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Autonomously Parking Cars in Sweden - When and How?

Implications for Parking Infrastructure in Gothenburg, Sweden

Master of Science Thesis in the Management and Economics of Innovation Programme

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CHALMERS UNIVERSITY OF TECHNOLOGY
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Abstract

This thesis is about autonomous parking cars and the implications for infrastructure of parking. The changes that are needed and the adoption of the new innovation are studied in the transition phase, the phase where there will be both traditional and autonomous cars in society. The methods used to study this have been an extensive literature review, databases, internal company data and mainly expert interviews. The results showed that there are clear benefits with autonomous cars but also some factors that can prevent a near market introduction. From the results section, a view of when autonomous cars of different levels can be introduced to the market was created. With the information gained using the different methods and analysing this information, clear recommendations of what could be done in different phases was illustrated in a timeline.

Keywords: autonomous cars, autonomous parking, autonomous vehicles, transition phase, infrastructure, self-driving, automated driving,

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We would also like to thank all the experts that participated in the interview part. The interviews did not only result in a great basis for the result section of this thesis but also lead to interesting discussions and sharing of knowledge. It is clear that there is a lot of knowledge in the area of autonomous cars in Sweden.

A special thank you to our supervisor Frances Sprei for helping out with your knowledge in the field and constantly guiding us in the right direction.

Navid Fallah and Axel Karlsson, Gothenburg, October 2016

Abbreviations and Terms

When describing that a car has some level of autonomy has in this thesis been explained in different words, the terms autonomous, self-driving and automated driving have been used interchangeably.

FAP - Fully autonomous parking, a fully autonomous parking cars is a car that can park on driver's command without any assist or even presence of the driver

TP - Traditional parking

SAP - Semi autonomous parking

Parkeringsbolaget - Göteborgs Stads Parkerings AB

NHTSA - National Highway Traffic Safety Administration

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1 Introduction

This section describes the context and background of the master thesis and also the purpose of the research. The research questions that will be answered throughout the report are also stated in this section.

1.1 Context

Autonomous cars have been on the agenda ever since cars started to appear over a hundred years ago. The development in the area during the last decade has been rapid and the idea is now a real concept rather than a futuristic idea. Autonomous vehicle is an area which is evolving rapidly as many of the leading car manufacturers in the world are focusing on developing new concepts and solutions for autonomous parking and autonomous vehicles in general. Cars are already becoming increasingly automated and some predict as many as ten million autonomous cars on the roads by 2020 (Greenough, 2015). According to a study performed by the Boston Consulting Group (2015), people think that the most important benefit from autonomous cars is the convenience it has in parking. With an autonomously parking vehicle, the user of the vehicle could potentially just leave the car somewhere, let it park itself and save massive amounts of time while the car perform tasks like being repaired or picking up your post. Apart from just helping humans in their everyday-life, the potential positive effects on infrastructure and society could be many. For example, no driver will need to drive around and look for a free parking space which could lead to reduced Co2-emission. In congested urban areas about 40 % of total gasoline use in vehicles is spent looking for parking spaces (Mitchell, Borroni-Bird & Burns 2010). It is also possible that the parking structures can be a lot smaller with autonomously parking vehicles since they can be parked tighter and the building does not have to be adapted to humans. A car today is only used 3-5 % of the time, with cars being autonomous, it is possible that the utilisation will be a lot higher, as a result less cars will be needed and less cars will be parked at any given time. A development like the one described above could free up space in the city that can be used for other purposes that could benefit all individuals in society (Boston Consulting Group, 2015). Some argue that autonomous cars could raise the miles per traveled vehicle since there would be a more frequent use of autonomous vehicles because of their availability. There are also skepticism about the technical feasibility of autonomous cars, if they really can be programmed to cope with all technical and moral situations (Anderson et. al., 2014).

Current scientific literature in the topic of autonomous driving has its main focus on the vehicle and its functions and benefits, technical development, feasibility, challenges and legislations (Litman, 2015; Beiker, 2012 and Garza 2011). However there is only recently that literature has started to focus on how to implement autonomous vehicles in current infrastructure and society such as parking facilities and roads (Litman, 2015) and there is a gap in the literature regarding the transition phase from traditional vehicles to autonomous driving vehicles.

1.2 Thesis Background

Starting from 2017 Volvo Cars will release 100 autonomous vehicles in the traffic of Gothenburg, the programme is named “Drive me” and is part of a collaboration between Trafikverket, Gothenburg City, the Swedish Transport agency, the Swedish Transport Administration, Autoliv, Lindholmen Science Park and Chalmers University of Technology (Volvo Cars, 2015). The purpose of the “Drive Me”- programme is to study the benefits of autonomous vehicles and to make Sweden a leading actor within sustainable mobility (Trafikverket, 2015). Parkeringsbolaget is a municipal company owned by the city of Gothenburg that is actively contributing to the development of the city by offering parking and mobility solutions and is working towards promoting new traveling habits (Parkeringsbolaget, 2015). Within the “Drive Me”- programme, Parkeringsbolaget is since 2016 working with a project named “Autonomous Cars” where they aim to evaluate how a potential transition from traditional cars to autonomous cars would affect the city and what potential benefits they could gain from such a transition. In this project Parkeringsbolaget’s primary target is to assess the autonomous vehicles from a parking perspective, however as an autonomously driving car will have the ability to also autonomously park, the view of autonomous driving is also highly relevant.

1.3 Definitions

According to Habibovic et. al. (2014) there are no agreed definition of vehicle automation levels. The literature is often using the definition from National Highway Traffic Safety Administration (NHTSA) and this thesis will refer to the model they present. NHTSA (2013) defines five different automation levels for vehicles. These are presented in Table 1.1.

Table 1.1: Automation levels according to NHTSA (2013).

Automation levels	**Description**
Level 0: No Automation	The driver is in complete and sole control of the primary vehicle controls– brake, steering, throttle, and motive power – at all times.
Level 1: Function Specific Automation	Automation at this level involves one or more specific control functions.
Level 2: Combined Function Automation	This level involves automation of at least two primary control functions designed to work in unison to relieve the driver of control of those functions.
Level 3: Limited Self-Driving Automation	Vehicles at this level of automation enable the driver to cede full control of all safety-critical functions under certain traffic or environmental conditions and in those conditions to rely heavily on the vehicle to monitor for changes in those conditions requiring transition back to driver control. The driver is expected to be available for occasional control, but with sufficiently comfortable transition time.
Level 4: Full Self-Driving Automation	The vehicle is designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip. Such a design anticipates that the driver will provide destination or navigation input, but is not expected to be available for control at any time during the trip. This includes both occupied and unoccupied vehicles.

1.4 Purpose

The purpose of this master thesis is to evaluate from different perspectives what elements need to be considered when making the potential transition from traditional vehicles to autonomous parking vehicles. In this thesis, changes will be proposed in different steps with help of a forecast that will predict how the diffusion of the technology will apply in society. It is also important to map the potential benefits or drawbacks that a transition and the use of autonomous parking vehicles could bring to society. This master thesis project aims to identify some of the issues that arise when assessing a transition from traditional to autonomously parking vehicles and proposing recommendations to manage these issues.

1.5 Research Questions

What factors will affect the transition phase from traditional vehicles to autonomous vehicles and what factors can affect the level of adoption?

What benefits for society could be gained during a transition from traditional to autonomous vehicles in Gothenburg?

Which customer segments are likely to be the early adopters?

When and how could Parkeringsbolaget start adapting to a potential technological change to maximize the benefits for the city?

1.6 Delimitations

This thesis will not be focusing on parking assisting concepts but rather concepts where the car navigates in the car park, finds the parking spot and drives autonomously into it without any human assisting and during this process is able to identify and manage obstacles on the way. This corresponds to a car with level 4 automation within the parking environment. However the thesis will also cover autonomous driving with level 3 or 4 automation since autonomously driving cars will also have the attribute of autonomous parking and therefore it will also be relevant to study those in this thesis. Since this thesis is aiming to propose recommendations to Parkeringsbolaget, the thesis will focus on Sweden in general and the City of Gothenburg in particular during the assessment of policies and infrastructure recommendations.

1.7 Report Outline

The report is divided into eight parts which are presented below.

Introduction. The introduction explains the context of this study and its relevance. This section provides the reader with the research questions of the study, its purpose and delimitations.

Method The method explains the research design and approach of the performed study. It also presents why the specific research strategies were chosen.

Theory/Literature Review. The literature review provides the reader with a theoretical review of the topic diffusion of innovation from different perspectives. It also provides a section where the current industry of autonomous vehicles and autonomous parking vehicles have been assessed.

Interview Findings The results section comprises of the expert interviews. It provides the reader with a list of all the interviews conducted and gathered summaries of each question.

Analysis. In this section the results are put in contrast to the literature review. Various theoretical models have been applied in contrast to the situation of Parkeringsbolaget.

Discussion. The discussion discusses the different parts of the study and their results critically.

Conclusion. The conclusion summarizes the study, answers the research questions and proposes recommendations

2
Method

This section describes how this thesis has been written in terms of research approach and design of the conducted study. Aspects such as research quality and ethical factors is also discussed in this chapter.

2.1 Research Approach

According to Teddlie Tashakkori (2003) and White (2011) the choice of methods in a research study is dependent on the research questions that needs to be answered. Exploring a wide range of issues implies that several methods might need to be applied. This thesis is based on a wide number of questions to be answered. Easterby-Smith (2015) argues that the method of triangulation could be adopted in research in order to increase the confidence in the accuracy of the observations. This thesis have used that approach by using 1. qualitative methods such as interviews with experts and stakeholders within the field. 2. Secondary data such as published journals, magazines and books. 3. Internal company data.

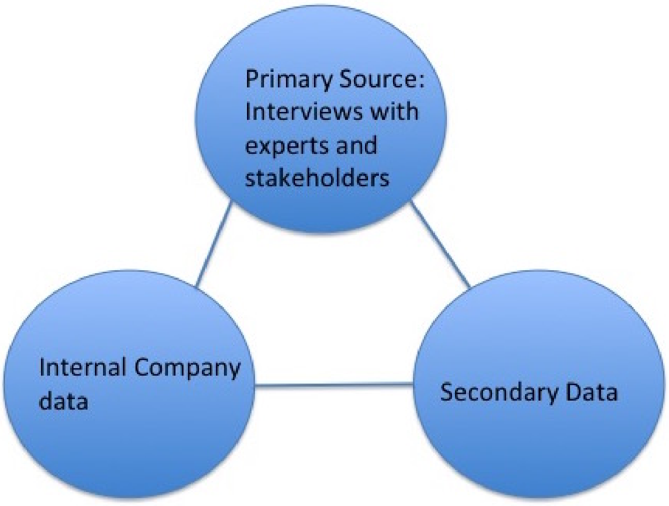

Figure 2.1: Illustrating triangulation in this thesis

According to White (2011) the research approach evolves from different epistemological considerations which according to Easterby-Smith (2015) is a general set of assumptions about ways of inquiring the nature of the world. The epistemology is divided in two main parts: Positivism and Social constructionism. The research in this thesis has adopted a social constructionism view which according to Easterby-Smith (2015) deals with small sample sizes chosen for specific reasons, incorporates stakeholder perspectives and aims to increase general understanding of a specific situation. The analysis of this approach is mainly comparison, triangulation and understanding which leads to outcomes such as new insights and potential actions.

2.2 Research Design

The research in this thesis has mainly been done in three ways, a qualitative interview part where experts within the field of autonomous cars has been interviewed, a literature review where studies on innovations and technology has been reviewed and then combined this with an analysis of the current market of autonomous driving and parking vehicles.

White (2011) argues that it is important to define the different methods and how they complement each other and to what extent each method is used. To be able to give recommendations for the future of the business and the implications on society, it is vital to know what the state of the industry is to this date. To know the state of the industry, an extensive study as to what the different actors on the market is doing right now has been performed. Technology-wise, this has been done by looking at what the different car manufacturers and other technology companies are focusing on. When deciding the state of the industry in a societal perspective, legislation and other actors in the industry are being studied. The initiator of this study, Parkeringsbolaget in Gothenburg, has been interviewed to see how far they have come in the preparation of a possible implementation of autonomous cars and to determine how their infrastructure of parking looks like today. Without knowing the present parking situation, it is impossible to propose changes to it.

2.3 Data collection

Data was collected in a number of different ways and this section will describe all the data collection methods and procedures that has been applied in this master's thesis.

2.3.1 Studying the current market

To be able to study the current market of autonomous vehicles and autonomous parking vehicles content providers has been used to find the relevant data. Search engines such as Google have been used extensively when searching for data about the current market. Other companies research documents about autonomous vehicle driving and parking has given a hint of which the main actors within the field are and a more general view of where the technology is currently. The data from the research documents led to a search in the most relevant companies websites to assess where their technology is in the current state and has sometimes also given an indication of where it is going. The most relevant companies were chosen by assessing which vehicles are most driven currently in Sweden.

Research documents on autonomous parking and autonomous vehicles was gathered from the companies below:

- Boston Consulting Group
- KPMG and Car
- Transportstyrelsen
- Trafikverket
- Vinnova
- Thomson Reuters
- McKinsey & Co.

2.3.2 Studying Parkeringsbolagets current situation

To be able to propose recommendations for Parkeringsbolaget it was necessary to gather data on their current parking infrastructure where factors such as number of parking spots, location of car parks and the price of a car park was necessary to gather. These were gathered in three ways, firstly through their website Parkeringsbolaget.se. Secondly by reading their annual report and lastly by having a meeting with employees with insight in the organisation that could provide us with the content that could not be gathered through the first two methods.

2.3.3 Interviews

When selecting who to interview in this phase, focus was on people that had great knowledge within the business of autonomous vehicles. A list of potential names was developed, these names came both from who Parkeringsbolaget thought was interesting, but also from our supervisor and from our own investigations of the business. This list was immense and all persons on it could not be interviewed, it was decided that the persons with the most knowledge would be chosen but all different actors of the business had to be represented among these. The interviewees were also gathered through snowball sampling which according to Easterby-Smith (2015) is when you ask each interview subject if they have any other contacts that could be relevant for the research. This sampling strategy is relevant in settings with limited access (Easterby-Smith, 2015).

The qualitative interview part of the study was performed as semi structured interviews. A semi-structured interview is according (Easterby-Smith, 2015) a guided open interview. In a semi-structured interview, questions can be addressed in a flexible manner and follow-up questions can be asked. A set of standard questions were prepared and the standard questions were asked to all interviewees and the only varying factor was the secondary questions that varied depending on their reasoning. Easterby-Smith (2015) argues that there is a risk that the interviewee gets too personal in a setting with less structure. In the interviews made in this study, this risk was mitigated by remaining on the fixed set of questions and returning to those when the person interviewed get off-topic.

Specific questions were asked in such a way so that the answers could be compared and analysed in a scientific way. These questions could be seen as highly structured, for example one question was: “Name the three most important advantages with autonomous cars”. With that question, the interviewees could only name three and then reason around it afterwards, this created a valuable opportunity for comparison. The interviews were approximately one hour long and was conducted by two persons. One person led the interview and asked the questions while the other person wrote notes during the interview to be able to archive the answers of the interviewee. The interviews were performed in Swedish language and all the quotes in the report are the author’s translations of the answers.

2.3.4 Literature review

The literature review was conducted with two purposes. Firstly this method will help to strengthen the quality of the research and secondly, an analytical viewpoint of the subject could help to analyse the subject in a broader perspective. The literature review helped us to get insight in the topic, find past research, find gaps in the past research and find opportunities for future research. The literature review in this master thesis was gathered through mainly Google scholar, the library in Chalmers University of Technology and electronic databases which are listed below:

- Chalmers Library
- ProQuest
- JSTOR
- Science Open
- SAGE Publication

2.4 Data Analysis

This master thesis have used three types of methods for analysis and they are presented below.

2.4.1 Constant comparative analysis

This thesis has used constant comparative analysis which involves taking pieces of data and compare it with all the others that may be similar and through this process trying to find possible relations between various pieces of data (Glaser and Strauss, 1967). This type of analysis have been used during the compilation of the results where the questions from each interview have been compared to the other interviews. It was also used during the analysis to compare the results to the theory.

2.4.2 Scenario analysis

The thesis has also used scenario analysis which is mainly a method that analyzes future events by considering possible outcomes (Aaker, 2001). Scenario analysis have been used in this thesis to try to get a picture of how and when autonomous vehicles and autonomous parking vehicles could be spread in society. This method was used mainly in the analysis sections 5.6 and 5.7. The possible outcomes have been analyzed with help from the interview findings and the theory section.

2.4.3 Comparing existing theory in contrast to interviews

The thesis have been comparing existing theory and applying it to the interviews conducted. This have been done to try to find different types of relationships between the theory and the results. The frameworks from the theory have also been applied to the current market of autonomous vehicles in order to get a scientific viewpoint of the results.

2.5 Proposing recommendations

When all data had been collected and analyzed, recommendations were proposed to Parkeringsbolaget. The recommendations were developed by the authors by trying to generate potential ways to facilitate a potential transition traditional to autonomous parking vehicles and getting the most benefits even during a transition phase.

2.5.1 Research quality

One of the key justifications of doing research is that it yields results that are accurate and believable (Easterby-Smith, 2015). To examine whether the research has quality there are some terms that are discussed and used in order to judge the research quality. The three terms discussed is “Validity”, “Reliability” and “Generalizability”(ibid.). According to Easterby-Smith (2015) these terms have different criterias based on the different types of epistemological viewpoints. This paper is mainly based on a constructionist viewpoint and the criterias for these terms based on this viewpoint will be discussed below.

2.5.1.1 Validity

To gain high validity in research it is according to Easterby-Smith (2015) important to have a sufficient number of perspectives included in the research. This could help the research to analyze the problem from different viewpoints which in turn leads to a higher quality. This paper has tried to gain validity by not only looking at the benefits of autonomous driving but has also tried to evaluate the limitations of autonomous driving in order to get a subjective view on the research topic. The interviewees in this thesis were chosen in order to get as much insights as possible from different actors with different perspectives of the topic. The interviewees were gathered from industries and organizations with different motives and goals. This led to a lot of different perspectives in the qualitative part of the research. According to Björklund and Paulsson (2003) triangulation could increase the validity of a research. In contrast to Easterby-Smith (2015) they argue that triangulation has different types: method, data, theoretical and investor triangulation. This thesis have used two of these types as table 2.1 illustrates:

Table 2.1: Illustrating the different triangulation methods used in the report.

Triangulation methods	**Data**	**Investor**
Description of methods	Primary sources, Internal company data, secondary sources	By having two people conducting the research with a supervisor reviewing.

Method triangulation have not been used in this report. Usually other methods such as observations and focus groups could be used when conducting qualitative data. According to Schmuck (1997) observations could help to gather non-verbal expressions of feelings in qualitative research. Since this research is aiming to gather expert opinions and insights this method has not been used. Focus groups are often used in research relating to group norms, meanings and processes (Gill et. al, 2008). This research has avoided the use of focus groups since we would like the individual opinion of every expert without any possible bias from other participants. Theoretical triangulation have not been used in this report either. The main theoretical viewpoint used in the report is diffusion of innovation, it could be argued that other viewpoints could raise the reliability of the thesis but the theoretical viewpoint in this thesis is supported by expert interviews and other data which potentially could weigh up the validity of the thesis.

2.5.1.2 Reliability

According to Easterby-Smith (2015) the reliability of the research is dependent on whether other researchers could reach similar observations as this research did if they chose to conduct a similar research. This paper has aimed to be transparent in the data collection and interpretation to be reliable. This has been done through semi-structured interviews where the name and organization of all interviewees are presented in the report. The method of conducting the entire research is also communicated in the report in order to add transparency to the research which will enable other researchers to achieve similar observations.

2.5.1.3 Generalizability

The generalizability of research is dependent on how diverse it is. The more sufficiently diverse the research is the better it could inference to other context (Easterby-Smith, 2015). This research has been made in order to analyze a situation which is in the interest of Parkeringsbolaget which are based in Gothenburg, Sweden. The recommendations from this study are mainly based study of the market and future of autonomous vehicles is based on a diverse sample with global vehicle manufacturers and therefore the conclusions drawn in the context of the future and current market of autonomous vehicles could be argued to be generalizable however the recommendations proposed and the research questions are customized to Parkeringsbolaget situation which could hamper the generalizability of the thesis.

2.6 Research Ethics

The consideration of ethical issues in research leads to a higher research quality. Easterby-Smith (2015) argues that there are some key principles in research ethics which should be carefully considered when doing research. The principles are about protecting the interests of the research subject and the integrity of the research community. To protect the interests of the research subject ther research subject should be fully informed of the consent of the research and their privacy should be protected. This master thesis has aimed to protect the interest of the research subject by being transparent and informative during the qualitative part of the research and by not assigning the opinions and insights of the interviewees to their names in the report. This ensures protection of the anonymity of the research participants and has also increased the quality since the participants has been able to speak more freely. The research participants in this thesis has in all situations been informed about the aim of the research to ensure honesty and transparency in the conducted research. Prior to writing about the research participants opinions and putting their name in the report they have been asked for authorization.

3

Theory/Literature Review

The literature review is divided into two topics. These topics aims to give the reader an insight into the area of diffusion of innovation where it handles the issue of what factors impact the diffusion of new innovations. The section also deals with the subject of autonomous vehicles to give the reader an insight in the area of autonomous vehicles.

3.1 Diffusion of Innovation

Diffusion of innovation is a term coined by Rogers (1983) and he defines diffusion as: "The process by which an innovation is communicated through certain channels over time among the members of a social system" Rogers (1983, p.5) According to Rogers (1983) , four factors are influencing the spread,: communication channels, the innovation itself, time and the social system. Tidd & Bessant (2009) argue that in order to achieve a deeper understanding and a better planning for the diffusion of innovations we need to examine and analyse the factors that promote and constrain adoption of innovation. Also assess how these influence the rate and level of diffusion within different markets and populations (Tidd & Bessant, 2009). According to Tidd & Bessant (2009) and Porter (1997) there are a lot of barriers to the widespread of innovations and these are summarized in table 3.1.

Table 3.1: Barriers affecting the diffusion of innovations (Tidd & Bessant, 2009)

Barriers affecting innovation diffusion	**Description**
Economic	costs versus social benefits, access to information, insufficient incentives, economic climate
Behavioral	priorities, motivations, rationality, inertia, propensity for change or risk
Organizational	goals, routines, power and influence, culture and stakeholders
Structural	infrastructure, sunk costs, governance

According to Tidd Bessant (2009) these barriers are the reasons that historically large complex socio-technical systems only change incrementally rather than radically. Since there are a lot of different barriers and factors that innovations and technical systems depend on, the development of a technical system is a complex issue. Rogers (1983) argues that innovations could be either rejected or adopted either by individuals in a system or by more parts in the social system. He defines these decisions in three ways:

1. Optional innovation-decisions which are the choices made by an individual who is independent of the decision from others in the social system.
2. Collective innovation-decision which are the choices that are made by all members of a system. This type of decision usually has to be conformed by all of the units in the social system. Here the individual has some influence in the decision.
3. Authority innovation-decisions which are choices to adopt or reject an innovation that are made by few powerful actors in the social system who normally have power, influence and high technical expertise.

Usually the authority innovation-decisions are the ones that gives the fastest implementation. Followed by optional innovation-decisions and collective innovation-decisions are the one that gives the slowest implementation rate (Rogers, 1983).

3.1.1 Factors affecting adoption

Robertson (1967) argues that if an innovation appears to be much better than the existing form of it then there is only a matter of time before it is adopted. However Rogers (1995) and Lindmark (2006) argue that the adoption is based on more factors than only the advantage of the innovation. Tidd (2010) and Rogers (1983) argues that there are certain characteristics of a technology that affects the adoption of it. Tidd (2010) argues that five factors explain 49-87% of why a technology is adopted. These are: relative advantage, compatibility, complexity and trialability. However Tidd (2010) argues that contextual and environmental factors also are important. The five factors affecting the adoption of innovation are based on Rogers (1995) and are presented below.

3.1.1.1 Relative advantage

Relative advantage is the degree to which an innovation is perceived as better than the idea it supersedes. The degree of relative advantage could be in the form of functionality, technical performance or cost parameters (Lindmark, 2006). According to Rogers (1995), it is not important if the innovation has lots of objective advantage, what is of importance for a rapid adoption rate is whether individuals perceive the innovation as advantageous. The more advantageous the innovation is perceived, the faster the adoption rate will increase.

3.1.1.2 Compatibility

The compatibility of an innovation is the extent to which the innovation is consistent with existing values, needs, past experiences and investments. Lindmark (2006) argues that it is specifically important for the innovation to be compatible with existing products and services.

3.1.1.3 Complexity

The degree to which an innovation is perceived to be complex and hard to use. According to Lindmark (2006) the more complex the innovation is the slower the adoption process will be.

3.1.1.4 Trialability

The degree to which an innovation could be tested with on a limited basis or explored by potential early adopters. An innovation has a higher chance of being adopted if it can be tested or experimented with easily.

3.1.1.5 Observability

The degree to which an innovation and the result of it are visible to its potential adopters.

3.1.1.6 Complements and substitutes

According to Lindmark (2006) the performance, cost and availability of complementary and competing technologies also affect the rate of diffusion of an innovation. Innovations are often dependent on complementary techniques after it has been launched and the absence of these complementary innovations could slow the diffusion rate since they could take a long time to develop. Lindmark (2006) argues that previous technologies that are older often continues to be improved even after a “new” innovation is launched and these new improvements often tend to slow down the diffusion of the new innovation. Lindmark (2006) argues that in economics complementary goods are defined as goods which has a negative cross-elasticity of demand which means that if the price increases in the complementary product it leads to a decrease in demand of the focal product. Competing technologies are defined as goods for which the cross-elasticity of demand is positive which means that a price increase in the competing product will lead to increase in demand of the focal product. An example of a substitute product for an autonomous vehicle is a traditional vehicle and if the price for autonomous vehicles increases the demand of traditional vehicles will increase.

3.1.2 Adoption Chain of Innovations

There are various humans that adopt to innovation in many different ways and these people are categorized in five different categories in Rogers theory: innovators, early adopters, early majority, late majority and laggards (Rogers, 1983). Rogers divides the population according to their level of innovativeness. The level of innovativeness is likely to decide when and how the group will decide to adopt the innovation in question. The level of innovativeness is not a fixed variable and someone who is classified as an early adopter in one setting could be a laggard in another. To be able to discuss the different adoption categories they are here written as described by Rogers (1983).

The first group is the innovators. Innovators are always willing to try new ideas and are usually involved in a social relationship with a clique of other innovators. Innovators have control over enough financial resources so that if one of their innovations turn out unprofitable they will still be able to pursue with other innovations. An innovator is characterised with the fact that they can deal with a high degree of uncertainty about a new innovation and is willing to take risks. The innovator is at the beginning of the diffusion process and the one who introduces the product into a social system (Rogers, 1983).

The second adoption category is the early adopter. The early adopters are a more important part of a local social system and have some kind of status and are the ones that are “the individual to check with” for adopters when they look for information about the innovation according to Rogers (1983). Actors that want change fast usually looks for the early adopters in order to make the process of diffusion faster. The early adopters are not that different from the later categories when it comes to innovativeness and can work as a good example for other members in society. When an early adopter has adopted an innovation, other members will feel less uncertainty about adopting the innovation (Rogers, 1983).

The third category is the early majority, the early majority adopts to a new innovation slightly before the average member of society. A member of the early majority is interacting in a social system without leading it in the way that an early adopter does. According to Rogers, they need some time before completely adopting but they follow with “deliberate willingness” (Rogers, 1983).

The fourth category is the late majority. A member of the late majority does not adopt the innovation, as opposed to the early majority, because they really want to but because the outside pressure of adopting becomes too large. This category does not like uncertainty and does not have a lot of resources to gamble with(Rogers, 1983).

The fifth and final category in the adoption chain is the laggards. The laggards are traditional and base many of their decisions on what has been done in the past. Laggards are involved in social systems where mostly others with the same opinion are members. Laggards often have a weak economic position and can be over-cautious when it comes to adopting new innovations. Sometimes they adopt so late so that another better innovation has already taken over when they decide to adopt. (Rogers, 1983)

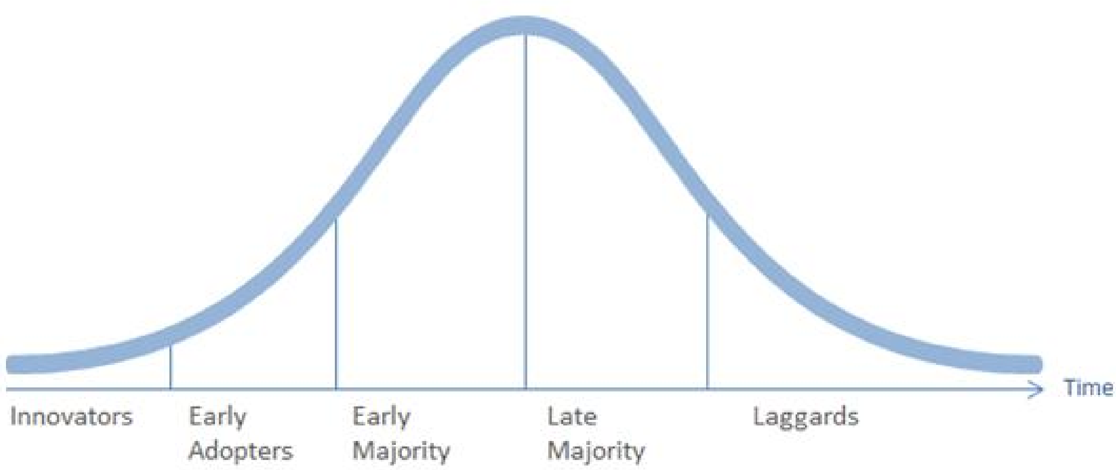

Figure 3.1: The different adoption categories (Rogers, 1983)

3.1.3 Forecasting innovation

Tidd & Bassant (2009) argue that forecasting the future of innovations is very challenging but nevertheless has a central role in business planning for innovation. However Tidd & Bassant (2009) argue that the predictions made are not the important part of the forecasting process. The importance lies within providing a framework for the data, making interpretations, assumptions, identifying challenges and risks. Common methods for forecasting includes: internal analysis, expert opinion, scenario development, market surveys. Porter (1997) presents additional forecasting techniques such as analysing technical trends, analysing substitutes of innovation, analysing patents and having unstructured interviews with experts. However Porter (1997) also agrees with Tidd & Bassant (1997) that it is a complex issue to forecast the future of innovations since it relies on so many variables.

3.1.4 Technology Transitions

Lindmark (2006) argues that most systems undergo changes and that the process through which a system undergoes such changes is called a transition. According to Lindmark (2006) technological systems undergo these transitions which leads to that the function, applications, performance, cost and technology-base changes. Lindmark (2006) defines a technological transition as when the technology base is changed by involving an addition and/or substitution of technologies within it, combined with advancements of knowledge within a specific area. According to Bulkeley and Marvin (2010), cities play a big role in technological transitions. Bulkeley and Marvin (2010) argues that private initiatives could be slow and risk averse since they primarily look for profits and that the cities themselves could have a role where they promote initiatives instead. Bulkeley and Marvin (2010) further argues that cities are likely to be the initial seedbeds in technological transitions, especially if the transition involves infrastructure change. Making transitions towards automation has according to Dodgson (2008) many benefits such as predictability, speed and efficiency. However Dodgson (2008) points towards some difficulties and argues that there has to be commitment from all stakeholders in order for successful implementation. There also has to be a shared view of project aims and implementation approach combined with a readiness to re-examine and change existing procedures and extensive user education to give a broad understanding of the purpose and implications of the automated system (ibid.).

Wejnert (2002) argues that innovations evolve in a specific context and that their successful transfer depends on their suitability to the environment that they enter during the diffusion phase. He defines the environmental context in four subgroups: geographical settings, societal culture, political conditions and globalization and uniformity. The last three subgroups refer to innovations with private and public complications that are adopted by micro- and macro-level actors.

3.1.4.1 Societal Culture

According to Wejnert (2002), belief systems has an influence in the adoption of innovations. The perception of the cost of an innovation that is incompatible with cultural values, norms and ideologies will be higher and could lead to a lower adoption rate.

3.1.4.2 Political Conditions

Diffusion studies has shown that the political conditions could affect the adoption of innovations where Wejnert (2002) argues that the political situation could inhibit or postpone the adoption of innovations.

3.1.4.3 Global Uniformity

Wejnert (2002) argues that institutional practices affect the adoptions of innovations where he emphasizes two important variables. The first is institutional practices, the spread of rule like behavior models that is commonly supported and has a special structure of incentives for the adoption standardized forms of programs, practices and policies. The second one is global technology, where global adoption of technological innovations that are facilitated by the growth of multinational corporations could lead to successful adoption of innovations within a specific context.

3.1.5 Technological Change

In the book “Gaining Momentum” by Joe Tidd (2010), it is described that when a new industry appears, the focus in the industry is on product innovations, then, after a dominant design has appeared in the specific industry the focus changes into a more process oriented approach where innovations are about the production and distribution. A dominant design is defined as a design of the product that has become a standard design in the market “because it meets the requirements and needs of a wide range of users” (Tidd, 2010). Tidd (2010) refers to a technology lifecycle as cyclical process divided into different steps. The first step in the cycle known as variation, is some kind of discontinuity, this could be that science has improved and made a new technological solution possible but could also be a combination of existing technologies. The variation-phase is followed by a phase called “the era of ferment”. Anderson & Tushman (1990) describes the era of ferment as an era of design competition and substitution, uncertainty is high and the old technology is starting to get substituted. After that a dominant design emerges and this is followed by a longer period of incremental changes rather than radical ones as in the previous phases (Anderson & Tushman, 1990).

Table 3.2: Describes the different phases of the Technology Lifecycle.

Technology Lifecycle			
Variation	**Era of ferment**	**Selection Stage**	**Incremental changes**
Science has improved, new technology or technological solution is possible	Competition of designs of technology	A standard design of technology that meets the requirements of a wide range of users has emerged	Incremental changes to the technology

Lindmark (2006) describes technological change in a similar way as Tidd (2010) but focuses on more variables and the time dimension in relation to technical performance. According to Lindmark (2006) technological change could be measured as changes in the technological performances of the innovation. The rate of technological development follows an S-shaped pattern where it starts with a close to exponential growth and when the technology in question stops developing as rapidly as before the curve starts declining (Lindmark, 2006). The technological parameters that influence the s-curve are usually the following: physical size of the innovation, complexity, efficiency, capacity, density and accuracy. The rationale behind the technology S-curve is that innovations open up for new opportunities and technological development. At the beginning of the technological life cycle the rate of progress is higher, however it slows down when limits are approached. Limits could be reaching as the lowest cost of producing the product, reaching the smallest size of the product or achieving the best accuracy. Figure 3.2 illustrates the technology S-curve.

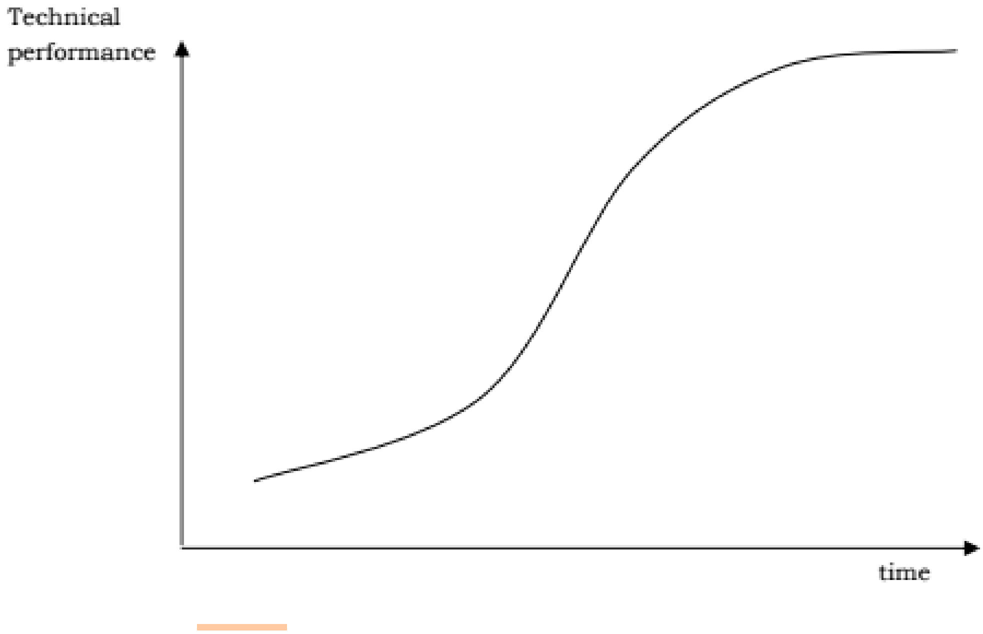

Figure 3.2: The technology S-curve as a function of time and technical performance (Lindmark, 2006)

3.1.6 Pre-Diffusion

In the book by Tidd (2010), an empirical study is being performed where 50 high-tech product categories in 5 different industries are being analysed. The study focuses on the time occupied from invention to large scale production referred to as the pre-diffusion phase. The pre diffusion phase is divided into three different milestones, the first milestone is the invention, the second is the introduction and the third milestone is large-scale production and diffusion.

The invention is being defined as the "first time the technical principle of this category is demonstrated and mastered" Tidd (2010, p.55). The second phase is the introduction phase and is defined as to when "the product is available for sales or can be transferred to users" (Tidd 2010, p.56). The milestone of large-scale production and diffusion is considered fulfilled when the following three aspects have been reached: "A standard product that can be reproduced multiple times", "A production unit with dedicated production lines" and "Diffusion of the product".

Table 3.3: Illustrating the duration in years of the pre-diffusion phases separately and combined. The result is from 50 cases gathered from 5 different industries.

Pre-diffusion Phase = Innovation and adaptation phases combined.
Innovation phase = The time period between invention and initial market introduction.
Adaptation phase = The time period between the initial market introduction and the industrial production and large-scale diffusion of products. (Tidd, 2010).

Industry **Mean value** **(std. deviation)**	Chemicals, metals and materials	Pharma & Healthcare equipment	Telecom, media & Internet	Electronic equipment	Aerospace & defence	Total
Total duration of pre-diffusion phases	11.4	26.1	15.3	19.2	11.6	16.7 (14.5)
Duration of innovation phase	4.9	21.6	8.9	7.2	7.6	10.0 (13.5)
Duration of adaption phase	6.5	4.5	6.4	12.0	4.0	6.7 (7.6)

The study concluded that the the pre-diffusion was an average of 16.7 years for the high-tech products but with a dispersion of 15 years and the pre-diffusion phase was as short as 2 years in some cases. The reasons for the variation in length of the phase were concluded to be varying but three main factors that affected the length were found. These were characteristics of, the main organisation, the technological system and the wider market environment (Tidd, 2010).

3.2 Autonomous vehicles

Autonomous cars is a rapidly improving field and all actors on the vehicle market today are working towards a higher level of automation in their vehicles (Transportstyrelsen, 2014). Since it is such a rapidly evolving field, the industry is currently performing product development which is a part of the process that is usually kept secret, this has led to some difficulties in knowing exactly what the different actors are doing.

Since a fully autonomous vehicle also is fully autonomous in its parking it is relevant to know what limitations and benefits there are for autonomous cars in general. In this section various literature will be reviewed to be able to identify aspects that will affect the development and direction of the market of autonomous cars.

3.2.1 Current development

The level of autonomy in vehicles is increasing rapidly. A review of the current market shows that the driver is still expected to control the vehicle and is supported by functions that helps him/her to drive more safe and efficient. Most of the systems that assists the driver currently are notification systems, brake/gas systems or systems that handles the sideway-control of the vehicle, this corresponds to a level 1 automation according to NHTSA (2013) definition. There are also functions on the market that can do critical functions combined which will correspond to a level 2 automation according to the NHTSA (2013) definition.

Table 3.4: Illustrates different systems that has some degree of automation. Mercedez-Benz (2016), Audi (2016) Volvo Cars (2016), Tesla (2016).

System	Function
Adaptive Cruise Control	Maintains a set speed and a set distance to the vehicle ahead
Lane Keeping Assist	Alerts driver when the vehicle starts to deviate, helps the car to stay on course when deviating
Park assist	The vehicle controls the handling
City Safety	Automatically brakes if another vehicle is close to the vehicle
Traffic Jam assist	Performs function belonging to adaptive cruise control andcould steer the vehicle in slow traffic.
Autopilot	Combined functions that brakes, steers and interacts with other vehicles on highways.

Most of the large manufacturers and other large corporations are currently investing heavily in innovations for autonomous driving. The number of patents in the field owned by different companies is illustrated in figure 3.3.

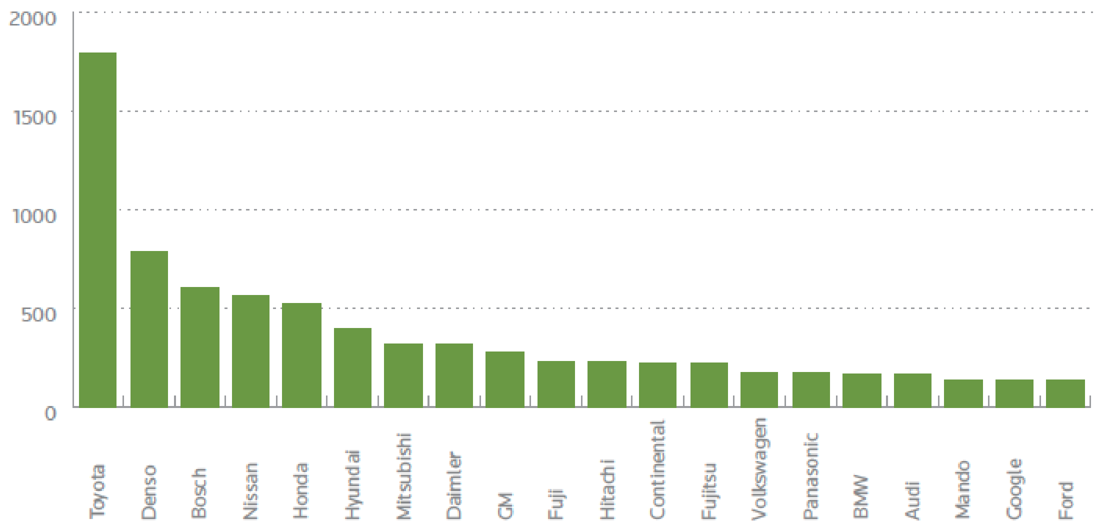

Figure 3.3: Illustrating the top autonomous driving innovators. The y-axis shows the number of patents (Thomson Reuters, 2016).

There is a not only vehicles manufacturers that are interested in autonomously driving vehicles. The public has also become increasingly aware and interested in autonomously driving vehicles. A search on the term "Autonomous car" in google trends reveals that the interest over time has increased dramatically in recent years as figure 3.4 illustrates.

Figure 3.4: Interest over time on the search term "Autonomous cars" (Google Trends, 2016).

3.2.2 First autonomous vehicle

The first autonomously driving cars for public roads at level 4 has not yet had an market introduction. According to Harris (2014) the invention had its first test in 2012 when Google had a test drive of their autonomous vehicle. The vehicle drove in different environmental types such as: highways, complex urban areas, residential roads and night driving. The vehicle did not drive in different weathers such as fog, rain, snow or high crosswinds and also it did not drive in conditions where the roads where unmarked.

3.2.3 Forecast

Predictions of the future market for autonomous vehicles is varying, Todd Litman (2015) at Victoria Transport Policy Institute is predicting that in the 2020's, autonomous vehicles will be available to a large price premium and will obtain 2-5% of vehicle sales. Litman (2015) expects the percentage of autonomous cars compared to the total number of cars sold will be close to 100 % in 2050's. According to the author, the market of autonomous cars is expected to be saturated in the 2060's which would mean that “everybody who wants it has it."

According to Tony Seba (2014), ride-sharing will evolve together with the introduction of autonomous vehicles. A car is today only utilized 4% of the time and with higher utilization fewer cars will be needed. Some predictors says that only 20% of the amount of cars today will be needed. Seba (2014) further predicts that this will imply a 80% decrease in highways and parking spaces needed.

The company IHS Automotive predicts that 230 thousand self-driving cars will be sold in 2025 with level 3 autonomy and 11.8 million autonomous cars will be sold in 2035, 7 million of which will be autonomous with driver control(level 3) and the rest will be completely autonomous(level 4). With that sell rate, IHS Automotive believes that 54 million autonomous cars will be on the roads by 2035. The study made by IHS Automotive predicts that “nearly all” of all vehicles will be self-driving by around the year of 2050 (Vinnova, 2015).

The Swedish governmental agency Transportstyrelsen has investigated the future of autonomous cars and makes the forecast that by the end of the year of 2020 there will be cars on the market that will be on automation level 3 on NHTSA's scale. When looking further ahead, Transportstyrelsen does not make any clear statement but refers to other predictors that forecasts that cars on automation level 4, without any human involvement in driving, will not be on the market before 2025 even though some manufacturers like Google has the technology to do it today (Transportstyrelsen, 2014).

A study performed by Mckinsey & Company from 2016 called “Automotive revolution – perspective towards 2030” makes many predictions regarding the future of autonomous cars. The study predicts that a “progressive scenario” could see as many as 50% of passenger vehicles sold in 2030 being partly autonomous and 15% being fully autonomous. This scenario is dependent on that the regulatory barriers are overcome, the technology is being developed fully and that customers are willing to pay for autonomous cars. If these factors are not fully met, another scenario could see as low as 5% of new vehicle market shares in 2040 (McKinsey, 2016). The study also reveals that in 2022 2-5% of the vehicle market will exist of autonomous vehicles of level 3.

A study from IHS Markit (2016) reveals that the younger generation in the age between 18-38 are most prone to purchase autonomous vehicles while the enthusiasm decreases as the ages of the participants in the study raises. These are illustrated in table 3.5:

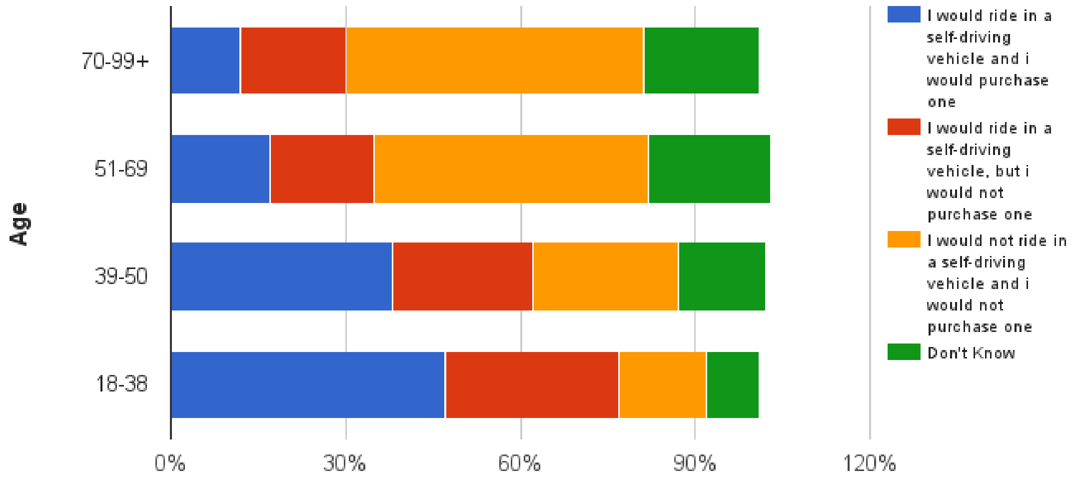

Figure 3.5: Level of acceptance in different age groups (Jonston, 2016).

3.2.4 Benefits

Autonomous driving and its technology could have many potential benefits, according to Anderson et. al. (2014) it could affect factors such as safety, congestion, energy use and land use. Anderson et. al. (2014) argues that the technology could dramatically reduce the frequency of accidents and refers to a report done by the Insurance Institute for Highway Safety (IIHS) that estimated that if all vehicles had warning systems such as forward collision and lane departure, an assistant for sideview and adaptive headlights nearly a third of accidents that occur on the road could be prevented. These are all technologies that would likely reduce the crash statistics since a large part of accidents that occur is due to errors from the drivers (ibid.). Driver errors are the cause of 90% of all crashes and mentions human errors such as inattention, distraction, speeding, drug involvement and fatigue that could be prohibited by having autonomous cars (Fagnant and Kockelman, 2015).

Anderson et. al. (2014) and Habibovic et. al. (2014) argues that autonomous driving will have the potential to increase mobility to individuals that are unable or unwilling to drive such as elderly or disabled people since a driverless vehicle could enable the transportation of this affected group of people. Anderson et. al. (2014) argues that this could have benefits such as reduction of social isolation.

Further benefits that autonomous vehicles could bring is a potential reducement of congestion in the traffic. According to Anderson et. al. (2014) the technology could increase the flow on the roads as a result of a more efficient vehicle operation and also it could reduce traffic-delays from crashes. Fagnant and Kockelman (2015) also argues that congestion and traffic operations could be reduced since autonomous vehicle could use lanes and intersections more efficiently on the roads. Atiyeh (2012) argues that if communication and algorithms for smoother traffics are implemented efficiently there could be massive savings in fuel economy and a more fluid travel stream.

Fagnant and Kockelman (2015) presents other savings such as parking savings where they argue that parking spaces could be placed in urban areas and save parking costs. Anderson et. al. (2014) focuses on the cost savings that could arise as implications from the benefits such as the private cost of driving would be reduced from the fuel savings and potentially lower insurance rates.

KPMG & Car (2012) argues that the emergence of autonomous vehicles could enable new models for the ownership of the vehicles. They argue that autonomous vehicles could expand opportunities for vehicle sharing. If vehicles could drive autonomously they could be used when needed and then returned to other duties when the usage is over and this could lead to significantly lower amount of vehicles on the roads and in the streets (KPMG & Car, 2012).

3.2.5 Challenges

There are several challenges that current science and literature have addressed as an issue with autonomous vehicles. Habibovic et. al. (2014) discuss some technical challenges that the transition from traditional to autonomous vehicles will face. They argue that the transition will happen gradually where the cars gain more and more control from the driver. There is a challenge in how to understand and monitor the transition from control to autonomous systems in the vehicles, especially in safety-critical situations (Habibovic et. al.,2014). There are also challenges in the interaction between autonomous vehicles, manually driven vehicles and other road users (pedestrians, cyclists etc.)(ibid.). KPMG & Car (2014) argues that the interaction between driver and the machine is also a challenge where the driver has to rely and understand the autonomous functions in order to use it correctly.

Other technical challenges that they discuss are the vehicle positioning and the technique that relates to it, there are a few solutions available, however electronic development and components follow a faster development than renewability cycles in the automotive industry which could lead problems such as insufficient system security (Habibovic et. al., 2014). According to KPMG & Car (2014) there is a challenge of standardising the autonomous vehicles, where it has to be assessed what should and what should not be standardized. KPMG & Car (2014) argues that the infrastructure will need huge investments in order to make the interaction between vehicles and the infrastructure as efficient as possible. Anderson et. al. (2014) also discuss an economic disruption that could occur since there are high payments of insurance premiums each year. A whole sector that deals with automotive crashes would decline drastically which will have the sector remade entirely.

Anderson et. al. (2014), Habibovic et. al. (2014) and KPMG & Car (2014) argue that there are also societal and political challenges that relate to the consumer acceptance and adoption of autonomous vehicles. There are also legal challenges where current legislation has to be adapted and new legal rules will have to be created.

3.2.6 Disadvantages

Anderson et. al. (2014) views the disadvantages from an infrastructure perspective where they argue that autonomous cars could lead to more vehicle miles traveled since they could be parked far away from its original destination, this potentially leads to negative externalities of increased fuel consumption and congestion. The development of autonomous vehicles could lead to an increase in traveling activity which further leads to more energy consumption. According to a study, the energy consumption could increase with up to 60% which according to the study would outweigh all the benefits that autonomous vehicles could bring to society (Wadud, MacKenzie & Leiby, 2016).

Anderson et. al. (2014) also discuss that jobs will potentially be lost. Jobs such as taxicabs, delivery services and municipal buses are under the threat of being diminished if autonomous cars will replace traditional and there could be high human costs if that happens.

Keating (2015) discusses the ethical issues that arises with autonomous vehicles. For instance if a child ran out in the middle of the road, would the vehicle swerve into oncoming traffic or keep going towards the child? These issues do not have to be considered with traditional vehicles since the driver takes the decision but in the case of autonomous vehicles the algorithm of the vehicle will. There are other sort of threats that could be seen as a disadvantage of the autonomous vehicle. According to Keating (2015) the autonomous vehicles could be hacked from outsiders and this could result in fatal accidents.

3.2.7 Policies

The project “Drive Me” by Volvo cars that will have 100 partly autonomous cars driving in the traffic of Gothenburg by 2017 is the first project where the car manufacturer claims to take full responsibility of the car’s actions. This will require a change in legislation since, according to swedish law today, the driver is always responsible for accidents involving the car (International Data Group,2016). The “Drive me” project is sponsored to some extent by the government. To look into possible changes in legislation, in november 2015, the government ordered an investigation that would analyze whether the rules for autonomous cars needed to be changed. The purpose of the study was to create better conditions for trials in real traffic. Jonas Bjelfvenstam was elected to perform the study (Johansson, 2016).
In his investigation, Bjelfvenstam proposes a system of permit where the testing company needs to apply for a permit. If the permit is approved and the car is

fully autonomous, the testing company can be considered the driver and take full responsibility. He makes the assessment that there are no rules today that prohibits the actual testing of autonomous vehicles. This applies to both international rules but also rules of the European Union. However, the permit system will make the testing more structured and will deal with the issue of responsibility. Bjelfvenstam also proposes changes in laws of camera surveillance since the autonomous cars often are equipped with cameras. If the changes are accepted by the swedish parliament, the law will enter into force the 1st of may 2017 (Bjelfvenstam, 2016).

Datainspektionen (DI), the swedish authority that is suggested by the investigation to be responsible for the supervision of camera surveillance for autonomous cars is criticizing the law proposal by arguing that it is not clear enough what personal information that will be gathered and how these will be handled and protected. The law proposal includes that pictures of people should be made anonymous before storage. However, DI means that it is not clear enough how this will be done. DI further argues that there are parts of the proposal that are against the Swedish constitution and says a complete ‘no’ to the proposal as it is described now (Datainspektionen, 2016).

Legislation regarding autonomous vehicles is an ongoing process and legislation is far from finished anywhere in the world. When policy makers makes these important decisions, the key factors that should be considered are liability, security and privacy (Fagnant & Kockelman, 2015). Users of autonomous cars will have concerns when it comes to privacy issues, especially regarding what data that will be logged about their personal travels. This is an issue today already but will be even more problematic with autonomous vehicles. Policy makers need to develop legislation of how the data should be handled. The legislation will also need to include high security standards to prevent outside attacks of the vehicles (Fagnant & Kockelman, 2015).

3.2.8 Parking For Fully Autonomous Cars

When a car is fully capable of handling traffic on its own, without assist from any driver at all (NHTSA level 4), the car can drive long distances through traffic, not just drive from a drop-off zone into a parking garage. The possible changes that literature predicts that the development of autonomous cars will bring to society will be described in this section.

When cars reach autonomy level 4, parking can be moved to less attractive areas of a city since the driver can be dropped off inside the city and let the car park somewhere else (Vinnova, 2015). As a result of this, fewer vehicles will be in the city and the space that was earlier designated for cars can be used for other purposes such as more room for pedestrians and/or buildings. Litman (2015) discusses that car sharing services will be increasingly popular and that less people will need their own car and that it will reduce the demand for residential parking. Fewer cars will lead to fewer parking slots needed, the infrastructure of parking can be less extensive leading to reduced costs for society (Litman, 2015).

3.2.9 Autonomous parking current market

There are various parking solutions that are active on the market today that has some degrees of autonomy, all leading manufacturers are developing parking solutions to assist the driver. There is no solution available that could park autonomously on level 4, the autonomous parking solutions on the market today correspond to level 3 or lower in terms of automation levels.

The german car manufacturer BMW has developed a system where the car scans for free spots to park on and can maneuver into a spot on demand by the driver (BMW, 2016). The new Volvo XC90 released in 2016 is equipped with a parking assist system that can find a parking spot and help the driver to steer the car into both perpendicular and parallel spots (Volvo Cars, 2016). Toyota cars offers a parking assist where the driver only needs to sit in the car and monitor the speed whilst the vehicle autonomously does the parking (Toyota, 2016). Volkswagen offers a similar solution where the driver presses a button in the car to activate the parking assist function. The car will then back into the parking spot autonomously (Volkswagen, 2016). In january 2016, Tesla introduced a software update to their Model S and Model X. This introduced a concept called “Summon”. Summon lets the user of the car leave the car outside the garage and it can then park itself through a command in the user’s smartphone (Tesla, 2016).

3.2.10 Electronic Vehicles and Autonomous cars

Early versions of autonomous vehicles, such as Tesla, Google and BMW, have also been electrical. According to Mui (2016), autonomous cars are modular and are well suited to “facilitate the rapid development and testing of driverless technology” (Mui, 2016). Mui further argues that autonomous cars can be a way for electric vehicles to gain market shares and thereby success.

3.2.11 Autonomous vehicle parking techniques

The following section describes autonomous parking techniques and solutions that are currently under development. Four different programmes for autonomous parking have been identified. This section could help to clarify in which direction the technology is developing and how mature it is.

3.2.11.1 V-Charge

The V-charge project which was was finalised in 2015 is a parking-project that aims to introduce a new mobility concept for electrical vehicles and is issued by the European Union in collaboration with Volkswagen, Bosch and academia. The project aimed to diminish the problem of driving ranges and increasing refueling durations and this required automated car parks which was built around the vision of having autonomous parking vehicles. The system will make it easier to switch between the car and other ways of travelling (EC, 2014).

The technique that was developed in the V-charge project requires collaboration and technical understandings between the vehicles, the car parks as well as the need of monitoring with a smartphone. The vehicles is left in a drop-off zone and then the driver gives a signal to the vehicle to park through a smartphone application. The project developed three prototypes where each car had 360 degree vision with cameras. The vehicles are also equipped with ultrasonic sensors and wheel odometers to help the car to be autonomously directed in the car parks. With the help of offline pictures of the parking lots, simulations can be performed and iterated so that the system can learn what a parking slot is and what is not. When the car later searches for a free space, the offline pictures are compared with the actual situation to find one. The concept allows the vehicles to detect moving objects such as pedestrians and predicts their movement to pass them in a controlled and safe way. In the project, both combustion engine-vehicles and electrical vehicle prototypes were built, in the case of the electrical vehicles, they were also re-charged while being parked (V-charge, 2016).

The project resulted in insights in the scheduling of car parks as well as concepts for autonomous parking. Bosch Mobility Solutions (2014) argues that the full valid parking system is expected on the market within a decade but also says that some of the specific features could be available much earlier. The two main concerns with the technology is the navigation and parking precision which both could be further improved before the solution is implemented in the market. The V-charge project has focused to be cost-effective to enable easier implementation and adoption by the market.

3.2.11.2 Audi

Audi is a german vehicle manufacturer focusing on premium vehicle manufacturing (Audi, 2016). Audi has started to develop a new technology for autonomous parking which could be used by stepping out from the vehicle, pulling out a smartphone app and clicking a button. The vehicle will then drive to a nearby garage and navigate itself through it to find the nearest parking spot. The technique works by internal and external sensors in the vehicle to get its position. However the technique requires customized car parks also since the car park requires laser sensors to record the vehicle's movements and also need a computer system that takes over the vehicle's control system and guides the vehicle through WLAN connection to the nearest parking slot. The function the car has is to monitor the surroundings while finding the empty parking slot and this is enabled by 12 ultrasonic sensors within the vehicle (Volkswagen, 2013).

Audi's autonomously parking vehicles are expected to be deployed in a small series in 2018 where the autonomous parking technology in the vehicles will interact with a car park specifically designed for autonomous driving vehicles (Crucchiola, 2015). Audi estimates the vehicles to need 21 square feet less per vehicle and also estimate that such a car park could fit 60% more vehicles compared to a traditional car park (ibid.).

3.2.11.3 Mercedes Benz, Bosch and Car2Go

Mercedes-Benz, Bosch and car2go are currently developing an autonomous parking service solution. This parking technique is built in a similar way as other techniques currently under development where the driver leaves his car at a drop-off zone, pulls out a smartphone app and presses some buttons. The car will then navigate itself to an empty parking lot in the designated car park. For this solution to be possible the car park needs space-occupancy sensors, cameras and communications technology (WLAN) to be included in the car park. As in the V-charge project the car parks control the parking process and the vehicles will be equipped with communication systems and sensor systems to be navigated in the car park (Daimler, 2015).

3.2.11.4 BMW

The german car manufacturer BMW released a autonomous parking system with its concept vehicle BMW i3 research. The technology is called Remote Valet parking assistant. It is based on a smartwatch that could be activated when the driver needs to park the vehicle. By activating the smartwatch the Valet Parking Assistant in the vehicle will navigate itself into the parking lot to find a suitable parking spot. The vehicle navigates itself through four advanced laser scanners that helps the vehicle to scan the surroundings and avoid collision with other objects. The vehicle also needs a WLAN connection to download a digital layout plan to the system in order to navigate itself through the car park. (BMW, 2015).

3.2.12 Parking in Gothenburg Today

There are 41 000 parking spaces for vehicles in Gothenburg today that are owned or managed by Parkeringsbolaget. The size of a parking space is varying but the most common measurement is 4.80 x 2.30 metres which is just the actual spot where a car parks. The space that a parking lot occupies is a lot larger than just the parking spaces. If one parking space is estimated to require 25 square metres of land, the parking infrastructure owned by Parkeringsbolaget occupies 1 025 000 m2 or 102.5 hectares of land.

According to the company, the costs of building a parking lot directly on the ground costs them approximately 30 000 SEK/ parking space. Building it like a car park instead will cost 200 000 SEK / parking space but will require less land per parking space. A new type of car park is now being built at Skeppsbron in Gothenburg where each car space will cost around 1 000 000 SEK. The car parks owned by Parkeringsbolaget today has a capacity of 9395 parking spaces and a net worth of 633 100 000 SEK. The depreciation time of a car park is 50 years. (Rehnström, 2016)

Parkeringsbolaget currently owns 20 car parks in the City of Gothenburg. These are illustrated in the figure below:

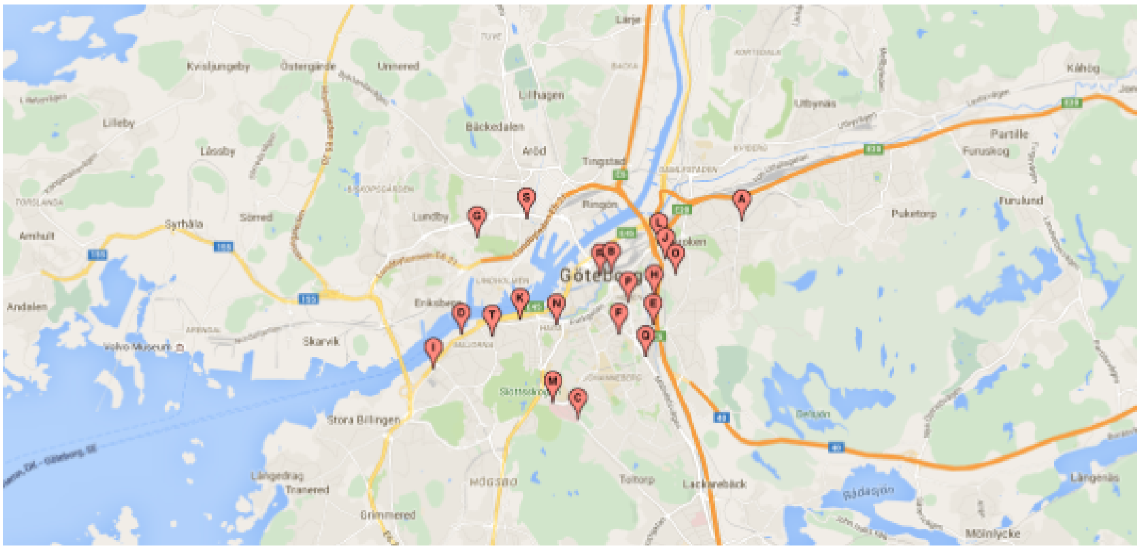

Figure 3.6: City map of Gothenburg with car parks owned by Parkeringsbolaget. Source: Göteborgs Stads Parkerings AB (2016)

3.2.13 Modern Car Park

The parking infrastructure of today will not be the most optimal way of organising parking. In this section, modern ways of organising car parks will be presented.
In USA, a lot of work already goes into designing car parks that can work for a mix between traditional and autonomous cars there is also car parks that are designed only for autonomous cars. A lot of thoughts goes into how to design the car parks for the potential development of a drop in demand for parking. This reasoning is based on the fact that less people will own a car in the future when ride-sharing and other services becomes increasingly popular.

Figure 3.7: A parking garage that was designed for a future conversion to other uses ,Ward (2016).

4
Interview Findings

This section presents the findings from all the interviews with experts within autonomous driving vehicles. The results are presented in the form of tables. The interview template is found in appendix 1.

15 interviews has been performed with experts during the period June-August 2016. The interview subjects have been picked from different companies and the roles of the participants are varying. The specific information about each interview subject is presented in table 4.1 below.

Table 4.1: Names and positions of the interview subjects.

Name	**Company**	**Title**
Azra Habibovic	Viktoria ICT	Senior Researcher
Anders Lie	Trafikverket/Chalmers	Traffic Safety Specialist
Marcus Rothoff	Volvo Cars	Autonomous Driving Programme Director
Jan Hellåker	Drive Sweden	Head of Programme
Anna Svensson	Stadsbyggnadskontoret	Project Manager of Innovation and Development
Malin Andersson	Trafikkontoret	Head of Department, Development and International Affairs
Claes Tingvall	ÅF	Sustainable Mobility Developer
Christer Ljungberg	Trivector	CEO
Kent- Eric Lång	Viktoria ICT	Vice CEO
Maria Krafft	Trafikverket	Goal Director
Anders Grauers	Chalmers	System Specialist Hybrid Powertrains
Hans-Martin Duringhof	Nevs	Director of Powertrain and Chassis
Carl-Johan Alden	Semcon	Global Autonomous Driving Advisor
Peter Alguren	Sunfleet	CEO
Per Gustafsson	Autoliv	Research Engineer

4.1 Results

To be able to asses the business of self-driving cars, the believed benefits and challenges was needed to be identified. If the potential benefits are a more important factor than the challenges it is possible that the adoption of the technology will occur faster. The contrary is also possible, namely that the drawbacks outweigh the benefits at this stage and that the market introduction will be prolonged. The results are presented in the form of diagrams and quotes that has been interpreted from the interviews.

4.1.0.1 Which are the three main benefits to society regarding self-driving vehicles?

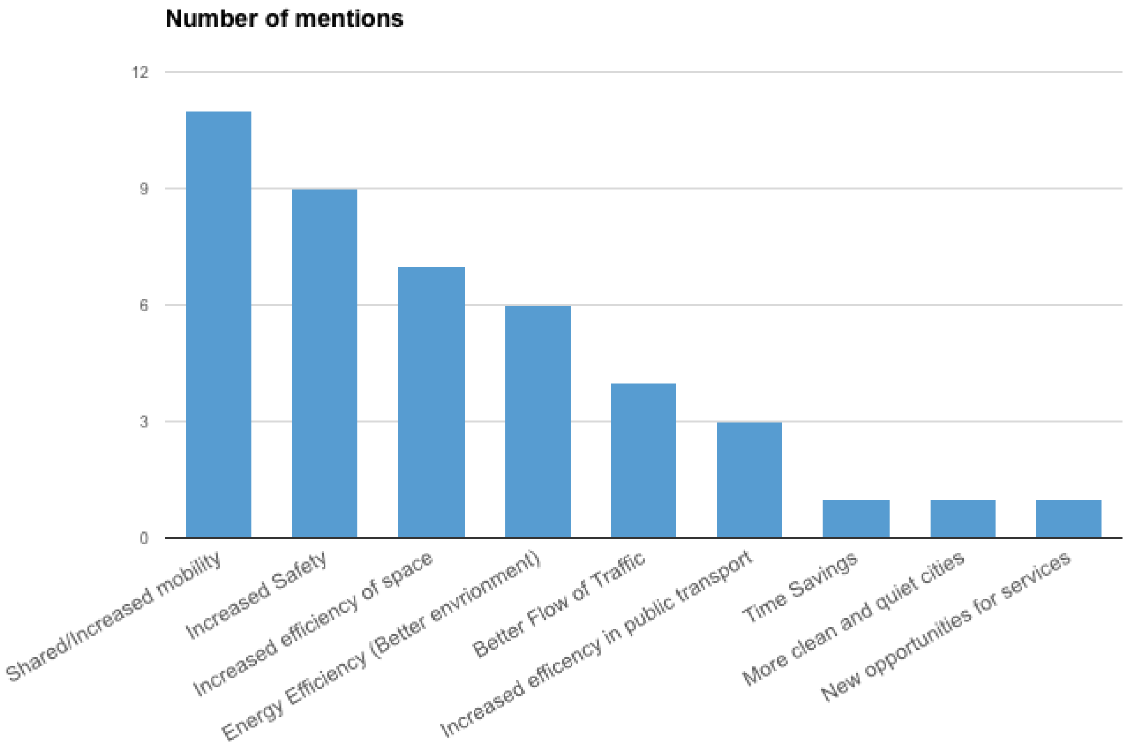

Figure 4.1: Which are the three main benefits to society regarding self-driving vehicles?

As illustrated by figure 4.1, the most mentioned benefit of autonomous cars are the fact that mobility will be increased. With increased mobility the respondents mainly referred to the possibility to have a transport service that rents out vehicles to users. This could enable fewer vehicles on the streets since they are shared by the population. If the vehicles are autonomous the gains for society could potentially be large. One of the respondents said:

"A vehicle is used about 2-3% of the time. Share a car between 10 people and it will still not be used more than 20-30% of the time."

This quotation shows that the respondent believes that vehicle sharing could give a better mobility. One of the respondents put focus on the increasing mobility that products could achieve. The respondent believed that not only humans can gain efficiency in traveling but that this also holds for products. Safety was also mentioned by most of the participants. The safety aspect was explained by the fact that an autonomous vehicle is programmed to drive safe without crashing and that human errors are eliminated with autonomous vehicles.

One of the respondents said:

"Autonomous vehicles will increase the traffic safety in society dramatically."

This quotation shows that the respondent believes that the traffic safety in society will be substantially higher if autonomous vehicles are implemented in society. Only one respondent mentioned time-savings as one of the main benefits for society. The other respondents did not mention it and one of them said:

"The general society seems to think that the largest benefit for society regarding autonomous cars is a man reading a newspaper while driving his car on a motorway. I don't think this is the case"

This citation shows that the time saving aspect is really not the most important thing when it comes to societal benefits that comes with autonomous cars according to the participants.

4.1.0.2 Which are the three main benefits to the individual regarding self-driving vehicles?

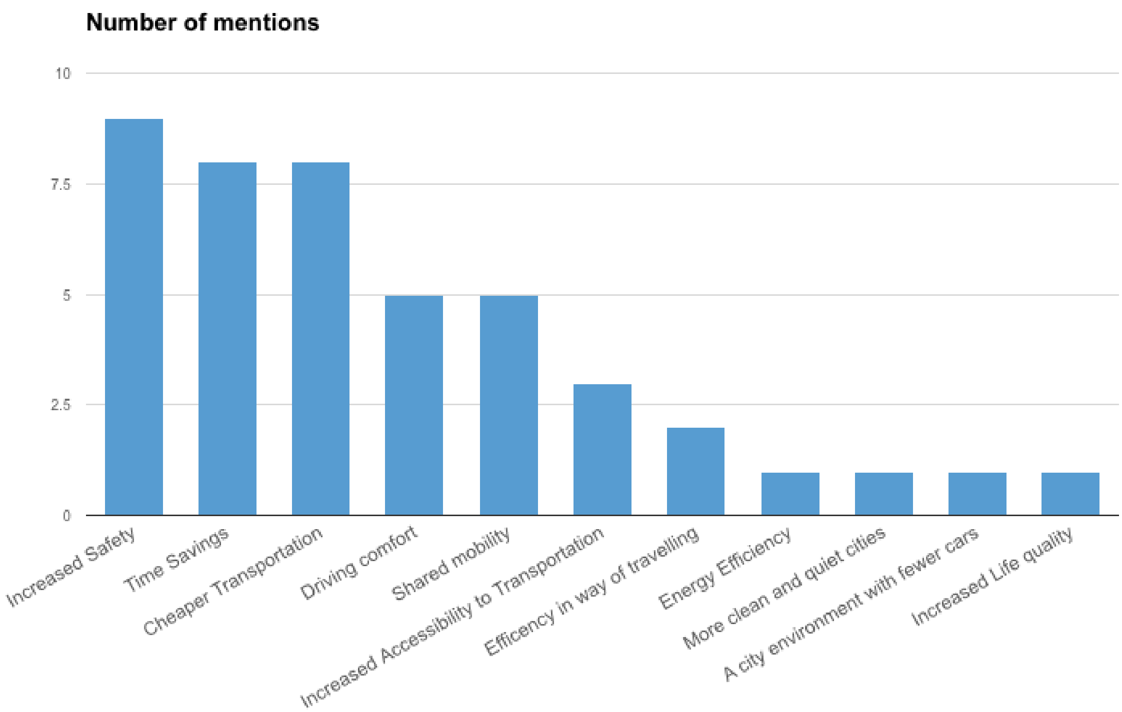

Figure 4.2: Which are the three main benefits to the individual regarding self-driving vehicles?

The most frequently mentioned benefit for individuals were increased safety. The respondents mainly argued that the driver will be safer from car accidents in an autonomous car since most of the accidents on the roads happens because of human

errors. Cheaper transportation and time savings were also mentioned frequently by the respondents. With cheaper transportation they referred to the fact that with autonomous cars, transportation can become much more effective. When drivers are not needed, taxi services and public transport can become cheaper and the fact that car does not need to be driven will facilitate car sharing which will make travelling from one place to another cheaper.
With times savings they referred to the possibility for the user of the car to use his or her time more efficiently since other tasks can be performed while the car is driving. Some respondents also referred to the time savings achieved when the individual does not have to bother about parking the vehicle. One respondent specifically said:

"In time savings, not having to park your car is one of the most prominent benefits."

The above quotation shows that the respondent has the opinion that autonomous parking could save a lot of time to the individual.
One participant said that one of the most important benefits for the individuals will be a city environment with less cars. According to that person, this will enable for space to be used in a much more efficient way that can gain everyone.

4.1.0.3 Which are the three main benefits to the society regarding autonomously parking vehicles?

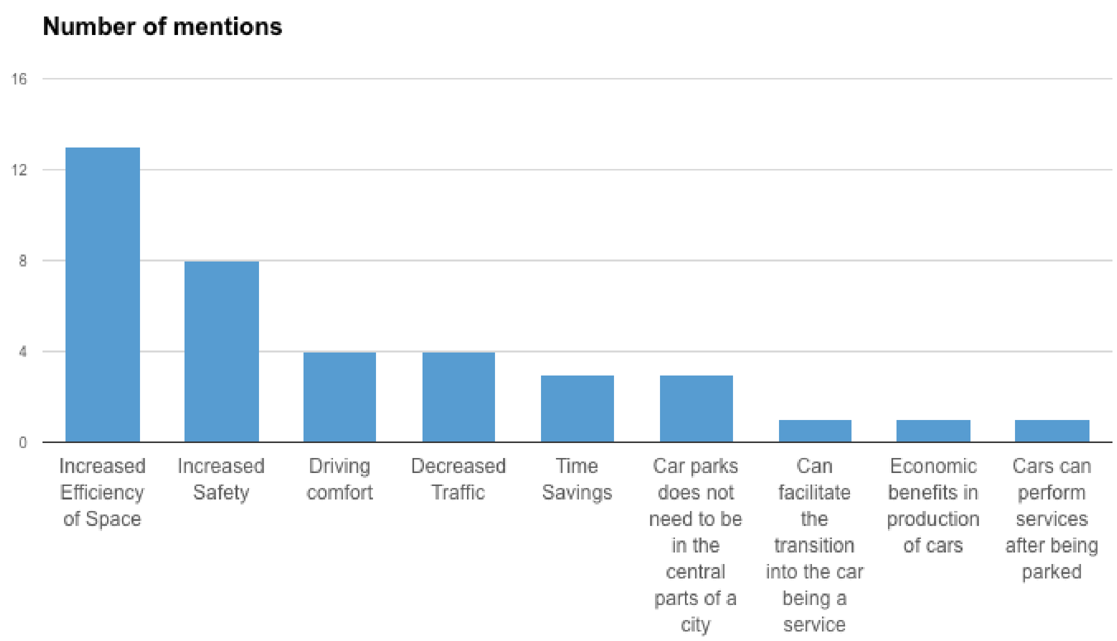

Figure 4.3: Which are the three main benefits to the society regarding autonomously parking vehicles?

Before asking about the benefits from autonomously parking vehicles, this type of vehicles were defined to the participants. It was defined as a vehicle that you could leave outside a parking lot or car park and then let it park autonomously which corresponds to a level 4 automation. More advanced applications than that such as leaving a car anywhere in town were also included.

As seen in figure 4.3, 13 of the respondents mentioned the most important benefits as the utilization of space. This is not only due to that the cars can be parked closer to each other but also because car parks does not have to be put in the most attractive spots since cars can drive away and park themselves anywhere. Some respondents mentioned that autonomously parking vehicles could save space since they potentially could enable the car parks to be arranged more efficiently like for example having lower roof height since there does not have to be any human interaction within the car parks.

Figure 4.3 shows that a large part of the respondents mentioned safety as a factor that increases from implementation of autonomous parking vehicles. The respondents mainly referred to the possibility of the drivers to not have to go in to a car park which could increase their safety. Safety in this case also includes some kind of security since many people apparently feel insecure in car parks since they see it as a hostile environment where they risk getting their possessions stolen.

The figure also shows that 4 of the respondents mentioned driving comfort as a benefit where they mainly mentioned that since the driver does not have to park the car by himself/herself their comfort will be increased. One of the respondents said:

"For instance in Stockholm the cars [are sometimes] parked a bit down in the car parks. This makes it hard for the customers of a car sharing service since the customers would have to firstly get down in a big garage. Secondly they have to find and familiarize themselves with a car they have not drove in before. If their ordered car could meet them up outside of the garage it would be much more comfortable for the customer."

With this quote the respondent thinks that autonomously parking vehicles could make it more comfortable for the customers of car sharing services. Another respondent said:

"[The potential market introduction] of autonomously parking vehicles could open up the opportunity for mobility to become a service."

The above quote was stated during the discussion about autonomous vehicles as a base for a mobility service and the respondent thought that autonomous parking vehicles could be a step in the direction of this type of service.

4.1.0.4 Which are the three main problems/disadvantages with autonomous vehicles according to you?

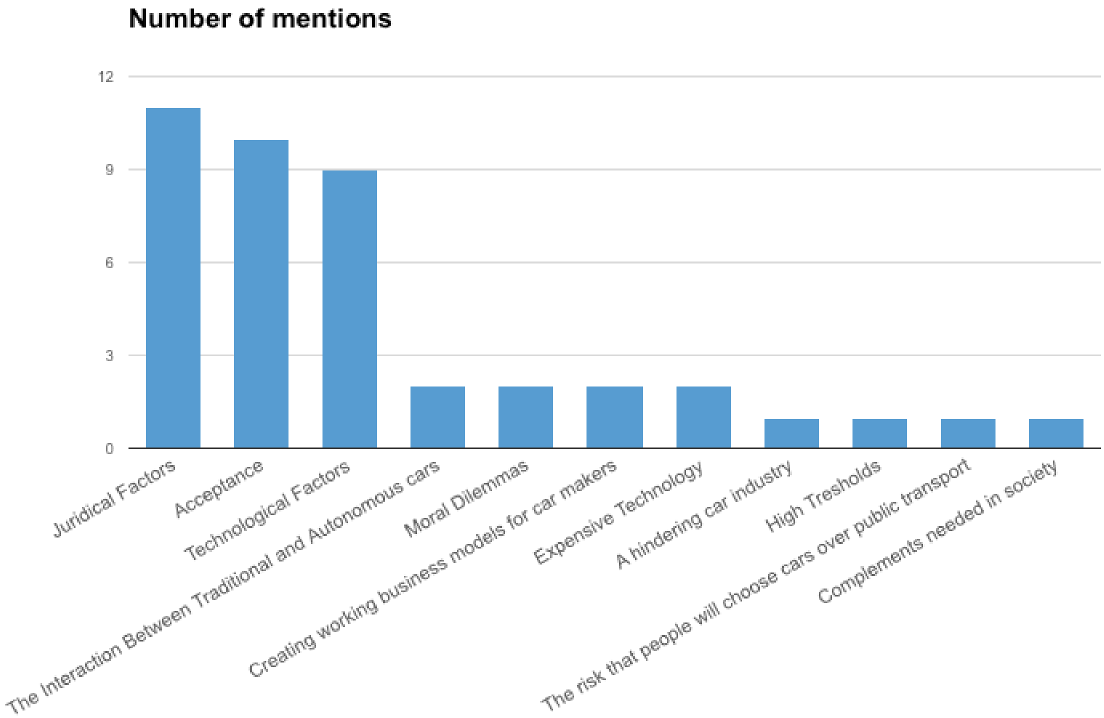

Figure 4.4: Which are the three main problems/disadvantages with autonomous vehicles according to you?

The participants were asked to mention three challenges for autonomous cars. When asking about the challenges, they were explained as obstacles that can be identified in the future of the business. As illustrated in figure 4.4, legislation was seen as the factor most hindering followed by acceptance and technological factors.

As described in the section of empirical findings the legal situation in Sweden is close to a law for testing of autonomous vehicles while the rest is quite uncertain, which many of the interviewees pointed out. The need for legislation that involves real driving and not only testing is evident. The fact that Datainspektionen (DI) has been critical to the proposal was neglected by one of the participants who said that this will not play a key role in the law proposal. The legal issue in general, and the responsibility issue in particular is a problem according to most of the respondents. Many pointed out that who will considered responsible when an accident happens is the vital question.

As seen in the figure 4.4 above, acceptance was described as a hurdle by some of the participants, this is due to the fact that it will take time for people to really trust the technology and to see the car for as a service rather than a personal belonging. One participant described the cultural change that is ongoing by saying that:

"The car is transforming from something that has been an extension of the body and is instead becoming a mobility solution."

This statement shows that the participant believes that the vehicle will transform from a personal belonging to a service solution.

"Autonomous cars is a technological development, at first it was not asked for and was developed just because the technology advanced"

"Even if it (autonomous cars) is safer than today that will not be enough, safety has to be on a completely different level to make people feel secure and create acceptance"

This statements shows the reasoning around the acceptance issue with autonomous cars. Even if safety will be better than before people in general will have difficulties in trusting a computer to make safety critical decisions for them.

4.1.0.5 Which are the three main problems/disadvantages with autonomous parking vehicles according to you?

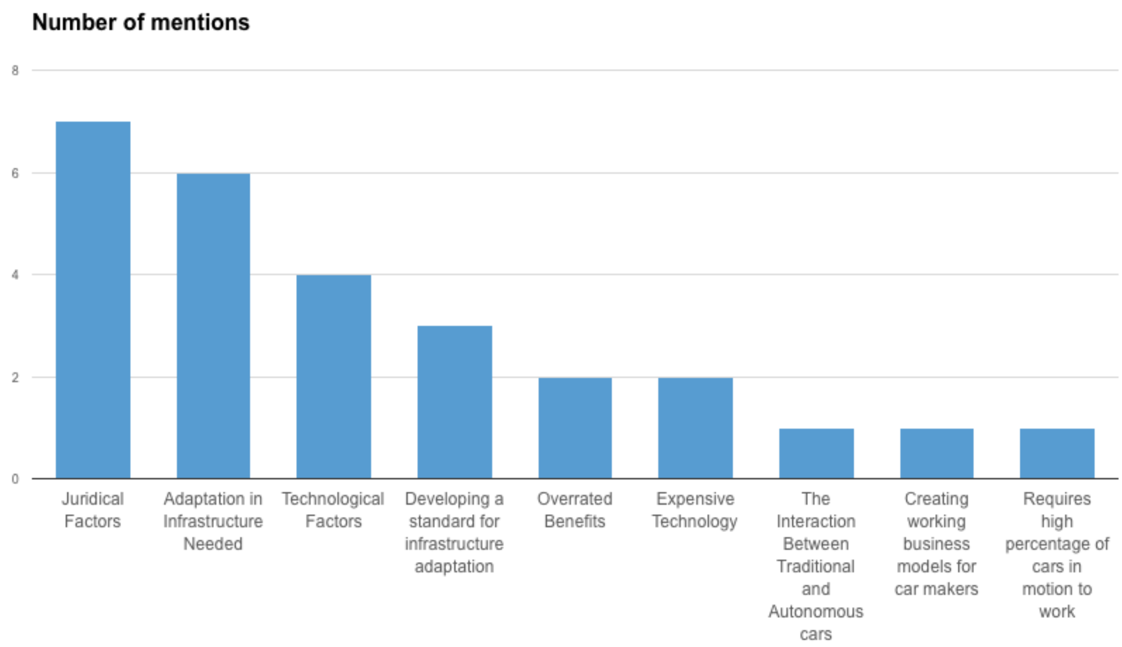

Figure 4.5: Which are the three main problems/disadvantages with autonomous parking vehicles according to you?

Some of the respondents had difficulties mentioning three factors on this question. Since all participants did not mention three factors, the frequency of mentions of each factor are lower than on the other questions.

Two factors were mentioned much more frequently than others. The most mentioned factor was juridical factors. The second most mentioned factor was “Adaptation in infrastructure needed”. The legislation-problem was described as the problem of who is responsible when the driver leaves the car to leave and go parking. This could potentially be both the owner of the parking facility or the owner of the car but could also potentially be the car manufacturer according to some respondents. The second problem was regarding the adaptation in infrastructure needed. One of the respondents said when being asked about the problems with autonomous parking:

"Autonomous parking has less problems than autonomous driving in general, they will soon be on the market. The problem is that the payment and looking for a free spot can not be solved by a car manufacturer solely. They will have to get along with other actors in society, the car has to be able to communicate with anything on the Internet, like a camera system on a parking lot etc.”

This quotation shows the fact that adaptations from infrastructure are needed, not only to make it easier for autonomous parking but also for the car makers to want to invest into these kinds of systems. This also interlinks with the fact that three of the respondents answered “Developing a standard for infrastructure adaptation”. Actors in the field will need to agree on exactly what is needed inside for example a car park, otherwise it is possible that all brands can not be parked inside all facilities.

Technological difficulties were mentioned by four of the participants. However, the majority of them said that the difficulties are much greater in autonomous driving in general than in the application of autonomous parking since the speed is much lower. Especially applications like a car park where just autonomous cars can drive since no humans will risk being injured.

4.1.0.6 When will the autonomous cars on dfferent levels of autonomy be introduced on the market?

As a part of the forecast, the participants were asked to state what years they believed that the different autonomy-levels would be on the market. Many said that this is a hard prediction to make since it is depending on so many factors but the results were uniform as illustrated in table 4.2.

Table 4.2: The participants predictions of market introduction.

Type	**Result**
Mean level 3	2022.2
Median level 3	2022
Standard Deviation level 3	3.4 years
Mean level 4	2029.2
Median level 4	2030
Standard Deviation level 4	7.9 years
Mean FAP	2019.4
Median FAP	2018
Standard Deviation FAP	3.7 years

Table 4.2 shows the mean, median and standard deviation for different levels of autonomy and for FAP. The standard deviation is quite similar between the predictions of FAP and level 3 of autonomy. However the level 4 of autonomy shows a higher standard deviation.

When discussing the future of autonomous vehicles the respondents agreed that in 10 years of time we still are in a start-up phase for autonomous vehicles. Out of 11 respondents 3 of them think that in 10 years there will be a small amount of level 3 and level 4 vehicles on the roads. However they argue that these vehicles will be in the luxury segment which means they will be quite expensive. One respondent said that in 10 years the development in cities will be very different where some cities could have adapted autonomous vehicles in the city better than others.

One participant said that the future development will proceed in two directions, one direction which will focus on premium cars and comfort and another which will focus on various types of taxi services. The premium models will make having a car more expensive while the taxi services will become much more effective and cheaper than they are today.

A common opinion from the interviews is that fewer cars will be needed in the future. The rapid technological advance in the field right now will make a new car old in just a couple of years. A car will probably cost as much as it does today and probably more, the drawbacks of having a car will be more visible when there is an alternative to having one. This is illustrated by the citation below.

"Why would anyone decide to buy a car when it will cost you a fortune to buy and drive it and the technology is old within two years when you can just press a button and get a car directly outside your house within minutes."

4.1.0.7 What type of propellant is most likely to dominate the future market of cars?

All of the interviewees (15 out of 15) believed that the vehicle-type of the future is not a combustion engine-vehicles but instead electrical vehicles. One of the interviewees also mentioned that the first step for the parking municipality should be to implement a larger scale of charging stations within all car parks in the city since he/she believed that electrical vehicles will feature in a higher scale and should therefore be better implemented in the infrastructure. It is however important to note that the persons interviewed in this study is experts on autonomous vehicles and not on vehicle types. Electrical vehicles could have a separate development from autonomous cars but if these shifts occur simultaneously it is vital to consider the implications that comes with electrical cars too.

4.1.0.8 Which difficulties do you see in a transition phase from traditional to autonomously driven vehicles?

Space efficiency that can be achieved by making the roads smaller and introducing lower safety margins can not be achieved successfully without a high percentage of the car fleet being autonomous. For example, traffic signs, traffic lights and speed bumps can not be removed until all cars can drive without them. Some of the participants believed that there is a possibility that some types of cars will not be allowed on some roads in the future to speed up the transition.
The technology for autonomous cars will have to be more advanced if they are to be driven together with traditionally driven vehicles since the actions taken by people in traffic are hard to predict for autonomous cars. The mixing as a safety problem was something that was mentioned by the majority of the respondents.

"Yes, I see diffculties if you think that robots will behave like humans. Humans need to behave like robots, you have the adapt the driving to the rules in the autonomous world, everything else is dumb. Mobility Solutions in city can decide to preclude traditional cars from a city in the future."

"Traffic in Gothenburg is complex and that makes it hard for autonomous vehicles, there has to be clear rules about alignments on roads and for example where to walk as a pedestrian. When all cars are autonomous it will be easy but when they are mixed, a more visible system is needed."

These above citations shows how two of the respondents thinks that the transition will work.

Some respondents discussed the matter that it is possible that people will try to challenge the autonomous car with their own traditional cars to try and see what they are capable of. The obvious risk with that is that this will cause accidents.
Cars with level 3 automation on the NHTSA-scale can, according to some of the persons interviewed, be totally excluded in the transition towards increasingly autonomous cars. Since level 3 autonomy requires the driver to handle the vehicle at

some moments the hand-over could be dangerous. Humans could be having a hard time to judge when to handle the vehicle versus when to trust that the vehicle drives autonomous.

4.1.0.9 Which customer segments are most interesting for a introduction phase concerning autonomous vehicles?

There will be some kind of premium segment that will be 'early adopters' according to many of the respondents. One participant explained his thoughts in the following way:

"The premium segment will be first since their cars are expensive and their customers are less price sensitive and can then afford to put extra safety systems inside the cars to prevent accidents and the potential bad will that comes with it."

The persons that will adopt these kind of vehicles were described in the interviews as individuals that are interested in technology and resourceful since an autonomous car could cost 100 000 SEK extra compared to a traditional vehicle according to one respondent.

Another customer segment often described by the interviewees was delivery services. These services could benefit a lot from not having to have drivers for their deliveries and the technology for driving in low speeds that could be sufficient is basically already on the market. These cars or vehicles could be really small and with low speeds they would not be able to cause any serious human injuries. If it is needed, these transports could be performed at nights when there is less traffic if that is needed according to one of the respondents.

Different services like taxi services or car sharing services were also described as companies that will adopt quickly since they will earn a lot of benefits from not having to have drivers to their cars. Their target customers will be people living in cities according to one of the respondents since it will be easier for them to order a car and get it delivered quickly. These customers are more price sensitive than the customers that buy premium cars.

"Private customers will be the new generation of young early adopter. It will be more women than men since they enjoy driving their car less in general. Small taxis and small buses should come first. The car manufacturers wants to begin testing with taxis so that could be a good test fleet."

This citation illustrates what one of the interviewees thought about the first customer segments of autonomous cars. Note that the word "young" was used to describe them. This was a constant theme throughout the interviews. Many of the respondents thought that the level of adoption will vary a lot between age groups and that young people will adopt it more quickly.

4.1.0.10 Can you make any societal benefits during a transition phase? If so, which?

This question was asked to see if the respondents think that there could be any societal benefits in a time where there are only a fraction of autonomously driven vehicles while the rest are traditional.

Out of the 14 respondents that answered this question, six of them mentioned that there could be better security for the passenger and those around him/her even during a transition phase. With the safety aspect, they argued that the small part of autonomous vehicles will increase safety for individual drivers and also create a better traffic flow which increases the overall safety of the streets. In terms of parking for autonomous vehicles one respondent said:

"Half of the vehicles on the road may have to be autonomous to be able to make space savings by having less/smaller parking spots."

With this quote the respondent means that some infrastructure changes are not possible before a larger fraction of vehicles on the road are autonomous. Another respondent said that the transition could help to increase the acceptance towards autonomous vehicles.

Four of the respondents agreed that the transportation services could give societal benefits even during a transition phase by being increasingly automated. This could lead to better availability of transportation and possibly cheaper transportation. One of the respondents said:

"You may not be able to create an autonomous car-sharing service for the whole city, but it could still be done locally. Then you can give huge societal benefits for that local part of the city."

With this quote the respondent argues that even if you can not spread the technology widely, you can start locally and still achieve societal benefits.

Overall all the respondents think that there are societal benefits even during a transition phase from traditional to autonomous vehicles. These societal benefits are mainly within safety. The respondents also believe that there could be environmental benefits during a transition phase. Some respondents argue that if you implement autonomous vehicles locally in small residential areas then you could have more societal benefits than just safety and environmental benefits.

Most of the respondents believe that the biggest societal benefits could be achieved once a larger part of the vehicle fleet are autonomous. One respondent argued that the societal benefits are exponential. His argument is illustrated in the figure 4.6:

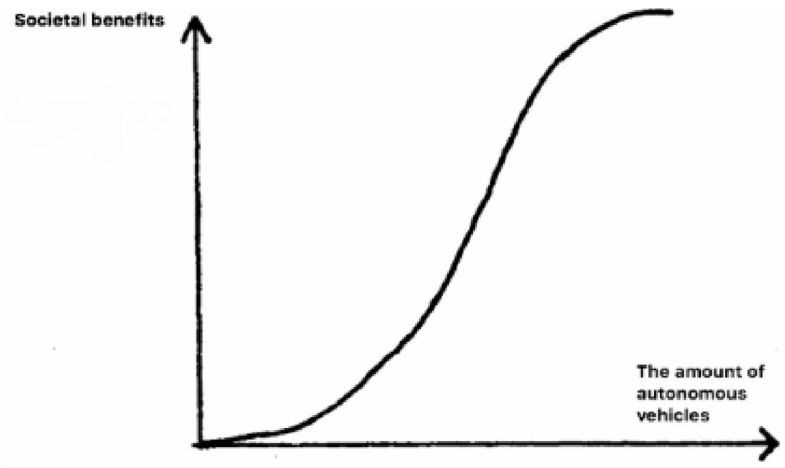

Figure 4.6: Illustrates the societal benefits as a function of the amount of autonomous vehicles on the street.)

4.1.0.11 Which actors do you believe could quicken/delay the implementation of autonomous vehicles in society?

The authorities and decision makers on both regional and national level can affect the development in both ways. According to the experts interviewed, creating a well functioning legal system for testing will be crucial to quicken the implementation of autonomous cars.

"This is a usual technological development since it is the first time that cities really can set the pace and affect how fast they want [autonomous cars] to come and how they want their infrastructure to be in the future."

This quote shows what one of the respondents said about the power of cities in the future development towards autonomous cars. The participants of the study seemed to have a mixed view regarding the role of the car industry. Some see it as a change that will help the car industry to attract new customer segments and differentiate while as other see it as something that will truly change the car industry rapidly and that it is possible that some of the traditional car manufacturers will hesitate in developing autonomous cars since it is possible that less cars will be needed in the future and thereby threaten their business. Even if the question remains if the car industry will quicken or delay the development, it is clear that they are an important actor since they were mentioned as an actor by 11 of the 14 participant that got the question.

"If trials with autonomous cars will be successful, the acceptance from the general public will be less hesitant in adopting the technology. If they are not, the adoption rates can remain low for years."

The quote above shows the role of the car industry in creating acceptance for autonomous cars.

Services that can gain a lot from a society with a high percentage of autonomous cars will also be important actors in quickening the implementation. One participant's reasoning around this is quoted below:

"New companies that understands that services are the products of the future will play an important role. A third of the cost associated with a bus is the cost of salary. If you can remove the driver the cost will decrease heavily."

Other actors that were mentioned included insurance companies, IT-companies and other public companies.

5
Analysis

The analysis section analyzes the current situation of Parkeringsbolaget and autonomous parking in general in contrast to the literature review and the results.

5.1 Factors Affecting Adoption

This section will evaluate the different factors that according to Lindmark (2006) affects the adoption rate of new innovations. These are evaluated in contrast to both autonomous driving vehicles and autonomous parking vehicles.

Table 5.1: Shows to what degree each factor is fulfilled. Red = Slows down level of adoption, Yellow = Does not raise or slow down level of adoption, Green = Raises level of adoption.

Factors	**Complexity**	**Relative Advantage**	**Complements and Substitutes**	**Compatibility**	**Observability**	**Trialability**
Degree						

5.1.1 Complexity

The complexity of the innovation is a factor that affects the level of adoption. The development towards higher levels of automation is proceeding gradually. It is unlikely that one single step of this development will be seen as complex. According to the scale of NHTSA (2013) mentioned in table 1.1, when the level of automation gets higher less is required from the driver and thereby it could be argued that the innovation will be perceived as less advanced. Looking at the autonomous driving vehicles from a technological perspective it could be seen as a more complex innovation since it will need more advanced technology that has to be relied on heavily in order for successful implementation. However the end-user will most likely not see this complexity as they will be using the vehicle and experience the simpler functions which requires less from them as drivers.

5.1.2 Relative advantage

Another factor that will affect the level of adoption is whether the innovation is perceived to have a relative advantage compared to the already existing solution, in this case manually driven cars. It is clear that the innovation has an objective advantage in many ways compared to traditional, which of these advantages that are perceived by people in general is a harder task to answer. Before the innovation has entered the market people in general know very little about it. However, when being asked to list the biggest benefits for autonomous cars in a study made by BCG (2013) the top three was that they did not have to park their car, they could do other things while driving and to switch to self driving mode during traffic, these are all functions that are developments to the functions of a manually driven vehicle and it could be argued that the individuals therefore perceive the autonomous vehicle as advantageous compared to traditional vehicles. All these three are under the comfort-category and did not match what the experts in the interview-phase answered. That the perceived benefits were seen as so different is maybe inclining that the general public knows very little about the potential benefits which could be an indication that their perception of the autonomous vehicle in comparison to traditional vehicles could be seen as either relative advantage or a relative disadvantage when they are more informed about about the implications of it. The majority of the experts sees a lot of advantages with autonomous vehicles that could affect both society on a general level and each vehicle driver on a personal level. The top three benefits with autonomous vehicles on a personal level was according to the experts cheaper transportation, increased safety and time savings. These could be argued to have a high relative advantage in comparison to the market of transportation in today's society which is why we argue that autonomous vehicles have a high relative advantage. This is dependent on a development where people in general get more informed and knowledgeable in the area of autonomous cars.

5.1.3 Complements and substitutes

When autonomous cars enter the market, they could have benefits that people today associate with public transport such as doing other things while travelling.The interviews has indicated that the car will be less important as an object on a cultural level. This will mean that travelling with car and travelling with public transport will be more alike and will likely act as substitutes to each other. As Lindmark (2006) suggests the older technology will be forced to improve, in this case public transport will need to get better and it is possible that this will make the technology an even stronger substitute to autonomous cars. Other substitutes are traditional vehicles, walking and bicycles. The benefits of autonomous vehicles is depending on a lot of complements that are not available today. Many of these complements are needed in infrastructure for them to be efficient or even to work at all. Without having car parks that are adapted for self-parking vehicles, the technological feature of self-parking will not be utilized fully. Conclusively there are few complements today that supports autonomous vehicles and there are a lot of substitutes which could make it harder for such an innovation to spread in society.

5.1.4 Compatibility

The compatibility of an innovation will affect the level of its adoption. To be compatible, an innovation needs to be consistent with existing values, needs, past experiences and investments (Lindmark, 2006). As one of the interviewees pointed out, the car is becoming less important for each individual in society. This inclines that driving your own car is becoming less important and that is a development that will be advantageous for autonomous cars. 67% of the participants in the interviews stated ‘acceptance’ as something that can be hindering for autonomous cars, the values of the general public will determine whether they will feel safe with leaving the responsibility of driving to a computer, which is something that is totally against what they experienced in the past and as the study from IHS Markit shows there is a scepticism towards autonomous vehicles especially amongst older people (Jonston, 2016). One member of the expert-group said that autonomous cars was not asked for and that the need has been created by actors in technology. However, when looking at the potential benefits with the innovation, it is clear that autonomous cars have the potential to solve many of the individual’s problems with driving today. Regarding the investments had to be made, some information points towards premium models that will be significantly more expensive than the models of today while others say that transportation in general will become cheaper than today if autonomous car-sharing will be widely available .

Concerning the compatibility of the autonomous vehicles with current infrastructure it could be argued that it is compatible since vehicles already have been tested in current infrastructure however as the interviews revealed and Habibovic et. al (2014) argues there could be problems within the interaction between autonomous vehicles and traditional vehicles on the road especially if a higher number of autonomous vehicles are incorporated on the roads. The policies and laws are another part that are not compatible with the autonomous vehicles yet and there are actor such as Datainspektionen in Sweden that have shown resistance towards the technology.

5.1.5 Observability

For adopters to start using the innovation they will have to see the results and benefits of it clearly. Since the implementation of autonomous vehicles could occur in different ways the observability could be of different types. However the potential benefits of autonomous vehicles that would be most observable for potential users could be argued to be the feature of autonomous parking or autonomous pick-up since it is the part where the users behavior differs the most compared to traditional vehicles. Other benefits such as less congestion use and more safety could be argued to be larger however it is not certain that they are visible to a potential user that has not been testing the features. For autonomously driving vehicles to be implemented there will have to be some sort of adaptation from the society (for instance infrastructure changes and policy changes) and it could be argued that these changes will show the result and benefits of the innovation as they are implemented.

5.1.6 Trialability

An innovation could have a higher chance of being utilized if it could be tested on a limited basis or explored by potential adopters. At the moment there has not been any market introduction for autonomous vehicles however there is a spotlight on the autonomous vehicle and its development, prototypes and trials which could be argued to raise the trialability of autonomous vehicles. The Drive Me project is an example of the trialability of autonomous vehicles. Where Volvo Cars plan to release 100 autonomously driven vehicles in the road by 2016 as a trial. Also as figure 3.4 shows there is a great hype towards autonomous vehicles which could imply that it is a topic that could be explored and trialed by potential users. These are all factors that raises the trialability and could raise the chance of innovation acceptance among potential users. Conclusively the trialability could be argued to be good.

5.1.7 Summary of factors affecting adoption

Table 5.1 shows that most of the factors are set up for autonomous vehicles to have an effective adoption by potential users. However there are two important factors that are slowing down the process. Compatability and complements are two factors that have not been developed towards either autonomous vehicles or vehicles with FAP functionality. It could be argued that investments in infrastructure to raise compatability and investments in complements for autonomous vehicles and autonomous parking vehicles could raise the level of adoption to a large extent once the vehicles are introduced to the market.

5.2 Pre-diffusion Phase

Earlier in this thesis, literature on the so called ‘pre-diffusion phase’ has been described. The Pre-diffusion phase is defined as the time from the invention to the time of industrial production and large-scale diffusion (Tidd, 2010). The first step is determining when the autonomous car was invented. This is not an easy task since an autonomous car has a different set of technologies that together makes it autonomous and all functions were invented at different dates. In Tidd’s (2010) research, various industries were analysed, however, none of them were close to the car industry on a technological level which makes it hard to applicate this tool on this industry. The average time from invention to large-scale production was 16.7 years. Various features that are necessary for an autonomous car to work have been invented for years and new features are still being invented. In this thesis, we chose to define the date of invention as the 1st of may 2012, when an autonomous car from Google passed a driver’s license test in Las Vegas, USA (Harris, 2014). Google choose the route for the test and all parametres was not tested but it could be argued that this was the first functional level-4 vehicle on the NHTSA-scale.

The average time for the innovation phase was 10.0 years (Tidd, 2010). With the invention date set to may 2012, this means that autonomous cars will be on the market by 2022. Adding an adaptation phase of 6,7 years it means that autonomous cars will according to this theory be in large-scale production by the start of 2029 when level-4 vehicles are considered.

This date can be compared with the results from the interviews where the mean value for market introduction and when experts believed there would be greater volumes of level 4 cars was in 2029. It could be a coincidence that the results are so similar but it shows that it is not unlikely that autonomous cars will be widely spread in 2030.

5.3 Standardization of parking techniques

From the interviews, the need of communicating between car manufacturers and parking facility-owners is clear. At this stage it is vital that these two parties can agree upon a common standard to develop the technology in a direction in the interest of both parties. This will make the further development of self-parking cars easier and faster. From the theory section it is clear that the solutions that are being developed today by Audi, Mercedez and BMW are all dependent on smartphones/smartwatches that communicates with the car and also being dropped at a drop-off zone. This underlines the importance of having drop-off zones where cars can be dropped off before being parked. Since none of these techniques are dependent on any humans inside the car park it creates room for a lot of creative solutions around how to park the cars smarter and more efficient. All of the parking solutions described in the theory sections have the ability to find a parking space by itself without any adaption from infrastructure. However, if a connection between the car and the car park is developed, the parking becomes more efficient since the car will know where to park without having to drive around and look for a free parking space. In BMW's case, this is solved by establishing a WLAN- connection to download a digital map of the car park that shows where there are spare parking spaces.

The fact that electrical cars will, according to the experts, be the vehicle type of the future is something that could be worth considering when building infrastructure for parking. Charging for electric cars may be considered standard in all parking facilities in the future and it shows that the V-charge project for autonomous parking has considered to implement electrical charging stations in the car parks. One of the interviewees also mentioned that the first step for the parking municipality should be to implement a larger scale of charging stations within all car parks in the city.

Table 5.2: Shows the similarities between the different manufacturers.

	Drop-Off Zone	WLAN Communications	Mobile App	Electrical vehicles/synergy with electrical charging
Audi	X	X	X	
Car2Go	X	X	X	
BMW	X	X	X	
V-Charge	X	X	X	X

5.4 Adoption chain of autonomous parking

As described in the theory section, the innovators are the group that will start the diffusion process. The innovators are characterized by being risk taking and having financial resources. This is aligned with what the experts thought would be the first segment to adopt the technology. The most frequently mentioned group was people that are interested in technology and today has premium-segment cars together with mobility services that will be able to profit a lot from autonomous cars and are willing to take risks.

The early adopters are the group following the innovators in the adoption chain. These are individuals with a high social status. This will be the people that will dare to adopt the technology of autonomous parking and will help others to make the step of really trusting the technology. One of the groups mentioned in the interviews that are likely to be early adopters are young individuals that already today use the car as a service and that will benefit immensely from a service that will be much cheaper and much more effective.

As figure 3.5 in the theory section describes, young people are highly likely to buy and/or ride in a self-driving car while as older people are more hesitant. Even if autonomous parking is just one part of autonomous driving there will still be people that wants to stay with their old car and thereby park their car themselves. This group of older individuals is a potential group of laggards and will be the last group to adopt to the new technology and will not do so until they feel entirely safe.
Conclusively, this thesis has identified some characteristics that early adopters will have. When trying to assess how the innovation will be utilized. The theory and the results suggest that the autonomous vehicles could be sold in two different ways, either to private consumers or be sold as a mobility service. The mobility services are suitable for young technology enthusiasts since it is affordable for them. Premium vehicles will be more expensive and hence more suitable to technology enthusiasts with financial resources. Table 5.3 shows the characteristics of the early adopters for each type.

Table 5.3: Shows the revenue models of the ways autonomous vehicles could be utilized and the early adopters for each model

Revenue model	**Characteristics**
Mobility services	Young technology enthusiasts
Private Premium Vehicle	Technology enthusiasts with financial resources

5.5 Time estimations of market introduction

The studies from Vinnova(2015), Mckinsey(2016), Transportstyrelsen(2014) and Litman(2015) predict that autonomous vehicles with level 3 automation will be produced and sold on the market on a small scale between the years of 2020-2025 with a mean of 2022. This can be compared to the interviews where the market introduction was predicted to happen in 2022, which is uniform to what was found in the theory section.

From the interviews, level 4 vehicles will be introduced on the market in 2029, however, it should be noted that the standard deviation was 7.9 years which was a lot higher than the predictions for level 3 and FAP. This illustrates the fact that the future of fully autonomous cars is more uncertain than the other categories. By applying the literature on pre-diffusion phases to level 4 vehicle the result was large scale production as early as 2029. It should be remembered that this analysis was made on innovations in general and the length of the pre-diffusion phase was not determined by any industry-specific factors. Vinnova (2015) and Litman (2015) believes that the majority (more than 80%) of the market will be fully autonomous vehicles in 2050's.

Regarding FAP it was hard to find any numbers of when these features will be released on the market. This could be due to the fact that these features are currently under heavy product development close to market entry and the companies wants to keep it secret. As figure 3.3 shows Toyota and Denso are considered to be the largest innovators in autonomous vehicles, however we could not find any information about if or how they are developing their FAP function in their vehicles. So it could be argued that a lot of the information and solutions of various companies are kept secret. As described in the theory section, Audi believes their technology could be deployed in a small series in 2018. The experts in the interview section predicted that FAP will be introduced on the market in 2019.

Other actors that has to be closely monitored in order to know the date for market introduction is the car industry, public companies and decision makers. If the legal system does not come into place in a near future, Sweden can lag several years behind other countries.

Assuming a moderate level of involvement from the actors in the city and that the legal issue will be solved in the near future, we predict the following development (figure 5.4):

Table 5.4: Comparing the data from the interview findings to the theory does not demand any changes in the prediction.

Vehicle Type	**Predicted Market introduction**
FAP	2019
Level 3 Car	2022
Level 4 Car	2029

5.6 The Transition Phase

The time period when there are traditional cars mixed in traffic together with autonomous cars will last for a long time. If fully autonomous parking is assumed to be introduced in 2019 and that all cars that are being sold will be on level 4 autonomy in 2050. It is not impossible that this transition will last for 40+ years. The implementation of autonomous vehicles could be argued to be a collective innovation-decision which are the choices that are made by all members of a system. According to Rogers (1983) a collective innovation decision takes the longest time to implement into society. The theory and results both suggest that when level 4 autonomy have been implemented then there will be a minimal need of car parks in central city.
From the interviews, it became clear that all benefits will not be able to obtain until a large proportion of cars are autonomous. The benefits will become larger as the percentage of autonomous cars increase as adaptations of infrastructure can be made continuously. There is however no doubt that benefits can be made directly from the beginning of the transition. The biggest benefit of autonomous parking vehicles was according to the respondents the increased efficiency of space and this is in line with Crucchiola (2015) argument that an autonomous car park could fit 60% more vehicles compared to a traditional car park. However that study is based on a car park that is designed specifically to autonomous vehicles. It could be argued that it will take a long time before all the vehicles on the road have FAP functionality and therefore there will be a phase where the FAP vehicles will interact with traditional vehicles in the car park and then the question is how to get the most societal benefits from that. According to the result there could be societal benefits even during a transition phase where FAP vehicles interact with SAP/TP vehicles and the results showed that the introduction of FAP could help to raise the acceptance towards autonomous vehicles in general and be an opening step towards it. This is in line with Lindmark (2006) argumentation that diffusion of innovation is a continuous process that evolves over time and that a technological system can start with a technology base that with time adds/substitutes functions, applications and technology base changes.

The results shows that there could be a problem during the diffusion phase since their could be lack of initiatives from key actors. Wejnert (2002) argues that for a successful implementation of an innovation it is dependent on a suitable environment. The environment is defined in three subgroups. Analyzing these subgroups in contrast to Parkeringsbolaget situation results in table 5.5:

Table 5.5: Factors that could affect the level of adoption, green= could fasten the level of adoption, red=could slow down the level of adoption

Subgroups	**Societal culture**	**Political conditions**	**Global uniformity**
Factors	Moral Acceptance	Legal	Drive Me, V-charge All large car manufacturers have invested in autonomous vehicles

The table shows that there are factors in the form of moral questions, acceptance obstacles and legal issues that currently can affect the adoption of autonomous vehicles in general. However the table also shows that programmes like Drive Me and V-charge could raise the level of adoption since it raises the level of global uniformity. The fact that all large car manufacturers are investing heavily in the technology is another factor that facilitate a successful implementation.

It is important to note that the length of the transition-phase can be affected by decisions made by Parkeringsbolaget. If it is not possible to park a traditional car in Gothenburg it may result in fewer people that will decide to purchase one, hence shortening the transition-phase. According to Bulkeley and Marvin (2010) if a technological transition involves infrastructure changes then the city will have a primary role in a technological transition. With this argument it means that for successful implementation of autonomous parking vehicles Parkeringsbolaget and other municipal actors will have a key role. According to Dodgson (2008) there has to be commitment from all stakeholders for a successful implementation and it could be argued that Drive Me is a sufficient program where many actors are involved however there has to be a shared view of the purpose of the programme between all actors.

Assuming that the largest society gains from autonomous parking vehicles comes once a majority of the vehicles have the FAP function. Then the question is how to implement car parks that only allow FAP vehicles. This could be done in several ways. To create a picture of what could be done, series of actions that can be taken is divided into various action modes which are described below.

5.6.1 Action Mode 1

Make a strategic alliance with a mobility service or found a car-sharing service with vehicles that have the FAP functionality and designate automated car parks. The results argue that mobility services could be an early adopter of autonomous parking solutions and through a strategic alliance Parkeringsbolaget could integrate a mobility service in the concept.

Implications:
- Could raise the mobility in the city.
- Could create a competitive advantage for the car-sharing service since it could raise the availability and comfortability of the service.
- The car park could be customized to the number of vehicles that the mobility service is in need of.
- Could result in space savings.
- Could act as a pilot test project.

Challenges:
- Could be challenging to find an actor that wants to cooperate.
- Difficult to know exactly when to initiate such a cooperation and build the designated car parks.

5.6.2 Action Mode 2

Build for current demand with an eye for the future. This means that the car parks could be built for the current demand which is vehicles with SAP/TP functionality. However the car parks could also have one floor that is designated for vehicles with FAP functionality and the others floors convertible to being floors for autonomous cars in the future. According to the data about Parkeringsbolagets current parking facilities, they are mainly situated in the central parts of Gothenburg. In the future, cars with level 4 automation will be able to drop a passenger off at an address in the central part of Gothenburg and then drive to a parking facility somewhere else. This frees up expensive land to be used for other things than parking. If car parks still will be built in the central parts of the city, make sure that these can be converted into residentials or offices if the need for parking declines.

Implications:
- Action mode 3 is built in line with current demand.
- The specially designated floors could help to test the demand for FAP vehicles.
- The specially designated floors could raise the trialability of the solution..

Challenges:
- Difficult to know the demand of autonomous parking vehicles, especially since the demand could vary throughout the year.
- Challenging to build car parks that could be convertible especially since it is difficult to know when/if they will be converted.

5.6.3 Action Mode 3

Implement a few autonomous car parks in the central parts of Gothenburg.

Implications:

Could generate in space savings for the city since more vehicles could be parked in a smaller area.

Challenges:

- Challenging to know the amount of car parks that will have to be implemented.
- There is a need for FAP vehicles to park in this car parks which could be hard to achieve since the function will be costly according to the results. This could implicate that average citizens will not be able to use this car parks and it will become a premium choice.

5.6.4 Action Mode Summary

These action modes are suggestions on how to implement autonomous parking vehicles in the society during a transition phase where there are also traditional vehicles on the roads. It should be noted that the results and the theory both suggests that in the future the vehicles on the road will have level 4 automation and the need for car parks will be absolutely minimal especially in the central parts of the city, so it is important to also know that the FAP vehicles and their designated car parks in some decades could result in excess of parking space. However even if that is the case for the future, Lindmark (2006) and the results argue the introduction and implementation of FAP vehicles could help to create acceptance and diffuse autonomous vehicles of level 4 in society. As the results suggest the experts seem to be quite unclear about when level 4 autonomy could be introduced in the market which is proved by the standard deviation of 7.9 years so the first step may have to be to implement the first part of the technical system which could be argued to be FAP functionality.

It should be noted that these action modes do not take all factors into account. For instance the cost of building a car park is unknown and could be a restriction. There could also be juridical restrictions, which have been presented in section 3.2.5 in the theory section. Another question that may have to be further assessed is if these action modes are realizable. The results suggest that the vehicles are likely to be driven by electricity so these action modes could also include charging stations in the solutions.

The action modes could be implemented during different times and as the Lindmark (2006) argues there has to be compatibility between an innovation and surrounding needs and values. Therefore it could be argued that the timeliness of the action modes is of importance. By analyzing the experts predictions of market introduction in contrast to the action modes there are suggestions of when the action modes are the most applicable. This is analyzed in the section below.

5.7 Timeline

To structure when various events will happen and what action mode that should be engaged at what time, a timeline was created to show this in an illustrative way. It should be noted that all action modes does not necessarily have to be executed the technical evolution could evolve in a way that maybe suits only one of the action modes. This is more an illustration that shows in what times they could be implemented and as written in section 5.6.4 some variables such as price and chance of realization of the action modes have not yet been evaluated. Figure 5.1 illustrates the timeline.

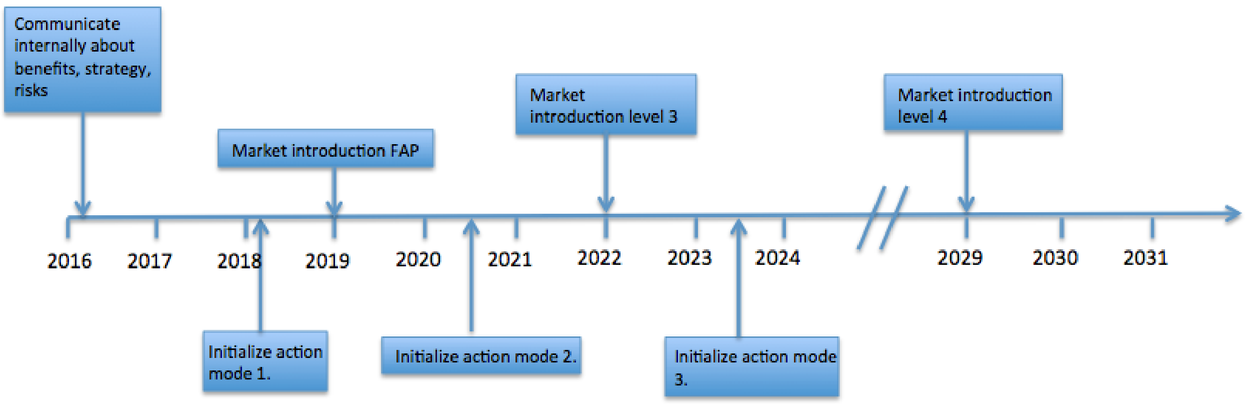

Figure 5.1: Illustrates the societal benefits as a function of the amount of autonomous vehicles on the street.

The theory suggests that for a successful implementation of innovation and strategies it is important to communicate internally about the purpose and the goals of the organization. Parkeringsbolaget has invested in several projects concerning autonomous vehicles and to make the most out of this there needs to be communication down in the organization about the purpose of the investments made. To make the organization understand the investments variables such as benefits also needs to be communicated in the organization so the whole organization knows about the potential of both autonomous vehicles and autonomous parking vehicles. If the benefits are communicated the risks should also be so to give a transparent view on the innovation to the organization. This further enables the organization to have a common view on autonomous vehicles and autonomous parking vehicles which potentially can help them to build a strategy that is understood and implemented in the whole organization. This communication could start directly since the investments are already made.

As figure 6.1 illustrates the market introduction of FAP is estimated at 2019 and this thesis have suggested action mode 1 to be implemented approximately a year before the FAP introduction. This is since the action mode firstly wants Parkeringsbolaget to start communicating with a mobility solution actor and by the time of the market introduction have a set strategy of how to work to get the most benefits from this cooperation.

Action mode 2 is set between the market introduction of vehicles with level 3 automation and vehicles with FAP functionality. This action mode is hard to estimate since to build a car park there needs to be a demand for parking spaces and if there is a high demand this action mode could start basically anytime. However this thesis have put it a couple years after the introduction of FAP since then the solution exists and may have spread amongst other actors in Sweden or the world.
Action mode 3 depends a lot on how the innovation is spread in society. So the year could vary a lot but it is estimated around 2023 and basically there needs to be a demand for the innovation in order to implement autonomous car parks and when that demand is reached is hard to predict.

Conclusively, action mode 1 is the one that is the easiest to set a date on and the communication and cooperation with a mobility solution could start quite immediately and it is not dependent on the demand of autonomous parking vehicles.

6 Discussion

This section discusses the research in contrast to different topics. It discusses the methods used in the research. It discusses the importance of the results, analysis and recommendations of the thesis. It also discusses unexpected findings in this thesis.

This thesis is mainly based on a literature study combined with interviews of various experts within the field. In this research we chose to not make any recordings of the interviews and also keeping the interviewees opinions anonymous. Even if the interviews would have been recorded the participants were promised anonymity and the recordings could not have been published.It could be argued that this approach gives less transparency to the research. However since all the interviews were performed by two persons where one wrote notes and the other asked the questions it could be argued that most of the relevant comments by the interview-subject was to be written down. By making the interviewees opinions anonymous the interviewees may feel more free to state their opinion which means that the quality of the answers will be increased even if the transparency could be argued to have decreased.

Reviewing the list of chosen interviewees it could be seen that they represent a variety of different industries and it could be argued that the interview-subjects that does not work within the automotive business does not have the knowledge to be able to answer the questions in the questionnaire that are related to the development of autonomous vehicles. This thesis has chosen to interview experts from a variety of industries to get a comprehensive picture of the situation of Gothenburg City. In some aspects, apart from the interview-phase, it could have been better for the thesis to have a closer collaboration with a car manufacturer since they are the only one that really knows exactly where the technology stands right now. On the other hand, this is a period of time when the car makers are very hesitant when it comes to sharing information about their upcoming products, therefore, it is not sure that a car manufacturer would have been interested in such a close collaboration.
Reviewing the literature study it could be seen that some parts such as the section 2.3.13(modern car parks) and section 2.3.12(autonomous parking techniques) would preferably have more content. However it was hard to find more information on those sections. It is possible that if more information could have been gathered in these sections, a more exact prediction about the future of the industry could have been made.

The fact that the market introduction is according to the experts happening so soon was an unexpected finding in the thesis. Even if many actors in the car industry are predicting a soon market introduction it was surprising that the experts interviewed believes that the market entry is very close.

The results and the recommendations of this thesis could be used in different ways. The results shows how a variety of actors within Gothenburg perceives autonomous and autonomous parking vehicles. Their opinions could be used as a basis for other actors and not only Parkeringsbolaget since the questions are generally asked and not asked in subject to Parkeringsbolaget situation. The analysis have used the results in contrast to the literature review and strengthens the credibility of the thesis. The recommendations are mainly useful for Parkeringsbolaget since they are directed towards them. It should be noted that from a global point of view Parkeringsbolaget is a small actor and the influence they could have on the adoption of autonomous vehicles and autonomous parking vehicles from a global perspective is very limited. This thesis has mainly recommended steps that they could take in order to prepare and facilitate a technological change that according to experts and reports will happen.

6.1 Recommendations

The recommendations from this thesis are summarized below:

- Evaluate the possibility of starting to co-operate with a company that delivers mobility solutions with cars, this could be a company that has a pool of cars up for rent. This company would pay a lot if their cars could be parked autonomously since it would benefit their customers and create value for them. This co-operation could begin with building a small car park and equip it with the technology needed for the cars to park safely and efficient. Since no other cars would be needed inside the car park, space and cost efficiency can be massively improved compared to a normal car park. This could be the first step in the implementation of autonomous car parks.

- Try to communicate with other actors such as the car making industry and other companies in the parking industry to create a standard of what kind of technology that is needed in a car park. Whether the standard is radar, various kinds of sensors or something else, it is important that this is provided to make the car makers more willing to develop autonomous parking vehicles. The communication also helps Parkeringsbolaget to be up to date with current technology and autonomous parking solutions.

- Communicate internally at Parkeringsbolaget about autonomous vehicles, autonomous parking vehicles. For successful implementation there needs to be a shared understanding of the implications and possible benefits/risks it could implicate.

- Investigate the possibility of building the car parks in less central areas of the city. The depreciation of a car park is 50 years which means that long term planning is a requirement for successful infrastructure planning. If there is a need to build car parks centralized then assess the possibility of remaking them in the future.

- Analyze the action modes and assess when and how they could be implemented or if there is a possibility of them being implemented.

6.1.1 Future Work

The transition phase that this thesis has dealt with to some extent is an area that is unexploited and it would be beneficial to make more research within it for future research. Another relevant area for future research could be a research on how to implement a strategy to gather all different FAP techniques and standardize them. As the results have shown the experts believe that autonomous vehicles will be electrically driven, this could also be a topic for future research, to see if autonomous vehicles really are best suited to be electrical.

7
Conclusion

This thesis has through reviewing existing literature on autonomous vehicles and conducting interviews with experts of varying background tried to evaluate how the future of autonomous vehicles could look like. The thesis has mainly focused on autonomous parking vehicles but since an autonomous vehicle most likely will have the function of autonomous parking there has been a focus towards autonomous vehicles in general as well. The thesis has shown that the customers that are likely to be the early adopters have different characteristics. It could be young technology enthusiasts and/or technology enthusiasts that have financial capacity to pay for such a solution. It has also been showed that the most benefits for society will probably be when the majority of the cars are autonomous. It will, however, take a long time before that will be reality and until then there will be a transition phase when autonomous vehicles are mixed with traditional vehicles. This transition phase can have possible gains for society and this report has developed three action modes that describe three different plans on how to obtain the benefits of autonomous parking vehicles even during a transition phase. Gains such increased mobility, increased safety and space savings could be achieved even during a transition phase.

By reviewing literature and communicating with experts the thesis have resulted in predictions of specific years when autonomous vehicles of various degrees and autonomous parking vehicles could have their market introduction. By analyzing these dates together with the action modes , different time suggestions of when Parkeringsbolaget could take various actions were developed. This was done for Parkeringsbolaget to adapt successfully to a potential technological change. This was compiled into a timeline where it is clear that actions should be taken today already in order to prepare for a successful implementation. The action modes shows that even during a transition phase it is possible for Parkeringsbolaget to achieve benefits for society.

This thesis has shown that in order for successful diffusion of innovation for autonomous vehicles the whole city which includes Parkeringsbolaget has an important role and could be an actor that either delays or hastens a potential technological change, which is why it is important for all actors to contribute in different ways if they wish to keep up with the technology. The level of adoption could be affected by different factors and the most important ones currently are the actors willingness to invest in complements for autonomous vehicles and invest in making them compatible with current infrastructure.

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A
Appendix 1

A.1 Interview questionnaire

The questions that were asked when interviewing the experts are presented below, the original question in swedish in bold and the english translated version in italic.

Vilka är de tre största fördelarna för samhället gällande självkörande bilar enligt dig?

Which are the three main benefits to society regarding self-driving vehicles?

Vilka är de tre största fördelarna för den enskilda gällande självkörande bilar enligt dig?

Which are the three main benefits to the individual regardingself-driving vehicles?

Vilka är de tre största fördelarna för samhället med självparkerande bilar enligt dig?

Which are the three main benefits to the society regarding au-tonomously parking vehicles?

Vilka är de tre största hindren med självkörande bilar enligt dig?

Which are the three main problems/disadvantages with autonomousvehicles according to you?

Vilka är de tre största hindren med självparkerande bilar enligt dig?

Which are the three main problems/disadvantages with autonomousparking vehicles according to you?

Kan man göra några samhällsvinster under en övergångsfas? Vilka?

Can you make any societal benefits during a transition phase?If so, which?

Vilka svårigheter ser ni med en övergångsfas mellan traditionella till au-

tonoma bilar?

Which difficulties do you see in a transition phase from tradi-tional to autonomously driven vehicles?

Vilka segment/kundgrupper kommer vara mest intressanta i en introduktionsfas för självkörande/självparkerande bilar?

Which customer segments are most interesting for a introduction phase concerning autonomous vehicles?

Vilka aktörer anser ni kan påskynda respektive försena en implementering av självkörande bilar i Sverige?

Which actors do you believe could quicken/delay the imple-mentation of autonomous vehicles in society?

När tror du att fordon på level 3 enligt NHTSA introduceras på marknaden?

When do you think that a car on level 3 on the NHTSA-scale could be intorduced on the market?

När tror du att fordon på level 4 enligt NHTSA introduceras på marknaden?

When do you think that a car on level 4 on the NHTSA-scale could be intorduced on the market?

När tror du att en självparkerande bil skulle kunna introduceras på marknaden? (level 4)

When do you think that a self-parking caron the could be intorduced on the market? (level 4)

När tror du att fordon på level 4 enligt NHTSA har 100 % av nybilsförsäljningen?

When do you think that completely self-driving cars will be 100% of cars sold?

Hur ser ni på framtiden/marknaden för självkörande bilar om 10,20 respektive 50 år?

How do you look at the future for autonomous cars in 10, 20 and 50 years?

Hur ser du på tanken att fler kommer åka bil?

How do you reason around the thought that the development of autonomous cars will lead to that more people will be driving?

Framtidens typ av fordon?

What type of propellant is most likely to dominate the future market of cars?

Okej om vi använder ditt namn längst ner i rapport?

Is it OK if we use your name in our report