congestion, improved road safety and reduced carbon emissions. But will the automotive market turn into a sharing economy or will it stay as an individual luxury? Could it turn the Automotive market and the way we are interacting with the transport systems more sustainable? Just by taking the time to think about it permits one to recognize that AVs represent a significant paradigm shift to the mobility ecosystem – not only a technological revolution, but a value chain transformation. They offer several benefits once deployed, but a large number of challenges need to be resolved to achieve this sustainable mobility ecosystem in the future.

The US market is a good example of what could be the impact of AVs on our everyday life. Let’s start by providing some numbers: the automotive industry is a critical component of the US economy, with “7 million private sector jobs supported by auto manufacturers, suppliers and dealers in the United States” (Center for Automotive Research, 2015). This number includes people employed by the Original Equipment Manufacturers (OEMs), in the automotive parts sector (including workers in the rubber, plastics, battery, aftermarket, and parts export sectors), and in the dealer network. Still according to this report, “Every vehicle manufacturer job creates almost 7 other jobs in industries across the economy”. This is providing $500 billion in annual compensation and is accounting for approximately 3 percent of Gross Domestic Product (GDP).

Regarding safety, John Maddox from NHTSA reported in 2010 that there were approximately 6 million vehicle crashes, from which 32,788 led to traffic deaths, or approximately 15 deaths per 100,000 people. In fact, vehicle crashes are the leading cause of death for Americans between 4 and 34. And of the 6 million crashes, 93 percent are attributable to human (Maddox, 2015).

Now, how often are cars used by a single individual? The average American spends 250 hours a year behind the wheel of a vehicle according to the US Department of Transportation. This is the same amount of time that this same average American could spend doing something else, pursuing other interests. The value of that time is measured in low productivity, and its related cost is high. According to the website Edmunds.com (car-shopping website), on average, a car is unused 22 hours out of every day.
If the goal of the AV is reached, which basically tend to be a “crash-less” car (Volvo promised 0 traffic deaths due to their new vehicles at the horizon 2025, for example), this technology could save lives, time, and improve our everyday life. To which cost, and what are the side effects, will be the purpose of the next part.

4.1 An attractive new business to dominate

The AV is the emerged part of a new business that will mainly be shared between two groups of actors: the OEMs and the software providers.

The first group of actors contains all the automotive players, including the OEMs that are directly or indirectly working on the development of AV and the technology it will have to rely on. We could mention the traditional players, the patriarchs of the industry like the large automotive groups (Volkswagen, General Motors, Toyota, Fiat Chrysler, Renault Nissan, Tata…), but also the new-comers like Tesla, and all the suppliers which are, in the end, the ones delivering the software (Robert Bosch, Denso Corp, Johnson Controls…).

The second group of actors is the trickiest to identify because its business model is not yet clearly defined: it includes the technology providers, not to mention Google via Alphabet, its parent company, Apple, but also the maps providers like Nokia for example. What are they looking for is real-time driver data coming from the different gadgets embedded in each autonomous cars.

According to Eric Nang-Tchee, from FAAR Industry, Google has no will to become one day an OEM. Its only objective is to be able to be the platform of communication for the main informations that will have to be shared between an autonomous car and its network.

Eric explained that the reason why the AV is a revolution doesn’t stand in the fact that it will change the way the customers will consume the technology and its benefits and its properties.

The AV shouldn’t be only considered as a set of tools that will be implemented as the technology will improve thanks to the development of new modules, software, which will have to drag the development of communication solutions between cars (Vehicle to Vehicle – V2V) and between cars and infrastructures (Vehicles to Infrastructure – V2I).

The AV will not only be a system communicating with an infrastructure in order to have access to pre-established maps and informations and use them to go from a place to another, but as it will be able to read the road, analyses the interactions in real-time, the technology will then permit to transfer information and to create data that will be implemented in the global system.
4.2 The Google Car specific example

As a large set of systems connected between them (radars, infotainment, thermometers, and accelerometers), the AV will be the main tool for the development of a Big Data network. The main contributors will be the final users, but also the technology providers, since this type of data will be implemented in their systems, and this is where Google for example is willing to become a standard.

Google’s business model is the organization at an international scale of the information and to allow its access from any part of the world. Naturally, the access to this source of information is most of the time free but always comes with a source of revenue, which could be personalized marketing, ads, or the re-sell of informations of communications.

The strategy behind the GoogleCar development is to test the implementation of those numerous informations into a database that will then be usable on a larger scale, directly implemented and in real-time updated within the software on which will rely the interaction of the AV with its environment.

Added to the Google database, the informations gathered by the AV have infinite applications, on the same scale as the browsing history of a regular internet navigator has on our daily use of the internet network.

The trip between home and work for example will then be a totally new experience, thanks to the new features allowed by the exploitation of the information gathered by the on-board Google software. Thanks to the geolocalisation and to the numerous captors embedded in a connected and AV, the car computer could be able to detect your hungri ness and to propose you a detour by a restaurant of your favorite food, based on your previous researches, and the source of revenue would be a commission on the menu.
4.3 Scenario Analysis

Different scenarios are possible for the supposed expansion of AVs. Its development relies on 5 main criteria:

- **Technology Readiness and Availability**
  
  - How much the technology is advanced, how many years it will take before a reliable version? Google is already doing more than 10,000 miles a week with its Google Car, totaling yet more than 1 million miles in the streets of both Mountain View, California, and Kirkland, Washington. Until now, only one crash happened, in February 2016, proving firstly that the technology is not ready yet, but in the meantime, only one crash, at 3km/h, after more than 1 million miles (Google website, 2015) is quiet encouraging. What is missing is the convergence of sensor-based technologies and connected-vehicle communications, according to a KPMG and CARgroup report from 2015. The perception of the global environment is central for the accuracy of an AV decision taking. Unfortunately, so far the fusion of available sensors and artificial intelligence is not capable of seeing and understand the vehicle’s surrounding as accurately as a human being can.

- **Cost, customer willingness to pay and perceived value of the innovation**
  
  - The solutions needed in order to make this technology viable, reliable and practicable are for the moment, very costly. For example, creating a 360-degree view of the vehicle’s environment requires a combination of sensors and radars, and it may cost more than customers are willing to pay. 360-degree systems are the minimum requirement and must be associated with Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) for an AV to be able to operate in a secured and accountable way. The problem is, such a system actually costs $70,000 dollars in the Google Car for example.

- **Customer innovation acceptance**
  
  - No timeline is mentioned here. Some analysts are talking about a full AV technology available in 2025, some are talking 2030, 2035. Whenever it will be, the customer acceptance will be what will determine the market entry, or not, of the AV. As for any new technology, legislations, behaviors, needs, willingness to pay and desire will be really different depending on the region of the globe and social class of people.
- Infrastructure

  o As stated before, the AV will be a connected vehicle or will not be. To do so, an infrastructure will have to be created, associated with a legal basis. When we mention infrastructure, it’s both on the hardware and software side. Will it be necessary to standardize? Those questions have to be answered by the authorities and will most probably differ from a country to another. The governments and regulatory bodies have to develop future state urban network that address the gradual increase in vehicle automation, network connectivity and data requirement of AVs; these vehicles are gathering 750 MB/sec of date while fully functioning, and the infrastructure must be ready to provide a full-time reliable connection to the network for V2V communication. In the meantime, the authorities will have to anticipate the evolution of the technology and impact their solution choice, thanks to independent research and analysis. The conclusions will determine the new urban infrastructure. On the other hand, the infrastructure will rely on the technologies available in the portfolio of telecom companies. More than just a requisite data transfer speed, the telecom companies will be responsible of data mining and privacy.

- Specific legal basis

  o We shouldn’t forget that the AV is developed to answer to identified needs in the market. We already mentioned some requirements but the main purpose is to delegate the driving to the integrated computer of the AV. Thus the question of the responsibility if anything not planned happen will have to be addressed by the legal structures and one again, they are different depending on the continent, the region, and the country where the AV is used. For example, in order to allow the Google car to drive itself on the US roads, some legislations had to be modified. The same problem occurred in Europe, where the central legislation in Brussels had to adapt the Vienna convention via an amendment to authorize an AV to drive on European roads.
4.4 The solution to a lot of expected recitals

From what is mentioned above, the future automotive market looks bright, thanks to the AV, at least from the final customer point of view.

Some key facts and trend indicators (UN World Urbanization Prospects) can help to have a glimpse of what is the present market made of, on the specific subjects that the AV is focused:

- Road accidents are the 8th leading cause of death globally (the seven first are diseases)
- 95% of road accidents are due to human error
- 2 times more delay hours due to congestion in traffic by 2050 without a clear change
- 6.3 billion urban dwellers accounting for 70% of population by 2050

By the solutions that the AV provide, associated with a relevant infrastructure, relevant and reliable technology, with positive feedbacks from the final customers, this forecast could be embellished. The Earth Institute at Columbia University also estimated that autonomous driving can improve fuel efficiency by over 50% in some circumstances in developed countries.

Some countries are already looking forward to this technology, this is the case in Japan where the authorities and government roadmap aims to introduce the practical use of “Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communication by 2020 and fully autonomous driving by 2030” (Roland Berger, 2014)

As we can see in figure 2 (next page), there is a few more stages before having a fully AV for sale in the market. Going from a level to its next one doesn’t only include technology evolution, but all the factors that we mentioned in the scenario analysis as well.

In its final form, which could be available between 2030 and 2050 depending on which consulting firm or expert is talking, the autonomous will provide a fast, secured, adaptable, reliable transport system in the regions it will have been accepted by the authorities and adopted/imposed to the customers.
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### Stage Notes

<table>
<thead>
<tr>
<th>Stage</th>
<th>Notes</th>
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<tbody>
<tr>
<td>Level 2 - Limited Automation (steering, braking and lane guidance)</td>
<td>This is the current state of art, available on some new vehicles.</td>
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<tr>
<td>Coordinated platooning</td>
<td>Currently technically feasible but requires vehicle to vehicle communications capability, and dedicated lanes to maximize safety and mobility benefits.</td>
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<tr>
<td>Level 3 - Restricted self-driving</td>
<td>Currently being tested. Google experimental cars have driven more than 1 million miles in self-drive mode under restricted conditions.</td>
</tr>
<tr>
<td>Level 4 - Self-driving in all conditions</td>
<td>Requires more technological development.</td>
</tr>
<tr>
<td>Regulatory approval for automated driving on public roadways</td>
<td>Some states have started developing performance standards and regulations that AVs must meet to legally operate on public roads.</td>
</tr>
<tr>
<td>Fully AVs available for sale</td>
<td>Several companies predict commercial sales of &quot;driverless cars&quot; between 2018 and 2020, although their capabilities and prices are not yet specified.</td>
</tr>
<tr>
<td>AVs become a major portion of total vehicle sales</td>
<td>Will depend on performance, prices and consumer acceptance. New technologies usually require several years to build market acceptance.</td>
</tr>
<tr>
<td>AVs become a major portion of vehicle fleets</td>
<td>As the portion of new vehicles with autonomous driving capability increases, their portion of the total vehicle fleet will increase over a few decades.</td>
</tr>
<tr>
<td>AVs become a major portion of vehicle travel</td>
<td>Newer vehicles tend to be driven more than average, so new technologies tend to represent a larger portion of vehicle travel than the vehicle fleet.</td>
</tr>
<tr>
<td>Market saturation</td>
<td>Everybody who wants an AV has one.</td>
</tr>
<tr>
<td>Universal</td>
<td>All vehicles operate autonomously.</td>
</tr>
</tbody>
</table>

Figure 2: NHTSA (National Highway Traffic Safety Administration), 2013
4.5 The sharing economy disruptive innovation and associated growth

In the meantime, the sharing economy will grow. According to the Boston Consulting Group (2016), 35 million users will book 1.5 billion minutes of driving time each month and generate annual revenues of €4.7 billion. Europe will be the biggest revenue-generating region, followed by Asia-Pacific and North America. In 2015, Europe already boasts the largest car-sharing service per capita, with 2.1 million users and 31,000 vehicles. Figure 3 is providing some numbers to have an idea of the worldwide market.

Figure 3: Car-sharing vehicles & customers in main regions
Still according to BCG, car sharing is taking hold in large urban areas in both the developed and the developing world. But even in Germany, most especially in Berlin, one of the world capitals of car sharing, the service is only one several mobility options and far from the most widely used.

Thanks to AVs, and starting in large urban areas like developed and developing countries capitals (+ suburbs), most drivers will not forgo car ownership entirely and will prefer to choose to use shared vehicles, belonging to fleet of companies that bought them directly from the OEMs.

The modern society is very attached to the car ownership and if in developed countries the tendencies are starting to change, Chinese people for example are on the other hand valorizing this marker of social status, and the transition will be made less easy than in mature countries like Western Europe or North America.

The sharing economy applied to the car transport industry will then need the AV technology to grow and will most probably know its highest grow when the technology will be ready and accepted by the customers. This will have a lot of benefits, starting with the parking struggle, the capitals citizen owning a car biggest fear. Indeed, “in some US cities, parking lots cover more than a third of the land area, becoming the single most salient landscape feature of our built environment” (MIT Press, 2012). Even worse, “in congested urban areas, about 40 percent of total gasoline use is in cars looking for parking” (Edmunds.com, 2012).

In the end, the AV will not only be a solution to accommodate individuals in their daily transport needs, it will also permit to reduce parking lots, freeing new areas for the expansion of urban areas, and permit to save fuel and most generally energy to park. And it would be a mistake to think that this is an exception: the United Nations reported that 82.1 percent of Americans lived in urban areas in 2010, up from 79.1 percent in 2000, and estimated 84.4 percent in 2020, including 28 percent living in urban areas of more than five million people (World Urbanization Prospects, 2011). To finish with, the number of registered vehicles in the United States tripled from 74.4 million in 1960 to 250.2 million in 2010, corresponding to an average of a car for every 2.4 people in 1960 to a car for every 1.2 people in 2010 (Bureau of Transport Statistics, 2012).

If the numbers continue to go down as we can see between 1960 and 2010, the sharing economy and its expected growth thanks to the development of AV could lead into a more sustainable way to buy and use vehicles.

In terms of ethics, the ecological footprint of the Human race could be lowered thanks to the reduction of car production.
4.6 The obstacles to overcome

The AV technology still has a lot of obstacles to overcome. We started to mention them in the Scenario Analysis, such as authorities and society acceptance, and the development of the technical side of the technology.

It makes common sense to mention that the AV technology growth and development relies on a numerous other technologies development, coming this time from diametrically opposed industries, such as telecommunication or energy industries.

The growth of the technology will rely on the capacity of the developers and on the reaction of the market to make the AV become a connected vehicle. Right now, the technologies on which rely the different embedded technologies that allow the driver to release the steering wheel and the pedals only need the vehicle captors, radars, cameras. But in the near-future, the vehicles will carry less and less captors and will gradually rely on the infrastructure, which will become the “eyes” and “ears” of the vehicles that lost their captors. This specific fact point out the fact that without the evolution of the network, infrastructure, the reliability of the communication systems (internet, 4G-5G network, GPS), the AV expansion will be slowed by the development of those technologies.

The development of the infrastructure is a topic, but its standardization is another one: the network that will progressively be created in order to support these new communications will have to be synchronized, coordinated between the different countries and players that will have a role in its development and its exploitation.

Indeed, a quite recent example of a new trend on the automotive market showed that the standardization of the industry should be a topic taken seriously by the authorities and regulation institutes, and this the maximum upstream in order to avoid any mistake. This example is the electric vehicle, which was not standardized and which created a situation where two adjacent countries, France and Germany, decided to develop and install on their respective national territory two different versions of charging stations. This peculiar situation led to the decision of the European council to force France to change their systems, for a global price of €20 million (Les echos, 2013).

Hacking and Cyber security are also hot topics feared by the main players developer teams. Will AVs be worth it? This is the question The Guardian (2016) asked to specialists and the results are alarming: in 2015, a pair of hackers “caused a Jeep to crash” by accessing some of the car’s software through a poorly protected entertainment system. If this is possible for a single car, what could happen on a crowded street of New York, with only 10% of the vehicles equipped with self-driving technologies? The consequences could be tragic.
4.7 The negative impacts on economy and employment

Over the next 5 years, automation and robots will eliminate 5.1 million jobs globally, according to a new report from the Economic forum. The findings are based on a survey of 15 economies that account for about 65 percent of the world’s total workforce.

The World Economic Forum says that “The First Industrial Revolution used water and steam power to mechanize production, the Second used electric power to create mass production, and then the Third used electronics and information technology to automate production. Now a Fourth Industrial Revolution is building on the Third, the digital revolution that has been occurring since the middle of the last century” (Klaus, 2016).

The revolution going on will not help employment in the Automotive industry, and most generally in all the industries and services. Slowly replaced by artificial intelligence, the workforce is less and less valued and losing its relevancy in mature industries.

The AV, supported by the growth of sharing economy, will have an important impact on sales volumes. It is difficult to estimate since the technology is not ready yet but BCG states that “Car sharing will reduce worldwide vehicle sales by approximately 550,000 units by 2021 and cause a net revenue loss to OEMs of €7.4 billion” (figure 4).

<table>
<thead>
<tr>
<th>VEHICLE SALES, 2021 (THOUSANDS)</th>
<th>REVENUES, 2021 (€MILLIONS)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Car sales</strong></td>
<td><strong>Car revenues</strong></td>
</tr>
<tr>
<td>Europe:</td>
<td>Europe:</td>
</tr>
<tr>
<td>21,333</td>
<td>427,158</td>
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<td>18,882</td>
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<td>Germany:</td>
<td>Germany:</td>
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<tr>
<td>3,431</td>
<td>71,700</td>
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<tr>
<td><strong>Sales into car-sharing fleets</strong></td>
<td><strong>Car-sharing fleet revenues</strong></td>
</tr>
<tr>
<td>Germany:</td>
<td>Germany:</td>
</tr>
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<td>15</td>
<td>113</td>
</tr>
<tr>
<td><strong>Lost car sales</strong></td>
<td><strong>Car-sharing use revenues</strong></td>
</tr>
<tr>
<td>Europe:</td>
<td>Europe:</td>
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<tr>
<td>-278</td>
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<tr>
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<td>181</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>Lost car revenues</strong></td>
</tr>
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<td>Europe:</td>
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<td>Germany:</td>
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<td>-28</td>
<td>-852</td>
</tr>
</tbody>
</table>

Sources: IHS, BCG analysts.
1 Includes Germany.
2 Includes aftermarket revenues.

Figure 4: Car Sale Losses in Asia-Pacific and Europe (The Boston Consulting Group)
Out of the more than 100 million cars expected by IHS institute in 2020, it represents only 0.5% volume reduction, but this reduction is only linked to sharing economy by CBS.

In the long-term, the numbers are not precise enough to estimate the volume reduction that the AV will cause. There is no need of numbers to understand that a reduction of 1 million cars means a production need of 1 million less cars.

The other industry that will be influenced by this innovation is the personal transport industry, including taxis and personal drivers. Autonomous cars could make taxi and truck drivers obsolete in a really short period of time.

Regarding the taxis, the service would be different, in the sense that an AV is not able to store your baggage in the trunk, but otherwise, the taxi companies are right to fear this technology coming entering the market. Research firm ARK Invest concludes that the cost of operating a shared AV fleet could be “as low as $.35 per mile, less than 1/10th as much as the cost of traditional taxis, and about half of owning a car” (Cardinal, 2016). This stated, it’s obvious that the employment could be directly impacted by the growth of this technology. There is more than 13,000 taxicab medallion licenses, only in New York, and a market like France means 51,000 jobs. The impact on employment could be dramatic. Some startups are already working on it, such as nuTonomy which starts bringing driverless taxi service to Singapore (Matheson, 2016): “In a 2014 paper published in Road Vehicle Automation, Frazzoli and colleagues estimated that 300,000 driverless taxis, in theory, could do the work of the 780,000 privately owned cars currently operating today in Singapore, while keeping waiting times below 15 minutes”

Regarding the truck drivers, Mercedes-Benz is already working on the automation of truck transports. The Daimler Group company communicates about its “Future Truck 2025” (Mercedes-Benz, 2016) which relies on the same technologies developed for the automotive market. While it could improve drivers’ working conditions and security on one hand, it could also slowly replace them on the other hand.
5. Conclusions

5.1 Implications

The purpose of this study was to make a state of the art of the AV technology perspectives and its impact on society and automotive market.

One of the oldest and most mature industries on this planet, employing 7 million people only on the US market, is about to take a turn that some may call a revolution, which will change the way we use vehicles and most generally will change our relationship with transport in a general way.

This doesn’t come with sacrifices: as some other innovations, it comes with obstacles to overcome, on the technical and societal perspectives. The technology readiness is challenged by the development of other solutions such as telecommunication and infrastructures, while the society will have to become familiar with the idea that in a near future, we could be surrounded with AV fleets of electric vehicles.

The result of this thesis shows that in this precise situation, an innovation will on one hand improve everyday life of a lot of people, free parking lots in crowded urban areas, give access to transport system to persons without driving license. On the other hand, the AV will most probably decrease the production of vehicles. The emerging/developing countries will keep on having a growing demand in the mid/long term, while developed countries will certainly slowly decrease their demand.

Just as the expertise in the electric vehicle, the AV technology will be a game changer in the competition for market shares that opposes the largest automotive groups worldwide. But the strategy which will be used by the main actors to have a weight in this future market must involve ethics just as much as it does economics.
1.1 Limitations

The limitations of this research are firstly the level of knowledge available for this technology: as an innovation, most of the technologies are patented and/or in development, which basically doesn’t allow us to have access to it. On the other hand, we have to make hypothesis and to rely on other’s conclusions instead of real facts, this is one of the main limitations of a qualitative research. To finish with, the interviewees also had limits and by two times, they were not allowed or able to answer to the questions asked in order to keep the numbers and technologies secret.

1.2 Further researches

The trend toward car sharing should nonetheless make automotive OEMs consider reconceiving their mission, at least in part. While continuing to serve as manufacturers and distributors of personally owned vehicles, OEMs should also experiment with providing mobility services and devise new business models accordingly.

The next 10 years promise to be very exciting for the automobile industry, but also for all the players that gravitate around it, not to mention tier1, tier2, tier3 suppliers, gas companies, insurances, banks. The weight of Automobile industry is huge and even if it has nothing to be compared with the real-estate crisis that happened in 2006, the changes that are about to happen must be taken in consideration and anticipated by all the stakeholders related to this beautiful industry.
6. Appendix

Interviews questions

- Which problems the Autonomous Vehicle, in its final and optimized version, will be able to solve?

- Which scenarios are possible to your opinion?

- Do you think that it is necessary for car manufacturers to change their business models with the entry on the market of the Autonomous vehicle? If yes, why, and how?

- To your opinion, what could be the impact of the Autonomous Vehicle on the automotive sector? In what extent could it have an impact on society in a general way?

- What is your opinion regarding the newcomers on the automotive market, pretending to revolutionize our travel habits, such as Google or Tesla? Their approaches are different and they are feared by the historical car manufacturers, should we take them seriously? If yes, why?

- When do you think the technology will be ready for the mass-market, and what could be the obstacles to overcome?

- What are the most important requirements, the minimum viable product that the Autonomous Vehicle should include?
7. References

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