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Impact of autonomous vehicles on urban mobility

Paper

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Master Thesis

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is identical to the version submitted to my advisor for evaluation.

Date  29th July 2015
Signature
MASTER THESIS

“IMPACT OF AUTONOMOUS VEHICLES ON URBAN MOBILITY”

Author
Muhammad Azmat
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A master thesis submitted in partial fulfillment of the requirements for the degree program “Masters of Science in Supply Chain Management” to Univ. Prof. Dr. Sebastian Kummer and Dr. Clemens Schuhmayer at the Vienna University of Economics and Business.

Vienna, Austria
July 29th 2015
ABSTRACT

The urban population is growing at an exponential rate throughout the world leading to the problems related to swift and speedy mobility or issues caused by convectional mobility options. This study illustrates and explores the new ways to transport people specially taking into account the self-driving cars concept and discusses the concept of mobility 4.0 (smart / intelligent mobility) and briefly highlights the technological aspects of autonomous vehicles, adaptation advantages and progress in laws and legislations of autonomous vehicle. The study is primarily qualitative and relies on the work of previous researcher, technical reports and blogs but the part of this study is quantitative where empirical data was collected from the experts in a conference held by BBG Austria. The result of the studies shows adaptation readiness of Austrian professional market and business prospects associated with autonomous vehicles. Moreover, different business models are suggested, which could be adopted to incorporate the driverless vehicles in day-to-day life of an individual living in urban environment. The models basically suggest that the adaptation of the technology would help curbing transport externalities especially external cost associated to transportation of each individual; which includes congestion, accident, infrastructure costs and environmental costs which are incurred by least efficient conventional cars and would also help shrinking the diseases like premature mortality, aggravation of respiratory as well as cardiovascular disease and sleep disturbance which are the result of city level congestion and pollution.
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Mobility Systems & ITS Deployment,
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Muhammad Azmat

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1 INTRODUCTION

The future of mobility is changing at an exponential rate. The dramatic advancements in the automotive industry have been observed over a last couple of decades, which resulted in the phenomena of Self driving cars (car capable of driving itself without human intervention) this is considered as a leap frog jump in automotive industry. These cars, which are also popularly known as Autonomous Vehicle, Driverless-Cars, Self-propelled Cars and Robotic-Cars, have a potential to significantly affect safety, congestion, energy & land usage. Exploration into such vehicles has progressed remarkably since the first demonstrations in the 1940s till recent past when four self-propelled cars traveled from china to Italy in 2010 (Hudda, et al. 2013).

1.1 Overview

Innovation in automotive industry is not new. Over a century innovation and automotive sector has strong relationship between them over a period of time research and development in this automotive industry has brought major technological advancements, which lead to securer, convenient, and inexpensive vehicles. But it is also true that despite of the assistances conferred on humanity no other invention has harmed human race as much as the automobile. Someone in every ~25 to ~30 seconds (approximately) dies in a traffic accident, and it adds to over 1 million deaths per year. This invention is amongst one of the prominent cause of death In the United States alone, for people between the ages of 3 to 34. Moreover, 90% of automobile accidents are caused by human error (Hudda, et al. 2013).

![World Traffic Deaths by Region (2010)](attachment://World_Traffic_Deaths_by_Region_2010.png)

Figure 1 2010 - World traffic deaths by region (in 1000) (Morgan Stanley 2013)
According to the Statistics provided by (The European Commission; Directorate General for Transport 1995) more than 95% of their entire life, traditional/conventional cars sit unused at garage or parking spots. (Schwarz, et al. 2013) Stated that an average car is not used and remains idle for 22 hours a day. Whereas, the following figure depicts the peak time maximum usage of the vehicles with respect to vehicle age and time of the day when it is being used mostly. This figure also let us understands the peak congestion hours in a day (Fagnant and Kockelman 2013).

![Image](image-url)

**Figure 2 - Peak time maximum usage of the vehicles (Fagnant and Kockelman 2013)**

It is also calculated that a freeway’s surface is covered approximately 5% with vehicles, when operating at maximum efficiency. According to an estimate to find a parking spot in a congested urban area consumes almost 40% of the fuel, which is waste of money and time both. All this adds to transport externalities, where either a transport user does not pay the full cost of the trip or journey (for example: cost related to environment, congestion, accident etc.) or does not receive the full benefits from it (The European Commission; Directorate General for Transport 1995).

![Table](table-url)

**Figure 3 - Transport related social costs (The European Commission; Directorate General for Transport 1995)**
Numerous researchers are estimating the social costs (transport related external cost) incurred by human driven vehicles (Anderson, et al. 2014). The internal and external costs are separated by a criterion on who pays for the journey, the cost paid by the transport user for the use of resources (for example: energy, infrastructure, etc.), the allied charges can be considered as internal costs. On the other hand, if the well-being of others is affected by the transport user (for example: by polluting the air, sound pollution etc.) without compensating for the amenities and services used for a conveyance activity than the succeeding costs are considered as external costs for that person. To understand, the pollution related cost should be paid by the polluter as described in the "polluter-pays-principle" instead not by those who are being effected by the pollution (The European Commission; Directorate General for Transport 1995). As described ahead, two kind of costs are imposed by Conventional driving, one is tolerated by the chauffeur (for example: gas, devaluation, coverage etc.) and other type of cost which is known as external costs, or “negative externalities”, are involuntary imposed on other members of society. For example, with one extra driver on road would add up the congestion and would also increase the chances for a road accident, the calculated cost for such negative externality is 13 cents, which means if on average a driver who drives around ~16,000 kilometer would inflicts $1,300 worth of costs on others and this cost does not comprise the cost stood by the driver (Anderson, et al. 2014).

<table>
<thead>
<tr>
<th>Mobility Costs</th>
<th>External Costs from Automobile Use ($/Vehicle-Mile)</th>
<th>External Cost OF Transport (Expressed as a % of GDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congestion</td>
<td>0.056</td>
<td>2.0%</td>
</tr>
<tr>
<td>Accident</td>
<td>0.024</td>
<td>1.5%</td>
</tr>
<tr>
<td>Noise</td>
<td>0.001</td>
<td>0.2%</td>
</tr>
</tbody>
</table>

1.2 Research Questions

Keeping in view the above stated issues and problems the paper aims at answering the following research questions:

<table>
<thead>
<tr>
<th>RQ1</th>
<th>What could be the possible role of public procurers in procuring innovative products like autonomous vehicles?</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ2</td>
<td>How could self-driving cars change the conventional urban mobility?</td>
</tr>
<tr>
<td>RQ3</td>
<td>Would self-driving cars be adapted (future of self driving cars)? – Expert’s Opinion</td>
</tr>
<tr>
<td>RQ4</td>
<td>What are the business prospects associated with to Self-driving cars (an estimation)? – Expert’s Opinion</td>
</tr>
<tr>
<td>RQ5</td>
<td>What are the fundamental requirements for launching a self-driving car pilot project?</td>
</tr>
</tbody>
</table>

1.3 Background of the study

With the increased numbers of cars being produced and sold each year has not only increased the problem of congestion in urban areas, but also have significantly shown negative impact on environment, in terms of wastage of fuel in commuting as well as increased over all carbon foot print. Despite of the fact that there have been strict regulations on CO2 emissions from cars, the objective is yet far away to be achieved to control the global threat. Not to forget that the lives are always on stake, as human error is one of the biggest cause of death or fatal injuries in road accidents, and driving a conventional way with a driver in charge of the vehicle (as prescribed in Vienna Convection on road safety 1965) cars have put both drivers as well as humans life on risk.

1.4 Objective of the study

Keeping in view the above facts the study aims to identify as many possibilities as possible to incorporate driver less cars (Autonomous Vehicles) into the lives of individuals. It has been observed from prototype testing that the cars without drivers and onboard system (hardware & software) tend to be more reliable than the cars with human drivers. The study aims to come up with the supportive arguments, techniques
and possibilities for any practical and possible usage of autonomous vehicles in day-to-day life of every individual. The four main objectives are defined as below:

Figure 4 - Research Objectives

1.5 Significance of the study

Although there are certain limitations, which cannot be overlooked, but with the passage of time and rapidly changing technological world the technology related problems would not be an issue soon. But in case of accident (there has not been any accident reported so far with autonomous vehicles) who should be held responsible; is the biggest debate since the birth of autonomous vehicles. The study was initiated to investigate if autonomous driving could really have any positive impact on individual transport. If yes, then how and using which medium could an individual be benefited from the technology? The study on the other hand would also be helpful for those who look futuristic technologies as business opportunities. The results of the studies could attract concrete investors to plan a business model, which is equally important for them and for the society in general.
1.6 Outline of the study

Chapter 1 – The study starts with an introduction to the current scenarios of driving and related issues and then introduces the autonomous vehicles, highlighting recent advancements followed by key facts and figures. The problem statement and brief description about the objective and significance of the study is also discussed in chapter 1 of this study.

Chapter 2 – Reflects the highlight of the related research work of the previous researchers, technical reports related to the topic and blogs on autonomous vehicles. It primarily focuses on the technology, progress and laws & legislations regarding autonomous vehicles.

Chapter 3 – Is the research methodology, it is explained what methodology has been used to write this paper and after defining the methodology for this study, it also illustrates the “Research Model” developed specifically for this study.

Chapter 4 – Represents the finding and analysis of this study. More precisely it contains the discussion, analysis and suggestion for the predefined objectives. Furthermore, it also contains the possible solution to the question of impact of autonomous vehicles on individual transportation.

Chapter 5 – This is the conclusion of studies and this chapter includes the possibilities for future studies and also briefly highlights the options for the extension of this study.
2 LITERATURE REVIEW

Over the past few years the exclusive human function: driving has been compromised by the technology industries by introducing significant jumps in bringing computerization into it (Fagnant and Kockelman 2013). The World Health Organization (WHO) predicts that road traffic injuries will turn out to be one of the top five death causes globally by 2030. Car manufacturers have long been involved in increasing the safety of passengers. They introduced passive safety systems such as; seat belt, crush zones and airbags. However, these passive safety systems have reached a performance limit. In order to achieve further enhancements in safety, most major car manufacturers with Mercedes in the lead, followed by BMW and Volkswagen pursue the idea of self-driving, driverless, autonomous or robotic vehicles (Visser, Ehrenhard and Nordhoff 2014). Recent models of vehicles increasingly include functions such as ACC (adaptive cruise control) and (PAS) parking assist systems that let automobiles to pilot themselves into parking spaces (Fagnant and Kockelman 2013).

2.1 Phases of AV’s evolution (A brief History)

The term “Autonomous Vehicles” means an automobile that can steer itself between two points safely, without unceasing human intervention (Barker, et al. 2013). From decades’ researchers have been finding a way to drive cars autonomously, for the better understanding the research into autonomous vehicles technology can be divided into 3 phases.

2.1.1 Phase 1

The idea of self-driving cars has been with researcher on technology almost as long as the age of automobile industry. The State of Nebraska and RCA Labs, amongst other efforts, conducted a complete test of an automated highway in 1958 near the University of Nebraska on a 400-foot strip of public highway. Guidance signals dependent technology was used by introducing detector circuits that were installed in the roadway which could detect the speed of the car and send it back to the system to help navigate it (Schwarz, et al. 2013). Between 1980 and 2003, university research centers worked on two visions of vehicle automation, first were automated highways systems which where relatively “dumb” because vehicles had to rely on highway
infrastructure to guide them. Other groups worked on self-driving cars that did not require special roads (Anderson, et al. 2014).

2.1.2 Phase 2

The U.S. Defense Advanced Research Projects Agency (DARPA) between 2003 and 2007, held three “Grand Challenges” that evidently enhanced progresses in self-driving technology. Out of three Grand Challenges, first two were held in countryside environments, whereas, the third took place in the metropolitan setting. All of these challenges urged university teams to progress in the AV technology (Anderson, et al. 2014). The challenge was to make an autonomous vehicle, which could drive the deserts and roads on high speed; the purpose was to add the autonomous vehicles in army fleet. This project started to grow every year and with loads of improvement for meeting new challenges, the participants finally were successful in making a car, which was able to drive itself in urban conditions on the roads of California, and the Chevrolet named BOSS won the title in 2007 (Urmson, et al. 2008).

2.1.3 Phase 3

Private companies have most recently advanced AV technology. Google’ with its self driving car has take a lead by developing and testing a fleet of cars and initiated promotions to exhibit the uses of the technology (for example: by using internet platform to show videos emphasizing mobility offered to the blind). Other car manufacturers are also showing their keen interest in this technology like Audi and Toyota in 2013, revealed their AV ideas and research programs at the “International Consumer Electronics Show”. Nissan on the other hand has also recently publicized plans to sell self-driving cars by 2020 (Anderson, et al. 2014). The world is now heading towards Industry 4.0 and Internet of things and Mobility 4.0 is part of the complete automation of mobility.

2.2 Mobility 4.0

Global economic development is subject to mobility and all the stakeholders have a involvement to guarantee the long-term practicality of the transport division. The rapid growth of the number of vehicles in past decades and unbridled urbanization mean that urban traffic has become a sensitive issue in cities around the world. Infrastructure
cannot be built to keep pace with traffic. Solutions do exist and others still have to be invented to reduce the number of lost hours, wasted fuel and offer quality mobility for the largest majority (Guinot and Tondeur 2014). Mobility 4.0 is termed as smart (intelligent) mobility in 4\textsuperscript{th} industrial revolution or Industry 4.0 (a connected and completely automated industry concept), Mobility 4.0 aims at accident, emission and congestion free completely autonomous individual and public transport. The objective is supposed to be achieved by complete automation of the vehicles under the 4\textsuperscript{th} level of automation as described in this study under heading “2.3.5 Level 4 (Full self-driving automation)”. The technology of complete automation is suppose to work in combination with the technology named “V-2-X Communication” which would make sure that every car on the road will communicate with its surroundings, be it another car on the road, traffic signals, traffic signs or any other infrastructure in surrounding. The clear purposes of the connected vehicles program are to use vehicle-to-vehicle (V-2-V) and vehicle-to-infrastructure (V-2-I) communication to considerably influence safety, movement, and sustainability in the transportation system (Schwarz, et al. 2013).

![Image](image_url)

**Figure 5 - The 4.0 concept (CAETS 2012)**

### 2.2.1 Connected Cars (C-2-X Communication)

Wireless technology is used for real time vehicle-to-infrastructure (V2I), vehicle-to-vehicle (V2V) communication between Connected-vehicle systems (KPMG 2012). Car2X-Communication is a field of research with high interest and considerable potential for improving road safety (Röglinger and Facchi 2009). Car2x communication which is also known as Vehicle-2-X (V-2-X) communication or Connected Vehicles (Schwarz, et al. 2013) is the exchange of information between traffic participants (V-2-V or C-2-C) and the exchange of information with infrastructure (V-2-I or C-2-I) the technology aims at enhancing safety and convenience and optimizing traffic flow
V2V and V2X capability should enable autonomous cars to know the position of surrounding traffic and create significantly more efficient traffic flow. Car positioning based on V2V/V2X communications should allow traffic to negotiate intersections without stopping, and cars should be able to travel at higher speeds and in closer proximity to each other (Morgan Stanley 2013). The higher-level engineering system for assuring Car2x communication is known as the Intelligent Transport System (ITS). Car2x communication concept basically involves transmitting and accepting harmonized messages using air as a medium and allowing understanding of the position information they contain by traffic participants (Schaal and Löfler 2012). According to (Röglinger and Facchi 2009) the rise in causalities over the period of time encourages researchers to look into the field of engineering and find a solution for that could alleviate the injuries and deaths caused by vehicles. There are many possible scenarios of implementation of C-2-X communication;

![Figure 6 - Possible scenarios of implementation of C-2-X communication (Röglinger and Facchi 2009)](image)

The figure above shows the fundamental separation of the major categories for crash scenarios which were used for a comparison between killed persons and the total amount of accident victims because this allowed (Röglinger and Facchi 2009) to figure out where the scenarios with high crash rates are located.
The analysis of the statistical data by (Röglinger and Facchi 2009) indicates that out of all those who use urban roads 64% of them become victim of the road accidents and out of them 27% is the rate of fatalities, for main roads the statistics are 29% victims and 61% are the fatalities, whereas, the number for highways are quite surprising as 7% of total number of vehicles on highways become the accident victims but only 12% of them are recorded fatalities. A Car2X-Communication system could improve its performance if it dynamically adapts to the road type the car is driving on. So, the complexity of the whole system could be reduced to two or three major crash types depending on the road type with an at least 72% coverage of all accidents with fatalities.

### 2.2.2 Applications of Connected vehicles

(Schwarz, et al. 2013) Defined some limited application of connected vehicles as following:

<table>
<thead>
<tr>
<th>Application</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency stop lamp warning</td>
<td>Surrounding vehicles receive an emergency braking signal by the host vehicle</td>
</tr>
<tr>
<td>Forward collision warning</td>
<td>The same lane forward collision warning signaled to the host vehicle</td>
</tr>
<tr>
<td>Intersection movement assist Blind Spot</td>
<td>Blind spot occupied signal transmitted to the host vehicle</td>
</tr>
<tr>
<td>and Lane Change Warning</td>
<td></td>
</tr>
<tr>
<td>Do not pass warning</td>
<td>Host vehicle is warned not to pass a slow vehicle if the sensor detects an oncoming vehicle from the opposite direction</td>
</tr>
<tr>
<td>Control loss warning</td>
<td>A control loss warning is signaled to surrounding vehicles in case of loss of control</td>
</tr>
</tbody>
</table>
2.3 **Levels of Automation**

Five levels for vehicle automation have been suggested by National highway traffic safety Administration (NHTSA) (Litman 2015):

**2.3.1 Level 0 (No Automation)**

At level-0, the human is solitary responsible for safety and control of acute functions like accelerator, brake and steering at all times (Horrell 2014). According to Vienna convention on road traffic safety, keeping the driver in a chief role is a guiding principle of road traffic guidelines (Economic and Social Council 2014). Therefore, override-ability as well as the likelihood for the chauffeur to turn systems off guarantees that the driver’s will is put forth (Litman 2015).

**2.3.2 Level 1 (Function-specific automation)**

The individual has ample authority but surrenders a few controls of certain functions to the automobile in specific normal driving or in crash-possible circumstances (Litman 2015). It is commonly referred as function-specific automation, which most commonly includes anti-lock break system and anti skid systems, which assist driver to control the vehicle in certain critical situations (Horrell 2014).

**2.3.3 Level 2 (Combined-function automation)**

The 2nd Level is subject to working harmony of minimum two control functions like ACC (adaptive cruise control) and LC (lane centering) in certain driving circumstances. Hands-off-wheel and foot-off-pedal driving modes are also enabled at this level, but driver is still accountable for observing and harmless operation and driver have to make himself available all times to control vehicle when needed (Litman 2015). Driver Assistance Vehicle systems help the chauffeur in his driving task. They also can affect the way automobiles are driven. Therefore, it is safe to say that they have the significance to take instant beneficiary influence on road safety or ultimately reducing driver’s workload (Economic and Social Council 2014). Some researchers also stated that his level also includes stop and start technique within city areas where heavy traffic and loads of signals are expected (Horrell 2014).
2.3.4 Level 3 (Limited self-driving)

All safety features under specific traffic and environmental situations are controlled by vehicle. Human can surrender supervising authority to automobile, which must alert chauffeur if circumstances require changeover to driver control. Anyhow, the motorist is expected to be available for intermittent control (Litman 2015). This level includes a widely researched and quite adaptable Vehicle-to-Vehicle (V-2-V) and Vehicle-to-Infrastructure (V-2-I) systems, where cars would communicate with the leading vehicles on the highway and with its surrounding within the city premises. These systems in combination with super cruise would lead to a plenty of free time for a driver to do other necessary tasks (Horrell 2014).

2.3.5 Level 4 (Full self-driving automation)

At the level of full self-driving, the car is expected to do all the work of driving and the human intervention is not required at any time (Google.com 2015). All the safety functions are vehicles controlled and the car is also responsible for monitoring conditions for the entire trip. The human specifies endpoint in the navigation system.
but is not expected to be available for control of vehicle during the trip. The safe operation is solely the automated system’s responsibility (Litman 2015). The car could analyze all type of traffic, see perambulators / pedestrians and cyclists, and react appropriately to traffic lights even in heavy traffics and at complex junctions. The system use both recognition functions and a prediction algorithm. Which helps in exact approximation to know exactly where the car is on the road, the accuracy is far better than GPS, the systems mostly uses the real-time images from its cameras for mapping the route and sense the hurdles (Horrell 2014).

2.4 Time Line for Complete Autonomy

Self-propelled cars were first suggested in the 1940’s. Initially the centralized grid idea was suggested, which was suppose to direct your car while you enjoyed the ride. But the modern autonomous vehicles will intelligently examine their environment and other drivers, and will operate with true independence without needing new infrastructural arrangements (Barker, et al. 2013). The current advancements in technology suggest that the full autonomy would be a gradual process. The high automation in vehicles was commercialized since 2013 and it is expected that the fully autonomous vehicles would commercially be available in the next decade that is 2020 onwards (Morgan Stanley 2013) and (Bartl 2015).
The current market analysis drives the conclusion of automation in driving, as following:

- **2013**
  - Traffic emergency breaking, Autonomous braking, acceleration and lane guidance at speed

- **2014**
  - Full autonomy at up to 31 MPH (*Example. Mercedes S-Class 2014-15*)

- **2015**
  - Super Cruise: Breaking and lane guidance at speed, Autonomous steering
  - Autonomous throttle, steering, self-parking and gear shifting

- **2018**
  - Autonomous car technology is expected by Google
  - 100 autonomous cars on road by Volvo

- **2020**
  - "road trains" guided by a lead vehicle and Accident-free cars by Volvo
  - GM, Audi, Nissan and BMW all expect fully autonomous, driverless cars.
2.5 Technical Aspect of AV’s (Benchmarking Google’s Driverless Car)

A vehicle capable of driving itself from one point to other on any given geographical layout without continuous involvement or input from a human driver is called Autonomous Vehicle or a Self Driving Car. Apart from the combination of cameras, radar systems and sensors the vehicle uses a global positioning system (GPS), which helps detecting self-driving car’s surroundings and uses AI (artificial intelligence) to determine the fastest and safest pathway to its endpoint. When necessary, the car’s steering, braking and acceleration is controlled by the mechatronic units and actuators, which allow the intelligence system to take charge (Morgan Stanley 2013). A combination of sensors and software is used by the vehicle to locate itself in the real world they take help of highly accurate digital maps by overlaying the surrounding onto it and sensing the difference. At the heart of an AV lays three main components (listed below), which make a car real self-driving car (The Guardian 2014).

2.5.1 Navigation

Google’ driverless cars uses Google Maps for navigating the vehicle. It takes full leverage of 3D visualization in real time by mapping LIDAR results on its current maps for more precise results. It would provide the information regarding speed limits, traffic updates directions, obstacles etc. (Rayej 2014).

2.5.2 Hardware

Apart from the car itself, hardware mainly includes the sensors, which would provide the real time information about the environment. So that reliable information is communicated to the artificial intelligence system on board. The main components are LIDAR, RADAR, video cameras (360 view), position and distance estimators. LIDAR (Light detection and ranging) is the heart of the system as it is responsible to scans up to 60 meters of surrounding environment in real time and plot the surroundings on the current map for immediate decision-making (Rayej 2014)

2.5.3 Artificial Intelligence (Software)

Google uses software named “Google-Chauffer” which is responsible to take decisions in the real time scenario. It interprets all the communication between hardware and environment and plans its next step accordingly. Chauffer controls the decisions about acceleration, breaking and directions. Its objective is to take passenger
to its desired place safely. The software obey the rules of the road and can recognize objects, people, cars, road marking, signs and traffic lights and detects numerous random dangers, including cyclists and pedestrians. The miracle of the technology is that it can even detect road works and safely steer around them (The Guardian 2014).

2.6 Autonomous Vehicle Hype to Adaptation

According to a report published by (KPMG 2013) the discussion on the topic of self driving cars has been accelerating and it clearly depicts the consumer trend and interest in the topic of self propelled cars which has been over hyped in all sort of media. An increasing trend in discussion volume has been observed from July 2012 through August 2013 as seen in figure below, mainly influenced by news, regulatory announcements and marketing. Despite of the fact that opinion volume increased steadily during July 12 to August 13 but spikes are observed in July 2013, followed by the United Kingdom’s declaration that “Autonomous Vehicles” have been granted permission for testing, and in August 2013 when a car manufacturer giant from Japan “Nissan” publicized intent to present a self-propelled vehicle by 2020. Due to the theoretical nature of discussion, the discussion on this topic in general public still remains largely mixed. Although optimistic review has also progressively augmented
during this tenure, which shows a positive trend between people, who are discussing about this topic.

![Self-Driving Car discussion is accelerating...](image)

Figure 14 - Self-Driving Cars public discussions (KPMG 2013)

There exist a gap between the research on the user perspective and acceptance indicators for the near future (Bartl 2015). Coalescing the Diffusion Model of Innovation with Hype Cycle of Roger’s and Gartner’s respectively for Autonomous vehicles would give us an outlook as seen in the figure below and can assist us in better understanding of the direction of this new technology.

![Autonomous Driving Hype Cycle and Adoption Curve](image)

Figure 15 - The hype cycle and Adaptation Curve (Bartl 2015)

To evaluate the current stage and relative maturity of the technology in the early phases of their life cycle The Hype Cycle offers is a suitable tool. It could provide the basis to
understand the consumer’s attitudes towards technology and analyzing opportunities and investment risks regarding a certain technology could also be indicated by the Model. The shape of the Hype Cycle curve in above figure illustrates the media fanaticism through the period of disillusion to a subsequent understanding of the technology’s significance and role in the marketplace. On the other hand, according to Roger’s Diffusion of Innovation model the comparative benefit over current answers, the compatibility with prevailing standards, the comparative complication and the observability (KPMG 2013) will determine the pace of user acceptance and the course of the traditional adoption curve starting with the innovators and early adopters (Bartl 2015). A point where Hype cycle meets the Diffusion model (Adaptation) would be the decisive point. For the auto manufacturers, when it comes to the introduction of a new car model it is a familiar exercise. But, the case AV cannot be treated simply as a new series, because this innovation is too disruptive in all dimensions to do so (Bartl 2015). (Morgan Stanley 2013) On the other hand, has presented an adaptation curve which represents 4 phases of adaptation, but if we look more closely to the subject they should rather be presented as phases for technology availability than adaptability. The curve presented by Morgan Stanley shows an increasing trend over the period of 2 decades but fail to represent any numbers or % of technology adaptation instead displays four phases as: phase1 (0-3 years) passive autonomous driving, Phase 2 (3-5 years) Limited driver substitution, Phase 3 (5-10 years) autonomous capabilities, Phase 4 (two decades) 100% penetration utopian society.

Figure 16 - Time line for adaptation (Morgan Stanley 2013) (see appendix A)
2.7 Monetary Advantages of Autonomous Vehicles Adaptation

There have been numerous predicted monetary advantages linked to the adaptation of Autonomous Vehicles for daily commuting and travelling. First estimations state that self-driving cars can contribute up to $1.3 trillion in annual savings to the United States economy alone, and an expected sum of $5.6 trillion for global savings (Bartl 2015). Break up of this sum could be visualized in the figure below, presented by (Morgan Stanley 2013).

![Figure 17 - 1.3 Trillion/year $ Savings (Bartl 2015) and (Morgan Stanley 2013)](image)

(Morgan Stanley 2013) Grid shown in the picture above could be broken down in the following categories of monetary advantages for the better understanding of how $1.3 trillion would be saved (ZHANG 2014).

2.7.1 Savings from Fuel consumption per annum

In today's cars, even using cruise control can drive swiftly and can easily deliver a 20-30% enhancement in fuel economy vs. a manually controlled “coursing” brake and throttle. Empirical tests have demonstrated that level of fuel savings increased dramatically from cruise control use. The best thing about AV is that they will run on cruise control completely. Add to this aerodynamic styling and light weight, plus active traffic management, and we can potentially get up to a 50% improvement in fuel economy from autonomous cars on top of the fuel economy improvement from new engine and transmission technologies that are going to be incorporated in cars.
anyway. In order to be conservative, researchers assume that an autonomous car can be at least 30% more efficient than a comparable conventional car. If states economy manages to decrease $535 billion fuel bill by just 30%, it would save the United States $158 billion (Morgan Stanley 2013).

![Figure 18- Total $ spent on fuel in 2012 (ZHANG 2014)](image)

### 2.7.2 Accident Savings per annum

According to The Federal Highway Administration (FHWA) as reported by Morgan Stanley (2013) calculates the crash cost per vehicle resulting in an injury, adjusted for inflation, to be around $126,000, and the cost per casualty at almost $6 million. The EPA and FDA also have calculations for the statistical value of life, $9.1 million and $8 million, respectively (we use the “midpoint” FDA number as the basis for our base case calculations). Costs from injuries represent $282 billion, and costs from fatalities represent $260 billion per year. Total cost of $542 billion per year is incurred due to motor vehicle-related accidents in US alone. It is proved by many research organizations that 90% of accidents are instigated by driver’s error, so, taking the driver out of the equation could academically reduce the cost of calamities by 90% resulting in the savings of $488 billion (90% of $542 billion) per year. This is only achievable in utopian society where 100% of vehicles on road are autonomous.
2.7.3 Savings in terms of productivity

US drivers drive approximately 3 trillion miles a year. One of the main rewards of self-driving cars is that riders are freed from the hazel of driving and are allowed to do whatever else they want. For instance, people can work in their cars while traveling to work or at any other time. Three trillion miles driven at 40 mph equals 75 billion hours spent in a car (again, conservatively assuming only one occupant in a car at all times). If it is assumed that people work 30% of the time while riding a car, would equals 18.75 billion hours. It is assumed that the “cost of time” is $25 per hour (based on US median income of $50k/year) and that people are 90% as productive in the car as behind a work desk. This means the value of the productivity generated from being able to work in the car is $507 billion (22.5 billion x $25 x 90%).
2.7.4 Savings by avoiding congestions and efficient consumption of fuel

European Commission for Mobility and Transport estimates that congestion costs Europe about 1% of GDP each year. According to the Texas Traffic Institute’s Urban Mobility Report, supported by the US DOT as reported by (Morgan Stanley 2013), in 2011 the average US driver lost 38 hours to congestion, which is more than double to 16 hours in 1982 (calculations based on the difference between traveling at congested speeds rather than free-flowing speeds). That is the equivalent to almost five vacation days. In areas with over three million people, travellers experienced higher bottleneck delays and lost an average of 52 hours in 2011. The report analyzed over 600 million speeds on 875,000 roads across the US. The speed data was collected every 15 minutes, 24 hours a day, at hundreds of points along almost every mile of major road in North America.

The report also estimates that there are about 145 million commuters in the US, which means they are collectively losing to congestion around 5.5 billion hours a year (38 hours x 145 million commuters).

Autonomous cars should be able to largely eliminate congestion due to smoother driving styles and actively managed roundabouts and traffic patterns. Autonomous cars should also intensely encourage traffic pooling. Again, assuming the cost of time is $25
per hour, 5.5 billion hours saved in congestion is worth $138 billion of potential productivity generated.

There is another aspect to congestion saving—the fuel wasted by being stuck in traffic will no longer be needed. This was also calculated by the Texas Traffic Institute’s (TTI) report, which quantified congestion by taking the free-flow results and subtracting them from congested results. First, TTI calculated the emissions and fuel consumption during congested conditions by combining speed, volume, and emission rates. Then it estimated the amount of gas needed to produce those CO₂ emissions. The average fuel wasted was 19 gallons per commuter and a total of 2.7 billion gallons for the entire US in 2011. Just sitting in traffic wasted $10.8 billion dollars, moving to a congestion-free autonomous car’s world could also eliminate this waste.
Hence, the total saving in terms of avoiding congestion is expected to be $149 billion. But this may also be noted that, the figures above are only achievable in utopian (phase 4) era, which is expected to be at least 5 decades from now. The complete diffusion of self-driving vehicles could result in humongous social benefits such as saving lives, plummeting prevention from traffic jams, and giving people more elasticity with travelling or vacation driving. These social benefits also have noteworthy possibility of economic implications. And the results of this adaptation is truly significant, which is $1.3 trillion of freed up cash flows, theoretically generated by autonomous Vehicles and this $1.3 trillion amounts to over 8% of the entire US GDP (Morgan Stanley 2013). The results would be visible once the market starts to adapt the autonomous vehicles when they are available which is expected to be by the end of phase 3 in the adaptation time line.

2.8 Google’s Driverless Car’s Highlights and Aspiration

According to the Google website on self driving cars (Google.com 2015) Google is aiming at transforming travelling experience by making it more safe, user friendly and pleasing. According to the information on the self driving project available of Google’s self driving website, it considers that the full latent of autonomous vehicle technology
will only be conveyed when an automobile can drive on its own from one place to other just by pushing a button, exclusive of continuous human intrusion. In this revolutionary concept of autonomy in driving “Google” stepped up and pioneered the concept of commercializing the technology of autonomous driving by introducing “Google Driverless Car” in mid 2009 driven by “Google Chauffeur”, software used to drive the vehicle autonomously. Google cars are experienced drivers, Since the beginning of the project 6 years ago, Google’s self driving cars have driven over 1 million miles without a driver and have accrued the equal of 75 years of driving experience on the road (the calculation is based on an American adult driver who drives on an average 13,000 miles a year). They were mainly tested in California, Florida, Nevada and Michigan roads, highways and controlled test tracks with no recorded accidents when operating in self-drive mode. It has tested its vehicles in California’s city traffic by ferrying around a number of journalists and critics to test its features and safety. Google showcasing its self-driving car technology to a number of journalists in April 2014 demonstrate that autonomous driving is also feasible in dynamic and unpredictable environmental conditions (Visser, Ehrenhard and Nordhoff 2014). Google aims to make the technology of self-driving cars commercially available for purchase between 2017 and 2020. The technology giant (Google) petitioned two bills that made the state of Nevada first in line to test autonomous vehicles legally on public roads; the action was followed by Florida, California, and Michigan too. Google estimates the following key societal and monetary benefits from adopting driverless cars.

![Figure 23 – Goals and Objectives of Google's driverless cars (Google.com 2015)](image-url)
2.9 Legal Perspective (Benchmarking US legislations)

Progress of legal or regulatory systems is slower when compared to the speed of technological innovation. AV technology is encouraging an outbreak in regulatory debates at the International, national and state level. Till July 2013, Washington – D.C. and three other states California, Florida and Nevada had sanctioned legislature authorizing the operation of self-driving cars on public roads for assessment purposes (KPMG 2013). Every state that has passed regulation on this issue has chiefly plagiarized such laws from one another. Concerns connecting to the testing, physical presence of the driver, and scope of the law are closely indistinguishable. Manual override is one of the main requirements by all states, with fluctuating need of precise condition of technology (Barker, et al. 2013).

2.9.1 Definition & Scope

The current bill in DC has allowed the testing of self-propelled cars on public roads even before the development of authorized safety criteria. The chief requirement of the bill is that a focused driver should accompany the car all the time during its
testing period and this bill hold responsible the operator for any associated criminal and infraction liability. In contradiction to this bill other states hold responsible the person who is engaged the autonomous technology (Barker, et al. 2013). Including Washington’s HB 1649 (Bill), all methods exclude all other companion technologies which necessitate an alert driver to maneuver the automobile. Therefore, Intermediary assistive technologies would be administrated under prevailing traffic laws (Barker, et al. 2013).

2.9.2 Testing Legislations

Examination of self-driving vehicles on public roads is permitted by all passed legislation. Every state also bounds operation of AV to producer designees throughout testing. Special Approval is required during testing when an operator is not actually present in the vehicle during the period when automobile is being tested. A minimum of $5 million in insurance coverage is required by California and Florida for any manufacturer, and forbids assessment until the plan is permitted by California’s Department of Licensing (Barker, et al. 2013).

2.9.3 Licensing

Autonomous vehicle are subject to separate license for the operation in the state of Nevada. Other states have asked their respective agencies to necessitate a valid operator’s license pre-operating a driverless car, and have also asked their respective subdivisions to foster guidelines (Barker, et al. 2013).

2.9.4 Criminal and Infraction Liability

So far operator of the vehicle should be held responsible for criminal and civil infraction liability nearly in every approach reviewed for the laws and legislation by every state. Though, California’s SB 1298 is totally mute on the issue of accountability, passing that accountability on its Division of Motor Vehicles to cultivate guidelines by year 2015 (Barker, et al. 2013).

2.9.5 Civil Liability

As discussed before only California’s SB 1298 is totally mute on the issue of accountability, passing that accountability on its Department of Motor Vehicles to develop guidelines by year 2015. Florida and DC both enforce a manufacturer responsibility immunity provision to civil suits. So far States have largely ignored the
liability issues by simply passing the obligation on to their respective licensing agencies. This is intended to encourage insurance businesses to comment on the obligation issues when agencies begin the processes of rulemaking (Barker, et al. 2013).

![Figure 25 - who is liable (KPMG 2013)](image)

2.10 Urban Mobility

Planning of livable future cities is critically important because over 50% of world’s population is living in metropolitan areas, making these areas over populated (CAETS 2012). European figures on living are more alarming. Presently, around 74% to 80% of Europe’s populace lives and works in cities and towns, and it is expected that by 2050 over 82% of the region’s population will be condensed in metropolitan areas (TRIP & European Commission 2013) and (The European Commission 2004).

According to one of the reports from (CAETS 2012) cities today should comprise of a dependable and extremely recurrent public conveyance between outskirts and inner city with a high modality and secondly, some concrete actions to improve motor-powered individual transport must be taken (for example: better traffic control systems, traffic administration centers, and intelligent information systems for drivers). Transportation makes its utmost impact if it is cohesive so that shifts between different types are smooth for the users. This enables them to choose an optimal mix for every leg. This type of combined and improved transport systems come with many advantages like they would reduce the necessity for roads and parking; lessen congestion, air pollution and greenhouse gas emissions; would support the optimization of capitals used for transportation; and upsurge the living standards in the region. There are many ways to reach an optimum level of urban development, for example making such a mix of land use, where work chances and housing units are not far from each other, could
dramatically reduce the necessity to travel. Furthermore, Adaptable working time models along with public transport motivations can shrink unnecessary peak period travel and inspire off-peak mobility, resulting in public transport more effective, efficient and inexpensive (CAETS 2012).

2.11 Sustainability and urban mobility

(The European Commission 2004) In one of its report define sustainable transportation or mobility as: “Transport which allows the basic access and development needs of individuals, companies and societies to be met safely and in a manner consistent with human and ecosystem health, and promises equity within and between successive generations being affordable, operates fairly and efficiently, offers choice of transport mode, and supports a competitive economy, as well as balanced regional development and Limits emissions and waste within the planet’s ability to absorb them, uses renewable resources at or below their rates of generation, and, uses nonrenewable resources at or below the rates of development of renewable substitutes while minimizing the impact on land and the generation of noise”.

As discussed before almost 75% to 80% of the EU’s population inhabits in metropolitan regions. Over 30% of all transport kilometers in Europe are accounted by the transport of goods and people in urban areas (The European Commission 2004). A big assortment of environmental, social and economic impacts in many cities across the world is caused by road-based transport systems. These impacts include traffic congestion, air and noise pollution and the significances of traffic incidents (Brownea, et al. 2012). The most important traits of an urban environment are high population densities, settlements and consumption of goods & services. In such surroundings the infrastructure for transportation and the potentials for its exaggeration are very limited and unsustainable. Noteworthy glitches linked with urban freight transport are the result of the imbalance between demand and boundaries of the urban settings (For example: congestion, pollution, safety, noise and carbon creation). 40% of air pollution and noise emissions are just because of the transportation of goods in an urban environment. The joint consequences of these complications are both economic and social; these problems not only decrease the efficiency and effectiveness of UFT and logistics operations, but also on the other hand, destructively impact the living standards of citizens, through dangerous effects on health (Stantchev and Whiteing 2006).
2.12 Societal and environmental challenges
As we are getting more and more dependent on cars, an ageing populace, and requirements of novel and flexible lifestyles, cities are facing the new challenges of finding new mobility solutions for speedy and easy movement of people. Additionally, new technologies generate astronomical expectations for smart mobility possibilities, (For example: traffic information for travelers in real-time, same for network managers, drivers and fleet operators. Such advancement in technologies also bring chances for assimilating data for trip planning and electronic ticketing, and smart cards to simplify interoperability among different public transport types. European, national and local policy plans are topped by the challenges of global warming, scarce energy sources and increasing energy prices. This leads to an immediate need of green solutions to cut the environmental impression of transport in urban areas. Collectively, city traffic is accountable for 40% of CO2 emissions and 70% of other emissions from road transport in the European Union, which leads to the need of finding a solution to sustainably reduce transport related emissions (TRIP & European Commission 2013)
According to some researchers disability, premature mortality, aggravation of respiratory as well as cardiovascular disease and sleep disturbance is the result of city level congestion and pollution. At the same time on global scale these impacts are argued to be adding to climate change effects responsible for global warming. Metropolitan freight transport is a donor to all of these unwanted impressions, and in last few years as growth in urban population has grown, it also amplified its impacts ensuing the demand for freight flows ever required before as it is necessary to support these populations residing in the metropolitan areas (Brownea, et al. 2012).

2.13 Societal and Environmental Advantages of AV
Earlier in section 2.7 the monetary advantages of adapting the self-driving cars have been discussed and in this section the societal advantages of autonomous vehicles have been highlighted like;

2.13.1 Accidents reduction

The self-driving cars are expected to be safer as compared to the conventional human driven vehicle. It has been observed that with the use of advanced technology like Adaptive Cruise Control (ACC), Antilock Break System (ABS) and many such
advanced sensors and technologies has helped significantly curbing the rate of accidents in numbers as well as on an each vehicle mile travelled (VMT) base. Auto crashes have been shrinking in the U.S at an annual average rate of 2.3% for light-duty vehicles in the period of 1990-2011. Roadway injuries have also fallen at an estimated twelve-monthly rate of ~ 3.1%, over the same period of time (Anderson, et al. 2014).

![Figure 26 – Roadways injuries and Accidents per million vehicle miles travelled (U.S) (Anderson, et al. 2014)](image)

### 2.13.2 Mobility for Disables

According to (Anderson, et al. 2014) Self-propelled vehicles could considerably upsurge access and movement across a variety of populations presently incapacitated or not permitted to use conventional automobile. These include the incapacitated, older people, and children of age 16 or less. The most promising advantages would be personal independence, increased sociability, and access to vital services. Level 4 automation is expected to provide mobility and access at reduced cost when compared to the current system which provides mobility services for disabled for 14 to 18 percent of their budgets in the U.S.

### 2.13.3 Congestion

The traffic congestion could be directly affected by introduction of driverless cars, influencing vehicle mile traveled by empowering a new modality for urban travel like a taxi system that does not require a driver, over time it would substitutes old-style taxi service, sharing a car programs, and perhaps even subway and metro lines. On-demand, door-to-door convenience of traditional taxis could be offered by driverless at cheaper prices, as the payment for driver time would be excluded straight away. Self-driving cars are likely to support higher vehicle efficiency and outputs on existing roads by increasing overall vehicle travel. The technology that senses its surroundings and continually invigilate nearby traffic and respond with exceptionally well synchronized
braking and acceleration alterations would enable self-driving cars to travel harmlessly at higher speeds and with minimum space between vehicles, this would ultimately result in less congested roads. Furthermore, the crash related traffic congestion (non-recurrent delay) could also be well managed by adapting self-propelled cars in our daily shuttling. It is estimated that on an average 25% of all congestion delays (including both recurrent and non-recurrent congestion) are caused by Traffic incidents, and car smashes beholds a key portion of this whole. Successful indulgence of AVs in our society would avert the vast majority of such crashes, and would result in eradicating a respectable share of all types of traffic delays (Anderson, et al. 2014).

<table>
<thead>
<tr>
<th>Factor</th>
<th>Increase Traffic Congestion</th>
<th>Uncertain Effect</th>
<th>Decrease Traffic Congestion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced travel costs</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergence of driverless taxi service</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase in road throughput capacity from more efficient vehicle operation</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced vehicle crashes</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 27 – AV technology on traffic congestion (Summary) (Anderson, et al. 2014)

2.13.4 Better Land use and Reduced Car Ownership

The wide acceptance and adaptation of self-driving cars would have a deep impact on the current land use pattern. Underlying nature of trading off land values would not be altered by the introduction of AV in comparison to the transportation costs, but the computation of the latter could have a major effect. The value / worth of the time is also among one of the costs for a typical auto commuter apart from other transportation costs which include factors like maintenance, insurance, depreciation, and fuel related costs and the opportunity cost of such acts the driver might engage in if not driving. Traditional vehicles require drivers to must focus most of their attentiveness on the act of driving, barring other practical use of their time. On the other hand, a self driving car owner would be able to work for a couple of hours in the vehicle while going towards the workplace, spend four hours in the office and later on work another couple hours in the car while commuting back to home. Self-driving car gives you an ability to engage in other activities while riding (you ride an AV not drive it) an AV, ultimately decreasing the cost of transportation. Such a tradeoff between land value and transportation cost, might upsurge the readiness of families, and perhaps some companies also, to establish themselves away from the metropolitan center. Moreover, the need of parking complexes and plazas in the core urban areas would also be dramatically reduced by the emergence of AVs. A couple of
examples could help in better understanding of the subject; first, after dropping off its passenger(s) in a downtown location, a self-propelled car could direct itself to a distant parking place in an outlying zone, lessening the parking space requirements in the congested areas of the town, where land values are usually highest. Furthermore, if an Av is a driverless taxi, it would often need not to park itself; instead, it could work on a hop on hop off model or after concluding one tour; it would steer to pick-up the next passenger. It is expected that the handiness and low-cost of such a self-driving car induced business models are likely to appeal many urban natives to get rid of car ownership, and free up their cash or at least to condense the number of cars they might owned.
3 RESEARCH METHODOLOGY

Researchers suggest that a new investigation often starts with a qualitative research design exploring new phenomena while quantitative studies are later conducted to test the validity of the assumptions formulated in previous qualitative studies (Visser, Ehrenhard and Nordhoff 2014).

3.1 Methods of Data Collection

This study primarily follows the pattern of qualitative study and relies on the secondary data available through the Internet and books. The good thing with web-based data is that’s its easily available, accessible and inexpensive (Visser, Ehrenhard and Nordhoff 2014). The researcher has cited work of previous researchers, analyst and technical experts for this study. Apart from the core qualitative studies a part of this research concludes analysis of the experts who participated in a conference and gave their opinion on the topic related to future of self-driving cars.

3.1.1 Conference highlights

The conference was organized by The Federal Procurement Agency of Austria (Bundesbeschaffung Österreich). It took place at Austria Trend Hotel Bosei Gutheil Schoder Gasse 7b, 1100, Vienna, Austria on May 7th 2015 (see appendix B). The theme of the conference was “4.0 Plattform Innovation - E-Mobilität”. The Conference was chiefly divided into 4 following scenarios:

| Scenario 1: “E-Flotte – Hype oder Zukunft?” Moderation: Thomas Lang; hosted by Bundesbeschaffung GmbH |
| Scenario 3: “Elektro Auto teilen – Carsharing 2.0” Moderation: Willy Raimund; hosted by Austrian Energy Agency (AEA) |
| Scenario 4: "Future Scenario: Self Driving Cars - The future has already begun" Moderation: Dr. Clemens Schuhmayer / Muhammad Azmat; hosted by the Institute of Transport and Logistics, Wirtschaftsuniversität Wien. |
The main language of the event was German but “Scenario 4: Self Driving Cars – The future has already begun” was presented in English and was hosted and moderated by the representatives of Institute of Transport and Logistics, Vienna University of Economics and Business (Wirtschaftsuniversität Wien). Approximately 130 professionals participated in the conference representing different institutions, mainly public procurers, automobile technology experts and experts from the energy sector. For scenario: 4 around 30 experts participated in the presentation and discussion and gave their opinion on the survey questions (see appendix G).

3.1.2 Survey Questions and Experiment Procedure

The participants were asked two main questions after the presentation on Scenario 4: "Future Scenario: Self Driving Cars - The future has already begun"

Q1. What is the future of self-driving cars?
   • Future was defined as adaptability of self-driving cars and their indulgence in our daily life for commuting and leisure travelling.

Q2. What is the business prospect with self-driving cars?
   • Business prospect correspond to the future of current businesses likes OEM, Procurers and technology providers for automobile industry. What changes (positive or negative) do the experts foresee?

The participants were asked these two questions in two rounds and everyone was allowed to give their opinion about it. The flash cards were used to record their opinion and they were then placed in a diagram to record their opinion and analyze what do they think about these 2 questions.

Figure 28 – Custom build graph to analyze the opinion of participants (see appendix F)
The participants were asked to do two things for each question, 1st they were expected to tell if they think there is a negative chance of growth or positive chance of growth for self driving cars and business prospects and then they were expected to rate their argument on the scale of ±1 to ±10 (The higher the number the stronger the argument. The blue dotted line in the middle was to indicate the opinions for those who were not sure about any one of the questions or both of the questions (See Appendix f).

3.1.3 Analysis Technique

The experiment was followed by the statistical analysis which was done using Microsoft Excel tool, as there were limited number of observations, therefore the mainline statistical software’s were avoided to maintain simplicity and reader understandable outputs were derived which are further discussed in the “Results and Outcomes” chapter of this paper. The opinions were displayed in the graphical and visual formats for better understanding of the outcome.
3.2 Research Model Developed

Figure 29 - Research Model
4 RESULTS

As of now Autonomous driving vehicles are at premature stage but still there are limitless possibilities and opportunities to maximize the possible benefits and advantages from this revolutionary technology. The study was conducted to achieve some predefined objectives, which are further discussed in this chapter.

4.1 Role of Public Procurement (Benchmarking Federal Procurement Agency Austria)

The role for public procurement agencies varies substantially depending upon their limitations of power and authority. Federal Procurement Agency of Austria (Party to this study) raised a question regarding procurement of innovative products (more precisely – Autonomous Vehicles) and their possible role as a procurement agency. The currently follow a set of standard procedure (shown in the picture below) which allows them the procurement of conventional or readily available products for public or private sector.

Figure 30 - Procurement Process of BBG AUSTRIA
4.1.1 Recommended Changes

After in depth analysis of the standard process of procurement of conventional or readily available products, following amendments were suggested in tendering procedure for procuring an innovative product like Autonomous Vehicles.

- **Request for tender**: The request for tender should be published in the newspaper with complete details and specifications of the project for receiving offers from the states or organizations willing to participate in the innovative products testing.

- **Open Offers**: Sealed offers should be opened in front of members or representatives of all participating states or organizations.

- **Negotiation**: The offers than should be negotiated with all qualifying states or organizations

- **Select & Award**: The winning state(s) or organization(s) should than be awarded the tender

- **Test Innovation**: The Procurement Agency should actively participate in the testing phase and set the benchmarks or milestones in order to achieve improved results.
• **Critically Review:** The review process should be critical and all the elements of the project must be inspected in detail. As this is the approval stage and procurement agency is responsible to make sure that all the requirements of the customers are met and justified.

• **Make It Available:** Make the product available for the customer by following the remaining processes of the current procurement procedure (as shown in the figure below)

![Procurement process after amendments](image)

Figure 32 - Procurement process after amendments

### 4.2 Re-classifying Existing Mobility

There are three different business models suggested as a concept of re-classifying existing mobility.

#### 4.2.1 Remote Assistance (Public Transport)

The idea is to take full advantage of autonomous vehicles for mass transportation of individuals from suburban areas to urban areas. The model suggests that the autonomous vehicles should be deployed in the outskirts of Vienna region where the efficiency (Efficiency in accordance to utilized capacity and total cost to transport an individual to subway station) of the autobus is below average. The model
would make use of autonomous vehicles combined with mobile technology so that people on a same route could be picked up and dropped to maximize the efficiency.

4.2.2 Airport Taxi

This idea follows the least complicated transportation model, which is referred as one origin and one destination. This is also presumed that the user of air transportation is technologically well informed as compare to the users of other transportation mode. Therefore, familiarizing with autonomous vehicle would be easier for them. The idea works in combination with web-based and mobile technology. The user would be able to reserve a taxi by using an application in smart phone or through World Wide Web on their personal computers. The flight information would directly be communicated with taxi and the taxi would be able to pick up the passenger from pre decided location within the airport premises. After confirming the destination address the car would depart the airport and join the car platoon going in the same direction. This real time data communication and advanced technology would save time, increase productivity and efficiency. Whereas at the same time would help curb the transport externalities, emissions and congestion both within airport and roadways.

4.2.3 Floating Car

Buying a car is a big investment and on the other hand the return on this investment is minimum. Previous researches have shown that the car for individual transportation is used on average 2 hours a day. This idea focuses on increasing

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1 The pictures of cars and houses and airport are extracted from open source files on the Internet using (Google.com 2015).
productivity of car from 2 hours a day to 20 hours a day, with healthy returns on investment. The model suggests that the car would be floated for others to use it when its prime owner is not using it. The car would be reserved using online platform and smart phones. The car’s owner would be kept updated with the necessary information like location, fuel/energy and safety conditions. The payment model would be “pay per kilometer”. The payments would also be executed online and would hence be recorded and taxable. This is a WIN-WIN situation for all the parties involved in the transaction and transit. The car would reach the docking station as desired and wouldn’t take any booking during that time. The graph below would help understand how we can perfectly fit the model of floating car in to the real life scenario.

4.3 Limitations
All driverless car models are subject to certain limitations, which might incur additional recurring costs and reduced service levels, like –

(i) Cleaning & Sabotage: Refers to the cost allied with cleaning the vehicle when its abused by spitting, spilling food and drinks, leave garbage inside etc. So is true with the vehicle being misused or sabotaged by riders as they might not act responsibly when they use the ride for their journey and no one is physically aware to control them.

(ii) Reduced Services: Passengers are usually helped by driver in picking and placing luggage in trunk, helping disabled to get into car and likewise but with autonomous vehicles these services would be truncated.

(iii) Reduced Comfort & Privacy: With autonomous vehicles passengers would have to be aware that their activities are being recorded for their safety and hence would result in reduced privacy, moreover, they will have to compromise on in car luxury as these vehicles are expected not to be as luxurious as cars in this to be price range.

4.4 Conference Proceedings
30 experts participated in scenario 4. (See Appendix) and gave their opinion on the questions:

Q1. What is the future of self-driving cars?
   
   • Future was defined as adaptability of self-driving cars and their indulgence in our daily life for commuting and leisure travelling.

Q2. What is the business prospect with self-driving cars?
Business prospect correspond to the future of current businesses like OEM, procurers and technology providers for automobile industry. What changes (positive or negative) do the experts foresee?

For the sake of anonymity, the respondents were assigned number and they were not asked to tell their profession and names in the data. The data collected is shown in the tables below:

**Table 4 - Expert's opinion on Q1 and Q2**

<table>
<thead>
<tr>
<th>Respondent #</th>
<th>Opinion Attitude</th>
<th>Opinion rating</th>
<th>Respondent #</th>
<th>Opinion Attitude</th>
<th>Opinion rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>positive</td>
<td>10</td>
<td>1</td>
<td>positive</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
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<td>10</td>
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<td>-7</td>
</tr>
<tr>
<td>3</td>
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<td>7</td>
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<td>negative</td>
<td>-3</td>
</tr>
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<td>positive</td>
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<td>4</td>
<td>positive</td>
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<td>8</td>
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<td>positive</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>negative</td>
<td>-5</td>
<td>6</td>
<td>positive</td>
<td>9</td>
</tr>
<tr>
<td>7</td>
<td>positive</td>
<td>8</td>
<td>7</td>
<td>negative</td>
<td>-8</td>
</tr>
<tr>
<td>8</td>
<td>positive</td>
<td>9</td>
<td>8</td>
<td>positive</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>negative</td>
<td>-7</td>
<td>9</td>
<td>positive</td>
<td>7</td>
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<tr>
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<tr>
<td>13</td>
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<td>13</td>
<td>negative</td>
<td>-2</td>
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<td>14</td>
<td>positive</td>
<td>10</td>
</tr>
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<td>8</td>
<td>15</td>
<td>positive</td>
<td>7</td>
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<tr>
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<td>16</td>
<td>negative</td>
<td>-8</td>
</tr>
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<td>17</td>
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<td>-4</td>
</tr>
<tr>
<td>18</td>
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<td>18</td>
<td>positive</td>
<td>8</td>
</tr>
<tr>
<td>19</td>
<td>positive</td>
<td>7</td>
<td>19</td>
<td>negative</td>
<td>-5</td>
</tr>
<tr>
<td>20</td>
<td>positive</td>
<td>7</td>
<td>20</td>
<td>positive</td>
<td>10</td>
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<tr>
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<td>8</td>
<td>21</td>
<td>positive</td>
<td>9</td>
</tr>
<tr>
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<td>22</td>
<td>positive</td>
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<td>positive</td>
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</tr>
<tr>
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<td>positive</td>
<td>5</td>
</tr>
<tr>
<td>25</td>
<td>positive</td>
<td>10</td>
<td>25</td>
<td>negative</td>
<td>-6</td>
</tr>
<tr>
<td>26</td>
<td>positive</td>
<td>10</td>
<td>26</td>
<td>positive</td>
<td>4</td>
</tr>
<tr>
<td>27</td>
<td>negative</td>
<td>-3</td>
<td>27</td>
<td>negative</td>
<td>-8</td>
</tr>
<tr>
<td>28</td>
<td>positive</td>
<td>8</td>
<td>28</td>
<td>positive</td>
<td>8</td>
</tr>
<tr>
<td>29</td>
<td>positive</td>
<td>8</td>
<td>29</td>
<td>positive</td>
<td>10</td>
</tr>
<tr>
<td>30</td>
<td>negative</td>
<td>-6</td>
<td>30</td>
<td>negative</td>
<td>-3</td>
</tr>
</tbody>
</table>

The (−) sign with the opinion rating are used to show the direction of opinion only. Where as all the positive opinion ratings hold with them a (+) sign, which again is a symbol, used for directions only.
4.5 Descriptive Statistical Analysis Q1

The collected data conveniently show that a vast majority thinks that there is a good potential for autonomous driving vehicles in future, but a small population thinks otherwise, according to them the concept would never become a reality or it would never make to a utopian world concept at least not in the time suggested by the industry analyst. The graphs below show the opinion rating and respondent’s opinion attitude in %.

![Graph showing respondent's opinion rating for Q1.](image-url)

*Figure 35 – Respondent's Opinion Rating for Q1*
For the question about the future of self-driving cars (where future was defined as adaptability of self-driving cars and their indulgence in our daily life), 80% of the respondents said that there is a bright future for adaptation of autonomous vehicles, making the utopian world concept true. However, the rating which supported their argument varied between 6 to 10, indicating a level of confidence that is not extremely high but still significant. At least everyone who is sure that this would become a reality has a strong opinion about it. Those who rated their opinion close to 5 are sure that it would become reality one day but not sure when it would happen, whereas, the other group who rated 7 or more are from the school of thought who believe it would become reality soon. Moreover, 20% of the expert respondents thought that self-driving cars would not be able to win the heart of people and would not be widely accepted and adapted, at least nowhere in near future (which they referred as 3-5 decades from now). But the opinion rating varied between -3 to -8, which highlights two very important points: 1) No respondent backed their statement with the highest rating, and 2) There was relatively weak opinion rating overall, which means respondents were not strongly sure about their opinion if the autonomous vehicles would be adapted and accepted widely. The table below shows the descriptive statistics of Q1.
Table 5 - descriptive statistics Q1

<table>
<thead>
<tr>
<th>Positive Opinion</th>
<th>Negative Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td><strong>Mean</strong></td>
</tr>
<tr>
<td><strong>8.375</strong></td>
<td><strong>-6.166666667</strong></td>
</tr>
<tr>
<td><strong>Standard Error</strong></td>
<td><strong>Standard Error</strong></td>
</tr>
<tr>
<td><strong>0.261077061</strong></td>
<td><strong>0.792324288</strong></td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td><strong>Median</strong></td>
</tr>
<tr>
<td><strong>8</strong></td>
<td><strong>-6.5</strong></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
<td><strong>Mode</strong></td>
</tr>
<tr>
<td><strong>8</strong></td>
<td><strong>-8</strong></td>
</tr>
<tr>
<td><strong>Standard Deviation</strong></td>
<td><strong>Standard Deviation</strong></td>
</tr>
<tr>
<td><strong>1.279011167</strong></td>
<td><strong>1.940790217</strong></td>
</tr>
<tr>
<td><strong>Sample Variance</strong></td>
<td><strong>Sample Variance</strong></td>
</tr>
<tr>
<td><strong>1.635869565</strong></td>
<td><strong>3.766666667</strong></td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td><strong>Range</strong></td>
</tr>
<tr>
<td><strong>4</strong></td>
<td><strong>5</strong></td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td><strong>Minimum</strong></td>
</tr>
<tr>
<td><strong>6</strong></td>
<td><strong>-8</strong></td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
<td><strong>Maximum</strong></td>
</tr>
<tr>
<td><strong>10</strong></td>
<td><strong>-3</strong></td>
</tr>
<tr>
<td><strong>Count</strong></td>
<td><strong>Count</strong></td>
</tr>
<tr>
<td><strong>24</strong></td>
<td><strong>6</strong></td>
</tr>
</tbody>
</table>

4.5.1 Count, Range, Minimum and Maximum

The total number of people participated and gave their opinion about the future (Adaptability) of autonomous vehicles were 30. Out of there 30 participants 24 showed positive attitude towards the question with an opinion rating from 6 to 10, therefore, the difference (range) between these opinion ratings was 4 which is not a very high difference as everyone who has a positive attitude about future of AV has rated their opinion with more then 5 points on the scale. On the other side out of 6 participants who had a negative opinion about adaptability of AV rated their opinion between -3 to -8 which shows their weak support of opinion. The difference of 5 points has ben observed between their opinion ratings. No one was cent percent sure about their opinion as no one rated their opinion with 10 points.

4.5.2 Mean, Median and Mode

The mean (average) and the median of the positive opinion ratings are 8.375 and 8 respectively, which shows that an averaged rating in positive opinion can be considered strong. And the mode (most recurring number) for the positive attitude is 8, which is again at higher side. Whereas, negative opinions rating the mean and median is 6.16 and 6.5 respectively, which clearly shows that the opinion rating is more
towards mediocre side and not hold a strong support. The mode for the negative opinion is also 8 as this number represent the most recurring value in the data set and in the negative opinion rating this value occurred twice in 6 opinions, but the over all impact may decrease dramatically if the number of respondents are increased.

4.5.3 Standard Error, Standard Deviation and Sample Variance

The standard error in both the cases is 0.26 and 0.79, which means the value of mean could deviate ±0.26 in positive opinions and ±0.79 in negative opinion. Whereas, the degree of variation from the mean (Standard deviation) in the collected data set is 1.27 in positive opinion, which is close to, mean when compared with 1.94 of negative opinions. Moreover, the selected number of items from the population, which tells us the sample variance, is 1.63 for positive opinion, which is close to standard deviation of the data set, but the sample variance for the negative opinion is quite high which is 3.76.

4.6 Descriptive Statistical Analysis Q2

The 2nd question asked from the participants of the seminar was about the business prospect with autonomous vehicles. The idea was to take the expert’s opinion about the possibilities in the business sector with autonomous vehicles (it could be involvement of OEM, public procurers, technology providers or business modelers etc.), the question had a little varied response as compare to question 1. The figures below show the respondent’s opinions ratings and the opinion attitude percentages:
The data graph in the figure one depicts visual outcome of the collected data from the respondents where as the graphical representation in the second picture depicts the % of the opinion attitudes. From the doughnut graph we can clearly visualize that 67% of the people have positive opinion about the business prospects with Autonomous Vehicles, whereas, 33% of expert respondents think the opposite. The descriptive table in the figure below tells the descriptive analysis of the collected data.

### Table 6 - Descriptive Statistical Analysis of Q2

<table>
<thead>
<tr>
<th>Positive Opinion</th>
<th>Negative Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>7.55</td>
</tr>
<tr>
<td>Standard Error</td>
<td>Mean</td>
</tr>
<tr>
<td>0.438148016</td>
<td>-5.4</td>
</tr>
<tr>
<td>Median</td>
<td>Standard Error</td>
</tr>
<tr>
<td>7.5</td>
<td>0.7333333333</td>
</tr>
<tr>
<td>Mode</td>
<td>Median</td>
</tr>
<tr>
<td>10</td>
<td>-5.5</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>Mode</td>
</tr>
<tr>
<td>1.959457497</td>
<td>-8</td>
</tr>
<tr>
<td>Sample Variance</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>3.839473684</td>
<td>2.319003617</td>
</tr>
<tr>
<td>Range</td>
<td>Sample Variance</td>
</tr>
<tr>
<td>6</td>
<td>5.3777777778</td>
</tr>
<tr>
<td>Minimum</td>
<td>Range</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Maximum</td>
<td>Minimum</td>
</tr>
<tr>
<td>10</td>
<td>-8</td>
</tr>
<tr>
<td>Count</td>
<td>Maximum</td>
</tr>
<tr>
<td>20</td>
<td>-2</td>
</tr>
<tr>
<td></td>
<td>Count</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>
4.6.1 Count, Range, Minimum and Maximum

Out of 30 respondents who gave their opinion on business prospect with autonomous vehicles, 20 had a positive opinion about the business prospects with self driving care, whereas, 10 respondents had a negative opinion about the same question. The statistics clearly show that the highest opinion rating for positive opinion is 10 and the minimum is 4 this means the difference in opinion ratings is 6. On the other hand, out of 10 who had a negative opinion about it varied in their opinion rating from as low as -2 to as high as -8 the difference in their opinion rating is 6 too.

4.6.2 Mean, Median and Mode

The positive opinion’s average (mean) rating is 7.55 and median is 7.50, it means those who had a positive opinion on average backed their statement quite strongly, and the most recurring value of the opinion rating which is known as mode is 10 which appeared 5 times in the selected data set for positive opinion. On the other hand, the mean and median for the negative opinion ratings are 5.4 and 5.5 which almost lies at the middle and it tells, those who had a negative opinion about the business prospects where not quite sure with this opinion as they thought there might be some bright future prospects but vision is not quite clear, the most recurring value in these ratings is 8 which is though at a higher end but recurred only three times.

4.6.3 Standard Error, Standard Deviation and Sample Variance

The value of mean could deviate ±0.44 and ±0.73 in positive and negative case respectively which is at the higher end in negative opinion rating where as relatively lower at the positive opinion rating. The overall degree of deviation from the mean in the collected data set is 1.96 and 2.32 for positive and negative opinion rating respectively. The degree of variation in the selected population sample (sample variance) is 3.83 and 5.37 in positive and negative opinion ratings respectively.
4.7 Fundamental requirements for realizing self-driving project

The realization of such a project is dependent of several factors and requires a matrix of interconnected experts, states and organizations, which work in a synchronized environment for common goals and objective without any conflict of interest. The fundamental requirements for realization of such a project would be as following:

4.7.1 Defining outline of the project

An institution or organization responsible for initiating the project must draft a clear definition of the project, entailing all the details that would be necessary to share with those whom they want to be on board. A clear statement of interest should be mentioned along with the timeline of the project and possible outcome.

4.7.2 Setting the objectives

A list of objectives associated with the project should be clearly communicated to acquire the best resources to meet challenges and have a nuance final product. For example the list of objectives could comprise of the following:

- **Legal and Insurance aspects:** A team of experts in the area of law and communication along with insurance industry experts would be required to do an in-depth state level research to develop and suggest legal and insurance aspects of such vehicles when they get on the road.

- **Real road testing and observing people response & behavior:** Team of technical experts would be required to build the modal vehicle and test it on the public roads (permitted for testing) and panel of psychologists would be required to analyze the behavior of people how do they interact with the vehicle and what changes are required to make this alien product look more familiar to them.

- **Congestion control and safety issues:** The team of experts consisting on urban developers, architects and safety specialist would work in collaboration to analyze the situation of such vehicles on road realizing the needs for infrastructural changes to make lives secure, roads congestion free and hindrance free driving experience.

These multidisciplinary teams are expected to work on the same floor in order to meet the common objective.
4.7.3 Finding the right partner

The next task is to find the right partner for building the final product. A self-driving car basically a mix of chiefly two parts which is

- **Hardware provider:** It is important to find a collaborative partner who would be willing to provide the vehicles for testing, many companies like Audi, BMW, VW, Mercedes etc. are more then willing to develop this concept a reality therefore it is expected to be an easy task to find one or more partners willing to participate for this project. Furthermore the other hardware equipment are now also easily available and accessible therefore arranging hardware like LIDAR, RADAR, SENSER and CAMERS should not be an issue.

- **Technology Provider:** To find a technology provider could be a little difficult as those who are working on developing this technology would not be willing to share it without patent rights and or some other reasons. Therefore a team of experts could be hired from technical institutes to develop or progress the existing technology for such vehicles.

4.7.4 Finding the right location

An urban setting is good for the testing of this project after it has been tested in a controlled environment. The selection of such a place could be done in two ways:

- **Autocratic selection:** This type of selection would be easier as it requires an over view of the state with respect to road infrastructure, available resources (technological, man force, and experts etc.). If a state meets the basic requirements it could be selected.

- **Tendering:** a proper tender for competition should be launched where the motivation for states could be *Intrinsic* or *extrinsic* as tender might would have some funds for the winning state (it could be extrinsic motivation for states). And on the other hand, being the pioneer state (could be an intrinsic motivation) which would lead to the realization of more jobs, the advantages of early bird and likewise.

Hence this is the brief summary of requirement for the realization of such a gigantic project, which could take years to develop and actually start working. Therefor, a greater and in-depth analysis is required to finalize the Dos and Donts for this project and selecting the resources.
5 CONCLUSION, LIMITATIONS AND FUTURE RESEARCH

5.1 Conclusion
The study was conducted to analyze the possible role of Autonomous Vehicles on urban mobility keeping in focus that how would it revolutionize the individual and urban transportation. The results of the study are very promising and it shows that there are limitless possibilities and practical implementation of autonomous vehicles in day-to-day life. Moreover, autonomous vehicle’s adaptation and business prospect is first of its kind studies in Austria. The findings from the opinions of first few experts from Austria who directly participated in the discussion on the self driving cars is comparable to the rest of the world. A rising interest was observed not only in discussion but the experts were also keen in realization of the projects related to autonomous vehicles. The results convincingly showed that a big majority of the experts think that future has already begun and the driverless cars are no more just a science fiction element, whereas, a small minority of experts think it’s a little far away from the reality and would need much more time then suggested by many researchers and institutions for adaptability of autonomous vehicles. The study also concluded that government procurement agencies could also be actively involved in the process of procurement of innovative technologies and products. This would not just represent the interest in innovation on state level but would also be a profitable business. The research analyzed and suggested amendments in the current procurement process to make it an efficient system for procurement of innovative products like self driving cars.

5.2 Limitations
The study although covers many aspects but still the results could have had been more promising if a wide variety of comparable data was available. More precisely the data for the taxi and normal vehicles kilometers driven per day, the emission associated with it, the capacity utilization, and average fines per vehicles per day in Vienna could help
understand better what impact the vehicles would have when adapted in Vienna like urban environment. The research has concluded the opinion of few professionals and it is possible if more professional get involved in the survey the result might vary from the current results though the chances of it to happen are very low.

5.3 Future Research

There are allot of researches going on currently on the Autonomous Technology in vehicles but there is a great gap between technology and implementation, there is a need to conduct such researches, which would bridge the gap between the technology and its economical implementation. A few practical implementations are discussed in this paper but there are still many unexplored areas, which need to be cited. There are limitless possibilities to develop the business models with the self-driving cars, mostly the research on this topic is uni-directional that is every one is researching the technical aspect of this technology but not much work has yet been done on the implementation side of the technology. Many researchers have suggested some car sharing models and self-driving taxis but no implications and acceptance of such models by general public has been discussed on broader scale. There are several topics related to self driving vehicles which are still unexplored and requires extensive attention from researchers.

During the discussion with experts in a conference many interesting topics came under discussion; like, concerns over the question “Who should be held responsible in the case of an accident”. Many had an argument that the company should be held responsible and other suggested that the user should be held responsible it is a debate on the global level too but at the same time it is an open challenge for policy makers, and involving the general public the solution to this question could be calculated.

Not everything associated with self driving cars in a utopian market is bright and full of colors though people fancy about it but this technology when would reach a utopian would bring with it many downsides like losses in skilled jobs of driving and there is an economical cost associated with it, the tax / fine revenues may decrease dramatically and it would have deep penetrating impact in the society too. There is a need to study the down side of this technology, although a few articles, blogs and papers have discussed these topics briefly, but still a deep insight on these topics is required.
6 REFERENCES


13. KPMG. *Self-Driving Cars: Are We Ready?*. Yearly Analysis, KPMG, 2013.


7 APPENDIX

(A-G)
A) Phases of AV adaptation

The Four Phases of Autonomous Vehicle Adoption

<table>
<thead>
<tr>
<th>Phase 1 – Passive Autonomous Driving (0-3 years)</th>
<th>Phase 2 – Limited Driver Substitution (3-5 years)</th>
<th>Phase 3 – Complete Autonomous Capability (5-10 years)</th>
<th>Phase 4 – 100% Penetration, Utopian Society (Two decades)</th>
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<td><strong>Capability:</strong> Autonomous capability is not meant to control the car but only acts as a second line of defense in the event that a mistake by the driver is about to cause an accident.</td>
<td><strong>Capability:</strong> The driver is still the primary operator of the vehicle under all conditions though he can give up some duties to the vehicle. This also includes limited external self park capability.</td>
<td><strong>Capability:</strong> The car can accelerate, brake and steer by itself in mixed and transitional driving conditions but the driver should remain in the driver’s seat ready to take over in the event of an emergency or system failure.</td>
<td><strong>Capability:</strong> This is an “ideal” world in which all cars on the road have at least a Phase 3 level of autonomous capability and full V2V/V2X capability, and the cars are capable of driving themselves with zero human intervention.</td>
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<td><strong>Functions:</strong> adaptive cruise control, crash sensing, blind spot detection, lane departure warning, night vision with automatic pedestrian highlighting</td>
<td><strong>Functions:</strong> All Phase 1 features plus automated braking/throttle/steering with GPS driven forward vision.</td>
<td><strong>Functions:</strong> All Phase 2 features plus capability to manage transitions, lane changes, navigate intersections, etc.</td>
<td><strong>Functions:</strong> All Phase 3 features plus focus on lifestyle/entertainment of occupants with car control as a backup/supporting function, cars can also travel with no occupants. Remote control/disable feature necessary</td>
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<td><strong>Tech needed:</strong> radar, front camera, infrared camera, AV display, mechatronic controls</td>
<td><strong>Tech needed:</strong> All Phase 1 tech plus more advanced forward radar (with multi-level forward sensing), GPS connectivity to map database.</td>
<td><strong>Tech needed:</strong> All Phase 2 tech plus redundant capabilities, advanced sensors to interpret surroundings, basic V2V/V2X system, access to a vast database of roads and other infrastructure</td>
<td><strong>Tech needed:</strong> All Phase 3 functions with advanced human machine interface, artificial intelligence, fully networked road and vehicle infrastructure</td>
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<td><strong>Cost:</strong> CPV ~ $100-200 each; total cost to customer of about $1000-1,500.</td>
<td><strong>Cost:</strong> Cost to customer ~ $2,000-5,000 (at today’s prices).</td>
<td><strong>Cost:</strong> Cost to customer ~ $5,000-7,000. (at today’s prices)</td>
<td><strong>Cost:</strong> Cost to customer ~ $10,000. (at today’s prices).</td>
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<td><strong>Our View:</strong> These systems are already available as optional extras on high end luxury vehicles and even some mid-line cars today. As the cost of these systems comes down, early adopters spread positive feedback and safety agencies like Euro NCAP mandate adoption of active safety systems, we could see mass penetration of these technologies ramp in 3 years.</td>
<td><strong>Our View:</strong> This type of limited autonomous vehicle should hit the road first in the 2014 Mercedes Benz S-Class, which allows autonomous driving in traffic and high-speed (but limited) highway conditions. Next gen self park systems will allow the driver to exit the vehicle while it parks. However, the driver may still have to drive up to a vacant spot.</td>
<td><strong>Our View:</strong> Prototypes of such vehicles exist today though mass introduction with an automotive grade of reliability will need a certain level of infrastructure development (for V2X), certain minimum penetration level of Phase 1/Phase 2 systems (for V2V) and widespread acceptance of the concept of autonomous driving.</td>
<td><strong>Our View:</strong> Despite the relatively small technological leap vs. Phase 4, we believe this will take much longer due to required high penetration of the existing car parc and some infrastructure development. However, this phase could be realized sooner than we think.</td>
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Sehr geehrte Damen und Herren,


Unsere Veranstaltung: Plattform Innovation

Folgende Themenbereiche stehen im Fokus der interaktiven Szenarios:

- E-Flotte (hosted by Bundesbeschaffung GmbH)
- E-Nutzfahrzeuge (hosted by Heise Fleet Consulting)
- E-Car-Sharing (hosted by Austrian Energy Agency)
- Autonomous Driving (hosted by Institut für Transportwirtschaft, WU Wien)

In den Pausen besteht die Gelegenheit, sich mit Unternehmern und Expertenorganisationen im Ausstellerraum über aktuelle Trends und innovative Produkte zu unterhalten. Es besteht die Möglichkeit, ganztägig E-Fahrzeuge zu testen! Nähere Details zum Ablauf der Veranstaltung entnehmen Sie bitte der Agenda.

Organisatorische Rahmenbedingungen:
Die 4. Plattform Innovation findet am 7. Mai 2015 von 9:00 Uhr bis um 16:30 Uhr im Austria Trend Hotel Bosei am Wienerberg (Gutheil Schoder Gasse 7b, 1100 Wien) statt. Hinweise zur Anfahrt entnehmen Sie bitte dem Lageplan.
C) Scenarios

4. Plattform Innovation
E-Mobilität – Alles was einen Stecker hat!
Moderation: Florian Unterberger

Details zu den Szenarien

Szenario 1: „E-Flotte – Hype oder Zukunft?“
Moderation: Thomas Lang
hosted by Bundesbeschaffung GmbH

Impulsbeiträge von:
Renault (Sandra Bayer)
Tesla (Robert Capewell)

Szenario 2: „E-Nutzfahrzeuge – Arbeitstier oder lahme Ente?“
Moderation: Nikolaus Engleitner
hosted by Heise Fleet Consulting

Impulsbeiträge von:
Graz Holding (Robert Schmied)
Post AG (Daniel-Sebastian Mühlbach)
Vlotte (Stefan Hartmann)

Szenario 3: „Elektro Auto teilen – Carsharing 2.0“
Moderation: Willy Raimund
hosted by Austrian Energy Agency (AEA)

Impulsbeiträge von:
Caruso (Christian Steger-Vonmetz)
Emil (Horst Kitzmantel, Hans-Peter Buchegger)
KPC (Wolfgang Löffler)

Szenario 4: „Future Scenario: Self Driving Cars – The future has already begun“
Moderation: Clemens Schuhmayer
hosted by Institut für Transportwirtschaft, WU Wien
Mitwirkung von Muhammad Azmat (WU Wien)
D) Participating organizations

Die Veranstaltung wird im Auftrag von folgenden Organisationen durchgeführt:

bmwf
Bundesministerium für Wissenschaft, Forschung und Wirtschaft

bmwift
Bundesministerium für Verkehr, Innovation und Technologie

BBG
Bundesbeschaffung

Die Veranstaltung findet in Kooperation mit folgenden Partnern statt:

EA
AUSTRIAN ENERGY AGENCY

TTL

WU
Wirtschafts universität Wien, Vienna University of Economics and Business

Heise
fleets consulting

austrian mobile power
The e-mobility alliance

austria wirtschafts service
aws
Ausstellerliste

4. Plattform Innovation:
E-Mobilität – Alles was einen Stecker hat!

Datum: 07.05.2015, 9:00 – 17:00 Uhr
Ort: Austria Trend Hotel Bosei, Gutheil Schoder Gasse 7b, 1100 Wien
Anmeldemöglichkeit: www.iobe.at/e-mobility

Folgende Unternehmen sind vor Ort vertreten:

Ladeinfrastruktur

ABB
Enio
Schrack
Smatrics

E-Mobilitätslösungen

AlphaCity Austria
AWS
Beko
GW St.Pölten
UCarver
Has To Be
Ibiola
Innovametall

E-Fahrzeuganbieter

AZ-Tech
BMW
Hyundai
Goupil
Kia
Lohner
Mercedes
Nissan
Renault
Tesla
Volkswagen
Ziesel
F) Experiment outcome on flip charts

(Questions about Future of Driver Less Cars & Business Prospect)
G) List of participants & organizations

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