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Autonomous Driving

Opportunities, Challenges and Risks of Self-driving Cars in Rural Areas from a User's Perspective

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FAKULTÄT
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Autonomes Fahren

Chancen, Herausforderungen und Risiken von selbstfahrenden Autos im ländlichen Bereich aus Anwendersicht

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Erklärung zur Verfassung der Arbeit

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Martin Kaufleitner

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Abstract

Autonomous driving has been rapidly developing in the recent past and it is expected to reach our roads in the upcoming years. Technological advances in various disciplines have made it possible to finally realize this futuristic way of traveling. Nevertheless, the success of this new technology is not only related to technical advances. Due to its interruptive and revolutionize nature, autonomous driving might have the potential to impact our society just as the industrial revolution or the invention of the Internet did. Hence, for a successful introduction of self-driving cars, not only technical, but also social aspects have to be considered and analyzed. However, current research focuses primarily on technological rather than user related issues, which creates a current lack of knowledge about people's perspective on self-driving cars. Furthermore, most current user related research is focused on autonomous car implementations in urban areas. Whereas self-driving cars might have the potential to revolutionize rural areas with its specific traffic structures, as well as completely changing the way mobility is experienced by people in the countryside.

This study uses a qualitative research approach to elaborate and analyze the user's perspective on autonomous cars in rural areas. Subjects explain their current mobility situation, mention current problems and express their wishes in an open interview. Additionally to their open speech, they are also confronted with actual open issues and considerations about autonomous driving in various fields. This includes potential use cases and related design changes, integration strategies and regulations as well as legal issues and ethical decisions. The interviews are focused on the very personal opinion of each individual participant and they provide detailed insight into potential real-life benefits as well as challenges and risks of self-driving cars.

As a first step during the analysis of the interviews, they have been summarized in individual case studies. These elaborations show, which issues, problems but also wishes and opportunities each individual emphasized during the interview. This provides authentic real-life considerations and gives an overview about the current mobility situation in the country side and people's attitude towards autonomous cars. As a second step, these case studies have been analyzed by categorizing, structuring and evaluating the individual statements in order to get comprehensive and sound explanations on each topic. For each research topic, the results have been used to formulate a conclusion, including potential solutions and approaches as well as still open issues and challenges. These findings should facilitate stakeholders in their decision making process and outline necessary further investigation in order to gain sufficient knowledge for a beneficial introduction of autonomous driving in our society.

Kurzfassung

Vor allem in den letzten Jahren ebneten bemerkenswerte technologische Fortschritte in verschiedenen Disziplinen den Weg für die Einführung des autonomen Fahrens in den kommenden Jahren. Allerdings hängt der Erfolg dieser neuen Errungenschaft nicht ausschließlich von der aktuellen technischen Machbarkeit ab. Wegen seiner revolutionären und umfassend verändernden Eigenschaften hat das autonome Fahren das Potenzial, gesellschaftliche Strukturen so sehr zu beeinflussen wie es schon die industrielle Revolution oder die Erfindung des Internets getan haben. Daher müssen für eine erfolgreiche Einführung nicht nur technische, sondern auch gesellschaftliche und soziale Aspekte betrachtet und untersucht werden. Diese Tatsache wird in der herrschenden wissenschaftlichen Arbeit zum autonomen Fahren noch zu wenig berücksichtigt. Des weiteren beziehen sich aktuelle Forschungen und Untersuchungen zu möglichen Anwendungen meistens auf Städte und urbane Gegenden. Diese Vorgehensweise vernachlässigt die potentiellen Möglichkeiten von selbstfahrenden Autos gerade auch die Mobilität im ländlichen Bereich, mit seinen speziellen verkehrstechnischen Eigenschaften nachhaltig zu verändern.
Diese Masterarbeit verwendet einen qualitativen Ansatz um das Thema "Autonomes Fahren" aus der Sicht von Benutzern im ländlichen Raum zu erarbeiten. Die Teilnehmer erklären dabei in offenen Interviews ihre momentane Situation bezüglich Mobilität mit all ihren Problem und Wünschen. Weiters werden sie mit aktuellen, offenen Herausforderungen und Problemen in verschiedensten Bereichen des autonomen Fahrens konfrontiert. Dabei werden zum Beispiel mögliche Anwendungsfälle und damit verbundene Änderungen im Design des Auto betrachtet. Auch diverse Strategien zur Integration von selbstfahrenden Autos in bestehende Verkehrsstrukturen und notwendige Regulierungen sowie ethische Betrachtungen werden beleuchtet. Die Interviews konzentrieren sich auf die persönlichen, individuellen Ansichten der Befragten und liefern somit detaillierte Einblicke in potentielle Vorteile aber auch Probleme und Risiken von selbstfahrenden Autos aus der Sicht von Nutzern.
Im ersten Schritt der Interviewanalyse wurden die Aufzeichnungen in individuellen Fallstudien zusammengefasst. Diese Ausarbeitungen zeigen, welche Aspekte, Probleme und Wünsche von den einzelnen Probanden während des Interviews besonders hervorgehoben wurden. Die Fallstudien bieten daher einen authentischen Überblick über die momentane Mobilitätssituation am Land, sowie über die Einstellung der Leute gegenüber selbstfahrenden Autos. Im nächsten Schritt wurden die individuellen Ergebnisse bezüglich zusammenhängender Aspekte strukturiert und induktiv kategorisiert. Daraus ließen sich vollständige und detaillierte Betrachtungen zu den einzelnen offenen Themen ableiten und eventuelle Lösungsansätze sowie noch

offene Fragestellungen formulieren. Die Ergebnisse sollen einerseits Entscheidungsträger unterstützen und andererseits aufzeigen, wo noch zusätzliche Forschungsarbeit notwendig ist, um eine erfolgreiche und vor allem nutzbringende Einführung von selbstfahrenden Autos gewährleisten zu können.

Contents

CHAPTER 1

Introduction

This chapter provides a general introduction to autonomous driving as well as an overview of the thesis' content. First of all, we will have a look at the relevance of autonomous driving considering some open issues. Next, the outline of this thesis will be presented providing a short overview on the thesis' chapters and the topics covered.

1.1 Autonomous Driving

In recent years, autonomous cars have experienced rapid development (Pettersson and Karlsson, 2015, p. 694) and it seems to increase even more in the future (ITF, 2015, p. 5). It is said, that self-driving cars have the potential to disrupt the current mobility situation in the years to come (Almeida and Arem, 2016, p. 65; HYVE Science Labs, 2015, p. 2). As shown in figure 1.1 (see p.2) autonomous driving has just surpassed the peak of the "Gartner's Hype Cycle 2016" (Gartner, 2016) and according to (HYVE Science Labs, 2015, p. 15), the rate of discussions of autonomous driving on social media platforms doubled every year since 2010, having peaks in March 2015 (Tesla announcement) and May 2014 (Google car). Vast progress achieved in technical fields like visual and thermal sensor systems, embedded systems and telecommunication increase automation capabilities of modern cars (Pettersson and Karlsson, 2015, p. 694; Levinson et al., 2011, pp. 1-2; Chen et al., 2014, pp. 17549-17550). Especially advances in computer science has brought car automation to a totally new level. Specific research areas in this discipline are for instance machine learning for visual recognition, algorithmic for sophisticated route planning or artificial intelligence facilitating adequate data processing from new sensor systems for autonomous driving (Levinson et al., 2011, pp. 1-5; Chen et al., 2014, pp. 17554-17558).

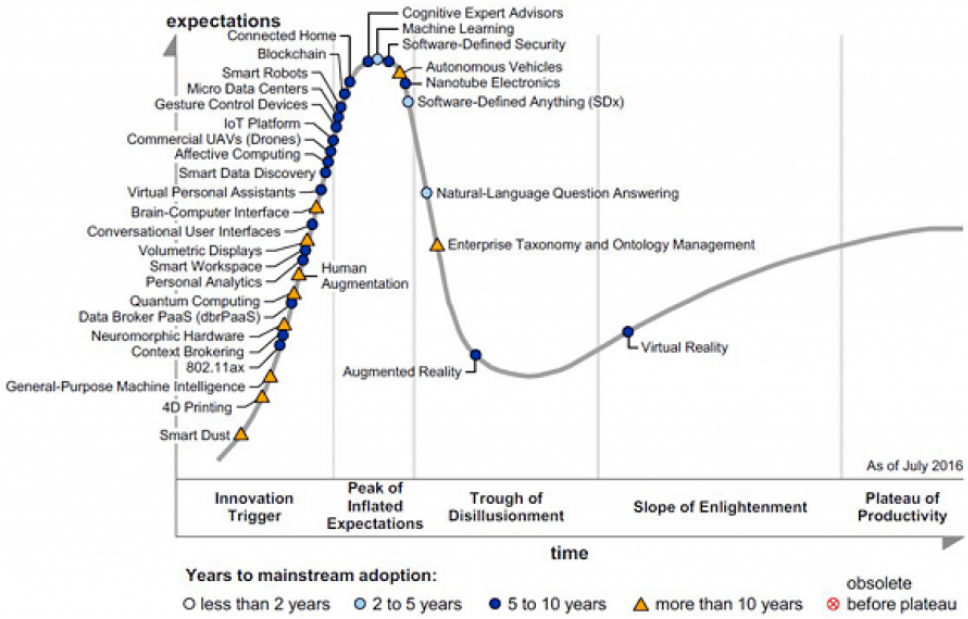

Figure 1.1: Gartner Inc.'s Hype Cycle for Emerging Technologies, 2016 (Gartner, 2016)

1.1.1 Objects are closer than they appear

The aforementioned ongoing progress leads to several assumptions, that autonomous cars will populate public roads within the next 25 years (ITF, 2015, p. 5; Litman, 2014, p. 17; Meschtscherjakov et al., 2013, p. 1; Kyriakidis, Happee, and De Winter, 2015, p. 136). These estimations refer to a significant percentage of autonomous cars in public traffic, but there are even more optimistic announcements about introducing first autonomous cars in public. Elon Musk, CEO of Tesla Inc. claimed in October 2016, that by the end of 2017 the first Tesla autonomous car will drive from Las Vegas to New York without any need for human intervention (Stewart, 2016). Waymo's (further Google Car) autonomous fleet consisting of 60 vehicles is already driving for testing purposes around cities in the USA (Waymo, 2016). Also other car manufacturers and autonomous driving companies like Uber, Ford, Delphi, Volkswagen, Audi, GM, BMW and more give optimistic estimations, that they will be able to ship their first self-driving cars between 2019 and 2030 (Driverless Future, 2016). Following to these predictions, this means that most likely at least we will be in contact with this new kind of technology in the upcoming ten years.

1.1.2 Open Issues

Although these optimistic announcements are very promising, there are still several issues which mark potential roadblocks in the way to introduce self-driven cars. The stated prognoses is mainly a result of technical advances and of what technology will be capable of in the near future. As stated, autonomous driving has surpassed the peak of the Hype cycle, which has an

interesting meaning. Looking at the graph, autonomous driving is said to enter the phase of disillusion in the upcoming years and it is hard to predict which of the current, rather euphoric prognoses, will become true.
Technicians tend to give estimations on future technologies solely based on the technical aspects and progress, but often leave out social issues (HYVE Science Labs, 2015, p. 5). Technical achievements always have an impact in social structures and the other way round (Rammert, 1993).
Given the technical possibilities, this thesis will examine resulting social conflicts, risks, open questions, concerns and problems as well as potential benefits, wishes and opportunities on the following main aspects of autonomous driving.

User's Perspective It is essential for the success of autonomous driving, that stakeholders take into consideration user's desires, hopes and concerns (HYVE Science Labs, 2015, p. 5). Self-driving cars have the potential to revolutionize and maybe completely change the way mobility is experienced by society. This results in a need to understand how people will respond to the introduction of this new technology (Pettersson and Karlsson, 2015, p. 694). What do they think about self-driving cars? Where do their concerns, lack of trust or even fears lie? Since possible changes in structure and processes, induced by this new technology, may influence their behavior and maybe even impact their whole daily life, it is crucial to understand what people expect from autonomous cars. It is important to examine, what the reasons are for people to have trust or distrust in driver-less cars.
Also considerations on the car as a personal status symbol, which might get lost due to mobility services, are of interest. People might also want to maintain manual control just for the sake of the driving experience and therefore neglect a self-driving car (Glancy, 2012, p. 1184). These personal preferences play an important role on the decision of accepting or even buying an autonomous car. Without sufficient research on the users' desires and concerns, it will be almost impossible to predict and react appropriately to their future behavior.

Rural Areas In contrast to urban areas, especially in rural areas, significantly less research can be found on the influence of autonomous driving technology systems on society. But rural areas demand to be investigated in more detail as well. Not only do rural areas differ in their demographic composition from cities (Pateman, 2011, p. 1), also their traffic environment is completely different having usually long distance trips with hardly any controlling input as traffic lights and signals. Furthermore there is often a lack of public transport in the countryside that can lead to decreased mobility. This situation is described in (Beitz, 2016, pp. 40-43) by using the Austrian state of Lower Austria as an example. A detailed description of the characteristics of rural areas can be found in section 2.6. For the qualitative study performed for this thesis, the area around the district of Braunau in Upper Austria was investigated.
So in addition to the explored scenarios, like self-driving cars in well organized traffic structures as they occur in cities, autonomous cars have the potential to change also the traffic system in rural areas. But in order to be able to extend autonomous usage to rural areas, further research on the special requirements of the countryside, considering its traffic structures as well as the people's perspective, needs to be done.

Integration in Traffic System An important consideration on the introduction of self-driving cars are potentially necessary changes in infrastructure such as: highways, intersections or roads in the countryside. First of all, the question arises: Who should pay for the additional costs? Do people agree with the use of their tax money, even if they might not even own a self-driving car? Should the car manufacturers take over the costs? Or maybe there will be a private organization. On the other hand, people maybe even prefer some kind of subsidized scheme for autonomous cars in order to improve availability and transport quality on the broad society (Kyriakidis, Happee, and De Winter, 2015, p. 129). Another open question is, if people prefer an "everything somewhere" or a "something everywhere" approach (ITF, 2015, pp. 13-18). Should there be separate lanes or even roads for autonomous vehicles? Do people expect the introduction to be initially limited to bus lanes or highway platooning? There are still a lot of open issues concerning the crucial transition period from conventional to autonomous cars. This phase can last from a couple of years to perhaps almost forever, depending on whether driver-less cars eventually fully take over public roads.

Legal and Ethical Issues There are also open questions considering policies and laws that have to be changed or introduced in order to regulate the usage of autonomous cars. Since cars are driving on their own, maybe driving licenses will be adapted or not be necessary anymore (ITF, 2015, p. 16). If not, what about drink driving, and should mentally/physically disabled, elderly people or children also be allowed to drive or be driven (HYVE Science Labs, 2015, p.20). These are still open legal questions that have to be discussed.
Additionally to those legal considerations, autonomous driving also brings personal and ethical issues, which produce sometimes hard to answer moral questions. A potential scenario might be the question of liability in case of an accident and what possible insurance schemes would be like (ITF, 2015, pp. 25-28). Is the car manufacturer fully responsible in case of failure and therefore has to pay or will the driver be partly liable as well and how is this related to the level of automation in the car? Furthermore, it is important to gather knowledge as to where there could be problems relating to unfairness between autonomous and conventional car users, for example regarding changes in insurances, infrastructure and public transport (Litman, 2014, pp. 17-18). Another ethical problem scenario is the so-called "lose-lose situation", where the autonomous car has to decide, which person will be involved in an accident in a hopeless situation. The crucial question is not only how to decide, but also who decides. (Kirkpatrick, 2015, pp. 19-20). This kind of situations, the users' opinions and ideas as well as their concerns have to be analyzed carefully to be able to provide meaningful solutions for society.

Privacy and Data Usage A very complex aspect of autonomous driving and the new technologies which come along with it, is privacy and data usage. First of all, it has to be regulated, as to what kind of data can be collected. This data might tell what destination the car was driven to, like shops, work, vacations or school and can also be used to identify at what time, how many times and even with whom (Glancy, 2012, p. 1188).
One can imagine, that this kind of data gives a big opportunity to optimize traffic management significantly by intelligent algorithms leading to less waiting time and higher throughput on the one hand, but depicts a huge cut in users' personal privacy on the other hand (Fagnant and

Kockelman, 2015, p. 178). Therefore, also the reasonable usage of data has to be clarified and defined. First of all, it has to be regulated, who has access to what data. Exemplary institutions might be the government, the police, car manufacturers or also other cars/users (Glancy, 2012, p. 1196). Having the data, one must think about what purposes may it be used for. This could be criminal prosecution, routing optimization, infrastructure planning and so on. Also the selling of data for personalized advertisement purposes and potential rewards have to be discussed.

1.2 Thesis Outline

After an introduction to autonomous driving in general, open issues which will be considered in this study have been stated. The second chapter explains the thesis' concept including its motivation and goal as well as basic definitions and classifications. Followed by an overview of the history of self-driving cars and modern advances. The next chapter shows the current state-of-the-art and related work in the context of user experience of autonomous driving, safety and ethical aspects, privacy and legal aspects and mobility in rural areas. Each section is concluded by a small discussion. The state of the art is followed by the methodological approach, including qualitative data gathering and induced category analysis. The following two chapters are dedicated to the thesis' results. First the individual interviews are analyzed in case studies which give insights in the interviewees' individual situations. Afterwards the findings are presented using structured induced categories, providing discussions and conclusions for every mentioned open issue. The last chapter states a small summary about the core findings of the study and gives some ideas for potential future work on the open issues.

CHAPTER 2

Concept and Definitions

This chapter explains the scientific undertaking and basic definitions of the thesis. The objective is to obtain basic knowledge on the topic of autonomous driving in general and to get familiar with important definitions before continuing with further chapters.
First of all, the research question and its two subquestions are stated. The overall goal of the thesis is to provide comprehensive to these questions. Afterwards, the most important term definitions will be given. This enables the reader to be able to fully understand the explanations and findings in the following chapters.
In the following two sections the importance of scientific work on the user's perspective as well as significant characteristics of rural areas are elaborated, in order to get an idea of the relevance of this thesis' work.
As the last part of this chapter, scales which allow a classification of car automation in well-defined levels will be explained. These scales are used to classify different advances in autonomous driving, based on their grade of automation.

2.1 Thesis Motivation and Research Goal

Following the need for research and understanding of users' desires and opinions in the field of self-driving cars, the primary goal of the thesis is to provide fundamental knowledge of user expectations and concerns on important aspects of autonomous driving. Using qualitative interviews, individuals will be asked for their opinions on how autonomous driving might influence their lives. The outcome will give an impression on what people are concerned about regarding this new technology, how they would want legal and privacy issues to be regulated and where they see potential problems. These problems might have a technical, personal, legal or ethical character. The findings of the thesis can be used to describe possible scenarios how driver-less cars may be introduced into society in a beneficial manner. By providing insights in the topics that people are concerned of, the results may be used to detect potential problems and misconceptions that will have to be issued before a potential integration. This way, the

thesis significantly contributes to ongoing research on autonomous driving, in particular from the user's perspective in rural areas.

2.2 Research Question

In order to define the scope of the thesis, one major research questions along with two sub questions were defined. These questions formulate the open issues of autonomous driving, that will be targeted with this thesis' work. Examining and elaborating comprehensive answers to these questions is the first of the thesis' two research goals. The main question is, what are the opportunities, challenges and risks of self-driving cars in rural areas from a user's perspective? This question can be defined more precisely by formulating two sub-questions. First of all, the outcome should answer which believes, fantasies and desires do people from rural areas have on how driver-less cars can influence their lives and society? And furthermore the result will give information on what requirements arise for stakeholders such as car manufacturers, government and infrastructure planners in order to introduce this new kind of technology in a beneficial way.

2.3 Basic Definitions

To establish a general understanding on the used terms and expressions, we want to state the most important definitions and determine their meaning in the context of this thesis.

Car and Vehicle The first basic terms we want to have a look at are "car" and "vehicle". As defined by the Oxford Dictionary, a vehicle is *"A thing used for transporting people or goods, especially on land, such as a car, lorry, or cart."* (Oxford-Dictionary, 2017) A vehicle can therefore be understood as a more general term than a car, which is defined as *"A road vehicle, typically with four wheels, powered by an internal combustion engine and able to carry a small number of people."* (Oxford-Dictionary, 2017).
In this thesis, all terms such as car, vehicle or automobile will refer to the same means of transport. There is no intended meaning concerning the degree of automation or anything else in the used term. If not stated differently, these three terms all refer to the same object, described as "car" in the former definition of the Oxford Dictionary. Additional attributes or characteristics such as "manual" or "conventional" are added to differentiate them from autonomous cars.

The Driving Task The "Driving Task" involves all necessary actions that have to be done in order to maneuver a car safely from point A to B in a given infrastructure and environment. This includes steering, accelerating and breaking as a matter of controls, as well as tasks such as using turn signals and the honk. Furthermore, the driving task includes the observation and appropriate reaction to all possible types of traffic situations such as overtaking, intersections, traffic jams, lane changes and so on (SAE International, 2016, p. 5).

Automated Car and Autonomous Car As defined in the "Car and Vehicle" definition, if not stated differently, the term "car" does not give any indication about the automation level whatsoever. An "Automated Car" in contrast, is a car that offers a specific level of automated assistance, but is not considered to be able to perform the driving task independently at all times. Examples are cars with lane-keeping, breaking or distance control assistance systems. Considering the NHTSA Automation levels (section 2.4.1), automated cars are ranged form level 1 to 3, whereas the simple term "car" might refer to the full range from 0 to 4 (NHTSA, 2013).
In contrast to automated cars, "Autonomous Cars" are cars which are able to perform the driving task completely autonomous without any human interference, thus referring to level 4 on the NHTSA scale (NHTSA, 2013). In this thesis they might also be referred to as "automatic car", "self-driving car" or "driver-less car" without any change in meaning.

User and User's Perspective We want to define what a user is in the context of this thesis. Since autonomous cars do not yet exist, the term "users" actually refers to potential future users. Because we can not know now which of today's people will use self-driving cars in the future, the term "users" basically refers to all people in the current society that are potential drivers, not only actual users of autonomous cars.
The user's perspective on autonomous driving is the point of view of conventional users on the topic of driver-less cars without any specific relation to the topic. This perspective includes the user's fears, hopes, concerns, wishes and ideas on the impacts of self-driving cars on their lives and on society. Since this viewpoint is made from a non-expert person, potential fundamental technical problems, legal contradictions or business relevant aspects might be ignored and left out, since these issues are not directly visible or perceived by the user. Although the thesis will provide comprehensive explanations on different topics of autonomous cars from various points of view and maybe also complementing missing aspects, the main focus will lie on the user's perspective.

Public Transport Public transport service can be defined as *"A form of travel provided by high-occupancy vehicles (for example, bus, train or ferry) along set paths of travel and at scheduled intervals during a day"* (The State of Queensland, 2015, p. 6). In this definition, taxi, car pooling and other similar services are excluded from public transport, since private people are involved. In the context of this thesis, public transport means all passenger transport that is not performed by their own private car, referring to the willingness of disclaiming the usage of a private car. Therefore, taxis, car-sharing and similar services are included in the term of public transport.

Something Everywhere and Everything Somewhere "Something Everywhere" stands for a strategy for integrating autonomous cars into the existing traffic infrastructure. It means that there will be automated cars with step-wise increasing automation technology, which are allowed to drive everywhere where conventional cars are also allowed to drive. Sooner or later it is expected that these automated cars will reach a level of full automation and therefore autonomous cars will be able to drive everywhere. This strategy is usually embraced by car

manufacturers as it can be easily expressed by the automation levels (section 2.4.1) and is less disruptive due to its step-by-step strategy towards full car automation. Examples are all kinds of assistance systems like speed control, lane keeping assistance and so on which eventually may lead to autonomous cars (NHTSA, 2013, pp. 4-5; ITF, 2015, pp. 13-18).
In contrast to the "Something Everywhere" approach, there is the "Everything Somewhere" strategy. Following this idea, completely autonomous cars, which are able to perform the driving task without human interference at least in a given environment, will be introduced only in special areas, possibly separated from conventional traffic. This could be for example highway platooning, autonomous shuttle buses or other self-driving transport in limited areas such as shopping malls, university campus, business district, farms or airports. Also semi-open areas like first-mile or last-mile shuttle transfer, for instance from the office to the next train-station and then from the closest train-station to home, might be considered. Over time, these areas are expected to expand, until eventually autonomous cars will be allowed to drive everywhere where conventional cars do (ITF, 2015, pp. 13-18).
It is important to mention that neither the "Everything Somewhere" nor the "Something Everywhere" approach define whether conventional cars will eventually be fully replaced by autonomous ones, or whether they will remain co-existing, sharing the same traffic infrastructure.

Regulators, Manufacturers and Stakeholders As stated in (Durham et al., 2014, p. 12) the term stakeholder covers *"anyone, or any group, directly or indirectly affected by a project, as well as those who may have interests in a project and/or the ability to influence its outcome, either positively or negatively."* This definition also includes customers and users. Due to their significant importance in this thesis, customers and users are excluded from this definition, if not stated differently. Important examples of stakeholders are regulators and manufacturers. In this thesis, regulators refer to all decision making instances concerning legal regulations. By now, these are generally public governmental and law making institutions. Later in this thesis, when it comes to the evaluation on user's opinion on moral questions, independent third party institutions will be mentioned. These will also be covered by regulators. The basic idea is that regulators are institutions which are, or will be responsible for laws, regulations and decisions that regulate the introduction and usage of autonomous cars.
Manufacturers, in the context of this thesis, are companies that develop self-driving cars. It is implicitly assumed that only self-driving car developing companies are targeted by this expression, leaving out manufacturers of conventional cars. Since the autonomous driving industry defers from the conventional one, we have to make a further definition for companies, which do not manufacture the mechanical car on their own, but only equip it with their own developed self-driving technology like for instance Uber does (Murphy, 2017). Since this difference usually does not affect any consideration of this thesis, if not stated differently, for simplicity reasons, companies that only equip cars with autonomous technology also belong to the term of manufacturers.

2.4 Classification Scales for Self-Driving Cars

In order to be able to classify and compare the advances of car automation, different levels and scaling models were elaborated. These scales allow to distinguish among cars with different kinds of technical driving assistance systems implemented or even self-driving capabilities. This is important for regulators in order to be able to formulate laws and regulations that have to consider the specific automation level of a car. An actual case happened in San Francisco in December 2016, when Uber started tests with their autonomous taxi fleet. To be allowed to perform tests or public use with self-driving cars in California, one has to apply for a permission of California's department of motor vehicles (DMV) (Department of Motor Vehicle DMV, 2017). Since Uber declared their technology as "Advanced Driver Assist System" (ADAS), which does not fall under the DMV regulations for fully autonomous cars, they did not apply for the according permission. After DMV investigated the performed tests, they indeed found the cars to be autonomous and banned all Uber taxis from the road (Geuss, 2016). In March 2017 Uber successfully applied for the necessary permission and finally managed their autonomous cars to be allowed to drive on the roads of San Francisco (Associated Press, 2017). This case shows how important uniform declarations and definitions considering the grade of automation of automated and self-driving cars are. It is crucial to internationally agree on a common and well defined terminology. We want to have a look at some widely accepted work that was already done in this field.

2.4.1 NHTSA Automated Vehicle Policy

The National Highway Traffic Safety Administration (NHTSA) is responsible for *"developing, setting, and enforcing Federal motor vehicle safety standards (FMVSSs) and regulations for motor vehicles and motor vehicle equipment"* (NHTSA, 2013, p. 2) in the US. Their main purpose is to reduce vehicle crashes and their consequences. For this reason, they are also considering autonomous driving as a chance to achieve this goal and therefore are increasing their research in this field.
In 2013, NHTSA was one of the first organizations that introduced well defined levels of car automation, which allow to categorize and describe the grade of automation of a vehicle. According to NHTSA, *"Automated vehicles are those in which at least some aspects of a safety-critical control function (e.g., steering, throttle, or braking) occur without direct driver input"* (NHTSA, 2013, p. 3). This means, that the system has to actively take control of the car to some extend. Simple warning lights and other safety signals are not considered automated, even if they use technology like sensors, cameras and GPS which might also be part of automated vehicles. The definitions of NHTSA try to cover the full range of possible car automation starting from level 0, which stands for no automation at all, until level 4, which represents the category of fully automated, thus autonomous cars.

Definitions (NHTSA, 2013, pp. 4–5)

- ***Level 0 - No Automation:*** Cars in this category do not provide any automation at all. The driver has to perform all necessary control actions such as brake, steer, throttle, motive

power and signaling at all time and alone. Support systems, which do not actively take control such as collision warning, blind spot warning or lane departure warning, may be implemented in this category, since this is not considered as automation.

- ***Level 1 - Function-specific Automation:*** There are some functional tasks, which are performed automatically, but they are implemented independently from each other. The driver is solely responsible to take care of the overall control, although they might decide to give limited authority to independent systems. This can be done directly, with cruise control, or indirectly, having the system to take limited authority on its own as in electronic stability control. Furthermore, the system can also add additional control such as dynamic brake support in emergencies. The main characteristic of this category is that the system may assist in different driving tasks, but the functions are implemented independently and therefore do not disengage the driver from their physical operation tasks in any way. It is not possible for the driver to take off the hands from the steering wheel and the feet from the pedals at the same time, since the implemented systems are not working together.

- ***Level 2 - Combined Function Automation:*** In contrast to level 1, at this level at least two primary function systems work together as a union in order to relieve the driver of control of this tasks. Any safety operations as well as monitoring the traffic still needs to be done by the driver. Furthermore, they are expected to be available to take over control at any time in case of an urgency. A possible example of level 2 technology might be adaptive cruise control in combination with lane centering. At this level, the driver can take the hands off the steering wheel and the feet from the pedals at the same time, disengaging them from the operational control.

- ***Level 3 - Limited Self-Driving Automation:*** At this automation level, the driver might hand over full control to the driving system including all safety-critical tasks. However, this might only be done under certain traffic situation and given environment conditions. In case of leaving these safe conditions, for example due to the occurrence of a construction area on the road or some other event, the driver is expected to be available to take over control as in level 2, although with a more comfortable transition time. The main advance to level 2 is that the driver is not expected to monitor the driving constantly, only on occasional events, given a more relaxed transition time for taking over control.

- ***Level 4 - Full Self-Driving Automation:*** At this level, the car is able to perform all safety-critical driving operation in all situations completely on its own without any need for the driver's availability. Therefore, it is not necessary for a human driver to be seated in the car while driving.

Adoption of SAE Levels

The NHTSA scale provided a basic categorization model to be able to classify car automation technologies. Parallel to the NHTSA there is the SAE International, former initialized as Society

of Automobile Engineers in the US. The organization developed a different scale which was adopted by the NHTSA in September 2016 making it the new world standard for vehicle automation clarification (SAE International, 2016a). The main reason for the adoption was standardization of different scales. Major differences are an additional level, making them six in total and a "cut" between the first and the second three levels for indicating that the car performs the whole DDT (NHTSA, 2016, pp. 9-10). However, older work on autonomous cars, before September 2016 refers to the original NHTSA levels.

2.4.2 SAE International Driving Automation Taxonomy

SAE International is a U.S.-based professional organization which was originally founded in 1905. When industrialization of automobile started in the United States, manufacturers joined trade groups to handle the need for patent protection, common technical design problems and the development of engineering standards. As a result of this movement, the Society of Automobile Engineers was born in New York (SAE International, 2016).
Nowadays, the organization operates under the name *SAE International* and works worldwide with more than 128.000 engineers in different fields of aerospace and automotive. In January 2014, SAE International published a new common taxonomy and definitions paper for automated driving in their *J 3016 201401* standard (SAE International, 2014). The standard describes six levels of automation from "No Automation" until "Full Automation". For each level, base definitions and functional aspects of the used technology were defined. One goal of the new standard was the categorical distinction of levels which are consistent with current industry practice and therefore eliminate confusion across numerous disciplines such as engineering, legal, media and public discourse. Later in September 2016, the new version of the standard, which was adopted by the NHTSA (SAE International, 2016a), was published. The new standard preserves the original level names, numbers and functional distinctions but includes a number of changes (SAE International, 2016, p. 2):

- Clarification and rationalization of taxonomic differentiators for level 0-2
- Clarification of scope of J3016 driving automation taxonomy
- Modification of existing and addition of new definitions
- Addition of examples

In the following section we want to have a look at some basic definitions of the new *SAE J 3016 201609* standard including its automation level description.

Scope

The standard provides a *"taxonomy for motor vehicle driving automation systems that perform part or all of the dynamic driving task (DDT) on a sustained basis and that range in level from no driving automation (level 0) to full driving automation (level 5)."* (SAE International, 2016,

p. 2) These six levels are described in detail in context of motor vehicles on the roadway. Using these definitions, the standard aims to provide a set of taxonomic terms, that can be used to describe the full range of driving automation features. The levels apply to the driving automation features which are engaged in the vehicle. Depending on the technologies, a vehicle may belong to more than one level, but it is at any time assignable to exactly one designated level, depending on which features are engaged. The document describes three main actors in automated driving: the human driver, the driving automation system and other vehicle systems and components. Excluded from the scope of driving automation are active safety systems like electronic stability control, automated emergency breaking or lane assistance systems. These technologies do not perform any part of the dynamic driving task and provide only momentary intervention, which does not influence the driver's role in performing the dynamic driving task. However, these technologies can be integrated in an automated vehicle to support autonomous driving (SAE International, 2016, p. 2).

Automation Levels

A summary of the different levels can be found in table 2.1. The levels are descriptive rather than normative and are formulated concerning technical aspects rather than legal. The step-wise definition does not imply any order of market introduction and indicates minimum rather than maximum system capabilities (SAE International, 2016, p. 17).

Human Driver Roles

After having defined the different levels of automation, we want to examine which different roles the user inherits while driving a vehicle of a certain automation level. Essentially, the six levels can be separated in two halves. On the first three levels, the user has the role of the driver at all time among some other roles. At level four, five and six, the system is mainly performing the DDT inheriting the driver role (SAE International, 2016, pp.19-21).

Taxonomy (SAE International, 2016, p. 16)

The standard includes a collection of various taxonomic terms and definitions in the context of the SAE definitions. We want to have a look at a few important ones in order to understand the level description of table 2.1 (see p. 15).

- **Dynamic driving task (DDT)** describes all operations like steering, braking, accelerating and monitoring the vehicle and roadway, that are necessary to maneuver a car safely. Furthermore, tasks like responding to events, changing lanes, using signals and so on are also part of the dynamic driving task. Aspects such as determining the destination and way points are strategic tasks and are excluded from the dynamic driving task.
- **Automated Driving System (ADS)** refers to the combination of all the driver assistance and automation technologies implemented in the vehicle that are able to perform the entire DDT. It specifically refers to describe level 3, 4 and 5 driving automation system.

Table 2.1: Summary of SAE levels of driving automation (SAE International, 2016, p. 17)

Level	Name	Narrative definition	DDT		DDT fallback	ODD
			Susteined lateral and longitudinal vehicle motion control	**OEDR**		
Driver performance part or all of the DDT						
0	**No Driving Automation**	The performance of the entire DDT by the driver, even when enhanced by active safety systems.	Driver	Driver	Driver	n/a
1	**Driver Assistance**	The sustained and ODD-specific execution by a driving automation system of either the lateral or the longitudinal vehicle motion control subtask of the DDT (but not both simultaneously) with the expectation that the driver performs the remainder of the DDT.	Driver and System	Driver	Driver	Limited
2	**Partial Driving Automation**	The sustained and ODD-specific execution by a driving automation system of both the lateral and longitudinal vehicle motion control subtasks of the DDT with the expectation that the driver completes the OEDR subtask and supervises the driving automation system.	**System**	Driver	Driver	Limited
ADS ("System") performs the entire DDT (while engaged)						
3	**Conditional Driving Automation**	The sustained and ODD-specific performance by an ADS of the entire DDT with the expectation that the DDT fallback-ready user is receptive to ADS-issued requests to intervene, as well as to DDT performance-relevant system failures in other vehicle systems, and will respond appropriately.	System	**System**	Fallback-ready user (becomes the driver during fallback)	Limited
4	**High Driving Automation**	The sustained and ODD-specific performance by an ADS of the entire DDT and DDT fallback without any expectation that a user will respond to a request to intervene.	System	System	**System**	Limited
5	**Full Driving Automation**	The sustained and unconditional (i.e., not ODD-specific) performance by an ADS of the entire DDT and DDT fallback without any expectation that a user will respond to a request to intervene.	System	System	System	**Unlimited**

- **Operational Design Domain (ODD)** is the sum of specific conditions for which the system is designed to function. This may include geographic, roadway, environmental, traffic, speed and/or temporal limitations.
- **Driving Automation System** refers to technology, hardware and software which is able to perform a part of the DDT.
- **Driving mode** refers to a specific driving scenario with a characteristic dynamic driving task like driving on a highway, stop-and-go traffic in a city and so on.
- **DDT Fallback** describes the response by the driver or system in order to handle unforeseen situations due to leaving the ODD.
- **Request to intervene** describes notifications by the system to prompt the driver to perform the DDT fallback.

2.5 Importance of User's Perspective

When it comes to autonomous driving, technologists get easily excited of this new technology and sometimes forget to think about actual impacts on the users. This upcoming revolution in mobility will not only influence its actual users but all participants of traffic and will have a significant impact on society in general. However, research on social aspects of autonomous driving is still way beyond technological related work (HYVE Science Labs, 2015, p. 5) although understanding the user's perspective can be crucial for its success (Fraedrich and Lenz, 2014, p. 3).

2.5.1 Identify Actual User Needs

There is various scientific work promoting that the introduction of self-driving cars will lead to increased traffic safety. There are various statistics on traffic analysis which show that more than 90% of accidents are caused by human failure (Waymo, 2016; Kirkpatrick, 2015, pp. 19-20; Adam D. Thierer, 2014, pp. 13-15; Kyriakidis, Happee, and De Winter, 2015, pp. 127-128). The question is, although it seems to be a common prognosis that safety will be improved by banning human drivers from the street, whether this makes it an actual user need. Do people really feel unsafe in current traffic and therefore prefer to be driven by an automated machine? Or would they rather prefer other approaches to increase their safety?
Especially in rural areas without public transport, elderly people easily get isolated from social life due to a lack of mobility (Schwanen et al., 2015). This also applies for handicapped people which have a hard time trying to get around individually without someone else's help. In (Beitz, 2016), an approach is shown how autonomous cars can be used for sustainable mobility especially in rural areas with a lack of public transport providing mobility on-demand. These are theoretical approaches on how this technology could improve the mobility situation of these people. But is it really there preferred solution? Or would they appreciate it if the resources were spent on other solutions such as the general improvement of public transport or other services? This is not a question whether people accept autonomous cars but rather if

they really want or need it.
So the actual task is not to justify technological advances by mapping them on existing or potential user needs, but to actually identify user needs in the first place and find appropriate solutions. This task requires comprehensive user oriented studies and this thesis' work intents to contribute to this still rarely explored field (Fraedrich and Lenz, 2014, p. 3).

2.5.2 Minimize False Predictions

If people's intentions and needs are not taken into account and considered as essential prerequisites for a beneficial introduction of autonomous cars, the risk of potential false prediction increases. One of the main arguments in favor of autonomous driving is the reduction of gasoline consumption due to intelligent route planing, economical driving and less cars (Adam D. Thierer, 2014, p. 20). This is predicted to result in a significant reduction of CO2 pollution and will therefore maintain a more economically friendly, less energy consuming traffic. As already mentioned, another advantage of self-driving cars might be the possibility of elderly people to retrieve mobility again in case they are not capable of driving conventional cars anymore. As a third consideration, there is the potential benefit of being able to send the autonomous car back home from work on its own. This could be beneficial if no parking lot can be found or if the car is needed by another family member.
All those mentioned advantages make perfectly sense when considered individually, but the latter two, among some others, have the potential to significantly increase overall traffic on the roads and therefore may result in an increased gasoline consumption, which conflicts with the claim of gasoline reduction in the first place. Without knowing how people actually plan to use their future cars and how regulators should manage autonomous car usage, the risk for potential considerable mis-predictions increases.
An interesting example for mis-prediction in the past is the one of the influence of personal computers on society. After the personal computer got popular in the broad majority of society and found its way into many jobs, overhasty predictions were made. Experts predicted that the resulting possibility to work from home on one's personal computer would significantly reduce traffic due to a decrease of travels to and from work. However, actual observations proved this forecast to be wrong. Although people often stayed at home for work instead of driving to the office, they had to leave their houses to do shopping, visit the doctor or meet with friends anyway. Before, they usually did these tasks on their daily commutes when they were already driving the car anyway. Given the opportunity to work at home, they had to do these trips additional, resulting in no reduction of traffic whatsoever. Such predictions can have a big impact on society. Although self-driving cars may improve rural areas where there is a lack of mobility (Beitz, 2016) it is believed to be introduced more likely in urban structures and on highways first (Kyriakidis, Happee, and De Winter, 2015, p. 127). But in urban areas there are already existing mobility services like taxis that may significantly be affected by this change. Truckers, taxi and bus driver might be endangered to lose their jobs (Adam D. Thierer, 2014, p. 22). The latest extensions of Uber in various cities lead to numerous protests of taxi drivers fearing for their jobs (CBC News, 2016). On the other hand, in (Litman, 2014, p. 16) an analogy with predictions on mobile banking is presented. It is stated that since the introduction of personal computers and the Internet from the 1980's on bank companies try to substitute local

offices by automated teller machines (ATM) and online-banking. However, although banking management changed due to increased digitalization, local offices are still in place because of user's preferences to consult personal assistance for important financial issues.
These considerations show that it is very hard to predict how new technologies will influence society, especially when little research on the user's perspective is done. The lack of knowledge about possible user behavior can lead to false predictions and mis-planning, which can be avoided through better research in advance.

2.5.3 Support Decision Making

Given the stated potential problems resulting from a lack of research on the user's perspective, this thesis' work can be used to facilitate stakeholders to be able to make more sophisticated predictions on future user behavior. This can help to find out what changes in mobility are beneficial and desirable for people, how these changes in mobility may affect them and how the necessary regulations can be done in the most supportive way.
Even if the cars are equipped with the necessary technology to provide real benefits for people's needs and they have the trust and confidence to use it accordingly, there is still the need for legal changes by the regulators (ITF, 2015, pp. 25–28) in order to cash in the mentioned benefits. This includes various aspects on insurances, decision algorithms for lose-lose situations or data usage. All those fields demand sophisticated user research in order to acquire profound knowledge which can be used by according stakeholders as assistance for their future decision making processes.

2.6 Characteristic of Rural Areas

A lot of research in autonomous driving focuses on aspects in big cities. Automated bus lanes, car sharing services and self driving public transport in general are some examples (Almeida and Arem, 2016; ITF, 2015, p. 26; Adam D. Thierer, 2014, p. 22). This is reasonable, since population density in cities is much higher than in rural areas and therefore possible improvement can potentially affect a bigger part of the society at once. Hence, technological approaches concerning the traffic infrastructure of society, like subway, trams, car pooling and Uber taxis, were often introduced only in cities or at least started in cities. Furthermore, the population in cities is usually younger (Pateman, 2011, p. 1) and therefore might be more technology affine and open for this new kind of technological changes.
However, autonomous cars might also bring changes in rural areas and might have the potential to revolutionize the future of mobility. But in order to be able to introduce this new kind of technology in these specific areas, the needs and concerns of the population in the countryside have to be examined. One has to be aware of the specific characteristics of in order to be able to understand the current situation and develop appropriate solutions.

2.6.1 Car Sharing & Public Transport

The above mentioned concept of car sharing is a well known and widespread service in most European cities (Loose, 2009). But the concept of car sharing, as it does for example car2go, relies on a significant density of population, since a parked car is expected to be picked up by someone else over time. This would not work in rural areas, since many destinations might be just too far away from each other. Self-driving cars are able to provide a solution for this problem, since they will be able to drive to wherever they are needed, even without a driver.
Another big issue in rural areas is the lack of public transport. Many people living in rural have to commute to get to their work (Brain, 2016; Copus and Hörnström, 2011, p. 22). They often spent hours in the car, driving on the highway or waiting stuck in a traffic jam. Without public transport, this time usually can not be used for meaningful purposes, since the driver has to observe the traffic.

2.6.2 Social Exclusion

The lack of public transport does not only bring less comfort on the way to work, but, causes a considerable dependence on private cars. This states a problem for people, which do not have a car or driving license, making public transport often almost the only way to leave home. For instance, elderly persons which are not physically able to drive a car anymore, often feel excluded from any social life due to a lack of mobility (Schwanen et al., 2015). But any other person can get into the same situation as well. This could happen if, for instance, an accident causes severe physical injuries which makes it impossible for the person to drive a car on their own or if they loose their driving license for some reason. In many cases, this can result in a 100% dependence from other persons or the availability of public transport regarding personal mobility.

2.6.3 Unstructured Environment

Another characteristic of rural areas is their often very unstructured environment including poorly constructed and narrow roads, dangerous curves, few traffic signals and lane marks as well as longer time needed to remove snow and other disturbances from the lane (Sheng-xue, 2011, pp. 1-3).
Rural areas might be a challenge for driver-less cars to be capable of detecting unstructured roads and unforeseeable interferences (Zhou and Iagnemma, 2010, p. 1). Even for human drivers, the missing lane marks on the side of the road or the lack of any guidance at all makes it sometimes difficult to distinguish the road from its verge. Especially during winter or after stormy weather, this can lead to very difficult driving scenarios on rural roads. When it comes to self-driving cars, this results in a need for sophisticated sensor and camera technology (Chu et al., 2015), which is capable of handling this extreme situations. Furthermore, special artificial intelligence software, using probabilistic models has to be developed in order to be able to navigate through this kind of unstructured terrain Chen et al., 2014; Zhou and Iagnemma, 2010.

CHAPTER 3

Historical Work and Modern Advances

This chapter gives interesting insights in historical work on automated cars containing visions and expectations on how people believed mobility to develop as well as actual modern advances and ongoings in the field of self-driving cars. First of all, important and interesting inspirational work from the past will be presented, stating how researchers and visionaries imagined the future of human mobility. This gives an idea about very forward looking ideas and expectations as well as the way of thinking of technological pioneers in the past. After every section a short discussion on the presented visions, their intended meanings and a link to the current situation will be provided.
Following this historical introduction with visions and expectations that partly came true, we want to have a look at the actual modern advances and ongoings. We will present three companies, which are rather new in the car manufacturing business, but were able to establish themselves in the field of leading autonomous car innovators.

3.1 Historical Visions and Expectations

We want to have a look at some interesting visions on autonomous mobility, which were presented many years before their actual technological feasibility. On the one hand, these visions present how people imagined future car mobility to be, but on the other hand, they also show, how these visionaries wanted it to be. Nevertheless, this historical work may still fascinate people and give inspiration for possible further developments in the future.

3.1.1 Leonardo Da Vinci's Automated Car

First ideas of autonomously moving vehicles already existed hundreds of years before actual cars were invented. Leonardo Da Vinci (15 April 1452 – 2 May 1519), the famous Italian artist, mechanic, mathematician, geologist, astronomer writer and scientist made concrete drawings of an automatically driving car, powered by two symmetric springs. The car's destination

could be "programmed" in the vehicle, using wooden blocks that are arranged between gears at pre-set locations. It even had some kind of mechanism comparable to today's car's differential mechanics, allowing the vehicle to turn, but only right direction (Fuller, 2008). One might simply call these historical plans just some past woolgathering without any prove of functionality whatsoever. But in 2004 the "Institute and Museum of the History of Science" in Florence successfully reconstructed Da Vinci's drafts proving its feasibility. Historians, experts in robotics and computer designers worked together in order to find out the intended meanings in the very detailed drawings of Da Vinci's automated car. A misunderstanding in the usage of the springs on the drawing led to the failure of former reconstruction attempts. The team finally succeeded in interpreting the historical plans in the right way, admitting that they are actually correct and that it was their own fault, that former reconstructions did not work. After solving this fundamental misunderstanding, they were able to reconstruct the car in the correct way and it was actually capable of driving its pre-determined route autonomously (Fuller, 2008).
The concept of the vehicle is similar to toy cars, which have to be wind up and afterwards are able to drive a couple of meters. The scientist think, that the vehicle might were panned to be used for some kind of spectacular surprise for the king, although they have no proofs for this guess (Schnabel, 2004). Nonetheless Leonardo Da Vinci's automated vehicle clearly marks one of the first and definitely very impressive milestone on the road to autonomous cars.

3.1.2 Magic Motorways

In 1939, General Motors was presenting a futuristic model of cities, industrial areas and countryside using completely autonomous car traffic systems at the New York World's fair exposition called "Highways & Horizons" (Geddes, 1939). It was considered as the most popular show of any Fair in history (Geddes, 1940, pp. 3). The traffic models at the exhibition was expected to become real in the year 1960. In the exhibition's journal it is stated, that *"The roads we travel today are the creation of little more than a score of years. In the same period motor vehicles increased in numbers and immeasurably in utility"* (Geddes, 1939, p. 1). The prediction was, that progress will continue in the coming 20 years, leading to the presented structures. However, it was claimed, that the project should not be a prediction of the future, but rather express the conviction, that forward-looking highway officials and experienced highway planning will influence traffic even more than in the past (Geddes, 1939, p. 2). Shortly after the exhibition and Norman Bel Geddes' Journal "Highways & Horizons", he wrote the book "Magic Motorways" (Geddes, 1940) published by New York Random House in 1940. It describes on 320 pages including numerous drawings and more than 150 photographs the current traffic situation of the United States, mentioning existing problems and giving solution approaches for the future. The author claimed, that the book was the first one, which was actually considering the emerging need for new solutions in Americas growing traffic systems (Geddes, 1940, abstract). But Norman Bel Geddes did not just analyze the current situation providing simple solutions. The book describes in 14 chapters very detailed futuristic approaches, how especially autonomous vehicles and completely new highway and road systems could solve future traffic problems. We want to have a look at five section of the book, which are related to todays considerations on mobility and autonomous driving. Afterwards a

discussion on the mentioned topics will be presented.

Mobilization of Rural Areas

As a starting point for the explanations in the exhibitions journal, the mobility situation of rural areas in the United States in the 1920 is described. Back then, isolated farms were poorly connected by bad roads resulting in costly, slow and difficult travel to remote civilizational facilities. Geddes explains, how road development changed the rural situation by removal of natural barriers and expansion of roads in the last three generations and still does. In many areas, roads that are capable of motor vehicles, were constructed before they even existed for horse drawn vehicles. This lead to significantly smaller travel times from former several days to only couples of hours and it was expected, that *"The future will see a still greater realization of this conquest of mankind over nature's distances."* (Geddes, 1939, p. 7).

Highway Traffic in Big Cities

As one of the main problems remaining in the vast ongoing progress of traffic infrastructure advances, the entering and leaving of big cities is mentioned. The main cause was identified as the fact, that cities had been planned before cars were invented and conquered the streets (Geddes, 1939, p. 8). Following their explanations, this resulted in a fundamental mismatch between existing traffic conditions in cities and the needed infrastructure for the new motor vehicles. This mismatch can only be overcome by *"creating new facilities which will diminish congestion until traffic, both vehicular and pedestrian, moves about with safety, convenience and comfort for all"* (Geddes, 1939, p. 11). Nothing else will contribute as much to the joy of a motorcar than the solution to this problem, so their explanations. In figure 3.1 (see p. 24) a conceptual design of city planning idea is presented.

Safety, Comfort, Speed and Economy

The work also considers what was believed that people desire concerning their mobility. *"From the beginning of time, whenever people tried to get from one place to another, they kept these same basic aims in mind. The first is their desire for self-preservation; the second is their desire for a pleasant trip; the third is their desire to reach their goal quickly; and fourth is their desire to spend as little money and effort on the way as possible"* (Geddes, 1940, p. 16). Following this statement, various factors in the former traffic situation that counteract these principles are explained. Cattle, sheep, buffaloes and other animals are mentioned as a fundamental problem while traversing Americas roads. The author is convinced, that vast advances in road capacity and travel time are a result of motorways and intelligent lane planing. But it is still not enough. *"Even cars driving in the same direction are required to keep in separate lanes, so that there is no weaving in and out and no sideswiping. Cars are not allowed to stop. All cars must drive at a constant, uniform speed."* (Geddes, 1940, p. 38) Improvements in safety were identified as well, giving predictions on the reduction of accident fatalities from annual 32.000 to less than 6.000 due to intelligent traffic regulation (Geddes, 1940, p. 38). The books final statement on this chapter implies, that *"just as the horse and buggy were replaced by the*

Figure 3.1: (1939) "General Motors - Highways & Horizons" conceptual design of highways in big cities (Geddes, 1940, p. 7)

motor car, so must the highway be replaced by the motorway." (Geddes, 1940, p. 41) Considering the vocabulary and its intended meaning, a "highway" refers to a normal main road mostly between two cities, whereas a "motorway" states a main road for fast-moving traffic, limited access and further, former mentioned regulations facilitating the increased traffic flow and safety (Oxford-Dictionary, 2017; Geddes, 1940, pp. 1-41).

Eliminate the Human Factor in Driving

From the very first beginning of motor vehicles in the 1920's until 1940, numerous technical progresses lead to increased comfort and more safety while traveling by car. These progresses include automatic start buttons, high-power electric headlights, automatic windshield wipers, automatic brake lights and a protective steel coach. But has the human driver improved to the same extend in this timespan? *"Not by any means"*, so the conclusion of Norman Bel Geddes in his book (Geddes, 1940, pp. 45-46) . Traffic volume multiplied a hundredfold and various new road situations might occur to the human driver each of which he has to be capable of reacting and corresponding the right way. *"His car has been entirely remodeled. His highway is being remodeled. How can the driver be remodeled?"* (Geddes, 1940, p. 47) is the resulting question. According to "Magic Motorways", the human driver is needed to evolve as well as technology does to be able to react faster, see clearer and think quicker in order to perform the driving task with advancing technologies. *"Human nature itself, unaided, does not make for efficient driving"* (Geddes, 1940, p. 48) so the conclusion. The mistake of only one driver might cause an accident, including several other innocent cars as well. But what would be the solutions to this increasing discrepancy between technological advances and the halt of human capacity improvement leading to more difficult to handle and therefore dangerous situations? Governments tried to keep the driver function like a machine, commanding him with various different signs, speed limits and rules in order to make him drive with robot like precision but despite all those rules, nine out of ten accidents were still caused by human failure. The chapters conclusion says, that it seemed as that the current strategy, increasing safety by restricting the driver, does not succeed, at least not sufficiently. The better way is to automatically remove risks in the driving tasks by automating the car itself (Geddes, 1940, pp. 52-57).

Proposed Solutions

As a result of the explained problems in the current mobility situation, Norman Bel Geddes explains in detail various different possibilities to overcome the mentioned problems and safety issues by increased traffic regulations.

Separated Lanes of Traffic The idea behind this concept is to stop exposing cars to each other that are traveling in different directions as well as to any other object that would cause them to brake or even hold. According to the author, there are four main attributes, that produce accidents on highways (Geddes, 1940, pp. 63-64):

- The crossroad. When two roads cross each other, causing the need for regulation creating various risks for passing drivers.
- The road edge. Objects, that are next to the roads like fences, hydrants, telephone poles and so on.
- Cars moving in opposite direction.

- Cars moving in same direction but different speeds.

All this factors are potential sources for accidents and therefore should be eliminated from the road system by introducing separate lanes for each direction and bound travel speed accomplished by obligatory automated car control devices. This will not only result in increased safety but also higher traffic flow due to loss of traffic friction at the mentioned points. Well elaborated route planing will facilitate changes from low speed to high speed lanes or changes of direction (Geddes, 1940, p. 64).

Every Highway Crossing is Obsolete For even better traffic flow, the first risk attribute mentioned before, crossroads, should be banned completely from highways. For this purpose, detailed drawings of lane alignment were presented which look a lot like typical intersections as they appear on today's highways but were said to bring even better improvement (Geddes, 1940, pp. 85-103).

Full Speed trough Bottlenecks Like for road-crossings, also other bottlenecks like bridges and tunnels will be drivable with full speed due to intelligent lane alignment (Geddes, 1940, pp. 107-121).

Discussion

The book of Norman Bel Geddes was the following work to his paper "Highways & Horizons" about the General Motor's world fair. It can therefore not be neglected, that his work may be influenced by the car manufacturer. The baseline of most of the explanations is, that automating the human driving task will result in both better driving performance and safety and will therefore be an essential key factor for the success of future traffic. The author did sophisticated research on the problems of traffic, but his implications and conclusions are sometimes very technology driven and lack of completeness. An example is, that he claims, that cities were constructed before cars and are therefore not perfectly serving for cars demands concerning infrastructure (Geddes, 1939, p. 8). This might be correct, but instead of criticizing the inherited structures of big cities, one might also conclude to question the use of cars in big cities and rather consider better fitting alternatives. Instead of having a neutral, distant viewpoint, Norman Bel Geddes seems to focus on how to establish the car as a solution for every mobility demand.
In his book, the author tries to undermine his explanations by stating user needs on current mobility. The examined needs and desires as safe, cheap, fast and pleasant trips might reflect the actual public opinion (Geddes, 1940, p. 16). However, his implicit assumption, that it has to be the automobile, to provide appropriate solutions in this context, shows again his rather car driven way of thinking instead of also taking other solutions into account.
Also his considerations on the missing human improvement compared to technology advances, leading to increasingly difficult traffic situation, is only party correct. One has to consider, that the purpose of many of technical advances, which are done in the automotive industry, is to

actually assist the driver, enabling them to handle more difficult situations and not to further challenge them.
As a conclusion it can be said, that Norman Bel Geddes clearly identified challenges and open problems concerning the mobility situation in former times. He also identified human issues which lead to ineffective or even unsafe vehicle usage on the road which still true. Although his provided ideas and explanations can still be used as valuable input for targeting some of today's traffic challenges, they are mainly too focused on the private automobile as the only concept of mobility. This leads to a rather one-sided viewpoint and prevents from finding solutions out of the private car context.

3.1.3 Driver-less Car of the Future

In 1957, when General Motors predictions on autonomous cars having conquered the roads were proven wrong, *"America's Independent Electric Light and Power Companies"* published a visionary article about driver-less cars. The base concept of the newspaper article is to emphasize the advantages that might come along with the expansion of electrical power supply.
Interestingly, among automatic lights and food cooked in seconds, they brought up the idea of autonomous driving, facilitated by electrical power. *"ELECTRICITY MAY BE THE DRIVER. One day your car may speed along an electric super-highway, its speed and steering automatically controlled by electronic devices embedded in the road. Highways will be made safe – by electricity! No traffic jam.. no collisions... no driver fatigue"* (Novak, 2010) This is the caption beyond the futuristic picture of a family, playing board games in their futuristic self-driving car shown in figure 3.2 (see p. 28)).

Discussion

As the report on the General Motor's world fair, this announcement is also highly connected to the business of General Motor's. However it shows, that the idea of electric cars, whether they are autonomous or not, already existed 60 years ago and even were considered by car manufacturers in combination with autonomous driving. Nevertheless, these technologies are still not fully developed nowadays.

3.1.4 Magic Highway U.S.A.

In 1958, about 20 years after the General Motor's exhibition, the Disneyland TV program showed a documentary called "Magic Highway, U.S.A." (Kimball, 1958). The movie shows traffic problems in that time that are still an issue like traffic jams, traffic regulation chaos and safety issues. After a short introduction, joking about pseudo solutions, they speaker claims, that *"perhaps these ideas are a little bit too eccentric to ever reach the final blueprint stage, however, there are highway experts. Men of vision who try to predict more seriously, what the highway of the future will be like"* (Kimball, 1958).
In the documentary, "speed", "safety" and "comfort" are identified as the *"keynotes of tomorrows highways"*. We want to have a look at some visions and approaches provided in the documentary, that are related to todays considerations on autonomous driving.

Figure 3.2: (1957) Futuristic Driver-less Car from *"America's Independent Electric Light and Power Companies"* (Novak, 2010)

Automating the Driving Task

The documentary shows different creative ideas and proposals how to achieve the mentioned keynotes in car driving. Windshields, which perform as radar screens, showing the surroundings in case of foggy weather are presented as well as and automatic *"electronic operating devices"*, that will be integrated in the car's dashboard panel including automated speed control and rear camera. These technologies surprisingly resemble today's car automation and the radar technology, used in autonomous vehicles. Cars will be driven automatically to the entered destination which can be specified by *"push buttons.* After having specified

the destination, electronic devices take over control and current travel progress and position can be watched on a *"synchronized scanning map"* which looks a lot like todays navigation systems. *"With no driving responsibilities, the family relaxes together"* the documentary continues, showing a video sequence of a family, sitting in a glass covered car, playing board games together. The seats can be rotated in order that the front row can turn around and everyone is sitting at the same table. Remote television communication for business purposes is also mentioned. After entering the city on the automatic highway, the car can be separated in two halves, enabling the father driving to his office, while the mother can go shopping with the kids. This, of course, states some old fashioned way of thinking concerning the roles of men and women in the 1950's society. However, the idea of module cars, that can separate and combine again might be a creative approach.

Infrastructure Considerations

Considering changes in traffic infrastructure, the documentary explains colored road lanes, which indicate the correct lane for the desired destination in order to ease navigation. It is also claimed, that the increased speed of future cars will demand for bigger and easier to read signs. Automatic traffic lights during the night and special road covering to overcome rain, ice and snow related problems are also a part of the futuristic concept. Emergency vehicles will be airborne and combine police, fire and ambulance services. Furthermore, streets will be build automatically in one sweep by huge machines and bridges will be placed prefabricated at the desired place. Cities will be decentralized into vast urban areas, connected by super speed highways which will facilitate longer distance commuter trips. Furthermore it is expressed how private homes will be *"closely integrated with the highway system"*, showing a private service garage included in the house. The office buildings will combine parking and elevator systems, connected with the traffic infrastructure and letting people drive with their cars directly into the office. The same applies for shopping centers and other public facilities.

Discussion

The movie shows in a very illustrative and understandable way how traffic related problems were expected to be solved in the 1950's. The presented concepts of navigation, radar detection and auto-pilot were already realized in today's cars and also other aspects of the documentary provide potential solutions to still existing issues. However, the documentary, as it was the case for the General Motor's project, is highly focusing on private cars as the solution of mobility. Furthermore, it can be clearly seen that some explanations are based on outdated societal standards which are not valid anymore. Traffic demands for families changed, since it is not only the father anymore, who works in an office and the mother who takes car of the household and the children. Nevertheless, some of their predictions came amazingly close to actual today's implementations.

3.2 Modern Advances

It seems that autonomous car development was taken out from the outmoded drawer of the science's desk and reanimated again. After various visions and prediction during almost seven decades, in the past five years numerous inventions and technical advances can be listed and progress does not seem to decelerate at all. The ongoing advances in industries like IT, Mechanical Engineering, Electrical Engineering and Electronics led to a number of various advances in the automotive area (Pettersson and Karlsson, 2015, p. 694; Levinson et al., 2011, pp. 1-2; Chen et al., 2014, pp. 17549-17550). Together they form important steps towards the development of a fully autonomous vehicle. Research and development in these fields are essential for the success driver-less cars. Among traditional car manufacturers like Mercedes, BMW, Audi, Ford and so on, especially in the self-driving car segment new companies, which were not significantly involved in traditional car manufacturing until now, successfully established. Interestingly, in contrast to traditional manufacturers, those companies already developed and brought fully autonomous cars on the road (Waymo, 2016; Tesla, 2016; Levandowski, 2016). Traditional car manufacturers seem to be more interested in an increasing level of automation until a fully automated car instead of disruptive changes that would force them to vastly restructure their business (ITF, 2015, p 16). However, a change can be observed and also traditional car manufacturers as BMW or Audi team up with sophisticated technology providers as Intel and Nvidia to push their self-driving car development (Mercer, 2017). Some of the new companies do not even have their own car production. They are just focusing on the development and integration of driver-less technology. We now want to examine three popular autonomous car developing companies, that entered the market in the past decade.

3.2.1 Google

In 2009 Google started to work on its autonomous driving project called "Google Car". The first goal was to drive ten uninterrupted 100-miles routes with its Toyota Prius, which was achieved a couple of month later. After three years of continuous progress, in 2012, they added the Lexus Rx450h to their fleet. Google invited its employees as early testers to use the new technology on their work and weekend trips accomplishing 300.000 miles of successful autonomous driving. Furthermore, the focus was shifted from driving long distance, open road trips to more complex environments as they occur in cities including pedestrians and cyclists. In 2014, the first all-autonomous car was developed by Google on its own. It is equipped with computer steering, braking and acceleration but no pedals and no steering wheel at all. With this new prototype, Google managed to firstly let cars drive autonomously on public roads in 2015. In December 2016 the autonomous car project under Google was moved to its own company under the "Alphabet Inc." called "Waymo" (Waymo, 2016).

3.2.2 Tesla

Tesla is an American car manufacturing company which was founded in 2003 with the goal to *"prove that electric cars could be better than gasoline-powered cars"* (Tesla, 2017). In the first years, Tesla mainly focused on upper class electrical limousines including highly automated

Figure 3.3: Newest generation of "Google Car" belonging now to "Waymo" company (Hard, 2016)

driving assistance systems. But with more sophisticated assistance technologies, Tesla also entered the autonomous driving sector. In October 2016, Tesla announced that *"as of today, all Tesla vehicles produced in our factory – including Model 3 – will have the hardware needed for full self-driving capability"* (Tesla, 2016). This was a remarkable announcement, since from now on some kind of price benchmark was set for autonomous vehicles. Furthermore, Elon Musk, CEO of Tesla Inc., claimed that an autonomous Tesla will be able to drive from Los Angeles to New York by the end of 2017 without any human interference needed. In order to be able to perform this technical masterpiece, a lot of collected driving data is necessary. In this field, Google's Waymo, with a 60 autonomous cars fleet and over two million miles driven autonomously is the clear market leader. However, Tesla gained experience using its assistance systems and autopilot technology. Elon Musk claims, that Tesla cars collected over 222 million miles of usable data in autopilot mode, which will be of advantage for the development of fully autonomous cars. Another advantage compared to Google could be the price of their car. Since Tesla uses eight cameras and a front radar instead of LIDAR laster system of Google, it can produce cars significantly cheaper while claiming to provide the same safety standards, although not every researcher supports statement (Stewart, 2016).

3.2.3 Uber

When Uber was founded in 2009, the basic idea was a transport network company developing an application, which allows consumers to request car transportation. In the following years, Uber extended its services by various new initiatives like UberX, letting people drive for Uber with their own car or UberEat which is used for food delivery (Business Insider, 2016).
In 2015, Uber CEO Travis Kalanick revealed his plans on Uber using self-driving car technology for the first time. The company established the "Uber's advanced Technologies Center" in Pittsburgh, starting development of autonomous cars mainly with researchers from the "Carnegie Mellon University's" robotics department. One and a half years later, in September 2016, the first self-driving Uber taxis were provided to selected customers in Pittsburgh (Levandowski, 2016).
Later in December 2016, Uber also started tests with self-driving cars in San Francisco. Claiming that they are not fully self-driving but only have "Advanced Driver Assist Systems" (ADAS). Since Uber claimed to not testing fully autonomous cars, they did not apply for the necessary permission and were later banned from the roads. Later Uber was again allowed to perform its tests after successfully applying for the necessary DMV permission (Associated Press, 2017).
Concerning its technology, Uber has a partnership with Daimler, the parent company of Mercedes-Benz in order to develop its self-driving cars in the coming years. Although Uber is developing its own self-driving car software and technology, it lacks in experience in making cars, resulting in a need for a partnership with an experienced car manufacturer (Murphy, 2017) which they found with the car manufacturer Volvo (Mercer, 2017).
According to the CEO, Uber will have an autonomous car fleet by 2030 and the service is supposed to be so inexpensive and available, that it will make private car ownership unnecessary (Driverless Future, 2016).

CHAPTER 4

State of The Art

This chapter provides an overview of existing research work on the topic of autonomous driving from a user's perspective, as well as mobility issues, especially in rural areas.

4.1 User Experience of Autonomous Driving

An interesting approach for exploring user experience was presented in (Pettersson and Karlsson, 2015) where the baseline was to interactively let users show what they want instead of asking them questionnaires. The reason for this approach was that according to (Visser et al., 2005) people's knowledge and experiences can be explored in more depth using practical techniques rather than questionnaires. Therefore the research team held two different workshops. The participants were not pre-selected in any specific manner and the experiment's procedure was creative, delivering rapid results. The participants only received a small introduction to the subject explaining that they would be confronted with autonomous cars of NHTSA 'level 3', capable of autonomous driving, but also capable of manual steering in special situations. In the first workshop, the participants of the study were shown the boundaries of a "car" drawn on the floor with movable chairs standing around to mimic the car seats. The participants were asked to place the chairs in the "car" to illustrate how they would like to travel in that autonomous car. As a result, they found that one of the main values perceived by the subjects was the possibility of increased interactions with other passengers while riding in the car. Daily travel, for instance, commuting to and from work, was generally expected to be smoother and therefore less stressful by the participants. In the second workshop, the persons were given drawn pieces of cars on paper and were asked to arrange them however they would want future cars to be designed. The outcome of the studies shows us which situations people think of when driving in an autonomous car and how this influences the design. They would arrange seats so they could see each other and be able to read, eat and relax together. They also prefer futuristic, rounded designs.

A completely different study was presented in (HYVE Science Labs, 2015) where the research group used social media mining techniques to obtain public opinions on autonomous driving. Altogether more than 100.000 posts were mined and analyzed to draw conclusions on wording, brands, sentiment, known concepts, and concerns. For instance, one of their findings was that Google was mentioned in the context of driver-less cars as often as all other brands combined. This shows that Google is somehow more established in people's minds on this subject than other companies. Also, the interesting question of what people would do with their new free-time was discussed. The results show that the majority would use the time for multimedia activities, as well as eating, drinking and sleeping. The potential increase in opportunities for blind and elderly people was also mentioned in the participant's answers.
An extensive questionnaire study with over 5000 participants was performed by (Kyriakidis, Happee, and De Winter, 2015). The goal was to determine *"user acceptance, concerns and willingness to buy partially, highly and fully automated vehicles"* (Kyriakidis, Happee, and De Winter, 2015, p. 127). The respondents from 109 countries were asked 63 questions in an internet-based survey. Using such a large pool of participants, they were able to gain new insight into how much the general public would be willing to pay for a self-driving car. One outcome, for example, was that men are willing to pay more than women. Furthermore, due to its level of international participation, the study allows for comparisons between different countries and age groups. For instance, according to this particular study, people from higher income countries are more concerned with the potential for data privacy issues arising from autonomous driving.
A way of defining quantitative measurements in regards to aspects of user experience is described in (Ive, Ju, and Kohler, 2014), which was developed during a workshop. As a result, the paper states the difficulty in this field to effectively quantify and measure user experience using quantitative measures. This leads to the assumption, that qualitative approaches might be better fitting int this context.
In order to better predict the effect of autonomous cars on the traffic in cities, (Almeida and Arem, 2016) elaborated a mathematical model which simulates this behavior. The basic assumption of the work was that an autonomous car fleet combined with existing public transportation would be capable of replacing the majority of conventional cars in a city. The model was constructed by defining different mathematical formulas to describe and predict the flow on roads in consideration to their capacities, as well as a number of other variables. For example, parking fees, number of cars per household, fuel prices, and number of parking lots. Using this definition, the authors aimed to formulate an *"open, multiple trip, capacitated VRP with time windows, pick-up and delivery of passengers and time-varying travel times"* (Almeida and Arem, 2016, p. 68). VRP stands for vehicle routing problem and the overall objective was to optimize the amount of privately owned cars in terms of costs as well as travel time. As a result, they found out that parking fees and the "value of travel time" (VTT) were the variables with the most impact. A lower VTT value means that people are enjoying more the travel time and therefore time constraints might be relaxed. This leads to smaller overall cost as people might consider longer commutes to work as a minor problem. The highest cost scenario during their simulations was achieved when they implemented parking fees throughout the entirety of the city. As a consequence, the authors suggest having different

parking fees in different areas in the city. In general, the work provides interesting insights into how different variables might influence traffic in cities and how they could be adapted to obtain a beneficial solution.

4.2 Safety & Ethical Aspects

The use of autonomous cars also has the potential for ethical repercussions within society. In (Adam D. Thierer, 2014) it is argued that while some jobs, for instance, taxi drivers, will disappear, people will find new ones. This also was the case during industrial revolution and with the initial fears of mathematicians after the introduction of computers. The work describes a comprehensive guideline mentioning different ramifications and concerns of autonomous driving and provides potential solutions for them. For example, considering missing regulations on liability, the work proposes a "permission-less innovation" as was the case with the introduction of the Internet. Research should be allowed to continue regardless of the potential for unforeseen problems. These problems can be solved later when they have proved to be relevant concerns. The author criticizes the so-called "precautionary principle" that requires innovators to proof their ideas to be entirely harmless, even before the innovation takes place. According to the author, this principle leads to living in constant fear of worst case scenarios that potentially never occur and therefore prevents the possibility of a best case scenario. Open ethical issues in the case of an accident should be considered in relation to the thousands of deaths in the current traffic situation. This work clearly represents a pro-autonomous driving state of mind, focusing on the advantages and relativizing problems. Notable work especially concerning ethical issues and the question of liability in case of an accident was done by (Kirkpatrick, 2015). They highlighted reasons as to why self-driving cars have the potential to be safer than human driven cars. Although they sometimes lack in hard to detect situations (e.g. when pedestrians are involved), considering that these scenarios appear to be relatively rare, and 90% of accidents are caused by human failure, they conclude that even non-perfect autonomous cars will still bring huge improvements to traffic safety statistics. Furthermore, according to their conclusions, the broader society should be involved in the ethical decision-making process concerning lose-lose situations by being asked how they want cars to behave in these situations. However, it is important not to aim for a majority vote on this aspect but rather to thoroughly discuss all possible views on the topic in order to find a comprehensive solution without discriminating against any group of people. Popular work on the ethical decision was also done by the Massachusetts Institute of Technology (MIT). During their research into how people would decide in worst case scenarios, they used a software simulation called "Moral Machine" (J. F. Bonnefon, 2016) as their research method. In the simulation, traffic scenarios involving various characters like children, elderly people, criminals, men, women and so on are illustrated. In each of the scenarios, the participant has to decide between one of two options. Each outcome involves killing some characters while allowing others to survive. After the test, a result page is displayed presenting aspects like gender, social status, age and so on that may have impacted the participant's decision. The result could conclude that the participant preferred young people over elderly people to survive in 60% of the cases, or that they favored the survival of the person that followed the

traffic lights in 70% of the cases.
Another interesting aspect concerning ethical safety issues is the fact that there is already an imbalance in today's current driving situation. For example, if you choose to drive an SUV, you are able to put your own safety in favor of others as your car is more likely to be unharmed in the case of an accident with a smaller car. Currently, nobody has serious ethical concerns on that (Kirkpatrick, 2015). There is also critical scientific work pointing to concerns and potential problems arising from autonomous driving. The work described in (Litman, 2014) argues against the usefulness of driver-less cars. One consideration is the promised reduction of overall CO2 emissions due to intelligent route planing and economical driving. This apparent advantage may be contradicted by the potential increase of overall traffic due to more comfort, remobilization of elderly people, the mobilization of children, and cars operating wile empty. They also doubt the overall improvement on safety as driver-less cars might introduce additional accidents due to technological errors. However, most scientific work agrees on an improvement in this field. Another aspect of safety is highlighted in (Nidhi Kalra, 2016). After providing statistics about how many accidents are caused by human failure, which might be improved by autonomous cars, they mathematically show, that it would simply take too long to statistically prove this. Tests, which could prove with statistical significance that autonomous cars produce fewer errors resulting in accidents than human beings do would simply take too long. The current data set of driven kilometers by e.g. Google car is by far not sufficient and not in any case comparable to the amount of kilometers driven by human beings every day.

4.3 Privacy and Legal Aspects

Privacy, as well as legal aspects, are mentioned in a lot of literature concerning autonomous cars. Because many papers often repeat each other in their basic explanations about privacy and legal regulations, only a few selected reports and papers with detailed findings will be discussed in this section.
By far the most comprehensive work found considering privacy is presented in (Glancy, 2012). The report elaborates every aspect of privacy issues related to self-driving cars. As a basic definition, they distinguish between self-contained and interdependent cars (Glancy, 2012, pp. 1174-1175). Self-contained cars are not connected to any network and perform all the necessary computing within the car itself, whereas interdependent cars might communicate with other cars and possibly a control system. Based on these definitions, different privacy issues can arise. A self-contained car, for instance, is not subject to external control or real-time surveillance whatsoever, which might relax data collection constraints for personal information. But on the other hand, due to the concentrated storage of the data, it might become a *"repository of personal information"* (Glancy, 2012, p. 1178) which needs special security protection. Another interesting consideration, besides the often mentioned data privacy, is the discussion on personal autonomy privacy. *"Personal autonomy privacy focuses on an individual's ability to control such matters as who knows where she is now, where she will go next, when she will depart, how she will get there and with whom, as well as who can predict or decide where, when, and how she will travel in the future"* (Glancy, 2012, p. 1188) This is a

very basic consideration on the free personal choice of mobility.
Notable work on autonomous cars in general, but especially necessary legal regulations, was done in (ITF, 2015). They consider different types of necessary regulations, distinguishing between public and private as well as ex-ante and ex-post regulations (figure 4.1).

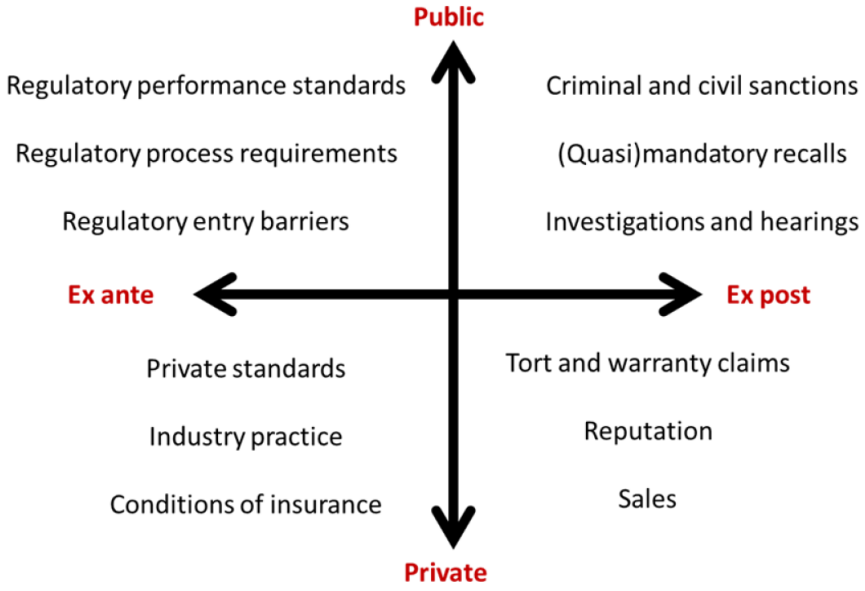

Figure 4.1: Different types of necessary regulations for autonomous car introduction (ITF, 2015, p. 25)

They analyze how forward looking ex-ante rules might ensure more certainty but reduce flexibility, whereas ex-post regulations have an exact opposite character (ITF, 2015, p. 27). Governments might either adapt all driving related laws in order to include autonomous vehicles in the existing set of regulations or they generate a whole new set of widely stand-alone rules for self-driving vehicles (ITF, 2015, p. 26). There are also two different introduction approaches, namely "everything somewhere" and "something everywhere" explained in detail in (ITF, 2015, pp. 17-18). The first approach describes a partial introduction of fully autonomous cars, for instance placing them on separate lanes or in restricted areas. The second strategy aims for a full integration of increasingly partly automated cars throughout the whole traffic infrastructure. These cars use technologies called advanced driving assistance systems which make them more and more automated until they eventually reach full autonomy.
Insurance concepts and regulations may also be affected by the introduction of autonomous cars. In (Tao Jiang, 2015, pp. 16-18), problems with different regulations in US states concerning liability are elaborated. Some US states have the rule that liability follows the car. However, contradictions may occur when a car equipped with third party automation technology causes an accident as the accident may have been caused by a technical fault of the equipment, and not by the driver. Furthermore, the question on the subject of insurance is raised. For vehicles of NHTSA scale 4, it is not clear if the car, the manufacturer or the automation technology

provider has to be insured. The paper suggests that the latter option might be a logical answer. However, the question is left as an open issue.

4.4 Mobility in Rural Areas

Rural areas differ in their traffic structures from urban cities and this may also affect the development of autonomous cars. Missing lane marks, bumpy roads and little to no traffic guidance lead to special requirements considering self-driving car technology. In (Zhou and Iagnemma, 2010) a method using fuzzy support vector machines in order to detect unstructured roads is presented. The explanations specifically focus on the special requirements of road detection in rural areas. Using heuristic fuzzy logic they try to gain more independence from conventional, exact lane detection using lane marks. Similar work was done in (Chu et al., 2015). They describe an approach for real time path planning especially for unstructured roads. These papers show that there will be necessary additional work to be able to implement self-driving car technology that is capable of performing in unstructured environments. More in depth research on specific demands in these areas will be essential to find appropriate solutions.
In the context of this thesis, especially research on the potential use of autonomous cars, regardless the technical burdens, has been evaluated. Very comprehensive work on the possibility of using autonomous cars to obtain sustainable mobility in rural areas was done in (Beitz, 2016). The goal was to find a solution for obtaining mobility in rural areas with the use of automated vehicles. After explaining the rural area situation in Austria, the work describes an approach as to how mobility on-demand, using self-driving cars, can improve the mobility situation in this area. An autonomous car fleet, which can be demanded by using a mobile application, is elaborated and evaluated as a potential solution. The work especially explains different demand peaks over time as well as age groups and considers theses aspects in the proposed solution. Autonomous fleet distribution in the rural areas, for instance, could be made related to traffic demand. The idea is, for instance, that autonomous cars are already "waiting" near living areas in the morning to bring people to work.
In (Cullinane et al., 1996) the authors present new approaches for rural traffic management. Triggered by the need for traffic management schemes for national parks due to the increasing amount of private car visitors, they tried to apply the elaborated schemes for further traffic planning in rural areas. The paper was written in 1992 and concerns the problems that arose as a result of the increase in car users during the traffic boom of the 1970's and 1980's. The two concepts elaborated in their results are the "carrot" and the "stick" approach. The word "carrot" in this context is used as a metaphor for an incentive to make it more attractive for people to switch from cars to train. For instance, this could be achieved by improved timetables and cheaper tickets. On the other hand, the "stick" approach is meant to change drivers behavior by some kind of punishment or designed inconvenience in order to regulate traffic related problems. This can be done by raising parking fees, introducing speed limits or other regulations that punish undesired behavior.
A detailed and comprehensive analysis of the characteristic of the rural Europe including also aspects of population and demographics, as well as public transport and commuters, is presented in (Copus and Hörnström, 2011). In their conclusions, they explain that wealth

tends to concentrate more accessible areas. This leads to the assumption that accessibility might be related to wealth. A statistical analysis focused on the commuter situation in the US is shown in (Brain, 2016). From the 128.3 million total number of commuters in the US, about about 30% are commuting from rural to rural or from suburban to urban areas. The vast majority commutes under 50 miles. Only 3 million commute for a distance of more than 50 miles everyday. 96% of these trips are done with a private car and 84% of them are made by males. Furthermore, the statistics show that 75,7% of all commutes are done alone, without any kind of car pooling.

4.5 Discussion

The analysis of the state of the art showed that there is scientific work on the user experience in autonomous driving, but it is mainly focused on what potential user want to do in their cars and how they expect it to look. Most of these approaches are quantitative and do not investigate potential personal reasons for using or not using an autonomous car. This thesis rechecks the people's mentioned desires on design as well as tasks to be accomplished while in a car, but will also examine which factors are important for people to trust in an autonomous car and where they see an actual benefit. Furthermore, this study further investigates if current statements on the increased safety of self-driving cars are perceived by the users. A field that remains almost untouched in current research is user's reasons for not using a self-driving car because of fears and concerns. Other reasons might be the higher price or the joy of driving manually, as well as trust issues. Considering laws and regulations, a significant amount of literature can be found. The reports explain potential strategies and regulations, but none of them considers people's desires within this context. This thesis only states a few actual possible regulations, but mainly focuses on the user's expectations what should be considered by regulators in order to make people feel safe on the road with autonomous cars. These regulations, for instance, consider guidelines on the integration of autonomous cars into normal traffic, as well as which people should be allowed to be driven in self-driving cars and under which conditions. Although there is research on how people want a car to react in lose-lose situations, the investigations mainly stopped at the question of how the algorithms should be developed to provide an acceptable and ethically correct solution. In the context of laws and regulations, data usage and privacy has to be mentioned. Again comprehensive work can be found on potential use cases and regulations, but almost none of these approaches incorporates the user's opinion on this topic. This might involve which data people want to be collected and which purposes it should be used for. There is research on the traffic situation in rural areas, but little focuses on autonomous driving and even less on the user's perspective on this topic. Most of them focus on technical rather than social aspects. Therefore, what people in the countryside expect from autonomous driving and how it may improve their mobility situation remains to be elaborated on.

CHAPTER 5

Methodological Approach

This chapter describes the scientific methods and techniques which were used in order to be able to answer the thesis' research questions. The chosen qualitative approach involved two major steps: the data gathering and the data analysis. Therefore, this Chapter is partitioned in the according two sections explaining the data gathering, using qualitative interviews, and the data analysis with cross-indexing and an induced categories approach.

5.1 Data Gathering

In order to be able to answer the research questions, qualitative interviews were conducted and used as a method to gather the necessary data. It was chosen over a quantitative approach to be able to obtain the necessary depth in the user's perspective. The idea is to let the interviewee explain their perspective in an open way, including all their feelings on the topic. Detailed questions are asked in an impromptu manner during the explanations of the interviewees, in order to comprehend the real reasons for their attitudes. Furthermore, the participant is asked to explain real-life situations and experiences instead of answering pre-formulated questions. These principles facilitate the necessary user-centered knowledge generation and personal insights in the interviewees' opinions.
All qualitative interview methods have the following common core features, regardless of its specific variation or style. First of all, the interview is held in an interactional exchange manner. This can be achieved either face to face, over the telephone or over the Internet, and might involve one-to-one interactions or focus groups. Furthermore, qualitative interviews have a relatively informal style instead of a formal question and answer format. Although the researcher does not have a complete and sequenced script of questions, they have a set of topics which they want to cover. The job of qualitative interviews is to ensure that the relevant context is brought into focus, and thereby be able to produce situated knowledge. Qualitative interviews operate in a manner that knowledge is produced or at least reconstructed, despite just being facts that are reported (Mason, 2002, p. 62).

Considering these characteristics, Mason also listed possible reasons as to why researcher would choose qualitative interviews as their scientific method for qualitative data generation. *"If you choose qualitative interviewing it may be because your ontological position suggests that people's knowledge, views, understandings, interpretations, experiences, and interactions are meaningful properties of the social reality which your research questions are designed to explore"* (Mason, 2002, p. 63).
Since the thesis' research question considers the user's personal concerns, wishes, and opinions, qualitative interviews seem to provide a facilitating method in the thesis' methodological approach. Among other qualitative methods such as conversation analysis or humanist approaches (Mason, 2002, pp. 56-58), quantitative questionnaires may provide the necessary flexibility and sensitivity in data generation in a personal individual real-life context.

5.1.1 Problem-Centred Interview

In order to be able to cover all necessary topics, while doing the interviews in an open manner, a problem-centred interview using an open interview guideline was chosen. This interview form evolved due to the need of alternative systematically developed research methods, that allow the situation-adequate, flexible and concretion facilitating investigation of individual, non standardized cases. The idea was to develop a more interpretative related method, that focuses on a better examination of individual perspectives in contrast to the existing normative approaches, describing human acting more as a result of social norms (Witzel, 1985, pp. 227-228).
The problem-centred interview follows three base principles: problem centring, object orientation and process orientation (Witzel, 1985, pp. 230-235; Witzel and Reiter, 2012, pp. 24-27).

Problem Centring As stated in its name, the problem-centred interview focuses on the individual problem situation of the interviewee. Therefore, the starting point of the problem-centred interview is a social problem situation, observed by the researcher. This requires the researcher to gain adequate knowledge on the problem field already before the interviews. This can be achieved by comprehensive relevant literature research, as well as by involving professional experiences. The resulting knowledge enables the researcher to confront the interviewee during the interview with specific questions and aspects, in contrast to a narrative interview, where the interviewees tell their story mostly alone (Witzel, 1985, pp. 230-232).

Object Orientation The concrete arrangement of the procedure has to be adapted to the particular research object and can not just adopt already existing pre-assembled methods. This contrasts former approaches, where research methods were either developed independent from its object, or the suitability of an established method to a given research object was simply postulated without any further investigation (Witzel, 1985, pp. 232-233).

Process Orientation This principle describes a flexible analysis of the scientific problem-field and a step-wise exploitation and proof of data. During this process, the correlation and constitution of the individual elements are carved out slowly under permanent reflexive

reference to the used methods. The idea is not to use qualitative methods to construct preliminary theories in advance, which then are verified empirically, but to generate them in an accurately organized data collection and data analysis process (Witzel, 1985, pp. 233-235).

5.1.2 Interview Guideline

In order to sort and organize the interviewer's a-priori background knowledge before and during the interview, the problem-centred interview style supports the use of an open, unstructured guideline. Its main task is to enable the interviewer to maneuver trough the whole interview process in an open way, without leaving out any important aspects (Witzel, 1985, pp. 236-237). Furthermore, it also prevents multiple repetitions of the same questions and topics, which would lead to unwanted data redundancy. Additionally, the interview guideline can be used to provide starting points, in case of situations where the interview partner does not have any idea concerning specific question and the interview gets hindered. As stated in "Das problemzentrierte Interview" from Witzel, *"The guideline's task is not to form a skeleton for a structured questionnaire, but is ought to organize the researcher's background knowledge thematically in order to obtain a controlled and comparable approach for the object of research."* [1] (Witzel, 1985, p. 236)
The main requirement on the guideline and its questions is openness. The basic principle of using an open interview approach is to give the interview partner the freedom to explain their ideas and opinions, without being biased by pre-formulated, restrictive questions. Therefore, all questions have to be formulated in an open way, without any constraining expressions. Additionally, they are formulated on a very personal level, inspiring people to talk about their personal concern, instead of just repeating public opinions. This can be achieved by asking questions which relate to personal experiences and actual life situations, instead of abstract formulations and generalizations.

To obtain a starting set of questions and topics, extensive literature research about the current state of the art was done before the interviews. This research led to the following research topics which are the main parts of the interview guideline.

- **Current Mobility Situation** - This section includes questions on the people's current mobility situation. Which vehicles do they use for which purposes and what are the problems and wishes that occur in their normal life situations.

- **Personal Usage of Autonomous Vehicles** - Questions on desires and expectations on how autonomous cars could be used. What would people do in their autonomous cars and how would they use them? Which areas of their lives would be impacted? This also includes the interesting question on trust in self-driving cars.

[1] *"Der Leitfaden hat nicht die Aufgabe, ein Skelett für einen strukturierten Fragebogen abzugeben, sondern soll das Hintergrundwissen des Forschers thematisch organisieren, um zu einer kontrollierten und vergleichbaren Herangehensweise an den Forschungsgegenstand zu kommen."* (Witzel, 1985, p. 236)

- **Introduction of Autonomous Driving** - How do people expect this new kind of technology to be introduced in society. One big issue is the possibly necessary change of infrastructure on for instance highways, intersections or roads on the countryside. The question is whether these infrastructural changes are made in an “everything somewhere” or in a “something everywhere” approach.

- **Legal and Ethical Issues** Questions on which policies and laws might have to be changed, added or removed, in order to regulate the usage of autonomous cars. This contains also questions on driving licenses, using alcohol or letting children drive, as well as the personal opinion on ethical questions about lose-lose situations.

- **Privacy and Data Usage** - Questions on which data can be collected, optionally or obligatory, and who gets access to it. For what purposes may the gathered data be used and how do people expect to be rewarded?

These topics result directly from the open issues, examined during the literature research and formulate the basic content of the interview guideline.
During the evaluation of the interview guideline's questions, they were categorized in three types: request-, establish- and detail questions. Request questions engage the interview partner to explain their opinions and thoughts, and build the main entry points of the interview. They are open-formulated such as, "How would you use an autonomous car?". If the interviewer sees further potential in the explanations to a topic, they might ask establish questions. These questions do not start with a new aspect of the topic, but try to facilitate the interview partner to continue in their explanations such as "What else?", "Do you see another opportunity?" or "Where else do you see potential risks in security using autonomous driving?". In some cases, answers to a specific topic or issue are needed. Detail questions are used to obtain specific answers and information on aspects which have not yet been mentioned. For example, "What benefits do you see in using autonomous cars for public transport in rural areas?"
Due to the desired open structure of the interviews, no restrictive interview guideline, containing all questions was created. The guideline provides only some form of red line through the different research fields, containing the request questions as main entry points, as well as some establish questions in case of the interview gets stuck. Additional detail questions were asked spontaneously on demand.
It is very important, that the questions asked during the interview are formulated in a way, that enables the interviewees to explain themselves and talk freely. Thus, so-called decision-questions which can be answered by a simple "yes" or "no" are mainly left out, especially for request questions.

5.1.3 Interview Partners

A crucial task during qualitative research work is the selection of appropriate interview partners. In this section, we want to have a look at some important considerations that were done in this context.

Number of Interview Partners

Since the number of necessary interviews for qualitative research can not be determined statistically as it is the case for quantitative methods, there are different opinions on this topic (Kurz et al., 2007, pp. 5-6). Comprehensive work on different opinions about the necessary number of qualitative interview was done in (Sarah Elsie Baker, 2012). 14 experts were interviewed and asked for their estimation on an adequate number of participants for qualitative interviews. One of the asked experts was Jennifer Mason, who's book on qualitative research was also used as a knowledge basis for this thesis. In her opinion, it is a common mistake of inexperienced researchers to think that a higher number of interviews necessarily leads to better results. According to her, it is better to focus on sound, in-depth interviews, rather than aiming for big number of broad and pseudo-representative interviews trying to mimic a quantitative approach (Sarah Elsie Baker, 2012, p. 31; Mason, 2002, p. 38). In (Przyborski and Wohlrab-Sahr, 2014, p. 182), it is argued that not the number of interviews is not of importance, but rather the theoretical saturation of the material. The concrete number depends on the type and field of the interviews.
After considering the explanations in the stated literature and analyzing the available temporal resources for the interviews in this thesis, a total number of 12 interview partners of different ages was found to be appropriate.

Sampling of Interview Partners

As stated in (Przyborski and Wohlrab-Sahr, 2014, p. 182) the number of interviews is not important, but their systematic sampling is, looking for contrasts in order to obtain a sound view on the topic. The decision on the correct sampling method is essential to be able to achieve this condition. Among the three different different sampling techniques theoretical sampling, sampling after pre-determined criteria and snowball sampling, explained in (Przyborski and Wohlrab-Sahr, 2014, pp. 178-180), the sampling considering pre-selected criteria was found to be suitable for the thesis. Using this method, different criteria which are thought to influence the interview outcome are selected before the interviews. These criteria could also be determined by the outcome of already performed qualitative studies (Przyborski and Wohlrab-Sahr, 2014, pp.178-180). In case of the thesis' sampling, three criteria were chosen: social environment, age and sex.

Social Environment People with different, but typical social standards were chosen for the interviews. Therefore, the pool of interviewees contains farmers, employees, students, long and short distance commuters, housewives, singles, families and family clans with more than two generations living in the same household. This reflects the very diverse demographic variety as it can be observed in rural areas.

Age Groups As a potential factor of variety, the different ages were expected to bring different ideas and opinions on the topic. Young people may tend to be more technology affine, and may possibly provide creative and interesting ideas as well as new approaches. Current mid-aged people ought to bring a lot of knowledge and experience on current problems and challenges.

They may also provide interesting inputs where there is a need for improvement. Likewise, older people can give valuable information on how they perceive this new technology, but also how they would use it to perhaps retrieve mobility again.
According to statistical data from (Statista, 2013; Statista, 2015; Statista, 2016) which provides information on the use and status of cars related to the age of a person, the three age groups 18 - 29, 30 - 49 and 50+ seemed to be the most relevant choice. Especially for the middle age group, which should represent the broad majority of driving society, the exact setting is important. In (Department for Transport Great Britain, 2016) it can be seen, that the chosen group from 30 to 49 years old represents exactly the biggest part of car driving people.
Those were the assumption considering age classification before doing the interviews. Apparently during the analysis of the interviews, these assumptions were proven to be wrong, showing that in the thesis context, age did not not influence the results at all.

Gender Additionally to age and social environment also the gender was chosen as a sampling criteria. It was assumed, that men and women may react differently to the topic of autonomous driving.

The number of interview partners of different social standards and other criteria was not sufficient for an equal distribution. Therefore, these features were considered informal, without any defined separation of the interviewee pool.
Using the remaining two attributes, the pool of interviewees can be divided according to the following criteria:

- age: 18 - 29 years (18+), 30 - 49 years (30+), more than 50 years (50+)
- sex: male (m), female (f)

Since the intention was to make the pool of participants as broad and diverse as possible, a heterogeneous mix of groups with different criteria was defined. Each of the three age groups consists of four persons, which are two females and two males. Following this pattern, the pool consists of half male, half female persons in every age group as well as in total and the number of persons in each age group will be the same.

A-priori Knowledge of Partner

The a-priori knowledge of the interviewee as well as the interviewer has great influence on the outcomes of the study. Whereas in expert interviews the knowledge of the interviewee usually predominates and the objective of the interviewer is to gather this expertise, in this thesis the a-priori knowledge distribution is basically flipped (Kurz et al., 2007, pp. 7-8). Since this thesis aims to gain information from the general public, there is no need for a specific, restricted group of lead users or experts as interview partners. They are usually average persons without any specific knowledge on autonomous driving, whereas the interviewer already gained sophisticated background on the topic by intensive literature research. Thus, it

was very important, that the interviewers knowledge did not influence the interview in any way and that the interview is always based on the interviewees knowledge.

5.2 Data Analysis

The second step in the methodological approach describes the analysis of the gathered data. After the interviews were carried out, the information gained had to be structured and organized in order to be usable for any further analysis. As a first step, the verbal, audio-recorded interviews were manually transcribed. Having obtained the research data in the form of textual interview transcripts, annotated with non-verbal information, the next step was to structurally analyze the data in order to find interesting aspects that lead to conclusions and answers of the research questions. The basic methods which were used to achieve this objective are cross-sectional indexing (Mason, 2002, pp. 150-164) and inducted categories (Mayring, 2010).

5.2.1 Generation of Qualitative Data

As stated in Mason, it would be wrong to regard to what counts as data as self-evident. Various different qualitative approaches result in widely differing views on the same question. A major concern in this context is how the researcher can make sure, that he is not just inventing data or maybe misrepresenting their research participants' perspectives (Mason, 2002, p. 192).
As a first step of turning interviews correctly into data that can later be analyzed, they might be audio or video recorded. For this thesis, audio recordings were found to be sufficient, although one has to keep in mind, that a significant amount of information during a conversation is encoded in the communicators physical behavior and gestures. Especially on his work on human communication, Paul Watzlawick mentioned in the fourth of his five aspects of communication, that a significant part of information is transmitted via body language. (Paul Watzlawick, 1974, pp. 70-78).
This means, that a part of the original interview information already gets lost during the audio recording due to the missing recording of body language. Furthermore, it is important to make oneself clear, that also the transcription of the audio files into textual form causes a loss of information. Differences in pitch and volume of the voice may significantly change the meaning of the spoken words. To at least partly overcome this issue and to facilitate later analysis, the transcribed audio recordings were annotated with verbal descriptions of the interviewers behavior, manner of speaking and also some body language aspects like laughing or harrumphing.
Nevertheless, textual transcriptions from audio-recorded interviews, even if annotated with additional information, always suffer from a deviation from the original information. Therefore, textual transcriptions can never be seen as fully objective records of the original interview (Mason, 2002, p. 77). This effect has an even greater impact, when the interviews are analyzed from a different person than carried them out, which is not the case in this thesis.

5.2.2 Reading the data

Following Mason's explanations, after having decided what the actual data is, one has to choose how it may be read, providing three different styles: literally, interpretively or reflexively. Reading an interview literally means, that one is interested in the actual literal form, structure, style or layout of the written text. Considering interviews this might contain analysis of the used words and expressions as well as the dialog's structure. The researcher is only interested in the actual literal meaning without any further personal interpretation. This separation might be considered as impossible, because there is always some personal influence on the way how we see things. Because purely literal reading is almost impossible, one has to consider, to which extent one will want to interpret the data while reading it considering an interpretive reading style. This involves the process of constructing an own version of the data, formulating intended meanings and possible conclusions. As a final decision, one has to consider, to which extent the interviewer is actually part in the knowledge generation process during the interview and wants to make use of a reflexive reading style. This reading style focuses on how the interviewer's perspective and role influenced the creation and interpretation of the data. Basically one can say, that the reading process usually involves all three kinds of reading, but the researcher chooses, to which extent they are applied during the interview reading. (Mason, 2002, pp. 78-79).

5.2.3 Cross-Sectional Indexing

The immanent unstructured nature of qualitative data makes it essential to apply an appropriate method to organize it in a systematic and consistent way. Indexing states a common technique in this field, with central idea to apply a uniform set of categories to the data. The simplest form of this method is so-called serial indexing, marking categories at the appropriate spots in the data like headings and sub-headings, comparable to the chapters of a book (Mason, 2002, p. 151). This simple approach comes with three main limitations. First, simple indexing of a text sequentially with headings and sub-headings may lead to a very broad set of categories that might not be applicable to other texts. This is especially the case when the texts are the transcripts of open interviews without a common structure. This results in either an unmanageable amount of categories or inconsistency among them. Second, the pieces marked in the text in qualitative data, as in interviews, are likely to belong to more categories than just one headline. This may not be represented by the strictly sequential structure. Third, serial indexing might be difficult to apply to qualitative interview texts without a common structure or sequence of topics. Since every interview may have a completely different composition and might even vary in its content from the others (Mason, 2002, p. 151).
Because of this considerations, Mason presents in her book the more sophisticated cross-sectional indexing technique as an alternative. Indexing categories may be applied simultaneously to different texts and in a multiple hierarchical manner, ending up with a set of both unrelated and related categories and sub-categories. The application of the appropriate tags on the data turns it into an information resource, that can be accessed in multiple different ways, retrieving information on different grained levels, accumulated from various text sources (Mason, 2002, pp. 152-153). Due to the fact, that the task of indexing and especially retrieving

data can be very complex, although it is possible manually, computer aided software support is recommended. In particular for cross-sectional indexing computer software can help to easily apply and retrieve categories in a big amount of textual data (Mason, 2002, pp. 151-152).

Qualitative Data Analysis Software (QDA Miner)

After comparing several different qualitative data analysis software tools, the free QDA Miner 2.0.0 Lite software from Provalis Research was chosen for the thesis' data analysis. The free Lite Version of the established qualitative software tool seemed to be sufficient for the necessary analysis tasks. Textual interviews are loaded into the tool by copy and paste and can be marked with different customizable variables to define gender, age group or other participant characteristics. Afterwards the text can be tagged with user specific categories, which can be organized in color coded category groups. The software also provides basic editor functionality for further text editing and comments. After tagging the according words, phrases or paragraphs in the transcripts, the color coded tags appear on the right border to provide an overview on the already tagged areas. Additionally to a standard search functionality, which is capable of searching for regular expressions in all contained or only selected interview resources, a sophisticated retrieving function is provided. After selecting the resources which have to be searched by using the given variables, all text areas, tagged with the selected categories are retrieved in a list. The result not only shows the according phrases and interviewee's name, but also statistical measures on the number of words and relative occurrence in percent. With the given features, the software provides simple but effective aid for the rather complex task of information retrieving after cross-sectional indexing.

Category Elaboration

A rather crucial task in the cross-indexing process is the elaboration of the categories. The set of categories has to be sound and complete regarding the research topics, consistent over all data sources as well as appropriate in number and depth to facilitate further reasoning and conclusions. Mayring explains in his work on the analysis of qualitative data (Mayring, 2010) the inductive exploration of index categories during the reading process. This method to generate the categories inductively by examining the data seemed promising for this thesis as well. It allows to identify the specific outcome of the personal interviews, without being biased by fixed, pre-determined categories. As a first step during the category examination, one has to become as familiar as possible with the data by reading, studying and thinking about it several times. This also involves being familiar with the overall goal of the thesis and its research questions in order to stay focused on the desired outcome and not to lose the final objective. An important aspect during category elaboration is the time when the categories are established. Although it can basically be done during any step of the research work, the actual phase will considerably influence the outcome (Mason, 2002, pp. 161-162). Categories, that had been elaborated before the actual interviews would solely rely on the formulated research questions and literature work and would likely have to be refactored during ongoing research progress. Although some basic ideas on the research topics and its resulting categories were developed in advance, the actual categories for indexing the data and especially for the following analysis

were elaborated after the interviews in an inductive manner as described in (Mayring, 2010). After being familiar with the data, a few trial categories were developed and tried on the first data sets. Theses categories have been extended and refactored until they could were applied consistently to the first half of the interviews, speaking six interviews. The obtained set of categories was then applied to the rest of the data without any further restructuring. In his work, Mayring analyzed the results of several hundreds of interviews with teachers concerning teacher unemployment. In order to be capable of analyzing this big amount of interviews in a qualitative manner, he describes a process of paraphrasing the indexed phrases of the interview until the desired abstraction level. In contrast to Mayring, int this thesis, the indexed phrases were not paraphrased before further examination because only twelve interviews had to be analyzed. Instead each interview was examined in a separate case study (6), focusing on the specific output of the participant. Afterwards, using the induced categories, results over all participants were elaborated and are presented in the results chapter 7.

CHAPTER 6

Case Studies

In this chapter we want to have a look at the different interviewees as individual case studies and analyze them separately. During this analysis, important reoccurring topics will be examined for further inter-casestudy elaboration in chapter 7. An overview of the interview partners and their demographic characteristics can be obtained from table 6.1 (see p. 52).

6.1 Case Study Marianne (IP01)

Marianne was quite nervous because of the interview and I had to convince her, that there is no right and wrong concerning her answers and that I am only interested in her personal opinion. She lives in a household with her husband Josef and their two children Patrick (25) and Christina (22). Patrick drives a company car from his work, Christina has her own car and Marianne and her husband share a car together, leading to three cars in the household. Since Josef is usually driving to work with his electric bicycle, Marianne has the car on her own during the week. Marianne also has an electric bicycle and wants to use it more often for environmental and health reasons. However she usually uses the car for her normal tasks like grocery shopping or to get to her work as a cleaning lady because it is more convenient. The comfortable way to transport her work utensils is a very important reason for Marianne for using the car.

> *"Yes, it [the car] is important and comfortable and thankfully we can use it. And afford it."* [1] (IP01, p. 2)

> "Well, sometimes I need the car because I have to drive to my cleaning job. Then I absolutely need the car, because I take my cleaning stuff with me." [2] (IP01, p. 2)

[1] "Ja, es ist wichtig und kommod und gottseidank können wir es nutzen. Und leisten." (IP01, p. 2)

[2] "Naja, ab und zu brauche ich das Auto weil ich zum Putzen fahren muss. Da brauche ich das Auto unbedingt, weil dann nehme ich mein Putzwagerl mit." (IP01, p. 2)

Code	Sex	Age	Education	Job	Household	# Pers.
IP01 (Marianne)	F	57	vocational training	household, cleaning	two generations, one-family-house	4
IP02 (Daniela)	F	22	high-school diploma	technical employee	three generations farm	6
IP03 (Erich)	M	60	high-school diploma	bank employee, farmer	four generations farm	7
IP04 (Josef)	M	49	high-school diploma	technical employee	two generations, one-family-house	4
IP05 (Felix)	M	72	vocational training	retired (farmer)	three generations, farm	4
IP06 (Alex)	F	46	vocational training	office worker	two generations, one-family-house	4
IP07 (Christian)	M	22	high-school diploma	student	two generations, one-family-house	4
IP08 (Eva)	F	39	high-school diploma	management assistance	one generation, one-family-house	2
IP09 (Florian)	M	22	high-school diploma	construction engineer	three generation, farm	8
IP10 (Andreas)	M	35	high-school diploma	teacher	single, flat	1
IP11 (Lisa)	F	20	high-school diploma	student	two generation, one-family-house	2
IP12 (Maria)	F	76	primary school	retired (farmer)	three generation, farm	6

Table 6.1: Demographic characteristics of interview partners

Marianne likes driving in her own car and she says, that she needs the car. She does not use any public transportation at all, because in her opinion, there is no useful option. Marianne would appreciate better public transport, like a bus which stops in front of her house, but eventually she prefers her car. She likes the independence and the fact that she does not have to consider any timetable and can control things on her own. At the time, when she was working in a near city and had troubles to find a parking lot, she would rather spend some more time looking for a free spot, than taking the bus. Her children do not use public transportation either. Marianne is concerned about her daughter Christina using the train to get to Salzburg, because of recent crime incidents at the train-station. She has safety issues when her daughter takes the train alone to Salzburg and therefore she is happy about her taking the car. Some years ago, Marianne and her husband were working in the same city about 20 kilometers away form their home. At that time, they formed a carpool community with others. When they go on vacation, Marianne and her husband usually share a car with their friends as well.

Marianne is not annoyed by any specific problem considering her daily driving. Because of their garage, she does not have to free her car from the ice and also small inconveniences like other slow drivers or finding a parking lot do not bother her. The only limitation she and her husband have to deal with, is to stay in Austria or Germany for their holiday trips, because they are not speaking any foreign language. Hence, for traveling abroad, Marianne likes to take a bus. When traveling by bus, she enjoys the ease of just packing the luggage and then sit in the bus, without any further things to do.

Since she seems to be satisfied with her current mobility situation, Marianne does feel the need for any change. She is not able to express any desirable changes or hypothetical solutions considering her mobility. Marianne only clearly emphasizes, that she does not like the idea of any kind of car sharing service because she is clearly attached to her own car. It is interesting that Marianne shared her car with friends to get to work and still does the same when going on vacations, but does not like car sharing in general. This shows that it is not a problem for her to take longer routes because of picking up other persons, as long as she is able to control the situation and maintains the convenience of having her own car. Although it is important for Marianne to have her own car, it is not any kind of a status symbol for her and it does not have to be any luxurious car at all. It only has to be big enough to provide space for her belongings and cleaning utensils. When she was younger, a luxurious car seemed more appealing to her, but she thinks this may have changed when she got older.

> "No, I would rather still want to have my car. Maybe because one is attached to it, I don't know how to explain this. It's simply mine and I can really do as I want. Yes you might do this with the other one too, but still. No, I would really prefer to have mine." [3] (IP01, p. 10)

Considering autonomously driving cars, Marianne heard about them, but prefers to drive on her own. The main reason is, that she does not want to be driven by someone else in the first place. On journeys together with friends, it is always her who drives the car. The only person, Marianne feels comfortable to be driven as a passenger, is her husband. She just does not feel save when someone else is driving the car and therefore does not like the idea of being driven by a machine. It is the lack of control that makes her feel uncomfortable. However, Marianne could imagine to get used to this new kind of technology over time. She might want to look at the landscape during an autonomous car ride, but she would not feel comfortable during the trip and definitely excludes sleeping. She really does not like the idea of giving away full control and imagines hypothetical horror scenarios that might happen when the automated car fails. Marianne doubts that the machine can be aware of everything and is able react appropriate. She thinks, that in case of an accident when the autonomous car failed, she possibly could have been able to avoid a crash if she was in control. For this reason, Marianne would clearly appreciate an optional manual mode, giving her the possibility to take over full control whenever she wants to.

[3] "Nein, da möchte ich doch einfach noch mein Auto. Weil man vielleicht auch dran hängt oder, ich weiß jetzt nicht wie ich das erklären soll. Es ist einfach meins und da kann ich wirklich so tun wie ich mag. Ja weil ich auch mit dem anderen das tun könnte, aber trotzdem. Nein da möchte ich schon am liebsten das meine haben." (IP01, p. 10)

> "But then I think, that when I am driving on my own I might be able to do something [in case of an accident]." [4] (IP01, p. 7)

Although Marianne likes driving, she does not drive just for fun and would not miss manual driving in a scenario where only autonomous cars existed. She would consider reading or knitting while driving and enjoy her free time, but she would not feel the urge to do other tasks. It does not make sense to her to be able to accomplish any tasks in the car that she had to do at home. She would rather stay at home to to finish them in the first place. Therefore, she does not expect the car's design to change in any specific way. The only thing might be a nice and comfortable seat and a cupholder a drink. The seats could be turnable in order to be able to chat with the other passengers or play cards together. Marianne is quite skeptical if autonomous and manual cars would work out smoothly together. She mentions an example, where she might be in a narrow intersection with another car and would signal the other driver with her hands, to let him drive first, in order to be able to pass each other. An autonomous car might lack of this inter-human communication which leads to problems in such specific scenarios. Marianne would be afraid, if autonomous cars drove on the same roads as she does with her normal car. She does not like bus lines in the city either because of their inflexible driving behavior. Hence she would prefer if self-driving cars had their own separate lanes in the city as well as on the highway. Marianne wants the people who are using one of these new cars to pay for the costs of this additional infrastructure with additional charges on their cars. However, if autonomous cars became more popular they should be available and affordable for everyone. Therefore Marianne would also consider subsidization for less wealthy people. Her main argument is, that if such cars are available and affordable for everybody, public tax money may be used for the infrastructure, but if the autonomous car remains some kind of luxury for a small group of people, then they should pay for the additional costs.

> "Well then those people who can afford this car should pay for it [additional infrastructure]. That you pay an extra supplement when you buy a car. Well, when it will be introduced in general, we have to, when more people are getting it, then I also want to have the chance to afford it..." [5] (IP01, p. 23)

It is difficult for Marianne to express her opinion about liability in case of an accident and potentially resulting obligatory traffic observation. Although she claims self-driving cars should generally be trusted, she does not seem to be convinced from her own statement. The baseline is that if an accident happens due to the car's fault, Marianne would feel guilty anyway. Hence, she claims traffic supervision and according manual interference in case of a critical situation to be mandatory. Marianne expects legislation to introduce new laws in order regulate who is to blame in case of an accident and who is allowed to drive an autonomous car in the first place, speaking of driving permissions. She is not able to express her own preferences for these things and wants the government think about appropriate regulations.

[4] "Aber da denke ich mir dann naja, wenn ich selber fahre, dann kann ich vielleicht noch etwas tun." (IP01, p. 7)

[5] "Naja wenn, dann sollen schon die Leute zahlen, die sich das Auto auch leisten. Dass man beim Autokauf schon ein Aufschlag drauf hat. Naja, wenn es jetzt generell kommt, dann müssen wir, wenn es jetzt mehr bekommen, dann möchte ich auch die Chance haben, dass ich es mir leisten kann..." (IP01, p. 23)

Considering data collection, she says that she does not have to hide anything and therefore does not appear to be very concerned about her privacy. Although she does not want to be supervised she thinks that tracking might be helpful when she has an accident in order to be found. For this purpose, real-time data collection should be activated automatically. Also for traffic analysis and optimization purposes the data should be available. Marianne would give away the data for free, but anonymously, since she has concerns that it might end up in wrong hands. However, if they pay, traffic planning and governmental institutions as well as car manufacturers might be able to collect also personal data from her. Law enforcement might be allowed to use her personal data for criminal persecution. They do not have to pay for it and the data collection should be mandatory for everyone in order to support criminal persecution. They only thing Marianne does not want her data to be used for is any kind of advertisement, regardless of the payed amount of money. Generally, the collected data should only be used for reasonable purposes that might potentially benefit her in some way.

Marianne was quite nervous during the whole interview and often expressed the feeling, that the topic appears too complicated for her. She appears to be very satisfied with her current situation and does not see any need for a change. She definitely likes driving with her own private car and although she claims that it is not any kind of status symbol, she definitely feels attached to it in some way. Therefore Marianne does not consider any type of additional public transportation or self-driving cars as necessary. Furthermore, she does not want to spend money for these things if she is not able to use them anyway. However, if self-driving cars became popular, she would want to benefit from the new technology too and therefore public tax money might be used. Considering necessary regulations Marianne is quite overstrained and prefers, that legislation institutions take care of the necessary laws and regulations.

6.2 Case Study Daniela (IP02)

Daniela is 23 years old and lives in a typical household in Austria's rural area, where three generations live together in a big house with a farm. Her brother also lives in the household, having his own car, her parents share one and also her grandparents have one car together. Additionally her father uses a motor-scooter to drive to work. Since the family cultivates a farm, tractors are also needed, but they are only used for farm work rather than transportation. After graduating from the polytechnic secondary school, Daniela started working in an automation technology company in her neighbor village about 15 km away. She drives to work every day with her own car and also for shopping and other she uses exclusively the car. Public transportation is not used at all and according to Daniela, her life would not be possible without a car. With public transportation she would need more than 2 hours to finally arrive at the office compared to 20 minutes by car. When it comes to free time, Daniela sometimes takes the train to go to Munich or Vienna. She likes this way of traveling, because it is comfortable and less stressful than driving by car. She actually likes public transportation, but since it is too complicated and simply not practicable, she does not make use of it. In case of better development of public transportation facilities she would use it to get to work instead of driving with her car. Considering her daily commute to work with her car she does not like trucks or slowly driving cars which prevent her from driving her own speed. Furthermore

she sometimes gets stressed when she is already late and does not find an empty parking lot. When Daniela goes on vacations, she sometimes feels a nervous tension when she is driving on the highway on a hot summer day which gets even worse when there is a traffic jam.

> "...I think it's exhausting, and above all, when you're driving in summer. It is hot, although you have air condition, it is so exhausting and there's a tension in the air, you can notice it. When you drive on the highway and there's a traffic jam and it takes more time, that's exhausting too." [6] (IP02, p. 5)

Because of these mentioned issues, Daniela likes traveling by train where she does not have to worry about driving and the additional stress that comes along with it.

> "Yes I think this [traveling by train] is more comfortable. Because you are simply calculating with the time you have to spend in the train. You are just sitting inside without having to concentrate on driving or paying attention when you have to exit the highway. You do not have to worry that much." [7] (IP02, p. 5)

Daniela could imagine a perfect mobility solution which includes a train that leaves at convenient times to get to work and a car for other individual tasks like shopping or visiting friends. She would definitely not want to fully give away her personal car. Furthermore, she prefers driving on her own over being driven for instance by a chauffeur, because she likes the driving experience. Although Daniela likes driving and the car is very important in her life, it is not any kind of status symbol for her. It does not even have to be necessarily her own car, as long as she can always have it when she wants to. Hence, a car pool service, providing full availability, would be an interesting option for her, especially if she could possibly even save some money using it. Her only concern about car sharing is having a different car model every day. She thinks, that it might be difficult to drive with a various amount of different cars without knowing them and their driving characteristics. If it was for instance an Opel Corsa every day, even though each time a different one, it would be okay. Also rules concerning the cleanliness of the shared car are important for her in order to use such a service.

Daniela is not sure about potentially buying an autonomous car in the first place. She is not sure whether she could have enough trust in a self-driving car to let it perform the driving task without human observation. However, self driving-cars might be a good idea concerning the experienced stress at the highway as well as for safety reasons. This is an interesting contradiction in her attitude towards autonomous driving. On the one hand, she feels like having a lack of trust to let the car completely drive itself, but on the other hand, Daniela is convinced that self-driving cars might improve safety compared to human drivers. She

[6] "....ich finde es anstrengend, und vor allem wenn du jetzt im Sommer fort fährst. Es ist heiß, du hast zwar die Klimaanlage laufen, es ist so anstrengend, es ist einfach eine Spannung in der Luft, das merkt man. Wenn du dann auf der Autobahn bist und es staut sich dann und es zieht sich, das ist dann auch anstrengend." (IP02, p. 5)

[7] "Ja also ich finde das dann als angenehmer. Weil du rechnest dann sowieso einfach mit der Zeit in diesem Zug, sitzt einfach drinnen und musst dich nicht auf das Fahren konzentrieren, auch nicht darauf aufpassen, ob du abfahren musst oder so. Du musst dir nicht so viele Gedanken machen."(IP02, p. 5)

does not like the idea of handing over full control to a machine, even though she knows, that humans might be even more faulty drivers.

> "I don't know. One wants to maintain control. So you are really dependent from this whole thing, you certainly have to have a lot of trust in the machine." [8] (IP02, p. 7)

If she had full trust in this new technology one day, she would agree to allow elderly people or children to be driven by a self-driven car. Although a driving license might not be necessary anymore, Daniela demands some kind of training in order to obtain basic knowledge about how to maintain a car and about basic traffic rules.

> "One should at least have an idea about some traffic rules and how to service the car. I mean, one should still be able to help oneself out in case of simple problems or if parts have to be exchanged. " [9] (IP02, p. 15)

This also applies to children, which should get basic introductions on how to behave and act in case of a problem with the driver-less car. Also drunk people may be allowed to be driven by an autonomous car. Daniela concludes, that self-driving cars would certainly be safer than drunk people driving on their own.

After having gained more trust, Daniela might watch TV, surf the Internet, read a book, listen to music or maybe even sleep a little bit during an automated car ride. She imagines the future vehicle to look a little bit like a trailer. There will be two seats in the front and a living area in the back. It may also be equipped with a small kitchen, a fridge and a small couch. Although she will mainly have a sitting position in her new future car, there should definitely be the option to lay down. She would use the self-driving feature mainly for holiday trips, since in her opinion, her daily trips to work are too short. Therefore she prefers a combined mode, where she is able to turn on autopilot in case of long-distance journey. In case of short distances for instance to visit friends, Daniela would prefer a manual mode. In order to trust autonomous cars, Daniela has to experience the faultless operation of the car on her own. Simple test results or reports from her friends would not convince her. Furthermore, all accidents caused by human errors, must be vanished by driver-less cars when they are introduced in order to make her able to trust them. In case of an accident, the driver should still remain at least partly responsible, depending on the situation. In her opinion, it is ones choice to drive in an automatic car and fully trust the technology, maybe even without observing. Therefore one has to take the according responsibility for potential consequences in case of any failure. Furthermore, she thinks that the algorithms behavior in case of an accident should be configurable by the driver in some way. She would not like to sit in a car without knowing or being able to influence its behavior.

[8] "Ja ich weiß nicht. Man möchte einfach da schon auch die Kontrolle behalten. Also man ist dann schon voll abhängig eigentlich schon von dem Ganzen, also man muss halt sehr viel Vertrauen ja dann auch in die Maschine haben, das ist klar." (IP02, p. 7)

[9] "Man muss zumindest irgendwie gewisse Regeln oder wie du zum Beispiel das Auto wartest oder solche Sachen, da sollte man schon ein bisschen eine Ahnung davon haben. Ich meine, man sollte sich schon noch selber helfen können, falls irgendwas nicht hinhaut. Wenn jetzt Probleme auftreten würden beim Auto oder dass etwas gewechselt gehört, einfach solche Sachen" (IP02, p. 15)

> "But there have to be, so I think, different options have to remain open and you can freely decide what is the best for your own." [10] (IP02, p. 10)

Autonomous cars may first be introduced on the right lane on highways and after people are accustomed to it, they may drive everywhere. Additionally, she might favor some kind of time limitation, regulating when autonomous cars are allowed to drive in certain parts. If people do not trust them yet, they may avoid these areas at that certain time and would not get in contact with these cars. Her main motivation for this kind of introduction phase is, that people should be given the opportunity to get accustomed to autonomous cars without any pressure. This clearly expresses an "everything somewhere" approach.

> "In the beginning, I could imagine that they, for example, might drive on the right lane. When this is okay after some time, when you are accustomed that they exist and that they are safe, then I can imagine, that it would be also okay to introduce them into the normal traffic. In the beginning you can certainly not let them participate in the normal traffic." [11] (IP02, p. 17)

Daniela thinks it would be too expensive for the government to finance the whole infrastructure. There should be some third party or private investors which support the integration by providing the necessary money. She thinks that many people would complain, however, it would be okay for her if tax money was used for this purpose. In her argumentation, tax money is wasted for so many stupid things, so they could also spend it on something in her opinion more meaningful, like autonomous driving infrastructure.

According to Daniela, it should be possible to activate or deactivate data collection in a car individually. If she has control over data collection, it would be okay for her if location and driving data, as well as personal data are collected. However, personal data of who is driving in the car must not be gathered. Furthermore, she does not like real-time data collection because she finds it too supervising. Car manufacturers should be allowed to gather data for analysis purposes, as well as the police for criminal persecution. These organizations do not have to pay any money, since the advantages of better route planning or engine optimization as well as increased safety are reason enough for Daniela to give away her data. She even proposes automatic data collection in manual mode in order to prevent a possible deactivation in case of a theft. Daniela would agree with data collection also for marketing and advertisement purposes if she gets financially rewarded.

Daniela seems to have a general interest in technology and is open for new technologies. However, concerning self-driving cars, she has typical basic concerns about the feasibility and trust. She sometimes expresses contradictions within her own statements for instance considering

[10] "Aber es muss, also ich finde, es müssen verschiedene Optionen einfach frei sein und du kannst dann entscheiden, was für dich persönlich am besten ist." (IP02, p. 10)

[11] "Am Anfang könnte ich mir vorstellen dass sie zum Beispiel die rechte Spur auf der Autobahn nützen dürfen. Und wenn das dann okay ist, nach einer Zeit wenn du dich auch daran gewöhnt hast, dass es das jetzt gibt und dass das auch sicher ist, dann kann ich mir vorstellen, dass das dann auch für mich okay wäre wenn sie im normalen Verkehr drinnen wären. Aber am Anfang kannst du das sicher noch nicht gleich in den normalen Verkehr lassen." (IP02, p. 17)

safety of manually and automatically driven cars. Nevertheless, Daniela expressed a mainly positive attitude towards autonomous driving and appears to be in favor of its introduction. Although she likes driving with her car, autonomous car services seem interesting for her and also the usage of public tax money would not bother her. The baseline is, that this new technology is still unknown which results a lack of trust, but she thinks this might change over time and then this new technology might appear beneficial to her.

6.3 Case Study Erich (IP03)

Erich's household is a very typical one in rural areas. He is running a farm with his whole family, including three generations. Next to the farmwork he has an office job, working at a local bank institute. Erich is 60 years old and is already planning his transmission from work to retirement. Also the farm was already passed over to his son, but Erich will still help out.

Erich's office is about 2 km away from his home. Although he is concerned these short trips might harm his Diesel car, he takes it every day to get to work. In summer he sometimes takes the bike and would like to use it more often. However, the cloth obligations in his job prevent him from riding the bike everyday. The households second car is used by his wife who shares it with the grandparents for daily tasks like grocery shopping.

Due to the lack of public transport, Erich feels fully dependent on their private cars. According to him, public transportation would not make much sense considering his way to work, since a bus for two kilometers would not pay off. For other dispatches, for instance in a nearby city, the current public transportation situation can be basically described as a single bus line. This does not provide enough flexibility for Erich, since he has to manage tight time planning for his farmwork and the additional office job. In his opinion, using the existing public transportation would be simply too cumbersome for their household. Erich and his family travel quite few for holidays. Sometimes they visit their daughter, who lives in Germany about one hour by car from Erich's home. In the rare occasion of any other trips, for example together with a group of people, Erich usually travels with a charter bus. Therefore, he almost exclusively uses his car for work and not for vacations. If there was a convenient public transportation solution to get to work like for instance a regular bus, Erich would definitely use it. This would possibly reduce the number of cars in the household to one. However, at the moment he can not imagine that any improvement in public transportation will happen. Erich likes driving with the car, because it is very convenient and easy to bring his things for work with him. Considering future wishes, he thinks about an electric car which could be powered by his own future photovoltaics system. He was already talking to his son about this idea and they would really appreciate faster development and progresses in the electric car field. Especially the invention of bigger cars like an electric pickup or something similar would be interesting for their farm.

Thinking about current problems on his daily routine, Erich mentions to feel stressed by his double work load from home and the office. Especially the time constraints which prevent him from finishing work at either home or office bother him. He really does not like to be threatened or stressed if some work could not have been done fast enough. Respective driving,

Erich names himself as non-standard since he always adapts to the current situation without complaining. What he does not like though are situations, where he is not able to adapt himself because of unforeseeable problems. This could be for instance a traffic jam when he is on his way to an important appointment. He also does not like it when the car does not work and he can not figure out the reason. The most important thing for Erich is, that he is aware of the situation and he can adapt himself to it.

> "... I have to adapt myself to the traffic situation. What I do not like is, for instance, when the car doesn't work and I don't know why. Because if I know it, I can say "Okay, it is like this" and I have to get it repaired or someone has to organize this and as long as no one is stressing me "Why haven't you finished with that?", it is okay. Then you simply have to do it. I have to adapt myself to the situation and it's the same concerning traffic. [12] (IP03, p. 3)

Erich says, that autonomous cars are currently definitely not interesting for him since they still have too many insecurities. He does not feel the urge to be driven around by something, because he manages on his own to get wherever he wants, without making himself dependent from any technology. For this reasons he mentions to definitely not be one of the first ones to try self-driving cars.

> "So the self-driving car is currently absolutely not interesting for me, because there are simply too many uncertainties. And I am generally, I have to say, I am like that. I do not need it for me, because I drive on my own and I manage on my own to get wherever I want to. And I do not want to make myself dependent from anyone or any technology. I want to remain a certain hold on it." [13] (IP03, p. 5)

Erich is not excited about being driven to work autonomously and the extra free time in the car because he does not have to accomplish any tasks on his short way from home to work anyway. He does not see any potential advantage or improvement for him or his household at all. One of his main concerns is the integration of still very unknown technology taking full control over the car. Furthermore he is concerned about who decides how the cars are programmed. According to Erich, decisions that influence the car's behavior have to be discussed in public. This facilitates finding a broad accepted solution which is universal for all companies and internationally valid. The same applies for the decision making process in lose-lose situations.

[12] "... ich muss mich auf die Verkehrssituation einstellen. Was ich nicht mag ist, wenn jetzt zum Beispiel irgendwie das Auto nicht geht, und ich weiß nicht warum. Weil wenn ich es weiß, dann sage ich "Okay, das ist so" und dann muss ich das reparieren lassen oder das machen oder dann muss jemand anderes das irgendwie organisieren oder machen und wenn mich dann nicht jemand anders unter Druck setzt oder nervt, "Warum bist du noch nicht fertig?", dann macht mir das nichts aus. Dann muss man das einfach machen. Ich muss mich darauf einstellen auf die Situation. Und das ist dann auch im Verkehr so." (IP03, p. 3)

[13] "Also das selbstfahrende Auto ist für mich derzeit absolut noch nicht das Thema, weil da einfach noch zu viele Unsicherheiten da sind. Und ich bin grundsätzlich, muss ich auch sagen, da bin ich auch so. Ich für mich brauche es nicht, denn ich fahre selber. Und ich schaue selber, dass ich dort hinkomme, wo ich möchte. Und ich möchte mich nicht ganz abhängig machen von irgendwem oder irgendeiner Technik. Sondern ich mag selber noch einen gewissen Einfluss haben darauf."(IP03, p. 5)

He describes a scenario where people would program their car only for their own advantage. Also companies might react in the same way and implement algorithms in order to privilege their own cars. Hence, these algorithms have to be implemented in the same way in every car and in every country. It is very important for Erich that a general agreement will be found in this field, otherwise he does not see any reason in further development of autonomous cars. Erich clearly expresses the need for independent organizations that control the development without being influenced by other stakeholders. There must not be any secrets leading to situations, in which only a single person or company knows how to resolve the problem. This kind of dependency is absolutely not acceptable for Erich. The independent controlling instance must not be payed by any company, but has to be financed by the government with public tax money. For potential necessary infrastructure and other costs related to the introduction of self-driving cars public tax money may be used too. Erich's biggest concern is the dependency from single persons or companies, making them unrulable in their decisions and behavior. In his opinion, technical progresses and advances in IT are already further advanced than people think, but society still lacks of necessary legal conditions and testing instances for the introduction. He definitely does not want people to be exposed to new technologies, without the mentioned necessary regulations. He pictures scenarios of people ending up stuck in a car or similar situations and nobody knows what to do. Despite these concerns, Erich thinks that the development of autonomous driving definitely has to continue as long as there are no secrets.

> "So the manufacturers still may, so every car may still work individually. But there have to, in general independent institutions must have access and have to know what is all behind it... there must be no secrets in the car..." [14] (IP03, p. 6)

At the moment, Erich would not drive in a driver-less car, because he feels that there is a lack of safety and experiences. He could possibly trust the car when he actually experiences that it is capable of driving completely alone. Then he wants the car to perform the driving task independently, but with the possibility to intervene in case of any problem. This intervention should be possible at any time, but not mandatory. Hence, the driver should not be obligated to permanently observe the traffic. At the moment, Erich would continue to watch the traffic while driving with the car due to his lack of trust but this might change over time. He can even imagine to let his grand children to be driven to school by an autonomous school bus. Although the driving task should be done autonomously, Erich still wants a mandatory driving license which might differ from current license standards. In his opinion, people will have to maintain basic knowledge and awareness on what is going on in the car. However, this does not apply to children. In his view, they are only provided with the car as a transport vehicle by some adult who takes the responsibility. Only these adults are allowed to launch the car and therefore have to pass a basic driving license. Drunk people may be driven home by self-driving cars in some kind of taxi mode without any intervention possibilities. In case of an

[14] "Also es ist so, die Hersteller die dürfen schon, also es kann schon genau noch individuell funktionieren jedes Auto als solches. Aber es muss, generell müssen unabhängige Stellen einen Zugriff haben bzw müssen wissen, was da dahinter ist... es darf nicht irgendein Geheimnis bei dem Auto sein..."(IP03, p. 6)

accident in this autonomous mode, Erich definitely sees the car to be liable. When the car is driven by an adult, the driver chooses between traveling in automatic or manual mode. This certainly affects the question of fault in case of an accident. In case of autonomous driving, the car has to take over full responsibility, whereas in manual mode the driver will be liable. In case of an accident caused by another car with an inattentive driver in autonomous mode, Erich would not be angry with the other driver, since they legally were not paying attention. As a consequence, insurance issues are related to the car manufacturer, since they have to know the capabilities of the car. In case of the manual mode, everyone will still be required to look for their own individual insurance.

Erich does not like the idea of personal data of him being collected, but he feels like he is not capable of changing anything of this fact. He would not prohibit data collection in general, but rather regulate car manufacturers to handle personal data carefully and responsibly and not only use them only for profit. If the data was used for optimization purposes, Erich could even imagine that it might be beneficial in some cases. He definitely does not want companies to pay for data collection, because this would cause money to become a main incentive to collect data and beneficial reasons might become less important.

> "No, because I decide it. He doesn't have to buy it [the data] from me, he gets it when I see a purpose in it for an improvement or enhancement." [15] (IP03, p. 20)

Erich would provide personal data like for instance the name of the person who started the car which might then be used for criminal persecution. In case of the taxi-mode, when the driverless car is transporting children, the owner of the car should be registered while collecting the data and not the actual person in the car. All the gathered data should be initially received by the independent controlling instance. Afterwards car manufacturers may request data for further development purposes. They will have to ask the personal owner of the car for data access and in case of a grant, the data is anonymized and then passed to the company. Also governmental institutions, which are in charge of traffic planning, may request data in the same way. Real-time data collection should only be possible if it is necessary for criminal persecution. In this case, the optional deactivation of data collecting is disabled in order to prevent the potential car theft from deactivating the data monitoring system.

Generally Erich seems to have an open minded attitude towards autonomous driving and is able to clearly express his viewpoint. He pictures different scenarios where autonomous cars provide automatic and manual modes and also thinks about according consequences considering liability. The only thing that really bothers Erich is a potential dependency from big companies because of a lack of regulatory counter measures of the government. If this issue will be handled by independent instances, Erich seems to have a quite structured view on a possible implementation of self-driving cars. There might be a taxi mode for children, elderly and drunk people and a manual mode if adults with a driving license want to take over

[15] "Nein, weil das entscheide ich. Der muss mir das nicht abkaufen sondern der bekommt es, wenn ich einen Sinn dahinter sehe für eine Verbesserung oder für eine Weiterentwicklung."(IP03, p. 20)

control. During his explanations Erich had a very clear opinion and got into considerably few contradictions, especially compared to other interviewees.

6.4 Case Study Josef (IP04)

Josef is 49 years old and works as a technical employee in an electrical engineering company in Germany next to the Austrian border. He is married and has two sons who are 14 and 17 years old and still go to school. In their household, they have two cars which are used by him and his wife. Additionally the older son has a moped for his way to school. Josef's car is a hybrid electric car which he uses almost everyday to drive about 5 km to work. During winter he takes his older son to the bus station. In summer, Josef would like to use the bike on his way to work more frequently, but since he needs his car for visiting customers during work, this is not always possible. Likewise, his wife uses the second car to drive to her work as well as during the cold season for taking the younger son to the same bus station, only half an hour later. During summer, the boys use their moped and bicycle to get to the bus station and then use the public school bus to get to school. Except for the school bus, the family does not use public transportation in their daily life, since there are no adequate possibilities, according to Josef. In their current mobility situation, the car represents an essential item fulfilling the families everyday transport demand. During weekends, they sometimes uses the train to go to Munich or Salzburg, mainly to visit events. In these cases, preference for the train is given based on cost reasons, since train companies offer cheap weekend specials for families. Grocery shopping and other tasks are still done by car for practical and convenience reasons.

Josef is a quite technology affine person, which can be observed by his usage of latest technological gadgets such as a new smartphone with latest applications as well as his hybrid car and two electrical bikes for him and his wife. One of the biggest problems in his daily routine is the lack of public charging stations for his car. In his opinion, under the current circumstances public charging of electrical cars is too complicated. He explained, that he has to apply for membership cards of different organizations providing public loading stations. This appears to be one of the most bothering things in Josef's current daily mobility situation. Considering the future, Josef is not expecting any improvement in terms of public transportation for his daily purposes. He is not even interested in this kind of development, since he prefers his car and the individual mobility that comes along with it. Josef would rather prefer an expansion of the electrical car infrastructure, especially in rural areas where he lives. According to his future vision, everyone will be using their own electrical car for daily trips like commuting to work, shopping and bringing the kids to school. In case of longer journeys to more remote destinations, car pool services should exist which offer conventional cars for rent. Josef would be even open to rely completely on vehicles from such a car service and therefore resign his own car, as long as there is no lack in individual mobility and flexibility. He mentions that the car does not state any additional status symbol whatsoever.

> "Well, so this is what I imagine for the future, what would be the optimum. Everyone has their electric car at home using it to drive their, so to say, regional kilometers electrical. When you need a car because you want to drive to further distances, then there should be a car pool at the place where you bought your car with which you could drive further. Which already exists. As far as I know VW already offers something like this. I think that would be the optimum." [16] (IP04, p. 3)

Speaking of automated cars, Josef is very skeptical about their feasibility in rural areas. He really doubts that these vehicles will be able to perform completely autonomous on the typical, often poor road conditions on the countryside. He could rather think of using autonomous driving on highways when going on vacations. In this case he would appreciate the comfort of not having to drive and he expect the journey to be more relaxed. Following his concerns on feasibility, Josef thinks that it might be easier if there are more self-driving cars on the street rather than only a couple of automated vehicles among a majority of conventional cars. They might communicate with each other which possibly facilitates interaction among traffic participants. Therefore, he suggests separate lanes on highways, which prevent normal cars interfering with the automated traffic. Interestingly he is not afraid, that autonomous cars might harm conventional ones by misbehavior or technical failures, but rather that manually driven cars could disturb the autonomous traffic system. In his opinion, only cars which are able to communicate with each other, should be allowed to join the autonomous driving system. When it comes to trust in this new technology, Josef maintains his rather skeptical view. After some time of testing and trying he might have enough trust to read books, watch movies or write Emails in an autonomous car, but he would still observe the road. Therefore, in the hypothetical case of self-driving cars being able to drive completely without any human influence, Josef might only consider minor design changes like a desk or more comfortable seats as valuable. He does not believe in full automation in all areas, especially not in rural regions and therefore the cars will have to maintain their ability to be driven in manual mode. This may limit the design of the car more or less to the status quo since a steering wheel, front seats, mirrors and so on will still be necessary. Josef could imagine some kind of combinational driving system, which is allowed to perform the driving task autonomously on highways and well prepared roads and switches to manual mode for other areas.

> "To be honest, on country roads I can not really imagine that this will work someday." [17] (IP04, p. 4)

A very important issue for Josef concerning autonomous cars is the legal aspect in case of an accident. He brings up the question how a car should behave in case of so-called lose-lose

[16] "Also ich stelle mir das für die Zukunft eigentlich so vor, das wäre halt das optimalste, dass jeder sein Elektroauto zu Hause hat und sozusagen die regionalen Kilometer elektrisch fährt. Wenn er ein Auto braucht weil man weiter fahren muss, dass dann das, wo er das Elektroauto gekauft hat, dass die dann einen Fuhrpark haben, wo man weiter fahren könnte. Was es schon gibt. VW bietet so etwas glaube ich schon an, soweit ich weiß, das wäre also ich fände das das Optimale." (IP04, p. 3)

[17] "Auf der Landstraße da kann ich mir das ehrlich gesagt noch nicht so richtig vorstellen, ob das irgendwann mal funktioniert." (IP04, p. 4)

situations, where the car had to decide on which persons will be involved in a potentially deadly car crash. In his opinion it is clear, that this decision is made by the programmer who developed the vehicle's software. Josef expects these decision algorithms to be configured in advance without any possibility of personal adjustments. The main reason is, that in case of an accident, he wants the car manufacturer to cover for all the consequences and to take over full responsibility. Josef is worried this concept could possibly be harmed if people would be able to adjust their car's algorithms. Although Josef does not want to configure his car's behavior in these situations, he definitely wants to know how the car would react. He demands full transparency of the implemented algorithms and their decision making processes. His main concern is, that manufacturers could secretly configure the cars for their own advantage without people knowing. Since Josef sees car manufacturers to be fully liable in case of any upcoming issues in case of an accident, they should also be in charge to care about potential insurances for the car. Josef's baseline is, that the car should be able take full control over all driving tasks, without the need of human interference in order to guarantee the driver's innocence in case of an accident. This leads to Josef's fictional assumption, that the human driver is not obliged to watch the road while driving an autonomous car. As a further consequence, also drunk people may be driven by automated cars. However, only under the premise, that possible intervention of the driver in the driving process can be retraced for later investigation in case of any problem. Although the car is able to drive fully automatic, Josef still favors an obligatory driving license. People should be aware of ongoings and able to react accordingly in case of any unexpected scenario. Therefore it should not be possible to let children be driven by autonomous cars on their own and the same applies for elderly persons. Josef demands at least on person with a driving license, that is aware of the driving to be present in the car. This contradicts his statement of drunk people being allowed to let themselves be driven alone, because they might not be aware of all ongoings in the car or even fall asleep.

> "So for me it would probably be most convenient if the car was programmed in a way that I am not guilty when something happens." [18] (IP04, p. 7)

> "No, so I think in case of an emergency you need a driving license. There has to be someone who knows how this works, how the machine works and there might be always an emergency." [19] (IP04, p. 10)

Although he is skeptical about the full automation of cars, Josef sees significant advantages that might come along with them. Primary benefits may be fewer traffic jams, a decreased number of accidents and risky maneuvers, as well as more relaxed driving on highways and a more meaningful use of time. Therefore, any additional costs for supplementary infrastructure should be beared by the same financial means as they are used for conventional traffic infrastructure. In his opinion there is no issue concerning unfairness between autonomous

[18] "Also, für mich wäre es wahrscheinlich am angenehmsten, wenn da in diesem Fall das im Auto konfiguriert ist, sodass ich nicht schuld bin wenn so etwas passiert." (IP04, p. 7)

[19] "Nein also ich glaube im Notfall braucht man einen Führerschein glaube ich. Da muss man sich einfach auskennen wie das funktioniert also die Maschine und es gibt immer einen Notfall." (IP04, p. 10)

and conventional car users in this matter. If self-driving cars improve overall traffic safety and convenience, every participant should pay for it whether they drive an autonomous car or not. In case of any extra costs for possible upgrades of conventional cars in order to join the autonomous traffic, Josef wants these costs to be payed by the government.

Giving the permission to gather data of his car, Josef would make this decision subject to which kind of data might be collected. Basically, he imagines data collection to be regulated by the same privacy laws and restrictions as they are applied for mobile phones or online shopping. How it is implemented in these cases is not explained by him in any further detail. It seems as if he just mentioned familiar technologies for which privacy issues have been already considered. In general Josef is not much of a friend of private data gathering. It may be implemented in an optional manner but definitely not mandatory and not in real-time. Neither potential financial rewards such as gasoline coupons or car discounts may not convince him to agree on real-time private data gathering. Although he personally most probably won't allow it, optional data gathering might be possible for car manufacturer and traffic planners for statistical purposes. In reward, he rather expects visible recompenses like actual coupons than any discounts on the car. He points out that car discounts won't be retraceable afterwards and that cars might have had the lower price anyway. At this point it can be noticed, that Josef shows a fundamental distrust in car manufacturers and the way they may perform their business. Despite his initial denial of any private data collection, Josef in the end acknowledged, that data may be used even for advertisement if people get rewarded for it. When it comes to criminal prosecution, Josef believes that the police can be trusted and therefore the gathering of data for the purpose of law enforcement should be possible. For this case he even considers options to prevent a potential thief from deactivating data recording.

Josef is very interested in new technologies and open for changes but due to his technical background he is skeptical about the feasibility of many things. He considers autonomous driving rather as further improvement of existing assistance systems than something completely new. Therefore he can not imagine vast changes in the way he will be traveling and would rather prefer advances that facilitate the use of electric cars. Furthermore Josef maintains a basic distrust against car manufacturers and big companies and their business processes in general. This can be observed in his statements on the question of liability, worrying car manufacturers possibly manipulate cars for their own advantages. Also his concerns on fake discounts in exchange for data gathering show his negative attitude against these companies. In summary one can say, that Josef would appreciate autonomous cars to be introduced in a regulated and controlled way. However, because of feasibility issues he has fundamental concerns about the grade of automation that can actually be implemented, especially in rural areas.

6.5 Case Study Felix (IP05)

Felix is 72 years old and retired. He used to be a farmer and still lives in his old household at the farm. He uses his car for every trip of his daily life. When he travels to cities like Vienna, he prefers to drive by car because he is used to it and does not have to worry about the subway and tickets. The main problem is, that public transportation appears too complicated to him

and if there is no conductor who could help him, he does not dare to travel alone. On the other hand, for more distant journeys enjoying non-German-speaking countries, Felix chooses organized bus trips over the car. He likes enjoying the view and getting to know new people during these trips and appreciates not having to worry about anything concerning his trip. When he drives to various events with his musician group, Felix and his friends usually share a car if the destination is more than 10km away. This is primarily done for financial reasons, since they are sharing the money for fuel, carpooling is a more sufficient way of driving.

Felix is a very humble person and appears to be satisfied with his car. The only thing he would like to have is an automatic passing light regulation. Other gadgets such as a seat heating are not necessary for him. He is rather annoyed by political discussions on traffic, unnecessary regulations and unsatisfiable infrastructure conditions. He prefers a toll system like there is in Austria, where you buy one toll ticket and there is no need to pay additional fees for every single street. Tolls in Switzerland are too expensive and he also dislikes how the system is implemented in Italy. In the debate about introducing a toll for German highways he would agree, but only if Germans had to pay it as well. Felix considers regulations on exhaust gases of his Diesel car engine. In his opinion, they should be more strict with gasoline engines too, since they also produce particulates. Moreover he does not like how streets are planned on the countryside being too narrow and including lots of curves. He finds it often difficult to drive past a truck. While driving with his tractor he would need more space in many situations too. Generally, Felix feels like politicians are denunciating car drivers too much with too many regulations and fees and too little work in favor of cars. According to his opinion the reason for this inadequate design is those being in charge of passing a law live in urban areas like Vienna and use the subway.

Concerning autonomous cars, Felix has already heard of autonomous trucks, self-driving city traffic and also legal issues. At the moment he would not trust this new technology, but he can imagine that this might change over time. Felix gives very contradicting answers considering his attitude towards autonomous driving. On the one hand, Felix considers an autonomous car ride to have similar characteristics to a bus trip, and therefore concludes that he would neither be in favor nor against their introduction. On the other hand, he is sure that autonomous cars will be introduced in near future and states being in favor of this technical revolution. Although he is worried about the loss of many people loosing their jobs in affected areas, in his opinion those countries, who miss to keep up with modern technological advances, will eventually lag behind over time. This shows even though Felix has already heard many different things about self-driving cars, he has not yet been able to form a coherent opinion on it leading to contradictory statements. However, Felix clearly expresses the joy he is experiencing while driving. He really seems to enjoy manual driving and can not imagine any valuable additional convenience gaining by self-driving cars.

> "Thus, i am still able to think, I have something to think about, I have to change gears (laughs)." [20] (IP05, p. 7)

[20] "Weil da kann ich noch denken da habe ich was zum Denken, da habe ich was zum Schalten (lacht)." (IP05, p. 7)

> "Yes, it is important for me to do this on my own. You have the gas and this and that, its simply... (euphoric)" [21] (IP05, p. 7)

> "... the joy itself. The joy of driving. Gas and changing gears. You feel alive." [22] (IP05, p. 7)

Felix really enjoys driving, including all the necessary manual tasks. In his opinion they are part of the experience and without them, it would be boring. He compared it to working on the farm at home.

> "It would be the same like while I'm working. As if i stood in the field the whole time, i would get back pain. And time would go by really slowly as well. But if I do something, time flies by." [23] (IP05, p. 7)

Consequently, Felix would not appreciate the possibility to relax or sleep during a journey and would definitely not pay extra money for this. He may not have any issues concerning the trust in self-driving cars, but he simply likes manual driving. Hypothetically, if he had an autonomous car, he would behave as during a bus trip, enjoying the view or sleeping a little bit. He can not imagine working or playing in the car, because he might feel sick afterwards. He does not expect autonomous technology to lead to any changes in the car's design. Since Felix would completely trust autonomous cars, if they are able to operate fully automatically, there is no need for any further human traffic observation anymore. Hence, sleeping should be allowed as well and in case of an accident, the car should take over full responsibility. However, Felix does not want drunk people to be allowed using self-driving cars, because they might be a danger to others. He pictures a scenario where someone may leave the car on the road and harm others. Felix heard, that children born today will be the first generation who will not have to make a driving license anymore and he also thinks, that it should be allowed to use an autonomous car without any license. However, he is skeptical whether children should be driven by a driver-less car. He would prefer regulations that prohibit them from driving alone.

Similar to his joy while driving manually, Felix also likes to have his own car, not sharing it with someone else or using a car pool. He would not want his neighbor driving his car and maybe causing a scratch. Felix expresses a strong sympathy for manual driving and is clearly attached to his own private car. Nevertheless, he recognizes potential advantages of self-driving cars. They could be beneficial for older people not being able to drive on their own anymore. In this case, Felix would spend a considerable amount of extra money for a self-driving car in order to maintain his individual mobility. He would even consider subsidization of autonomous cars for people in need. He argues, that electric cars are already subsidized and therefore autonomous cars should be made available for less wealthy persons as well. Furthermore, potential necessary additional infrastructure should be at least partly payed from public

[21] "Ja, das ist mir wichtig, dass ich da selber das. Naja, da hast du das Gas und das, das ist, das ist einfach... (euphorisch)" (IP05, p. 7)

[22] "... die Freude selber. Die Freude am Fahren. Gas und schalten. Man lebt halt auf." (IP05, p. 7)

[23] "Das wäre das gleiche wenn ich arbeite. Dann kann ich die ganze Zeit in der Wiese stehen, da bekomme ich Rückenschmerzen. Und das wird auch lange dauern bis die Stunden vorbeigehen. Und jetzt mache ich etwas und dann geht es vorbei." (IP05, p. 7)

budget as well as additional charges on self-driving cars. Concerning insurances, Felix would prefer one whole insurance for everyone, resulting in fewer arguments in case of an accident. Since he won't have any influence on the driving process, the car should take over full power to make decisions in the event of a crash and insurances should take care of arising payments afterwards.

> "Maybe the government could pay compensation because otherwise the whole highway, so in bad times it would have to pay something, but also those who buy this car will have to pay." [24] (IP05, p. 14)

If autonomous cars are capable of performing the driving task on their own, they should be allowed to drive everywhere, where conventional cars do, without any separation. However, provided that cars are fully developed and technically-mature, being able to handle even difficult situations. If, for instance, the autonomous car comes across another vehicle on a narrow road, Felix expects the self-driving car to drive off the lane to the side verge allowing them to drive by. He is afraid that automated cars might rather provoke difficult situations since they strictly act according to their configuration and are unable to adjust to given circumstances like humans are.

Felix considers the possibility of personal adjustments to the car's algorithms rather skeptical because this might lead to people being partly liable in case of an accident. Since car manufacturers could also adjust the algorithm for their own benefits them being in charge of developing the software is not an option either. Therefore, Felix suggests an overall solution designed by the government, but also this approach could lead to a problem. He describes a scenario, where the algorithm and therefore the car's behavior is publicly known. This knowledge could be used by criminals. They might jump in front of a car, causing it to leave the road, because they know it is programmed to do so. This could state a fundamental problem of autonomous car's safety which marks an open issue in current research.

Basically Felix does not care a lot about data collection while he is driving an autonomous car, but if they do so, they have to observe everyone. If data collection is implemented, Felix wants it to be mandatory and therefore facilitating the prosecution of criminals by the police. Also car manufacturers or traffic planners should be able to use collected data for optimization purposes without any payment. However, data collection for the purpose of quality control should not be mandatory and also anonymized since personal and real-time data should be only available for police. Companies should definitely not be able to use the data for advertisement and marketing, regardless of the payment.

[24] "Vielleicht zahlt der Staat auch etwas drauf, also wenn ja sonst schon die ganze Autobahn und in schlechten Zeiten müsste er da schon auch dazu zahlen, aber auch die die das Auto kaufen müssen da mitzahlen." (IP05, p. 14)

> "Basically I don't care. On the one hand they don't need to do it, but if it comes, they have to do it with everyone. Then I don't care. When it is like this, the car has it, there's a trip recorder and records exactly where it is, then they should also know who the person is. They may know this, but then they also have to know this information about thieves." [25] (IP05, p. 18)

Felix is a very enthusiastic car driver and really enjoys driving his car. Therefore he would never consider an autonomous car for safety or convenience reasons. However, the importance of his individual mobility makes him think of potential benefits of self-driving cars when he won't be able to drive anymore. Hence, he clearly favors subsidization in order to make these cars affordable for everyone in need of them. Interestingly, although Felix is a big fan of having manual control over his car, he does not have any trust issues whatsoever when handing over control to a machine. Once implemented, he seems to have full trust in this new technology. Furthermore, he would be definitely open for necessary changes to existing regulations considering the liability and insurances of cars. Although he gave several contradicting statements concerning his attitude towards autonomous driving, he managed to express a clear viewpoint. One would finally get the impression, that he is definitely not awaiting self-driving cars at the moment but would later appreciate them when he might need them.

6.6 Case Study Christian (IP06)

Christian is a 23 years old student who lives with his mother and four siblings together in a household. Except for his younger sister every family member has their own car. His sister is too young for the driving license and therefore has a moped. In winter, when the weather is bad, she is driven to the bus station by car to get to school and in summer she drives on her own with her moped. Christian has to drive about 10 km to the next train station and then takes the train to Salzburg where he studies. When it is possible, he shares the car with a study colleague who picks him up and they drive to Salzburg together. He mainly does this for environmental reasons and because it is less boring if you drive together with a colleague. Furthermore it is cheaper than traveling separately. When he goes by train, it usually takes 1,5 hours for one direction, whereas by car it would be only half an hour. Nevertheless he still prefers the train, because he has time to do some work for his studies and it is more environmentally friendly. When it comes to vacations and traveling, Christian usually takes the car, because it is more flexible. In this case, the flexibility of a car outperforms Christian's environmental concerns.

> "Yes indeed, you want to be more flexible then, I would say. You would rather take the car then [for vacations]." [26] (IP06, p. 2)

[25] "Im Prinzip ist das egal. Einerseits brauchen die das nicht, aber wenn es kommt dann müssten sie das bei jedem tun. Dann ist es mir egal. Wenn das so ist, das Auto hat das, da ist der Fahrtenschreiber und das zeichnet genau auf, wo es ist, dann sollen sie auch wissen wer das ist. Das können sie wissen von mir aus, aber dann müssen sie es von Banditen auch wissen." (IP05, p. 18)

[26] "Ja schon, da mag man dann schon flexibler sein sage ich mal so. Da fährt man dann schon eher mit dem Auto." (IP06, p. 2)

> "Because of flexibility. Definitely." [27] (IP06, p. 2)

For his daily business, the train is a reliable and well-known option, but he does not like the organizational part when he has to look up trains to go on vacations. If public transportation to holiday destinations was as easy as to get to university, he would definitely use it.

> "When you drive to school or university, then everything is always the same, but when you go on vacations you have to look up when and where the train leaves and so on. So it is also convenience I would say." [28] (IP06, p. 3)

Christian does not like icy roads or when there is a traffic jam, but those are minor issues for him on his daily rides. What really annoys him is, when the train is late for whatever reason and people start complaining to the conductor. He feels sorry for the train staff, because it is not their fault that the train is late. When driving in the city, Christian does not like the rude driving style of others and mentions how he is experiencing, that this is affecting his own way of driving too.

> "This is a bit stressing and you also notice, that you become the same." [29] (IP06, p. 3)

Furthermore Christian complains, that cyclists in the city are often driving too arrogant and they basically drive wherever they want to. Another annoying issue is the parking situation in Salzburg. The parking lots are either expensive or far off from his university. This is another reason why Christian prefers to go to Salzburg by train and take the bus afterwards. It can be said, that Christian does not complain about any things related to manual driving but rather external factors that influence the way he experiences driving. These can be for instance road conditions or other traffic participants. Christian does not consider his long way to Salzburg, including all the stops in between, as a problem. He says that the frequency of the stops does not bother him, because others may also get on and off the train. Concerning car driving Christian does not have any wishes. He likes to drive in the car, listen to music and relax. This has definitely an appeasing aspect for him. However, he does not refer to the actual manual driving task, but rather to the situation of being alone in his car without other distractions. This joy might be interrupted when he has to drive in unknown areas or if something unforeseen occurs. Since the joy of driving is related to situation of being in a car, but not specifically his car, he does not feel any importance to have his own private car. Therefore, car pooling services would also be an option for him if the necessary availability could be provided.

During English class in the technical high school Christian heard about autonomous driving the first time. He is not sure yet if this new technology is able to work out smoothly. He rather suspects these cars to be error-prone and might be hacked by criminals causing vast damages.

[27] "Wegen der Flexibilität. Auf alle Fälle." (IP06, p. 2)

[28] "Wenn du in die Schule oder zum Studium halt fährst, dann ist das immer gleich. Und wenn du jetzt in den Urlaub fährst, dann musst du wieder schauen, wie geht da der Zug und so weiter. Also das ist schon Bequemlichkeit auch sage ich mal." (IP06, p. 3)

[29] "Das stresst dann ein bisschen und man merkt auch selber, dass man selber dann irgendwie so wird." (IP06, p. 3)

> "I don't know if that all can work that flawlessly. I do think that this is error-prone and you can definitely hack this and cause vast damages." [30] (IP06, p. 6)

Christian definitely has concerns, that hackers might take control over the system and cause catastrophic scenarios by paralyzing the whole traffic in an area. He is not in favor of the introduction of self-driving cars, because he would not feel save and also doubts that society would accept these vehicles. An interesting situation occurred, when Christian was confronted with the question why he would not trust a technical system the same as he trusts a human taxi driver. Christian started realizing, that he also gives away control when sitting in a taxi. He further concluded, that a machine might be even more trustworthy than a person and realized, that his statements are contradicting each other. Nevertheless he still feels uncomfortable about the idea of a machine controlling the car. If manual driving was completely banned, Christian would therefore miss the control while driving, but not the actual driving task.

> "Of course it makes a difference, the machine is maybe less error-prone. In some way I am contradicting with myself right now (laughs). But I think it's somehow scary, that a machine controls that." [31] (IP06, p. 6)

After some time, when self-driving cars were well-tried successfully, Christian might also trust them. However, he has to try them on his own and does not believe in what people are telling him. An important aspect in order to increase his trust is the possibility to manually interfere in the driving process. This should be possible at all time in order to be able to prevent dangerous situations, but not necessarily mandatory. In case of an accident, Christian expects the car to have an insurance which is based on the vehicle's autonomous driving capabilities and therefore sees the car to be liable. However, if another automatic car causes an accident and the other driver was sleeping, Christian would be mad at him anyway. These specific situations make Christian very skeptic if self-driving cars will be introduced in the next 30 to 40 years. He would rather expect them in possibly 100 years. Christian's answers show, that he can not yet imagine a change in liability, handing over full control and the according responsibility to the car. His emotional feelings would still make him blame the other driver as well. Christian also sees opportunities in this new technology for instance for driving beginners or retired people, which both might not be considered as safe drivers. Autonomous cars could help younger persons with the problem of getting to school or work. He also thinks, that overall safety may improve due to less accidents. Because of his lack of trust in this technology, Christian can not imagine to sleep in an autonomous car and he does net want other driver to be allowed to sleep either. The same applies for drunk people and children. He would not even consider a secure driving mode approach for children and drunk people, without the possibility of any interference. He just does not like the idea of giving away full control to the vehicle. However,

[30] "Ich weiß nicht ob das alles so einwandfrei funktionieren kann. Ich glaube schon, dass das fehleranfällig ist und natürlich kann man da auch rein hacken in das Ganze und dann einen riesen Schaden verursachen." (IP06, p. 6)

[31] "Ja sicher macht das einen Unterschied, also die Maschine ist vielleicht nicht so fehleranfällig. Irgendwie widerspricht sich das ganze jetzt gerade (lacht). Also ich finde das schon irgendwie arg, wenn das eine Maschine steuert." (IP06, p. 6)

after evaluating all advantages and disadvantages, Christian might allow autonomous cars to drive empty, without any human interference. Christian again contradicts himself because of emotional feelings that can not be rationally explained. An empty self-driving car apparently appears less harmful to him than one with children.

> "This is hard to answer. Of course it would be an advantage if the car was able to drive back empty or drive elsewhere. This would be a huge advantage." [32] (IP06, p. 16)

Despite his rather low trust in self-driving vehicles, Christian considers to possibly lower the requirements for a driving license for younger people. They might be allowed to drive with an autonomous car already with 15 years as they are currently allowed to ride a moped. He further expects drivers to be obligated to do mandatory driving practice lessons every 3-4 years in order to maintain their driving abilities in case of necessary manual driving. In a fault scenario, where the car does not work in autonomous mode anymore, also 15 years old should be able and allowed to drive their car manually. A warning light should signal others, that this car is not operated in automatic mode. The mandatory driving practice lessons also apply for elderly people, along with regular health checks. This might result in even stricter conditions for old people and therefore would not improve their situation compared to the status quo. Nevertheless Christian insists, that these checks are necessary. Therefore, he withdraws his original statement and concludes, that self-driving cars might not improve the mobility situation of elderly people. This is another situation where Christian got into a contradiction in his explanations. It seems as if he had not yet fully made up his mind on various aspects of autonomous driving and therefore is not able to express a coherent view.

Although Christian is skeptical about autonomous cars, he does not feel the need to build separate lanes for them. He would assume the cars to be constructed in an according way, being capable to participate in the conventional traffic.

> "I would plan it to let them drive in my lane, because I think they will of course be constructed in a way that makes them capable of doing this." [33] (IP06, p. 11)

According to Christian, potential additional costs for infrastructure or organizational purposes, should be at least partly payed by tax money. He does not think that car buyers will be able to take over all costs and also does not believe that manufacturers will do so. He rather thinks that society has to move on and therefore favors the use of public money. It is interesting that he favors a public financing approach even though he maintains a skeptical attitude towards autonomous driving.

[32] "Das ist schwierig zu beantworten. Weil natürlich wäre das ein Vorteil, wenn das wieder leer zurückfährt oder irgendwo hinfährt. Das wäre ein Riesenvorteil." (IP06, p. 16)

[33] "Ich würde das schon so machen dass die in meiner Spur fahren dürfen, weil die werden ja natürlich so gebaut, glaube ich, dass die das können." (IP06, p. 11)

> "Yes, I have the opinion, that you have to keep up with the times. Yes, I do think, that the ministry for traffic has the right to facilitate this. Yes I do." [34] (IP06, p. 12)

But Christian does not expect the government to take over the full costs, since this would be too much. As a consequence, he thinks that in the beginning, this new technology will be tested only in cities, before it will be introduced all over the country. This might reduce the initial costs since the necessary infrastructure may only be implemented in parts of the traffic system. He is not sure about who may take over the additional costs for further extension, but he would accept it if public money was used for this purpose too.

For Christian the situation of driving in an autonomous car is more or less comparable to be sitting in a train. He would talk with other passengers, play cards or watch a movie. Therefore the design might change a little bit towards the facilities of passenger trains including a small table an turnable front seats to be able to eat together. Christian would appreciate the possibility, that the co-driver might also take over control in case of need for human interference. Although everyone has their fixed seat in the vehicle, Christian imagines a concept, where different persons can inherit the role of the driver on demand. He pictures a scenario where the current driver is eating with the family and has not yet finished. In this case, another person with a driving license might take over control if it is necessary.

Christian thinks, that people are instinctively looking for their own safety in critical situations. Hence, he would see a problem in the possibility to personally adjust the car's decision making algorithm. In his opinion, this adjustments should be done by special research groups and regulated by according laws. People should be informed on the implemented decision making processes, but not able to change them. Furthermore, it has to be guaranteed, that the same system is implemented in every car no matter of their age or other differences. This should prevent manipulation and ensure, that every vehicle behaves the same.

Data collection may be very useful in order to know where the vehicles of a car pool service are currently located or driving. When it comes to private vehicles, Christian does not consider this as necessary and would prefer an optional approach. Moreover, the data should be transmitted only once a day or a week and not in real-time. In order to be able to fight crime, police should be allowed to get access to the data but again not in real-time. Car manufacturers should be given only statistical data concerning mileage, without any personal relation and the same applies for traffic planning. Christian would give away data to the mentioned institutions without payment if they use it for the mentioned reasonable purposes. Although he could imagine other people to sell their data for advertisement, he would not do so.

It seems as if Christian heard about autonomous cars but has not yet fully made up his mind about this topic. It is difficult for him to express his opinion about who will be allowed to drive under which circumstances and it is even harder for him to see potential consequences. This results in a couple of contradicting explanations where Christian expresses for instance the well known advantage of elderly people being able to drive, but then demands health checks

[34] "Ja, da bin ich schon auch der Meinung, dass man da ein bisschen mit dir Zeit gehen muss. Ja, das glaube ich schon. Also dass das Ministerium da schon das Recht dazu hat, dass es das fördert. Ja." (IP06, p. 12)

and driving lessons for these people. He generally appears to be open for this new technology and expresses his opinion that society has to advance and develop. But on the other hand he can not yet imagine all the potentially necessary changes in trust and liability to achieve this progress.

6.7 Case Study Alexandra (IP07)

Alexandra is 46 years old and lives together with her husband and her two sons. She and her husband have two cars and the older son also has his own vehicle. Usually the older son takes the younger one to school about 3 km before driving further to his own school, which is about 20 km away. Alexandra and her husband work together and have their office about 50 km from their house. Although they work in the same office they drive with two separate cars. Sometimes they manage to drive together, but the main reason for the separate cars is, that her husband often has to leave the office to drive to customers and therefore Alexandra needs a possibility to get home on her own. Therefore she needs her own car because the way home would not be possible by public transport. Alexandra explains, that if she wanted to drive to work by public transport, she would have to take several different buses and trains, which do not provide satisfying connections and timetables. This would lead to about three to four hours of traveling to get to work each direction compared to about 45 minutes by car. This is a very interesting situation. Although Alexandra and her husband work at the same place in a rather distant place, work and public transportation related circumstances do not allow them to share one car together. This clearly shows how mobility circumstances in rural areas often generate an essential need for an individual car.

Alexandra is also very unsatisfied with the public transportation connection to his younger son's school. There is a school bus in the morning which leaves very late so the children are arriving late for school and afterwards it does not bring the kids back home. Alexandra already complained at the bus company and also at the school administration but without success. Because of the truck traffic on the way to school, Alexandra does not want her son to ride by bike either and therefore prefers to bring and pick him up by car. The school bus of the other son was not sufficient either according to Alexandra. Before her son had his own car he sometimes had to wait almost an hour for the bus. Furthermore, the closest bus stop was still about 3 km away from their home so she had to pick him up anyway. The school bus situation of her kids really seems to anger Alexandra and she gets quite upset when speaking about this topic. For other daily tasks as grocery shopping, Alexandra does not consider public transportation as an alternative to her private car either. Although there is a city bus lane operating in a close town where she usually does her shopping, the closest station would still be about 3 km away which is too far to carry the shopping bags by bike.

When the family goes on vacations, they use the car as well. They usually drive to Croatia and despite the fact, that the additional toll is a little bit annoying, they are very happy with the route. They do not even consider other travel alternatives since they are very happy with traveling by car. Alexandra does not have any transport wishes and definitely prefers her car because of its flexibility. However, if there was a cheap and satisfying public transportation

solution, she might make use of it and decrease her car usage. She would even consider to forgo her own private car and use a car pool service instead, if the necessary availability was provided. Additionally Alexandra would appreciate a public shuttle bus which can be called within her hometown. She heard about a similar approach from the neighbor town where you can call a bus which picks you up and drives you around the township. She considers this to be a good alternative to her private car for small trips for instance to visit someone or go to the doctor.

> "No. If I do not own it and I do not have it, then it's not mine. And I would not have any problem with that as long as it flexibly brings me from A to B." [35] (IP07, p. 5)

Alexandra is not very excited about autonomous driving, because she likes to have control over her car. She would definitely not use one of these cars at the moment, but this may change as soon as others drive with them and she can be sure that it is safe. She would possibly try it out, but only given the possibility to take over control at any time. She does not see a lack of trust as the reason, but rather the fact that this technology is not yet well-tried and society is not ready for it. She can not imagine to be able to use the spent time in the car for other things like eating. Furthermore she does not think that self-driving cars would make her car rides anyhow more relaxed either, because the only tasks she might be able to do are work related. Since she does not feel the urgency to do other tasks while driving, she would rather enjoy the view and imagines the ride as if she was a passenger in a normal car. Hence she does not expect any big changes in the car's design and imagines it to look more or less the same as now.

> "I don't know if this will be such a relief in order to have more time to do other things. When you don't have anything to do, you usually do something work-related. Therefore I honestly can't imagine that this would be relaxing. And what I've already seen like eating Spaghetti and things like that, I couldn't imagine doing this. Currently I enjoy my time on my own while driving. I don't want to be able to do hundreds of thousands of other things just because I have the time to do so." [36] (IP07, p. 7)

Considering liability and interference in the context of autonomous cars, Alexandra has very contradicting views. In her opinion one should always be able to manually interfere the driving process, but does not have to do so. However, in case of an accident she believes that "a thing" can not be blamed for anything and therefore the car can not be liable. Furthermore she thinks that a car can not take the decision who gets involved in an accident in a critical situation. These considerations lead to the change in her mind, that the driver remains responsible for

[35] "Nein, also wenn es mir nicht gehört und ich es nicht habe, dann ist es eh nicht meins. Und da hätte ich auch kein Problem damit, solange es mich flexibel von A nach B bringt." (IP07, p. 5)

[36] "Ich weiß nicht ob das so eine Erleichterung ist, dass man noch mehr Zeit für andere Dinge nebenbei hat. Was tut man, wenn man nichts zu tun hat, tut man irgendetwas anderes und das hängt meistens dann mit der Arbeit zusammen. Also entspannend kann ich mir das nicht vorstellen, muss ich ganz ehrlich sagen. Und was ich da schon gesehen habe, Spaghetti essen oder sonst irgendetwas, das könnte ich mir nicht vorstellen. Momentan, habe ich, genieße ich die Zeit selber beim Autofahren. Ich will nicht da hunderttausend andere Sachen, nur weil ich jetzt Zeit habe, tun können." (IP07, p. 7)

the car and therefore has to interfere. This clearly contradicts with her first statement that interference should not be mandatory.

> "..., I do want to interfere. And as with everything else, if I did not interfere, then eit's also my error. Well, my error. I am to blame." [37] (IP07, p. 8)

Although the human driver will be obligated to observe the ongoing traffic and take according actions, sleeping in the car or doing other things should not necessarily be prohibited. It is one's own decision to make use of the autonomous features or not. Hence, there will still be the need for personal insurances as well as an additional car insurance. Moreover, Alexandra does not see the need for a driving license anymore. These statements are very contradicting to each other and it is difficult to understand her view. The baseline is, that she sees the human driver to be responsible for the car, but they should be allowed to do whatever they want in the car and do not need a driving license. Alexandra does not seem to have trust issues but rather expresses fundamental concerns about autonomous cars because they may cause people to stop thinking. She is afraid of a scenario where machines take over every single task in people's lives and humans forget how to actually live their lives on their own.

> "I think thats a shame in general that you do not have to wonder about anything anymore. That's a shame." [38] (IP07, p. 9)

> "Humans do still have to use their mind, otherwise we do not need humans anymore. Then we will be robots and do not do anything on our own anymore. Because we do not have to think or plan or control anything anymore. What are you still doing then? Why do humans still exist then?" [39] (IP07, p. 17)

Despite her concerns, Alexandra also sees potential advantages in self-driving cars, especially for elderly people. They may be allowed to use an autonomous car even if they are not able to fully perform the driving task on their own. In this scenario, Alexandra also thinks about herself when she will be older and about her parents. This technology might help her to maintain her individual mobility when she is older.

Although she could never imagine to use an automatic car to go on vacations, she might make use of them for short distance trips in the township. She could imagine an autonomous bus service, that traverses through the township and can be used by anybody. The bus may transport children and elderly people and is even allowed to drive empty, without any drivers. In case of an accident, it would the bus' fault. Again this is a very interesting viewpoint of Alexandra. If there is a person in the car which is capable of performing the driving task, it is

[37] "..., nein ich möchte schon eingreifen können. Und wie bei allem anderen, wenn ich nicht eingegriffen habe, dann ist es auch wieder mein Fehler. Naja mein Fehler. Meine Schuld." (IP07, p. 8)

[38] "Nein ich finde es schade allgemein dass man sich keine Gedanken nicht mehr machen muss. Das finde ich schade." (IP07, p. 9)

[39] "Der Mensch muss schon auch immer noch seinen Verstand nutzen, weil sonst brauchen wir auch keine Menschen mehr. Dann sind wir Roboter und tun nichts mehr selber. Weil wenn wir gar nichts mehr denken müssen oder planen oder sonst irgendetwas oder kontrollieren, was tust du denn dann noch? Wozu ist denn dann der Mensch noch da?" (IP07, p. 17)

mandatory for this person to observe the traffic and interfere accordingly. On the other hand, if it is an autonomous school bus or traffic service for elderly people which are not able to drive, then the bus has to take over full responsibility. In this case it should not be possible to manually interfere the automatic driving process. It seems as if Alexandra does not have a lack of trust in autonomous cars that would prevent her from using it, but she is rather concerned about the consequences to the human mind because of this disruptive change. It does not feel right to her to blame a car for an accident if there was an adult person in the car who could have interfered and maybe prevented the crash. Since Alexandra does not have any issues concerning trust in autonomous cars, she wants them to be introduced in public on normal roads. There would be no need to put them on specific lanes, separating them from the conventional traffic.

> "I think I would not really care about that. If they act like I am acting with my normal car, why not? Then it can be mixed too." [40] (IP07, p. 11)

Alexandra says, that potential additional costs for infrastructure should be paid with tax money. If the money will be only used to facilitate the integration of self-driving cars, it is okay, even if not everyone is using autonomous cars. Furthermore, she would also consider subsidization in special cases for elderly people or others in need in order to make autonomous mobility available to everyone. This does not mean, that everybody should have their personal self-driving car, but they should at least have access to autonomous mobility.

When autonomous cars are collecting data, Alexandra does not see any problem in it. They may be allowed to gather all kinds of data and use it for whatever reason including traffic planning, car optimization and criminal persecution. The only thing that would annoy her and should therefore be banned is using the data for advertisement.

Alexandra has a very interesting attitude towards autonomous driving. She is not concerned about the technical feasibility and would allow everyone to do what they want in these cars. Also data collection and privacy as well as potential surveillance does not bother her at all. The only thing she is very concerned about is the fact, that humans may get more and more narrow minded by technology. Alexandra is afraid that humans may become slaves of their own technology and forget how to use their own mind. Hence, she strictly demands, that human interference should remain mandatory if possible and human drivers will still have to take responsibility for their cars. Critical decisions and the responsibility for their consequences should not be taken over be machines.

6.8 Case Study Eva (IP08)

Eva is 39 years old and lives in a household together with her partner. She is working in an office about 65km away from her home and she usually takes her car to get there. Her partner works about 6 km away and often takes the bike, but in winter he also uses his car. He sometimes drives home during lunch time to care for the dog which stays in the house and

[40] "Ja, das wäre mir glaube ich mehr oder weniger egal. Wenn sich das genauso verhält wie ich mich auch mit dem normalen, warum nicht? Das könnte auch gemischt sein." (IP07, p. 11)

therefore the car is more practical. Eva does not have any other possibility to get to her work except her car since there is no public transportation that she could use. Considering journeys and holidays they do not use any public transportation either. The main reasons for the car are comfort, flexibility and the fact, that they are used to it. Moreover, they usually head to destinations which would be difficult to reach by bus as for instance the mountains.

In her job Eva has very flexible working hours and therefore is able to arrange her timetable in a way to avoid rush hour on the road. Furthermore she chooses a fast route with low traffic and few speed limits. Hence she does not see the quite long distance as a problem, despite the money she spends on gasoline. She even mentioned, that compared to her partner, who works much closer but has to drive through the city, she is considerably fast at her office. Before her current job, Eva lived in another city in Germany and always had to commute about 80 km to Munich on the highway. She explains that the situation on the highway with all the hasty drivers, speeding, barging and traffic jams has always been quite stressful for her. She says that the trips from then were an hour of highly stressed driving and now it is an hour of relaxed driving. However, she sometimes still experiences stressful situations on country roads too for instance when other drivers perform risky maneuvers.

> "The hecticness and the barging of the others. The road raging. That was, you know, I didn't have a BMW 5, I had my VW Polo and couldn't drive so fast. Sometimes it was really precarious. So from behind, when I was overtaking and they were coming rapidly from behind. It stressed me to get back on the right lane in order to leave them their lane. That stressed me. And there were always traffic jams and that really stressed me." [41] (IP08, p. 3)

Basically all the stress during her daily commutes is caused by other drivers. She really does not like the aggressive driving-style of many other persons on the road. The driving task itself is not a problem at all for her.

If Eva had the choice to take a bus to her work which does not take longer than the trip with her car, she would definitely take the bus. But there has to be a convenient timetable and she has to be picked up at her house. In this case, she would prefer the bus over her car because she would not have to drive on her own for such a long time. Eva likes to drive, but only trips that are less than about 90 minutes. Longer trips are too exhausting for her and she gets a backache. Eva is not enjoying the task of driving itself but rather sees it as a duty in order to get to work. Therefore she would not miss manual driving at all if it was replaced by autonomous driving. Furthermore she does not necessarily need to have an own private car. Given the necessary availability and also cleanliness, Eva can imagine to make use of a car pool service instead of driving with her own vehicle.

[41] "Die Hektik und diese, das Drängeln der Anderen. Die Nötigungen. Das war schon, also weißt du ich habe keinen 5er BMW gehabt, ich habe halt meinen Polo und der geht halt mal nicht so schnell. Also das war teilweise schon brenzlig. Also von hinten, also wenn ich mal grad am Überholen war und die sind dann von hinten daher geschossen. Des war für mich Stress, dass ich wieder auf die rechte Spur komme und die dann da ihre Spur wieder benutzen können. Das hat mich gestresst. Und da waren dann auch immer Staus und das hat mich echt gestresst." (IP08, p. 3)

The car of Eva's partner has an automatic parking assistance and some other car automation systems. She and her partner already successfully tried them, but it was a weird experience for her and she would not trust autonomous cars. She will have to try these cars on her own for a long time but would still have trust issues and prefer to have the control over the car. After being confronted with the comparison with a bus, train or subway, Eva laughs and says, that this might be the reason why she does not like sitting in a train either. If it really worked someday, she would maybe get used to it and could even relax on an autonomous trip. Eva thinks, that this technology could help in case of unfocused driving in order to improve the car's reaction when a human driver would have failed.

> "When it's well-tried then yes. I think I would, letting alone the costs because this will probably cost a lot, I might use it, because every now and then you are not focused for a second and think: "Man, that was close!", For example if a deer runs on the road. The technology might be more dependable than oneself. If it works like this, I can imagine using it." [42] (IP08, p. 6)

If it worked, Eva would consider listening to an audio book or reading in a self-driving car. These things should be allowed while driving in order to be able to better use the spent time in the car. She does not want to do a lot of work in the car, but rather relax, maybe even sit on a massage chair. Eva is not sure if human drivers should still be able to interfere the driving task. On the one hand she does not want to give away full control, but on the other hand, hasty interference in a critical situation might result in an even worse outcome. Finally she comes up with the solution, that the driver can interfere, but the systems prevents manual changes that might have been done in the heat of the moment. Eva also wants to be able to adjust the decision algorithm of the car in critical situations. She does not like the idea of giving away this decision to someone else like the car manufacturer. If these implementations would work as she described, Eva might trust autonomous cars. In this case, it should be even allowed to sleep in an autonomous car. When it comes to drink and drive Eva is not sure about a potential solution either. Initially she wants to prohibit alcohol completely in the car, because in case of a failure one would have to be able to take over control. After further considerations she would allow drunk people to drive in a self-driving car under the pre-condition, that they are absolutely not able to interfere in any way and the car drives in a safe state to the side of the road in case of a failure. She compares this scenario with the situation of a drunk person sitting in a taxi. However, she does not appear to be convinced from her own approach and remains skeptical if alcohol should be allowed while driving. Eva is also skeptic if children should be allowed to be driven alone to school. She comes to the conclusion that this should not be allowed because a driving license with the current criteria should definitely still be necessary. The main reason is, that she does not trust in the responsibility of younger persons. The only exception might be physically handicapped people which may not be able to drive a conventional car, but could make use an automatic one. The baseline is that one has to be

[42] "Wenn es total ausgereift ist, dann schon. Ich glaube ich würde dann, also die Kosten außer Acht, weil das kostet wahrscheinlich ein Vermögen, dann würde ich das wahrscheinlich schon benutzen, weil man ja immer mal eine Sekunde hat, wo man nicht aufpasst oder wo man sich denkt "Mensch, das ist nochmal gut gegangen". Wenn ein Reh rausspringt oder irgendwas. Da ist die Technik dann vielleicht zuverlässiger als man selber. Wenn es so ist, dann könnte ich es mir vorstellen." (IP08, p. 6)

mentally fit and mature and not dependent from another person in order to be allowed to drive in a self-driven car. Therefore, also elderly people will have to prove a certain grade of mental awareness.

> "They may do it [Elderly people using a self-driving car]. But they have to be mentally fit. They have to be mentally fit, but they don't need a driving license or let's say, if their eye-sight is bad or theeir reaction time is slowly they may use it as long as they can't interfere." [43] (IP08, p. 13)

Since Eva's pre-condition for autonomous car is "1000% safety", she does not consider additional lanes to separate driver-less from conventional cars as necessary. The cars will have to be able to act with normal cars on existing roads. The payment for potential additional infrastructure should be related to the purchase of an automated car and no taxes should be introduced. She would rather expect persons who actually use autonomous driving to pay for it, than handing the bill over to the public. Eva has a general aversion against subsidization and therefore would not be in favor of it for autonomous cars. These statements show that Eva does see potential benefits of autonomous cars, but definitely not enough in order to accept public money being used for its introduction. Concerning insurances, Eva would prefer a fixed insurance for cars, since they take over the responsibility in case of an accident.

Data collection is a very crucial topic for Eva. Basically she does not want anyone to be able to supervise or control her trips. Anonymous data for traffic analysis as well as car data for engine optimization would be okay, but no data related to the car's location. In this point, Eva does not trust the companies, even if they claim that the data will be anonymized or transmitted only once a week. It is very important for her not to be controlled by anybody. Especially advertisement companies should be prohibited from using her data regardless on the amount of money they pay. She says, that she is avoiding Facebook because of privacy concerns and using WhatsApp is already a big deal for her. The only scenario where she can imagine to allow her personal data to be recorded is in case of any grave crime in order to support police for criminal persecution.

Eva appears to be a very skeptical person considering autonomous driving because it is very important to her to maintain control and not being supervised or controlled by anyone. Although she might theoretically benefit a lot from self-driving cars due to her long commute to work, she is not really excited about them. During the interview it does not seem difficult for Eva to clearly express her opinion on this topics but rather to think about consequences and related issues. This leads her to often change her mind during her explanations. As a summary Eva maintains a skeptical mindset concerning autonomous driving and although it might improve her mobility she is not really convinced by this technology.

[43] "Dürften sie machen. Aber sie müssten geistig fit sein. Sie müssen geistig fit sein, aber brauchen nicht den Führerschein in dem Sinn oder anders gesagt, wenn sie jetzt zu schlecht sehen oder die Reaktion zu langsam ist, dann dürften sie es nutzen, wenn sie nicht eingreifen können." (IP08, p. 13)

6.9 Case Study Florian (IP09)

Florian lives in a typical household at the countryside with several generations living together in the same house. In his household there are eight cars. Despite his grandparents who share a car and his sister, who does not have a driving license, everyone has their own car. The family does not use any public transportation at all, everyone usually drives to their close workplaces by car or works at home at the farm. After his eduction at the polytechnic secondary school, Florian started working in a local construction company which is about 2-3 km away from his home. In summer, he sometimes takes the bike to get there, but this is not always possible. In his company, they do not have a vehicle available for him to get to potential customer visits. Since they pay him for the extra mileage, Florian regularly drives with his private car to these appointments. This prevents him from riding the bike regularly for the 2 km trip to the office. He thought about car sharing as well, but since his working colleagues also use their private cars and have customer appointments, this is difficult. For vacations he also usually drives with his automobile, but in this case, he often shares it with friends. He prefers this over using the train, because he would have to drive to and from the train station anyways. Furthermore with all the luggage, for instance the ski equipment, it would be too impractical to travel by train. As the main reasons for the car in favor of the train Florian mentions convenience and time saving. He also appreciates the flexibility with a car compared to fixed train time tables. Florian would consider a car pool service if it was available. However, he would only use it additionally to his private car for his future family and not as a full replacement. It makes a difference for him if an automobile is his own or just rent from a service and he prefers to have his own car.

> "I mean, yes, it [own car] is important to me. When you have a nice car and you care about it, then you've got something. The more people share something, the less they care about it because nobody owns it." [44] (IP09, p. 6)

When Florian thinks about problems in his daily traffic situations, he is not really annoyed by many things since he has to drive only 3 km to work. What annoys him are speed limits on the highway which are posted for environmental reason. In his opinion, they are nonsense and they were only set up to make money. If he could wish something related to his mobility, he would like to have more load stations for electric cars and more advances in electric car technology. He thinks, that electric cars are still not as attractive as they could be and that development should progress. When they are well-tried, he wants to purchase a photo voltaic system and an electric car. His main intention is to be independent from power supply and gasoline.

The first things Florian mentions when asked about autonomous cars is, that he always hears about their crashes. He thinks they are a little bit scary and he is not sure if he could trust them. His main concern is, that every system is error-prone and in case of self-driving cars this might provoke vast multiple crashes or other worst case scenarios.

[44] "Ich meine liegen tut mir schon etwas daran. Wenn man ein schönes Auto hat und wenn man drauf schaut, dann hat man auch was. Je mehr Leute sich etwas teilen, desto weniger wird halt darauf geschaut, weil es halt niemanden gehört." (IP09, p. 6)

> "Every system is error-prone and I don't know, when everything, when there's a huge crash or someone hacks it, than there will be a vast multiple crash or I don't know what. I mean, they will certainly build in some safety-mechanisms that turn it off, but you will be able to bypass them. Everything that is electronic can be bypassed." [45] (IP09, p. 6)

Florian maintains a profound distrust against this technology and he does not think that he will live until the time autonomous cars are fully developed and he will trust them. He would try them out, but in order to trust them, he would need successful long-term tests. If there was an autonomous bus or something similar, he would prefer his conventional car. He says, that he prefers to do something while driving because the act of driving is more interesting. The only thing he mentioned to do in an autonomous car is some work for his job when he is driving to the customer. And if this technology really existed, he would like to have a fridge, a TV and a comfortable seat in his car. In every answer, Florian puts the phrase "if they really existed". It seems as if he wants to emphasize the purely hypothetic character of his explanations.

When driving in an autonomous car, people should not be obligated to observe the traffic, because the car has to be capable of doing this alone. Hence, in case of an accident the driver should not be responsible for any consequences. It should be allowed to sleep in the car because if you are not obligated to focus on the traffic it might easily happen to fall asleep. Also drink and drive would not be a problem as long as people are not able to interfere the automated driving process. Manual interference in this case should be only possible after approving an alcohol test. Elderly people and children might also use the car, but again solely in the autonomous mode and only a valid driving license will unlock manual driving. Florian has an interesting explanation why he might trust a self-driving car to bring his future children to school some day. It can be observed how Florian's attitude towards autonomous cars get more positive the longer he talks about the topic.

> "I would say, when I compare myself with the system, I do have to trust myself as well that I drive my child safely to school. So when I trust the system as I trust myself, what I suppose that will eventually be necessary anyways, then it [the autonomous car] may also be able to drive my child as a consequence." [46] (IP09, p. 11)

In order to obtain a driving license for the manual mode, the same requirements as today have to be met. Additional regular practical driving lessons have to be done in order to maintain

[45] "Aber jedes System ist irgendwo fehleranfällig eben und ich weiß nicht, wenn dann alles, wenn es da einmal einen Riesencrash gibt oder sich irgendjemand rein hackt, dann gibt es eine Massenkarambolage oder weiß ich nicht was. Ja ich meine, die werden da sicher irgendwelche Sicherheitsmechanismen einbauen, dass er dann abschaltet, aber das wird man auch wieder umgehen können. Alles was elektronisch ist kann man aushebeln." (IP09, p. 6)

[46] "Ich sage jetzt mal, wenn ich mich als Person mit dem System vergleiche, also ich muss mir ja selber auch vertrauen, dass ich mein Kind sicher in die Schule fahre. Wenn ich jetzt dem System genauso vertraue wie mir, was ich mal annehme, dass das sowieso irgendwann so sein muss, dann soll es in weiterer Folge auch mein Kind irgendwann fahren können." (IP09, p. 11)

one's manual driving capabilities. Florian does not see the need for manual interference during automatic driving in general and manual driving may only be enabled after proofing one's physical ability. This may include an alcohol test in case of potential alcoholics, the check for a driving license and also other sensors to detect for instance sleepiness. Manual driving should still be possible for example if someone wants to leave the road or drive to areas which are not supported in automatic mode. Another reason why Florian prefers to continue driving manually is because he does not like the idea that someone is permanently tracking him.

> "When I switch to manual mode, I also might not want it to be monitored where I am currently driving. Actually this is another crucial topic. Because then everyone, or at least everyone who really wants to, knows where I am currently driving." [47] (IP09, p. 13)

In his opinion, data collection should be regulated as it is done for mobile phones and should only be done for good reasons. This might for instance be done by the police for criminal persecution. Furthermore if someone has an accident the ambulance may use the on-board camera in order to get important information on the situation already in advance on their way to the accident. Also an emergency button for elderly people, establishing a video connection to the ambulance might be reasonable.

> "And I do think, when there will be, I don't know, some kind of emergency buttons, why shouldn't you connect them and one can have a look what's wrong with him in order to forward important information to the emergency forces while they're arriving. If anything is connected anyways, why shouldn't it be used for these purposes as well." [48] (IP09, p. 13)

Car manufacturers and infrastructure planners may use the data in order to be able to improve their services. However, they should only get anonymous data. Florian thinks, that they could for instance analyze peoples traffic flow to find well-situated locations for gas-stations and hotels. Although he does not believe that companies will pay, Florian thinks, that people should obtain money for giving away their data, because companies are making money with it too. Especially if the data is used for personalized advertisement people should be rewarded.

Florian thinks everyone prioritizes their own safety. He does not think that it is a good idea to give people the opportunity to adjust their car's decision algorithm. He has general concerns if these algorithms are adjustable. He rather prefers every car to be programmed with the same unchangeable properties. For Florian it makes a difference if you decide for you own advantage quickly when driving in a critical situation or if you can easily adjust some parameters of your car in advance.

[47] "Wenn ich jetzt auf manuell umschalte, dann möchte ich sowieso vielleicht auch, dass ich jetzt nicht überwacht werde wo ich gerade hinfahre. Das ist auch ganz ein heißes Thema eigentlich. Weil dann weiß ein jeder oder zumindest wer es unbedingt wissen will, wo ich gerade hinfahre." (IP09, p. 13)

[48] "Und ich finde schon, wenn die dann irgendwelche was weiß ich, Erste Hilfe oder Rotkreuz Notfall Knöpfchen drücken, warum sollte man das dann nicht koppeln und man schaut nach was demjenigen fehlt, so dass man dann schon sehen kann und die Einsatzkräfte schon bei der Fahrt wichtige Infos geben kann eventuell. Wenn dann sowieso alles vernetzt ist, warum soll man das dann nicht auch in diese Richtung verwenden." (IP09, p. 13)

> "It should be the same for everyone. I mean, everyone cares about their own safety. If you are able to adjust this, or let's assume it's politically predetermined for the whole country. Let's assume the car is produced for I don't know how many countries. So it will be adjusted to the countries guidelines before delivery. That's an electronic component or something similar, that can be manipulated. This might generate a market, as it already exists for chip tuning, to reconfigure this in order to obtain personal benefits. This might only be affordable by rich people which then are able to abuse and bypass this to take personal advantage." [49] (IP09, p. 16)

During the introduction of autonomous cars, there should be no need for separate lanes. If they are capable of performing the driving task, they should be allowed to drive everywhere as conventional cars do. According to Florian, the transition phase from manual to automatic traffic will last a long time, maybe forever. Concerning the financing he proposes to take the Austrian institution for road financing (ASFINAG) as an example. He thinks, that financing the infrastructure using toll money is a good idea. He would not be okay with tax money being used, because the current benefits of autonomous driving are not sufficient. He has the same argumentation for subsidization. When it comes to insurances, Florian prefers a general insurance which is automatically applied when purchasing an automatic car. This might help to reduce arguing in case of accidents and simplifies the situation when autonomous car get involved.

Florian is very skeptical if and when autonomous cars will conquer the streets. He is not even sure if he will still be alive when autonomous cars are introduced. However, in the hypothetical case that this technology may work, Florian seems pretty open for it and is able to clearly express his opinions. Despite the fact that he might miss manual driving because of the experience, he sees a couple of benefits in self-driving cars. Florian does not seem to have any trust issues and would use automatic cars for elderly people as well as for drunk people and children. The only thing that bothers him is the fact that the built-in electronic parts may be manipulated by someone or even hacked.

6.10 Case Study Andreas (IP10)

Andreas is 35 years old and lives alone in a flat close to Salzburg. He is working as a middle-school teacher and usually goes to work by car. A few months ago Andreas did not have a car and managed to do all his trips by bike and public transportation, but due to changes concerning his familiarly situation he now owns a car again. He says if you are used to not

[49] "Das soll für alle gleich sein. Ich meine, es schaut sowieso jeder auf seine eigene Sicherheit. Wenn man das einstellen kann, oder nehmen wir an, es ist politisch, also politisch vorgegeben, oder irgendwie vorgegeben, bundesweit oder keine Ahnung. Nehmen wir an, das Auto wird für, was weiß ich wie viele Nationen produziert. Dann wird es halt vor der Auslieferung für die entsprechende Nation konfiguriert und eingestellt. Das ist ein elektronisches Bauteil oder sonst irgendetwas also eine Konfiguration, die man manipulieren kann. Dann entsteht da wieder ein Markt sowie jetzt für Chiptuner, die das dann umstellen können, um dann vielleicht wieder einen eigenen Vorteil zu haben. Und dann können sich das gewisse Leute leisten und das dann vielleicht wieder missbrauchen und umgehen" (IP09, p. 16)

own a car, it is not a problem at all. But as soon as you have your own automobile again, you immediately fall back into your old costumes. He especially appreciated the increased available space in the car compared to a simple backpack when riding a bike and also the higher degree of convenience which comes with significantly higher costs.

> "It's more convenient. It's faster. However, it costs a lot of money. The costs rose enormously, that's for sure." [50] (IP10, p. 2)

Prior to living closer to the city Andreas lived in a small village at the countryside. Therefore he is able to compare differences between rural and sub-urban areas with his personal experiences. During his automobile-free time, he did weekend trips with his kids to his hometown at the countryside by train. Andreas mentioned, that it was a bit of a challenge, but in the end he manged to work it out. He has always liked to take the train because he gets among other people. However, as soon as he got his own car, he stopped using the train. Compared to more than one hour that he needed to get to work by public transport, he now needs only 20 minutes by car. He says that time is money, and the time he saves every morning because of the car has to be paid for costs such as gasoline and insurances. The extra money for driving a car really annoys Andreas. He actually seems happier when talking about the time when he used the bike, but in the end he now prefers the car. Andreas would definitely be in favor of car services which can be ordered on demand using mobile applications. Following his experience on the difference between living in rural or sub-urban areas, Andreas further argues, that this kind of services might not be implemented that fast in rural areas as in cities.

> "Yes that [car pool service] would definitely be smart to do. That there will be Apps and you say that you are driving here and there and you can subscribe where you want to be picked up. However, this comes again on the expenses of time." [51] (IP10, p. 8)

Andreas heard about autonomous cars to be introduced in the coming ten years. He sees this topic very critical because of privacy issues. He is very skeptical concerning his data privacy and would not allow any data collection. However, he is afraid that he will not have a choice anyway because sooner or later everything will be connected. The only aspect, where he sees data collection positive is for the support of criminal persecution.

> "Well, I see this [autonomous driving] rather critical. I mean, as a human that doesn't have to hide anything you don't have to worry, but we will be already very transparent then." [52] (IP10, p. 4)

Andreas does not like the idea of being supervised all the time and that some people might be even able to control his car while he is driving. He feels this to be cutting into his privacy

[50] "Es ist halt bequemer. Es geht schneller. Es kostet zwar einen Haufen Geld. Also die Kosten sind nach oben geschossen jetzt. Das ist klar." (IP10, p. 2)

[51] "Ja das wäre natürlich gescheit. Dass es Apps gibt und sagt ich bin dort und da unterwegs und man kann sich eintragen oder ich wäre dort und da zum holen. Nur das geht halt dann wieder auf Kosten der Zeit." (IP10, p. 8)

[52] "Naja ich sehe das eher ein bisschen kritisch. Ich meine als Mensch der nichts zu verbergen hat muss man sich bei solchen Dingen eh keine Gedanken machen aber wir sind dann halt schon sehr gläsern." (IP10, p. 4)

and freedom of decision. He is also concerned about potential surveillance via his mobile phone and has a critical attitude towards digitalization in general. In his opinion nowadays children are already too overloaded with permanent multimedia input and therefore not able to absorb other things anymore. If autonomous cars were introduced, he definitely would still want to have a manual driving mode. This is not because of trust issues concerning the driving capabilities of the car, but rather because of his lack of trust in the controlling instances such as the government or other institutions. Therefore he does not want to hand over full control of his vehicle to these institutions. He definitely wants to be able to decide whether the car is driven automatically or not. If this option was not possible anymore, Andreas would consider to let the car aside and change to public transportation again. He imagines the scenario that people will be forced to drive autonomous cars by increasing insurance costs for conventional cars. Therefore he seriously considers turning back to public transportation to avoid this.

At the moment, Andreas thinks he does not know enough about self-driving cars to be able to buy them. However, if he gains more experience and knowledge about these vehicles and they meet his privacy demands, he might consider buying them in a couple of years. According to Andreas the introduction of autonomous cars might be ecologically and economically beneficial by optimizing gasoline consumption and travel time. At this point, Andreas complains about slowly drivers in the city when it is raining or snowing. If everyone would be more focused during driving, traffic jams could be reduced and overall flow could be vastly improved. He further reasons, that this might be achieved if all cars were autonomously driven and connected by some intelligent system. However, in case of a system fault, this might provoke devastating crashes causing whole areas to be completely blocked. Therefore Andreas proposes some kind of emergency fail safe, that puts every car into a safe fail state in case of a system error.

> "The thing is, there will probably be fewer accidents, but if there's a gap anywhere in the system or the main computer crashes and everybody is driving into nowhere, then there'll be a huge crash. [53] (IP10, p. 7)

Andreas clearly sees self-driving cars as an advantage for elderly people. Since he does not have any trust issues concerning the automated cars' capabilities, he considers self-driving cars as a very beneficial option for elderly people who do not have the necessary driving skills for a conventional car anymore. Moreover, he does not see any problem for drunk people to drive either. In these cases he expects the car to identify the driver by a finger print or something similar in order to decide if the car can be operated in manual or solely in automatic mode. Although it would be one of the last things to consider, Andreas might allow children to be driven in self-driving cars too. During his explanations, Andreas is thinking about autonomously driven oil transports and other dangerous vehicles. He is afraid that the systems might lack of logical thinking in unforeseeable situations or when there is an obstacle on the street which can not be determined by the car. This might lead to very dangerous scenarios. He also sees a problem in the combination of self-driving cars and autonomous cars

[53] "Das Ding ist halt, es gibt wahrscheinlich weniger Unfälle, aber wenn dann irgendwo eine Lücke ist im System oder der Hauptrechner stürzt ab und alle fahren ins Leere, dann gibt es halt einen Riesencrash." (IP10, p. 7)

driving on the same street. Andreas thinks about adaptive controlling systems for conventional cars that interfere automatically in case of a dangerous situation. At this point it is difficult for Andras to clearly express his opinion because the controlling system would contradict his former claim to maintain manual control. As a consequence he proposes a solution with separate lanes for conventional and automatic cars to avoid any harmful interference.

While driving in autonomous mode you should not be obligated to interfere at any time. Andreas would like to use the time while driving for other things instead.

> "If you choose the autonomous mode, you should be able to lean back and maybe even use the time for a small nap or reading the newspaper or other things to do. Because then you can actively use the time which again saves you time." [54] (IP10, p. 10)

He would possibly play with his mobile phone or accomplish things for his job. He could imagine that a laptop will be implemented in his autonomous car for this purpose. Concerning any further design changes, he says that this would depend on the manual mode of the car. Without a manual driving mode, the vehicle might not even need space for actual driving related equipment. In this case he imagines the car to be like a limousine with a couch or maybe even a bed. He likes the idea of not being obligated to focus on the traffic and compares an autonomous car ride with sitting in a train. Since nobody is obligated to watch the traffic, the car has to take over full responsibility in case of an accident. Concerning the insurance Andreas would like to pay a monthly fee for a car service that depends on his car usage. This fee should include the costs for rent, gasoline, insurance and any other car related payments. He seems really annoyed by the costs for his private car and would prefer to pay a well calculable service. He imagines, that there might be small autonomous buses which pass by every couple of minutes and act like an extension of the railway system on the road. In this case he would definitely not need a private car anymore.

According to Andreas not enough benefits financed through tax money are being provided for the broad public during the introduction of self-driving cars. Later on, when there are autonomous services that can be used by everybody, all necessary costs should be included in the fee that he pays for the service. As soon as the cars are available for broad public, Andreas thinks it is okay to pay for it. Moreover, it might be a good idea to subsidize autonomous services for older people or students, who could not afford it otherwise, in order to improve their mobility. His main statement in this context is, that if autonomous mobility is introduced, it should be available for everybody and if this will be achieved, it is okay if everybody pays for it.

Andreas seems to be a person which clearly sees a lot of potential benefits in autonomous cars but is very skeptical about their beneficial introduction. He is very concerned about privacy and also the governments possibility to interfere with his own mobility. He maintains a

[54] "Wenn man sich für den autonomen Modus entscheidet, dann soll man sich zurücklehnen können und die Zeit dann vielleicht sogar für ein Nickerchen oder Zeitung lesen nutzen können oder sonst was was halt noch zu tun ist. Weil dann kann man die Zeit auch wieder aktiv nutzen, weil das ist dann wieder eine Zeitersparnis." (IP10, p. 10)

fundamental distrust against government and other ruling institutions in this context. Also the possibilities of criminals to exploit these new systems for any crimes bothers him. He is afraid of worst-case scenarios where hacker paralyze the whole traffic and control peoples mobility. On the other hand, Andreas does not seem to have trust issues concerning the technical capabilities of self-driving cars and sees a lot of potential use cases for public transportation and mobility of elderly people. He has very optimistic ideas on the usage of autonomous cars for mobility services which might revolutionize people's mobility and possibly reduce private car usage.

6.11 Case Study Lisa (IP11)

Lisa is 20 years old, lives together with her father in a house and studies in Salzburg. She usually drives with her own car to the closest train station and then continues by train and bus to her university. For the trip to the train station no acceptable public transportation is provided since the bus would take about two hours compared to 15 minutes by car. Sometimes when she has classes in a different, hard to reach building, she drives all the way to university by car because it is more convenient. Also in her free time and for holidays Lisa usually uses the car. Compared to the train, she likes that she does not have to look for the correct train and timetable but can just sit in the car and drive.

Concerning her use of public transportation in Salzburg, Lisa does not like the long, traffic related waiting times when she is on the bus. Once the bus even broke down and she had to walk all the way through the city to the next train station. She generally seems to be annoyed by the accumulated waiting times for different means of public transport. When driving with the car, Lisa does not see any problems and claims to actually like driving, also for longer trips. The only thing that bothers her is are other drivers on the road which drive slower than allowed. She would appreciate a solution that enables her to drive with her preferred speed at all time, without having to brake for others.

Lisa heard about self-driving trucks on the highway but she does not consider autonomous cars as necessary for her short distance trips with the car. This attitude changed, when she was confronted with the idea, that autonomous cars might fulfill her wish of everyone driving at the same speed. Lisa confirms this to be really beneficial and that self-driving cars therefore might improve the traffic situation also for her short trips. Although Lisa would not buy an autonomous car as soon as they are on the market, she might consider buying them in 20 to 30 years. Lisa compares this situation with electric cars and says, that if she sees other people using it successfully, she could imagine to use them for her own as well.

> "Yes, then I would be really interested in it [buying a self-driving car]. Actually it's like with electric cars. If someone else has it, you can imagine it better for yourself too." [55] (IP11, p. 6)

[55] "Ja, dann würde ich mich schon mal sehr dafür interessieren. Wie bei den Elektroautos eigentlich. Da ist es ja auch so. Wenn mal jemand eines hat, dann kannst du es dir gleich besser vorstellen." (IP11, p. 6)

Lisa would not like to sleep in an autonomous car as she does in a bus, because there might be not enough space to do so. As a consequence, she would consider a couch or something similar as convenient to have in a self-driving car for long distance trips. However, it should not be allowed to sleep alone, hence, someone will have to be aware of the traffic and interfere if it is necessary. She would not feel comfortable if control was fully taken away from her to a machine. It is interesting how Lisa gets exited when talking about a couch or even a bed in autonomous cars in order to be able to sleep, but then denies that it should be allowed to sleep in the subsequent sentence. It seems as if she would appreciate these new opportunities, arising from self-driving technology, but her emotional feelings do not allow her to fully trust them. She imagines the car to potentially alarm the driver at any time, making them to take over control in case of a critical situation. However, this should not be obligatory. Principally the car should be capable of performing the driving task and in case of an accident also be liable for the consequences. The alarm is just an additional assistance, giving the driver the possibility to interfere if they want to. The important aspect for Lisa is the possibility of interference. She wants to have control over her vehicle. Therefore, one would still need a private insurance in case of an accident that happened while driving manually. In case of a critical situation, Lisa thinks that it should be possible to interfere quickly using verbal commands. She definitely refuses an approach where the car's reaction is pre-determined by the manufacturer. Even though she might not be able to react quickly enough, she likes the idea of having at least a chance to save the situation. The decision in such a scenario should not be done by a machine.

> "For me it's like, if such a technology appears on the market, than the manufacturer has to be liable if the car makes a mistake. I don't think any human can be blamed for that." [56] (IP11, p. 10)

Lisa also sees potential benefits in autonomous driving. In her opinion, traffic safety could improve, because older people might be supported by the car. However, they still have to be physically and mentally able to drive. The self-driving car only supports them with the driving task but does not replace the need for a human driver. Therefore children should not be allowed to be driven alone in an automatic car. Lisa would rather prefer an improvement in public transportation instead of letting children be driven in autonomous cars. Basically Lisa has the opinion, that autonomous driving will be some kind of advanced assistant system that facilitates the driver, makes driving more convenient and increases safety, but does not fully replace a human driver. Therefore it should not be possible to let an empty autonomous car drive around either.

> "Yes, it is a facilitation. So I am not asking for a completely autonomous car. It does not have to be so advanced that you do not have to drive anymore just for convenience reasons." [57] (IP11, p. 14)

[56] "Für mich ist es einfach so, wenn so eine Technik auf den Markt kommt, dann muss einfach der Hersteller dafür haften. Also wenn das Auto einen Fehler macht. Weil ich finde da kann kein Mensch dafür haften." (IP11, p. 10)

[57] "Ja, nur dass es halt erleichtert wird. Also mir geht es nicht darum, dass das jetzt komplett autonom ist und so und dass das jetzt fortschrittlich ist, dass man nicht mehr lenken muss aus Bequemlichkeit oder so." (IP11, p. 14)

Her own car is important for Lisa and she likes to have it. She puts her personal belongings in it and would not buy any car. Therefore, she prefers her private vehicle over a car pool service or something similar. Moreover, she would miss the experience of manual driving if only autonomous cars existed. However, this might change over time when she gets used to it. Although she is interested in autonomous cars, she is not awaiting them and therefore does not want to pay for potential introduction costs. She thinks about a solution similar to the Austrian highway, where you have to pay a ticket for use. Lisa would not want potential costs to be paid with public tax money. This shows again how Lisa sees autonomous driving rather as an individual gadget for people who want to have it, than of a new revolutionizing technology for everyone.

Concerning privacy and the collection of data, it depends what the receiving institutions are doing with Lisa's data. A potential use case might be additional information for emergency and firefighter crews when they are on the way to an accident. They might be informed about the number of involved persons and their medical status. Public institution may have access to the collected data as well and might use it for traffic planning purposes. The police may use the data for criminal persecution. On the other hand, she does not see a reason why car manufacturers should get her data for potential optimizations. They should be able to optimize the car's performance without any data of her, not even if they payed for it. They same applies for advertisement. In these cases Lisa thinks that privacy should be maintained.

During the interview Lisa sometimes expressed contradicting statements that show her insecurity in the related topics. Generally Lisa seems to be open to new technologies and can imagine benefits of self-driving cars, but it is hard for her to imagine that they will work. She can not think about fully self-driving cars and the consequences that emerge from their introduction. She sees autonomous cars rather as an additional technical gadget like todays assistance system, than something completely new, revolutionizing humans mobility.

6.12 Case Study Maria (IP12)

Maria is 76 years old and lives with her husband together with two younger generations in their farm house. The challenging part of the interview was to get her to express her opinion even though she was convinced not to know things and felt over-strained in many cases. Nevertheless, the interview provided very valuable output for further analysis of the view on autonomous driving from elderly persons.

Maria explains, that she recently does the grocery shopping together with her husband, because it is more convenient. However, she still drives alone with the car as well sometimes. Only when driving in cities, she needs someone who explains the way while she is driving, since she has to focus on one task at a time.

Together with her husband, Maria likes to do little weekend trips with the car. They usually drive alone because their friends are already too old to travel with them. Once a year, they do an organized bus tour with the local pensioners association. In this case, Maria likes the companionship of the other people in the bus.

Maria can not think of any problem related to mobility in her daily life. She says, that she is not complicated and that there is nothing she wants to change in her current situation.

> "No we are not so complicated. No (laughs). Well, there are things where you would think that this was not necessary. But when there are more people together it is like this. No, we are not complicated." [58] (IP12, p. 2)

It is very interesting how she does not complain about anything considering her mobility, although it might be much more difficult to get around for her than for younger persons.

Maria read about autonomous driving in the newspaper. She read that they are still not so safe, but she is sure that they will come. At the moment, she would not have enough trust to use a self-driving car and believes that someone will have to watch the road while driving. She can not imagine sleeping while being driven in such a car. However, later in the interview when different aspects of autonomous driving were discussed and she felt more familiar with the topic, Maria said that she possibly would trust self-driving cars to drive without any observation, if they are technically capable of doing so. In this case she is not interested in doing other things like knitting or playing cards. She would rather prefer to talk to her partner and watch the surroundings during the trip. If everything works fine, she could definitely imagine to enjoy the trip, although she might miss manual driving sometimes.

Maria imagines autonomous driving to be an ideal opportunity for elderly people when they are not able to drive anymore. Even though she is not sure if she will still be alive when this happens, Maria is convinced from this idea. As a consequence, the requirements for obtaining a driving license might be lowered in order to facilitate elderly people to use self-driving cars. As long as they are not able to manipulate the car also younger people who are too young for conventional cars should be allowed to make use of autonomous vehicles. In order to use a self-driving car, a basic form of a driving license should still remain mandatory and the consumption of alcohol should be forbidden. Furthermore, Maria would allow children to be driven in an autonomous school bus and autonomous cars should be allowed to drive empty as well. This leads to a contradiction with her former statements, since it does not make sense to demand a driving license although empty cars will be allowed to drive on their own. Maria seems to have difficulties to express her view and appears to find this a very complicated and complex topic.

In contrast to increased safety due to fewer crashes Maria has also concerns about autonomous driving. She feels bad for less educated people, who might loose their job due to increased technology usage. In her opinion the situation for persons who have troubles in school and are poorly educated will become more and more difficult in the future. In this context Maria seems to have a skeptical view on digitalization in general, not just concerning self-driving cars.

Concerning the integration of self-driving cars into existing traffic infrastructure Maria does not see any problem at all. If they are capable of driving alone, they should be allowed to

[58] "Nein da sind wir nicht so kompliziert. Nein (lacht). Naja, Sachen gibt es immer, wo du dir denkst, das hätte jetzt nicht sein müssen. Aber mein Gott, wenn mehr Leute beisammen sind, dann ist das halt so. Nein da sind wir nicht kompliziert." (IP12, p. 2)

use normal roads as well, without any separate lanes. The costs for any necessary additional infrastructure should be covered by taxes on autonomous cars. She does not want to pay for these costs as long as she can not use self-driving cars for her own. However, in case of housings for retired people, Maria could imagine some kind of subsidization if otherwise they could not afford such a car.

In case of an accident, Maria clearly sees the car to be liable if the manufacturer confirmed the car's autonomous driving capabilities. Therefore, she expects the car to have a sophisticated insurance which is covered by the manufacturer. If the car manufacturer promises the car to be capable of driving alone, Maria does not see the driver liable for any consequences in case of an accident.

> "If it promises that you really do not have to do anything, then I would see the car to be liable. Well it will be profoundly insured as well then." [59] (IP12, p. 9)

A very difficult topic for Maria was the question on how to make decisions in a lose-lose situation. She stated that she wants to know how the car reacts and therefore according algorithms should be public. However, the topic was too complicated for her for any further detailed explanation.

Concerning privacy and data usage, Maria does not see any issue in giving away her data. This might be done in real time and for various different applications like criminal persecution, traffic planing or car optimization. The only thing she does not want her data to be used for is advertisement. In this case she would prefer her data to remain private although financial rewards might change her opinion on this issue.

Maria was the oldest of all interview partners. During her explanations she seemed quite nervous and tried to mention a lot of things that she heard about autonomous driving in the news or read in newspapers. This lead her to contradicting statements which often sounded as if she would not believe herself either. Nevertheless, the interview provides important clues about the view of elderly people on self-driving car. Although it is difficult for Maria to get around with her car, she does not see any problem in her current mobility situation. It is interesting how younger interviewees often mention autonomous cars to be beneficial for elderly people, but these persons might be not necessarily as interested as expected. Furthermore, Maria does not seem to have any trust issues considering self-driving car technology. Although she would like to continue driving manually she would make use of autonomous cars as well if she needs them.

[59] "Wenn das das verspricht dass ich wirklich nichts tun muss, dann sehe ich die Schuld beim Auto. Ja da wird dann aber auch eine gescheite Versicherung drauf kommen." (IP12, p. 9)

CHAPTER 7

Results and Conclusions

The following chapter presents the results of the interviews. The transcripts have been analyzed in order to provide answers to the previously stated research topics, as well as to find out interesting aspects which have not yet been discovered. The conclusions in each investigated topic will be backed up with corresponding citations from the original interview texts. The selection and structuring of the different topics result from the inductive category elaboration and therefore sometimes vary in scope and extent from the initially stated open issues in the introduction chapter.

7.1 Mobility Situation

The first goal of the interviews was to elaborate the current mobility situation of typical households at the countryside. The interviewees were asked to explain how they manage daily and occasional transport tasks. The idea of this elaboration was to understand what the actual needs of people are and where they have problems, inconveniences or wishes for change considering transport. As a further consequence, this knowledge can be used to identify potential issues and situations, where and in which way autonomous driving would be capable to provide beneficial solutions to people's everyday life.

7.1.1 Importance of the Private Car

After being asked on the current mobility situation, usually the interviewee started explaining how they use the car to get to work. This explanation was given for every member of the household holding a driving license leading to the information on the number of cars in the household. In most cases, the interviewee mentioned using the car for almost 100% of all their rides.

> "Yes, I am working. I mostly drive with the car." [1] (IP03, p. 1)

> "I normally drive with the car when I drive somewhere." [2] (IP05, p. 1)

> "Actually everyone of us drives with the car on their own." [3] (IP06, p. 1)

> "We basically always drive with the car." [4] (IP08, p. 2)

The interviewees often got a little bit embarrassed of the fact that they almost exclusively use the car. Sometimes, they even started to legitimize their use as if they felt sorry and wanted to excuse their extensive car use. Some explained that they try to use the bicycle more often, but usually the weather or their job prevented them from doing so on a regular basis.

> "When the weather is nice in summer I also use the bike..." [5] (IP03, p. 1)

> "But if my schedule allows it, I also use my bike in summer." [6] (IP09, p. 2)

After these explanations, stating the car as the central way of transport, one might wonder why it is so important for most people in rural areas as a means of transport? The two big reasons for the huge importance of the car for people on the countryside that came out during the interviews were a lack of alternatives and people's convenience.

Car sharing with work or study colleagues for instance could be a well working alternative to the daily trips with the car. People often work at the same company as their neighbor or at least as other persons from the same town anyway. About half of the interviewees confirmed that they share a car at least sometimes. This is usually done for economical, ecological and personal reasons.

> "We did this when we both worked in Braunau. We almost always had the car full, three friends of us were driving with us together to work." [7] (IP01, p. 4)

> "We drive together when we leave Hochburg-Ach... In this case not everyone has to drive on its own and we get some money." [8] (IP05, p. 3)

[1] "Ja, ich gehe arbeiten. Ich fahre die meiste Zeit mit dem Auto." (IP03, p. 1)
[2] "Ich fahre normal mit dem Auto wenn ich wohin fahre." (IP05, p. 1)
[3] "Ja, bei uns fährt eigentlich jeder selber mit dem Auto." (IP06, p. 1)
[4] "Wir fahren eigentlich immer mit dem Auto." (IP08, p. 2)
[5] "Wenn das Wetter schön ist im Sommer fahre ich auch mit dem Fahrrad..." (IP03, p. 1)
[6] "Aber wenn es von den Terminen her geht, dann fahre ich auch mit dem Fahrrad im Sommer." (IP09, p. 2)
[7] "Das haben wir früher getan wie wir noch alle beide nach Braunau zur Arbeit gegangen sind. Da haben wir das Auto eigentlich fast voll gehabt immer da sind immer noch drei Leute mitgefahren also mit uns mitgefahren in die Arbeit." (IP01, p. 4)
[8] "Ja dann tun wir uns zusammen. Wenn wir aus Hochburg rausfahren... Da muss nicht jeder fahren. Da gibt es dann ein Fahrtengeld." (IP05, p. 3)

> "In my case I sometimes drive to Salzburg together with someone because I have a study colleague from Tittmoning and she drives by car... Well, saving a bit of money is one of the reasons. And you also care for the environment, that's also important to me. And well, driving alone is boring. Together you can chat and plan some things and you really save some money." [9] (IP06, p. 2)

But all in all, people's usage of car sharing is rather sparse. As major arguments against it and for the car, people either stated convenience or at least convenience related reasons as well as inflexible working hours. One interviewee is working with her husband in the same office about 50km away from their home but even they are not sharing a car and drive separate.

> "Yes, you could, you could actually do it [car sharing] if I am honest, I don't do it because of convenience. I can drive when I want, I can drive where I want and I can drive home when I want. So car lifting would be possible, yes, but I am too lazy." [10] (IP02, p. 2)

> "If one would really care, one could definitely switch to alternatives. But there's clearly the comfort, the flexibility and the convenience [speaking about the car]." [11] (IP08, p. 2)

> "...when I say that I finish work at 4 o'clock it's still not guaranteed that she [working colleague] will be here at 4 o'clock or when I have to work longer you would always have to arrange with each other in advance." [12] (IP09, p. 2)

It seems that people on the countryside are very used to their absolute flexibility concerning mobility. They are accustomed to being able to drive whenever and wherever they want to, without any obligatory coordination with any timetable of another person or public transport.

For the way to work, full availability is not so important and regular timetables, as they occur in normal public transport, would be sufficient to change from the private car to public transport. However, for a complete replacement of their private car, people really do not seem to accept any kind of inconvenience even if they only have to wait for several minutes or if the whole trip takes a little bit longer.

[9] "Ja, bei mir ist es halt ab und zu so beim Salzburg fahren, dass man zusammen fährt, weil ich eine Studienkollegin habe von Tittmoning und die fährt hat mit dem Auto... Naja, da ist das eine, dass halt ein wenig gespart wird. Also dass man auf die Umwelt schaut, das sehe ich schon so. Und naja, alleine fahren ist auch langweilig. Weil zu zweit kann man sich noch ein bisschen etwas ausmachen, da kann man noch ein bisschen reden und naja, man spart sich wirklich etwas." (IP06, p. 2)

[10] "Ja, könnte man, könnte ich eigentlich machen, wenn man sich ehrlich ist, aus Bequemlichkeit, mache ich das eigentlich nicht. Ich kann fahren wann ich will, ich kann fahren wohin ich will und ich kann nach Hause fahren wann ich will. Also die Mitfahrgelegenheit wäre möglich, ja, aber, zu bequem, faul, ja" (IP02, p. 2)

[11] "Also wenn es einem wichtig wäre, dann könnte man bestimmt auch auf ein paar Alternativen umsteigen. Aber es ist natürlich auch der Komfort, die Flexibilität und die Bequemlichkeit." (IP08, p. 2)

[12] "...wenn ich sage ich höre jetzt auch um 4 Uhr auf, dann ist es auch nicht sicher, dass sie dann um 4 Uhr da ist oder wenn ich dann mal länger arbeite dann müsste man sich immer abstimmen." (IP09, p. 2)

> "When I'm cooking and I need to get eggs, I don't want to have to wait 15 minutes for the car." [13] (IP09, p. 5)

Although all interviewees stated their car as their absolute main means of transport, for only about half of them it has to be necessarily their privately owned car. In general people seem to be open to ideas like car pooling or other mobility services, but their essential precondition in order to accept these kind of solutions is absolute flexibility and availability. Otherwise the interviewees usually prefer to continue using their own car.
Given absolute availability and no inconveniences what so ever, many participants would definitely accept car pooling as a replacement for their own cars, and may completely disclaim on a private vehicle. The majority of the participants did not have any special relation to their car as a status symbol or anything similar which would make their own vehicle special to them. Another concern on car sharing, despite availability, are quality requirements like the cleanliness and general condition of the rented cars.

> "...I need to get it when I need it." [14] (IP07, p. 5)

> "If it's always available when I want to have it, it doesn't have to be mine." [15] (IP08, p. 18)

The clear message from all interviews is, that people are used to the flexibility and availability of their private cars and are not willing to step back concerning this comfort. If public transportation or other services were able to reach this level of convenience, people would generally be open to make use of them and maybe even disclaim the usage of a private car. The interviews lead to the conclusion, that the current public transportation situation in rural areas is not perceived as sufficient to provide this necessary quality of service. This leads to a very high importance of individual car mobility of people living in the countryside.

7.1.2 Public Transport

After having examined the car as the main means of transport, the perception of the current situation of public transportation in rural areas will be elaborated.
Despite convenience and availability the main argument for the frequent car usage is the lack of public transportation in the countryside. In almost all case studies, the question on the use of public transportation was negated. The common explanation was, that there would be either not sufficient public means of transport or none at all. Most interviewees started thinking how they could theoretically reach their job from home without a car. They usually came up with routes having significant higher travel times, including several changes and a couple of hours traveling, which is absolutely not acceptable for daily commutes to work.

[13] "Wenn mir jetzt einfällt, ich koche gerade, und mir fehlen fünf Eier, dann möchte ich nicht 15 Minuten auf das Auto warten müssen." (IP09, p. 5)
[14] "...ich müsste es haben wann ich es möchte." (IP07, p. 5)
[15] "Wenn es mir immer zur Verfügung steht wenn ich es haben will, dann muss es nicht meins sein." (IP08, p. 18)

> "Well public transportation isn't ideal here. You don't really have the opportunity, you wouldn't arrive on time at work. You would have to drive to the station anyway then you can already continue driving to work. It would be too far to walk in the morning." [16] (IP01, p. 5)

> "Because in this area it's almost not possible without a car. If you live 20km away from your work and there's no public transport, you need the car... No, it's not possible [by public transport]. I would have to drive to Salzburg, this takes a long time. So with the bus to Salzburg and then with the train to Lamprechtshausen, this takes, I don't know, two hours and with the car I need 20 minutes and that's it." [17] (IP02, pp. 1-2)

As it is the case for car pooling, people would principally use public transportation if it satisfied their demands for availability and flexibility. This can be observed by the group of participants which have access to public transportation at least for parts of their daily commutes. Most of them only use the car to get to the closest station in oder to continue by train or bus to the final destination. Many of them would appreciate a more sophisticated and extended public transportation infrastructure which would further reduce their car usage. But also those who do not use any public transportation at all confirmed that increased public mobility services would lead to a decrease in their car usage. However, most of them doubted, that these services might be able to completely replace their private vehicle.

> "If it worked with public transport, I would prefer it to get to work, if its timetable fits for me. Then I would use it, for sure. If there was like, I don't know, one of those city buses which comes by every half an hour, then I would absolutely use it and I would not use the car." [18] (IP03, p. 4)

> "If it took the same time, so if it was the same and didn't take much longer I would definitely use it [public transport] four times a week." [19] (IP08, p. 4)

When it comes to holiday and weekend trips, even more participants explained that they prefer trains and buses over the car. The interviews show that there are a couple of advantages of these means of transport that outperform driving in a car:

[16] "Ja öffentlich ist das bei uns ja auch nicht so ideal. Man hat nicht so die Gelegenheit, da kommst du auch gar nicht rechtzeitig runter (in die Arbeit). Zur Station musst du sowieso hin fahren und dann kannst du auch gleich weiterfahren. Die ist ja auch zu weit weg, dass du da jetzt hin gehst am Morgen." (IP01, p. 5)

[17] "Weil es bei uns in der Gegend ohne Auto eigentlich fast gar nicht geht im Prinzip. Wenn du deine Arbeit 20 km weiter hast, und keine öffentliche Verkehrsmittel nicht, dann brauchst du das Auto.... Nein, es geht nicht. Also ich müsste nach Salzburg fahren, also das dauert, mit dem Bus nach Salzburg, dann mit dem Zug über Lamprechtshausen, das dauert halt, keine Ahnung, zwei Stunden und mit dem Auto brauche ich 20 Minuten und fertig." (IP02, pp. 1-2)

[18] "Wenn es natürlich öffentlich ginge, wäre es mir für die Arbeit selber grundsätzlich eigentlich noch lieber wenn es zeitlich in meinen Bereich reinpassen würde. Das würde ich schon nutzen, das ist klar. Ich sage jetzt wenn da so ein Bus da, keine Ahnung, wie ein städtischer Bus der alle halbe Stunde bei mir vorbei fährt, dann würde ich den absolut nutzen. Dann würde ich das Auto nicht benutzen." (IP03, p. 4)

[19] " Also wenn das mit der Zeit, also wenn die die gleiche wäre, also nicht recht viel mehr wäre, dann würde ich das mit Sicherheit vier mal in der Woche nutzen." (IP08, p. 4)

As for the private car, also for public transport, people's main motivation for usage seems to be convenience. As on a regular working day it is the convenience of availability, independence and flexibility, while during holidays, the benefit of relaxingly be driven to the destination which plays an important role. Also the possibility to use the time in the meanwhile for something else seems appealing to people. Especially for older interviewees, these reasons seem to be crucial to prefer organized bus tours over private car trips to vacation. They seem to enjoy the relieve of having to do the planning themselves and prefer to just hop on a bus and be transported to various destinations.

> "Well Romania, that wouldn't work with the car. When the people don't speak German anymore and so on. Then you just sit yourself in the bustogether with other people, in a community. When traveling with your community, you just take the bus." [20] (IP05, p. 2)

> "We prefer driving with our car or maybe with a bus. We did that too a couple of times. We drove with the bus and really enjoyed it. With one of those travel buses. That's also nice... We went to Italy. I packed our luggage the evening before and the bus picked us up on time in the night and we got in and started. We could sleep inside the bus, that was really nice." [21] (IP01, p. 8)

The mentioned factors like flexibility and availability, that make people prefer their car during their everyday business, are not so important anymore when they travel to distant vacations. It seems that being able to flexibly change travel plans and destinations can often not keep up with the benefits of an organized convenient bus trip, at least for older people.
But also younger generations make use of public transport. Some of them on their daily commutes to work or university and others for longer distant weekend trips. They usually appreciate to have time to do some extra work or talk to each other. Another main intention to make use of the train are environmental reasons.

> "...more often in our freetime, that we take the local train to go to Salzburg. This is very comfortable, but we don't do this so much (compared to daily travels). We also take the train to Munich." [22] (IP04, p. 2)

> "When you drive to Vienna or Munich I take the train." [23] (IP02, p. 2)

[20] "Naja, Rumänien, das wäre mir mit dem Auto auch nichts. Wenn man dann nicht mehr Deutsch kann und so. Und da setzt du dich halt einfach rauf und das auch mit einer Gemeinschaft, mit einem Verein, mit deiner Gemeinschaft, da fährt man einfach mit dem Bus." (IP05, p. 2)

[21] "Wir fahren halt lieber selber mit dem Auto oder höchstens noch mit dem Bus. Das haben wir auch schon ein paar mal gemacht. Mit dem Bus sind wir dann mal gefahren, das hat uns schon auch gefallen. Da sind wir mit so einem Reisebus gefahren, das ist auch was Schönes... Da sind wir damals nach Italien gefahren, ich habe da zum Kofferpacken begonnen am Abend zuvor und in der Nacht sind wir weggefahren und dann ist der Bus auch pünktlich hier gewesen dann haben wir eingepackt und sind gestartet. Dann haben wir ja auch im Bus drinnen schlafen können das war richtig, ja das war richtig gut" (IP01, p. 8)

[22] "...in der Freizeit öfter mal, dass wir mit der Lokalbahn nach Salzburg fahren, das ist sehr angenehm, aber das tun wir natürlich nicht so oft. Und nach München auch mit der normalen Bahn." (IP04, p. 2)

[23] "Wenn du jetzt zum Beispiel nach Wien fährst oder München, dann fahre ich mit dem Zug." (IP02, p. 2)

Nevertheless, some interviewees also explained why they do not use any public transportation neither for vacations nor other trips. Despite the lack of availability the main reasons were inconvenience when traveling with luggage and a general aversion to being driven instead of having control. Detailed considerations on the loss of control will be further explained in section 7.2.3.

In conclusion, the interviews showed that people are interested in public transportation and also appreciate their advantages especially when traveling for vacation. Further improvement of public transportation would be considered valuable by almost all of the participants and might result in a decrease of private car usage. Nevertheless, the current public transportation situation is not perceived as sufficient to be able to fully disclaim private car usage.

7.1.3 Problems and Wishes in Current Traffic Situation

When people are directly asked for their problems, troubles or discomforts concerning their mobility, they could usually not think of any big problems. They only mentioned minor issues like removing ice from the windshield or annoying speed limits. Almost all of them concluded, that they like driving and that they do not experience any mentionable problems with it.

> "Actually I like driving the car. That's no problem for me. Also other drivers don't bother me." [24] (IP01, p. 7)

> "No this [driving the car] doesn't bother me. Since I like driving the car." [25] (IP07, p. 3)

> "...it actually relaxes me. I put on music. No, that doesn't bother me. That's not a problem." [26] (IP10, p. 3)

It seems as if people are very accustomed to their current mobility situation and have completely accepted all different aspects of it. They are so used to their daily commutes with their cars or trains, that they often do not see any problem or need for potential changes. It was the task of the interviewer to ask specifically about everyday life situations and things that might be annoying or at least not desirable in order to get the participants to start thinking out of the box. Typical answers were problems with other traffic participants, waiting time when using public transportation as well as traffic jams and weather related issues.

> "When you have a slowly driver in front of you or a truck, that's annoying. When you cannot drive at your own speed, yes that's annoying." [27] (IP02, p. 4)

[24] "Ich fahre eigentlich gerne mit dem Auto. Nein also das ist für mich kein Ding. Und mich stören auch die anderen Fahrer nicht so." (IP01, p. 7)

[25] "Nein, das stört mich nicht. Nachdem ich gerne mit dem Auto fahre." (IP07, p. 3)

[26] "...das entspannt mich eigentlich. Ich habe da Musik. Nein das stört mich nicht. Das ist kein Problem." (IP10, p. 3)

[27] "Wenn du jetzt einen langsamen Autofahrer vor dir hast oder LKW, das nervt. Wenn du nicht dein Tempo fahren kannst, ja das nervt ja" (IP02, p. 4)

> "Simply the waiting time. You wait for 5 minutes for the bus which takes you to the train station and then the train is too late and you have to wait again." [28] (IP11, p. 2)

Following the general explanations on their mobility situation, the participants were asked to describe a hypothetical perfect future transport solution. The interviewees were asked to think about their current situation and make up a futuristic solution regarding their mobility, that they would perceive as perfect. They were explicitly reminded, that it did not matter if the proposed solution was feasible, costly or doable whatsoever. Unfortunately this kind of question was usually quite overstraining for most of the participants. People were not able to think out of the box and therefore stuck to more or less the current situation as it is, providing only some minor changes. Interestingly, during the further interview, when given some additional input, more and more ideas and potential solutions showed up among the answers. We want to have a closer look at three of the ideas.

Solar Power and Electric Cars As a popular solution for further transport, electric cars were often mentioned. People would like to see advances in battery technology, load station availability and affordable car prices. Especially many interviewees living at a farm explained, that they would like the possibility of combining an electric car with an own solar power panel.

Public on Demand Bus Line Another interesting idea is a public bus, which can be ordered on demand for individual transport. It can be used to complement private cars or to help people without access to a private car nor fixed public transportation lines.

Car Service Fleet Also car pooling was mentioned by two participants. One interviewee described, that he would like people to have private electrical cars for their daily commutes. When they want to do larger trips to more distant destinations, conventional combustion engine cars should be available for rental. The rental service would be provided by the same company where the electric car was purchased.
Another approach was an autonomous car fleet that drives around on demand like taxis and will completely replace private car traffic on the streets.

Despite these futuristic ideas, many interviewees are very convinced, that things in the countryside will not change anyway and as a consequence they do not even bother thinking of possible changes and solutions. This mindset got even stronger when they were asked about their opinion about autonomous cars as explained in section 7.2.1.

7.1.4 Conclusion

People seem to be satisfied with their current mobility situation in the country side. The most significant fact, revealed by the interviewees, is the enormous importance of the car. It is used by every participant on a regular basis and often as the only means of transport. People are

[28] "Aber einfach die Wartezeiten. Du wartest 5 Minuten auf den Bus zum Bahnhof und dann kommt der Zug vielleicht auch nicht pünktlich und dann musst du da wieder warten" (IP11, p. 2)

very used to have an own car and the resulting individual mobility and high availability. They are not willing to step back from this comfort, at least not that easy. However, it is important to notice, that for the majority, it was not necessarily the fact of owning a private car which was desirable, but rather the flexibility which comes along with it. The analysis of the interviews shows, that people mostly have an interest in the expansion of public transportation and would definitely use it. This might result in a decrease of usage of private vehicles, as long as the desired level of availability can be achieved. Like it was proposed by some of the interviewees, autonomous cars could be used in a way of an on-demand taxi service, filling the gap between sparse long distant train or bus trips and short walking or bicycle distances. As stated in the interviews, this approach might improve the situation of older people and also reduce the number of cars per household. For further reading on sustainable on-demand mobility in rural areas with autonomous vehicles, information can be found in (Beitz, 2016).
Following the participants' explanations, the actual driving task is usually not considered annoying at all and the interviewees mostly stated, that they like or even enjoy driving. This can be interpreted in a way, that at the moment autonomous driving might probably not bring a desirable benefit concerning the convenience of driving, since the elimination of manual driving is not considered as something that is desired. This means, that drivers, which are able and allowed to buy and drive a conventional car, show a significant low interest for a change to autonomous cars. This is especially the case, when it comes along with additional costs. On the other hand, when people start thinking about getting older and get confronted with the potential loss of personal mobility, they begin to consider self-driving cars as a valuable alternative.

7.2 Opinion on Autonomous Cars

Having obtained a comprehensive overview over people's daily tasks including its challenges and resulting wishes we now want to have a look at people's opinion on driver-less cars. The interview questions were mostly formulated in a very hypothetical way. Assuming that autonomous cars existed, what do people think about them, how far would people trust them, what are their concerns and what might be potential opportunities?

7.2.1 General Attitude

The interview partners did not know from the beginning, that the survey would be about autonomous driving. They were told, that the thesis is about mobility in rural areas in general. After the introductory part, asking about the current situation, the actual topic was introduced by a very general question on their opinion about self-driving cars. All of the participants had already heard about autonomous driving and their reaction was usually very similar. It can be summarized as something like *"Yes I've heard about it. I don't know when this is expected to happen, but I'm pretty sure it will still take time until this arrives here in our town and I am actually not anticipating it, since I prefer to drive on my own."* All of them claimed to definitely not be one of the first ones to use a self-driving car. However, most said, that they would at least try it out after some time.

> "I heard about it, but I didn't think about it. That's not for me. No, that's not for me." [29] (IP07, p. 5)

> "Well. I'm not a kind of person who always needs all new things which appear on the market. But when others say it's good, I would consider also trying it." [30] (IP11, p. 6)

These reactions undermine the findings concerning the mobility situation, and show that people are basically satisfied with their situation. They especially emphasize how they like driving and the individual mobility that comes along with it. As a consequence, being confronted with a different concept generates a skeptical attitude. Leaving out specific concerns about self-driving cars that will be explained in the following section, the interviews showed, that people seem to have two reasons for their skepticism, sometimes even refusing attitude. As elaborated in the previous section people are used to have to buy a car in order to get around, hence they are also accustomed to all the flexibility that comes along with it. Furthermore, they are used to have to drive a car. At this point it does not really matter if they like it or not or if they want to change this. In the end, they have to drive a car to get to work or school. Therefore all of them mention, that they like driving, because they mainly do not even know how possible alternatives would work. So the first reason for their skepticism about self-driving car is the fact, that people simply do not see a reason for a change. They are used to and satisfied with the current situation and simply do not know any other way.

> "No, I wouldn't need that [self-driving car]. It's also nice to drive with a car. When I drive on my own and I have time to drive. No, that's also nice. No I don't want that." [31] (IP01, p. 20)

> "Currently the self-driving car is absolutely not relevant for me because they still have too many insecurities. And I have to say that I principally don't need this for me because I drive on my own." [32] (IP03, p. 5)

> "No, I would not need that [autonomous driving]. Personally, I prefer to drive on my own." [33] (IP05, p. 7)

The second reason, that was expressed in most interviews, is a very fundamental skepticism about the feasibility of autonomous driving and especially about its introduction in rural areas. The interviewees often did not believe, that autonomous cars would be introduced in their

[29] "Habe ich schon mal gehört, aber da habe ich nicht drüber nachgedacht. Das wäre nicht meins. Nein, das wäre nicht meins." (IP07, p. 5)

[30] "Naja. Ich muss sagen ich bin so eine, ich kaufe nicht immer gleich wenn etwas neu auf den Markt kommt. Aber wenn andere sagen dass ist gut, dann würde ich das vielleicht auch probieren." (IP11, p. 6)

[31] "Nein, brauchen würde ich das nicht. Es ist mit dem Auto fort fahren auch schön dann wieder. Wenn ich dann selber fahre und wenn ich die Zeit habe dass ich fahre. Nein, das ist auch schön. Nein, das muss ich nicht haben. Nein möchte ich nicht." (IP01, p. 20)

[32] "Also das selbstfahrende Auto ist für mich derzeit absolut noch nicht das Thema, weil da einfach noch zu viele Unsicherheiten da sind. Und ich bin grundsätzlich, muss ich auch sagen, da bin ich auch so ich für mich brauche es nicht, denn ich fahre selber." (IP03, p. 5)

[33] "Nein brauchen würde ich das nicht. Ich persönlich, ich fahre lieber so." (IP05, p. 7)

areas as well. They think, that this will possibly happen in bigger cities and highways, but not on the roads in the countryside.

> "To be honest, I don't think that I will live to see that I can trust that [autonomous driving]. Firstly it has to really begin and then it will come to us [countryside], this will still take forever anyways." [34] (IP09, p. 7)

> "I can not really imagine this [autonomous driving] to work on countryside roads." [35] (IP04, p. 4)

7.2.2 Concerns about Autonomous Driving

Additional to the rather skeptical attitude, there are also fundamental concerns on autonomous driving. During the interviews two aspects were clearly stated as the major concerns about self-driving cars: loss of control and dependency on a technology. Many interviewees did not like the idea of giving away full control to a machine or technology. This is interesting, because most of these people also take a ride in the subway or an auto-piloted aircraft. In these situations they do not have any kind of control either and yet, self-driving cars seem to be considered as different. One reason might be, that autonomous cars and the used technology is still widely unknown to people. They only get information about several successful or failed tests, but never got personally in touch with it. This seems to generate some kind of basic distrust considering self-driving cars in people's minds.

> "You still want to maintain control. Because you are really dependent on this whole thing, so you will also need to have a lot of trust in the machine then, that's for sure." [36] (IP02, p. 7)

> "Yes, I would miss the control." [37] (IP06, p. 18)

> "And I don't want to make myself completely dependent on anyone or any technology. I want to keep a certain control of it." [38] (IP03, p. 5)

Some participants mentioned, that they usually always drive and do not even like to be driven by another person and even less by a machine. They do not like the idea of sitting in a vehicle and giving away control. These answers were not always rational, since for instance one person stated, that they do not like to be driven by another person in a car, but a bus is not a problem. This shows, that reasons for feeling comfortable and safe in a vehicle are not always rational

[34] "Ehrlich gesagt glaube ich nicht, dass ich das erleben werde, dass ich dem vertrauen kann. Weil jetzt muss das erst mal richtig kommen und bis das dann zu uns kommt, das dauert sowieso nochmal ewig." (IP09, p. 7)

[35] "Auf der Landstraße da kann ich mir das ehrlich gesagt noch nicht so richtig vorstellen, ob das irgendwann mal funktioniert." (IP04, p. 4)

[36] "Man möchte einfach da schon auch die Kontrolle behalten. Also man ist dann schon voll abhängig eigentlich schon von dem Ganzen, also man muss halt sehr viel Vertrauen ja dann auch in die Maschine haben, das ist klar." (IP02, p. 7)

[37] "Ja die Kontrolle, die würde mir schon fehlen." (IP06, p. 18)

[38] "Und ich möchte mich nicht ganz abhängig machen von irgendwem oder irgendeine Technik. Sondern ich mag selber noch einen gewissen Einfluss haben darauf." (IP03, p. 5)

but related to the individual experiences. Positive test results might not have sufficient power to change such attitudes about trust in autonomous cars as explained in section 7.2.3.

> "Well this is also a little bit difficult for me because I don't like being driven by someone else. I mean, I like being driven by Pepi [husband], but, I don't like being driven by someone else. I prefer that we have it [car]. Therefore usually we drive when we go somewhere. Also with friends, often we are the ones driving. I feel more safe. I don't know if I am driving more safely, but I prefer it." [39] (IP01, p. 10)

> "I think this is the reason why I don't like traveling by train (laughs). Because then I am completely dependent." [40] (IP08, p. 7)

The fundamental concern about a loss of control is mentioned by many participants. It often results in a very strong desire to maintain the possibility of interference in the driving process. Interestingly, some interviewees even admitted, that the car might be a better and safer driver in difficult situations than a human being and yet, for reasons of control, these people would still prefer to interfere in the driving process.

> "Yes, that would be important for me. That would be important for me [being able to interfere]." [41] (IP08, p. 7)

> "Yes, because when you don't have any control anymore. That wouldn't be good." [42] (IP11, p. 8)

However, there are also participants who say, that if the car is able to drive alone, it should do it and resulting in no need for any further human interference. The opinions on these topic are rather diverse and sometimes even the same interview partner expressed contradicting statements in one and the same interview. Especially when it came to the questions of liability in case of an accident, participants often got caught in contradicting statements which will be shown in section 7.4 about legal issues.

Related to the potential loss of control, some interviewees had serious concerns about hypothetical worst case scenarios caused by a fatal system error. In this case, the participants are not afraid of the driving task being performed by a machine, but rather of the fact, that their whole mobility task might be controlled by another party. They do not have trust issues about the driving capabilities of an autonomous cars. Their main fear is, that if everything is connected and controlled by computers, hackers might have the possibility to shutdown the

[39] Naja das ist auch ein bisschen schwierig bei mir, weil ich fahre nicht gerne mit jemandem mit. Ich meine, ich fahre gerne mit Pepi [Ehemann] aber, ich fahre nicht gerne mit jemand anderem mit. Lieber ist es mir, dass es wir haben. Deswegen fahren auch viel wir, wenn wir wohin fahren. Auch bei Freunden, da fahren oft wir. Weil es mir so lieber ist. Da fühle ich mich sicher. Ich weiß nicht ob ich auch sicherer fahre oder sonst was, aber es ist mir so einfach lieber." (IP01, p. 10)

[40] "Ich glaube das ist der Grund warum ich so ungern Zug fahre (lacht) glaube ich. Weil ich da total ausgeliefert bin." (IP08, p. 7)

[41] "Ja, das wäre mir wichtig. Das wäre für mich wichtig [eingreifen können]." (IP08, p. 7)

[42] "Ja. Weil wenn du gar keinen Zugriff mehr hast. Das wäre nicht gut." (IP11, p. 8)

whole system. This would provoke catastrophic mass crashes or a complete standstill of the entire traffic.

> "This could also be hacked. That's another potential target in times of terror attacks, theoretically." [43] (IP10, p. 9)

> "But every system is somewhat error prone and I don't know, when everything, when there happens a huge crash or someone hacks it and then provokes a massive crash or I don't know what else." [44] (IP09, p. 6)

However, it was not only the fear of a criminal hacking attack but also well-directed manipulation from the government that was mentioned as a concern. The idea of being completely dependent on a complex system, without understanding how it actually works, frightens people. Some participants expressed a fundamental distrust in the government when it comes to control and surveillance (section 7.4.4).

> "Who decides what the car does? This has to be programmed by someone. I don't want that somewhere in the future someone will be able to completely re-direct your car or do something completely different with it. I do have these concerns because there's a lot of still unknown technology built in where you don't have any influence anymore." [45] (IP03, p. 6)

7.2.3 Trust in Self-driving Cars

There are different reasons for people to trust in autonomous cars or not. Many participants primarily fear the loss of control during driving and an uncontrollable dependency from the technology. The interviews showed, that there seem to be two different aspects of distrust that lead to these fears.
The first aspect is the distrust in the self-driving car itself, which leads to the already mentioned concern about loss of control. This means that people can at least not yet imagine driving a car without doing anything and giving over control to a machine. They are afraid that the automated car could overlook something, misjudge a situation or react inappropriately to potentially occurring dangerous events. These persons often doubt the technical capabilities of self-driving cars or the feasibility to make them able to handle specific road conditions and traffic situations. As an answer to why they have these doubts they often mentioned that this technology is still too unknown. In the interviews, these people usually say that they could not just lean back and let the car drive. They rather want to continue to observe the

[43] "Das könnte ja theoretisch auch gehackt werden. Das ist ja dann auch wieder in Zeiten der Terroranschläge ein potentielles Ziel, theoretisch." (IP10, p. 9)

[44] "Aber jedes System ist irgendwo fehleranfällig eben und ich weiß nicht, wenn dann alles, wenn es da einmal einen Riesencrash gibt oder sich irgendjemand rein hackt dann gibt es eine Massenkarambolage oder weiß ich nicht was." (IP09, p. 6)

[45] "Wer bestimmt dann was das Auto macht? Das muss ja auch irgendwer programmieren. Also nicht, dass es dann irgendwo, so ala Zukunftsvision, dass irgendwer wo sitzt der dann für dich das Auto sage ich jetzt auch mal ganz woanders hin lenkt oder ganz etwas anderes tut damit. Also diese Bedenken habe ich jetzt schon noch, weil da einfach immer noch so viel unbekannte Technik eingebaut werden muss, wo du überhaupt keinen Einfluss mehr hast." (IP03, p. 6)

driving process, being able to intervene at any time. Some of them also demand that others have to continue observing the traffic too. In this case, it is not only the own fear of a loss of control, but rather a basic mistrust in the car's capabilities which makes them want others to also manually interfere while driving. In order to overcome this distrust in autonomous car technology, the interviewees mention, that they would need time and they would have to see that it works. If they experience on their own or hear from friends, that these cars are capable of maneuvering critical situations, they might have increased trust in them. Phrases like *"It has to be 100% safe"* or *"It has to be completely mature"* are frequently mentioned. They often see positive test results only as an obvious pre-condition, but in order to actually trust autonomous cars, they need to create their own experiences.

> "It has to be really mature. Because when I am driving on a narrow street and the car drives on his lane and doesn't let me through, what do you do? It has to be able to detect when it's too narrow." [46] (IP05, p. 14)

> "I don't step in without any concerns. Not until it's really safe, when I don't know how many people have been driven with it. Not until I can be really sure." [47] (IP07, p. 5)

The second aspect of distrust is the distrust in the system which leads to the mentioned concerns about an uncontrollable dependency from a technology. Concerning these persons, they do not have any problems with the necessary trust to let the driver-less car perform the driving task, but they distrust the controlling entity in the background. They are afraid of hacker attacks as well as governmental surveillance and manipulation. These participants demand high security mechanisms as well as strict privacy guidelines (further discussed in section 7.4.4) in order to trust the technology. To at least partly relieve the dependency, there was often the demand for the option to deactivate autopilot and drive manually.

> "Sure, those two directions have to be existing, as you said, autopilot or not. This has to be existing, otherwise I would never buy such a car." [48] (IP10, p. 5)

7.2.4 Opportunities

Although people express various concerns about autonomous cars, the interviews show, that they definitely do also see opportunities. Whether people want to maintain the possibility of interference at any time or not, most of the interviewees stated, that automatically controlled cars might lead to a safer traffic situation in general. Many participants state, that dangerous threats like speeding, risky overtaking or other potentially dangerous maneuvers might be banned from the streets after the introduction of autonomous vehicles. Since these threats are

[46] Es muss halt wirklich ausgereift sein. Weil bei einer schmalen Straße wenn es dann auf seiner Spur fährt, und es geht sich nicht aus und das Auto steht nicht um, was machst du dann? Also das muss da schon auch erkennen, wenn es sich nicht ausgeht." (IP05, p. 14)

[47] "...aber so ohne mir nichts dir nichts setze ich mich da nicht rein. Erst dann wenn es so richtig, wenn ich sage, weiß ich nicht, da fahren wie viel damit. Erst wenn ich mir so richtig sicher sein kann." (IP07, p. 5)

[48] "Natürlich, also die zwei Richtungen muss es ja geben, wie du sagst, Autopilot quasi oder halt nicht. Das muss es geben, ohne dem würde ich so ein Auto niemals kaufen." (IP10, p. 5)

results of human drivers' behavior, people are optimistic that autonomous cars will improve this situation.

> "Yes I do think that there will be fewer accidents. For instance on the highway, well there are currently not that many accidents anyway, but I think that it will become even safer then." [49] (IP06, p. 15)

The traffic situation is not only believed to become safer, but also more convenient. As stated in the interviews, people think that traffic jams and overall driving experience might improve due to the ban of human drivers. The most mentioned advantage in this context is the relief of stress, usually caused by other traffic participants. It is interesting that people who claim, that humans should still be able to interfere in driving, say, that it is often human driving behavior, that makes them feel uncomfortable on the roads.

> "When you drive to holiday [in an autonomous car] and you arrive more relaxed, that's a different thing." [50] (IP04, p. 4)

> "Because if there's for instance more traffic, you've got to be concentrated and when it is more relaxed than you could also enjoy it [being driven autonomously], that would be the advantage, that's true, I would like that." [51] (IP01, p. 13)

According to the interviews people also see the opportunity that autonomous cars might improve the mobility of elderly people. An interesting aspect is, that persons who initially doubted their usage of autonomous cars because they do not see any reason in it often changed their mind, when they were confronted with the situation of being too old to drive a conventional car. In this situation, people started to explain that they possibly do want to use autonomous cars and that this might be a big advantage.
Some participants also stated, that the situation of young people, which not yet have a driving license but need to get to school or work could be improved. This might be also a relief for parents, which often have to drive their children to school, as stated in the mobility situation section 7.1.

> "Yes I see an advantage for elderly people, I don't want to exclude this. They certainly have an advantage because of them [autonomous cars]." [52] (IP07, p. 10)

[49] "Ja ich denke schon, dass es weniger Unfälle geben wird. Also zum Beispiel auch beim Autobahnfahren, naja da passiert jetzt eh nicht so viele Unfälle, aber dass das halt schon noch sicherer wird." (IP06, p. 15)

[50] "Wenn du in den Urlaub fährst und du kommst entspannt an, dann ist es etwas anderes als wie wenn." (IP04, p. 4)

[51] "Weil wenn dann jetzt z.b. mehr Verkehr ist oder so, dann muss ich mich eh konzentrieren und wenn es locker dahin geht, dann kann man es doch auch genießen, das wäre der Vorteil, das stimmt ja das würde mir schon gefallen." (IP01, p. 13)

[52] "Ja, ich sehe einen Vorteil für Ältere, das möchte ich jetzt gar nicht ausschließen, die haben sicher einen Vorteil davon." (IP07, p. 10)

Depending on people's trust in autonomous cars, especially in their driving capabilities, people mentioned that it could be nice to do other things while driving in a self-driving car and use the time. The opinions about this topic are very diverse and participants can be roughly separated in three groups, concerning their level of trust in the technology. Those participants, who wanted cars to be fully responsible for the driving task usually could also imagine, that it might be allowed to sleep while being driven in a self-driving car. There were statements arguing that, if you do not have to do anything while driving, you will get tired quickly and therefore it should definitely not be a problem if you fall asleep. In this context, also the consumption of alcohol is mentioned to be okay. Furthermore, these people could also imagine to have more comfortable, maybe turnable seats that would facilitate communication with other passengers. Additionally, tables for eating, couches, massage seats and camper like furniture were stated. They often compared the situation and things they would want to do with a trip in a passenger train.

The second type of opinions argue that, although the car drives on its own and a potential nap might be allowed, the driver has to be available for the occasional case where the system does not know how to continue. For these people drinking alcohol should remain forbidden, since it significantly degrades your ability to be able to take over control in case of an unplanned situation. However they would also use the time to talk or even eat with each other. An interesting concept which was mentioned by one interviewee is the idea, that there is not only one driver in the car. If the family eats together in the car and interference is necessary, the takeover of control should be possible for another driver in the car, if the current one wants to finish his meal. The interesting part of this idea is, that a car might lose the concept of one single driver performing on a designated spot.

The third group of participants sees automatic cars as an advanced driving system where you still have to watch the traffic all the time. These people would not allow sleeping or consumption of alcohol in a car and furthermore believe that driving licenses should remain mandatory. However, also these people usually could imagine to watch movies, play with the cellphone or eat while driving.

7.2.5 Conclusion

Following the interviews, people have different concerns about autonomous driving, but their basic attitude is very similar. They do not see a need for a change and therefore they are not awaiting self-driving cars to come. Moreover, many participants expressed their fundamental skepticism about the feasibility to introduce autonomous cars, especially in the countryside. This basically skeptic attitude is followed by various concerns. Except for the loss of jobs and the general concern, that people will be replaced by machines and stop using their own mind, there are two main categories of concerns mentioned during the interviews: loss of control and full dependency from technology. One the one side, there are people who are concerned about not being able to control their car anymore, because they doubt their technical feasibility to perform the driving task. On the other side, people are afraid of being fully dependent from a technology and controllable by others. Also potential worst case scenarios were mentioned in this context. Either way, both types of concerns lead the to demand, expressed by most

interviewees, for a separate automatic and manual mode and the possibility to interfere the automated driving process. Either because of doubts of technical feasibility or to regain partly independence from the system. Furthermore, the interviews showed two basic trust issues about autonomous cars as a result of these concerns. There is either distrust in the car and its driving abilities or the distrust in the system, speaking government, car manufacturer or the general controlling institution whatever it may be. In order to deal with a distrust in the car, people mentioned positive tests only as a pre-condition, but in order to gain real trust in these cars, they will have to try it successfully on their own and need time. Concerning the distrust in the system, people sometimes mentioned independent third-party supervision institutions which formulate strict publicly known regulations. Despite the mentioned distrust, people also see opportunities in self-driving cars. They definitely expect roads to become safer and they see advantages for the mobility of elderly people and students without a driving license. Furthermore, depending on their individual level and type of trust they would see a benefit in the possibility to do other things while driving and better use the spent time in a car.

7.3 Integration Strategies

Although almost all participants are quite convinced that autonomous driving will exist one day, most of them see it coming in a couple of decades rather than years. Depending on their individual trust in self-driving cars, the participants have different views on potential integration approaches of these cars in the existing traffic systems.

7.3.1 Traffic Integration Approaches

In order to introduce self-driving cars in a beneficial way, one has to think about how to integrate them in the current traffic infrastructure. Depending on their trust in automatic cars, the interview participants either favored separated or an inclusive integration of autonomous cars. Those who want the cars to drive on separated lanes are concerned about people being afraid of the unknown technology and think that society should be given time to get used to it. Some participants mentioned that they would feel uncomfortable if human interaction was missing among drivers. This inter-human communication is often used to solve tricky situations, where there is not enough space on the road or other scenarios. People are skeptical if autonomous cars are able to imitate this kind of human interaction. They are afraid to get stuck in situations, where self-driving cars stubbornly continue with their behavior and provoke some kind of deadlock.

> "When you are having eye contact with each other, let's say he would be allowed to drive, but you have eye contact. That's not right, but well. But this car would be stubborn. I wonder if this will fit together, such and such..." [53] (IP01, p. 21)

[53] "Wenn du jetzt mit dem anderen zusammen schaust, sagen wir er dürfte jetzt fahren aber man schaut halt zusammen. Das ist so auch nicht so richtig aber naja. Aber dieses Auto, das ist ja dann stur. Ob das dann zusammen passt, solche und solche..." (IP01, p. 21)

Interviewees also expressed the desire to be able to avoid getting into contact with autonomous cars if they wish to. Therefore, these interviewees proposed approaches with separated lanes or roads for self-driving cars. One participant even mentioned a separation in time, dedicating parts of the road system to autonomous cars for a given time frame. This should not be a permanent solution, but rather give people the possibility to get in touch with this technology step by step and by choice, rather than being forced to.

> "... I think it would be good, let's say, that for instance in the next two or three weeks, self-driving cars are driving here and there." [54] (IP02, p. 17)

Other participants have the opinion, that if self-driving cars claim to be capable of driving autonomously, they should be able to do so in the existing traffic infrastructure like conventional cars do. These people explain that it might be a little bit odd in the beginning, but this may change over time. They do not see a need for any kind of separation of self-driving and conventional cars.

> "No [to separate lanes]. If it works they can surely do it [drive on the same road]." [55] (IP12, p. 8)

As already mentioned in the introductory chapter, there are basically two approaches to integrate self-driving cars: the "everything somewhere" and the "something everywhere" approach. Considering the participants' view on this topic, none of these two approaches can be clearly identified as a favorite. A lot of people seem to have the desire to be able to choose if and in which intensity they get in touch with this new technology. A possible solution in this context might be a combination of the two strategies. Selected bus lines, taxis, high-way truck convoys or other separable traffic structures might be implemented in an "everything somewhere" approach, providing full autonomy in selected areas. People could decide on their own whether or not to use this technology but have at least the opportunity to get in touch with self-driving vehicles and maybe lose potential concerns. Furthermore, these implementations can be observed and analyzed to decide on further expansion or restriction of autonomous traffic, depending on the people's reactions. For the case of integration in the overall traffic structures, a "something everywhere" approach might be more appropriate. Increased automation technology as well as knowledge from observing fully autonomous vehicles in the separated areas might facilitate a continuous increase in car automation until eventually self-driving cars co-exist with conventional ones. This combination of the two strategies has the advantage, that integration can be regulated and adjusted according to people's response and behavior. This enables decision makers to react to user needs and implement self-driving cars in the most beneficial way.

7.3.2 Payment Approaches

Due to the necessary high-end technology used in autonomous cars they have the potential to be quite expensive, especially in the beginning when there is still no mass production as for

[54] "... ich glaube dass es gut wäre, wenn man jetzt sagt zum Beispiel die nächsten zwei bis drei Wochen fahren selbstfahrende Autos dort und dort." (IP02, p. 17)

[55] "Nein. Wenn es funktioniert, dann können die ruhig." (IP12, p. 8)

conventional cars. Also the interviewees stated their concerns, that these cars might be very expensive and not affordable for most people anyway.

> "Nobody will be able to afford such a car for a long time, will they?" [56] (IP12, p. 8)

> "It depends on if they are already able to afford such a car." [57] (IP06, p. 15)

But not only the cars might be expensive. People also think, that additional costs for infrastructure and regulations might have to be paid. The general opinion of the participants on this topic is, that if they can not afford a self-driving car, they do not want to pay anything for their integration either. A consequence might be the introduction of extra taxes on autonomous cars. This money could be used for the payment of additional costs for infrastructure. However, this approach would result in even higher prices for autonomous cars. This leads to some kind of deadlock. People are not willing to pay for something that they are not able to use but as a consequence it becomes even more expensive and unusable to them.

> "Well if so, then the people who buy the car should pay." [58] (IP01, p. 23)

A potential solution to this problem could be third party investors who believe in this new technology and cover the initial integration costs. Big companies might invest in autonomous driving by spending money for the elaboration of additional regulations, law changes and infrastructural adaption. The financing could also be done by a private company such as the ASFiNAG in Austria, which is responsible for the operation of Austrian highways.

> "Yes, I think this would have to be payed by some private investor. Because the government can definitely not say, that this will be payed with tax money, this wouldn't work in the beginning." [59] (IP02, p. 18)

However, in order to make expensive self-driving cars affordable for people who might need it, some interviewees would even consider subsidization as a solution. In this case they are okay with the idea of paying with their tax money for other people to have an autonomous car. These participants usually also think, that it is okay if the government uses everyone's tax money for additional costs of the introduction of self-driving cars. Some say, that the government wastes so much money on other, in their opinion meaningless things, that they could also pay for something reasonable as the introduction of autonomous cars.

> "So I would say, when I allow something like this [autonomous driving], then I have as a government a goal, like, I don't know, that we want to reduce cars. That we want to reduce cars with self-driving cars. It has to be a benefit for the general public and therefore they should also pay for it." [60] (IP04, p. 10)

[56] "Da wird sich eh lange niemand so ein Auto leisten können oder?" (IP12, p. 8)

[57] "Es kommt darauf an, ob sich die schon so ein Auto leisten können." (IP06, p. 15)

[58] "Naja wenn, dann sollen schon die Leute zahlen, die sich das Auto auch leisten." (IP01, p. 23)

[59] "Ja, das müsste irgendwie, also ich glaube einfach das müsste sicher von irgendeinem Privaten finanziert werden. Weil der Staat kann sicher nicht sagen, dass das jetzt von den Steuern benutzt wird, das ginge sicher am Anfang nicht." (IP02, p. 18)

[60] "Also ich sage mal, wenn ich so etwas zulasse, dann habe ich als Staat auch so etwas wie ein Endziel, dass

7.3.3 Insurances

Since in case of an accident the autonomous car might be responsible for the consequences, the question arises, if drivers will still need an insurance. The majority of the participants says, that they would still prefer to have a personal insurance. They claim, that if people are still able to interfere in the driving task, they will still need their own insurance.

> "And someone has to pay then. Hence, everybody still needs their insurance." [61] (IP07, p. 14)

In case of an accident caused by a self-driving car, the manufacturer should have to cover the costs without any personal insurance of the user. In this case, many participants expressed the desire for a general and uniform insurance, that covers all damages caused by the car. It should be automatically added when purchasing a car and should be linked to the vehicle. People say, that this might ease the scenario of an accident, because there would be less discussions and arguing among different insurance companies.

> "Yes for the autonomous mode the manufacturer either has to insure the car or provide a guaranty in case of any damage." [62] (IP03, p. 16)

> "Yes, I want this to work with a uniform thing, without struggling around with things. I don't have to go to the insurance and then the argue with the other insurance. If I don't have any influence on the driving, then it should simply,... there has to be done something to provide a big solution." [63] (IP05, p. 15)

Although many participants expressed their wish for a general insurance, some also mentioned the desire to still be able to choose their individual one. The main reason is the ability to to decide which damages should be covered by the insurance which influences the resulting costs. Taken into account the participant's views, a potential solution might be a personally configurable private insurance for human caused damages and a general uniform solution for damages that were caused by the car. This approach seems to be able to combine people's different demands in a practical way.

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es heißt, was weiß ich, wir wollen die Autos reduzieren, dass man mit selbstfahrenden Autos also die Autos auch reduziert. Also das muss für die Allgemeinheit auch einen Mehrwert haben und deswegen soll es auch die Allgemeinheit zahlen." (IP04, p. 10)

[61] "Und irgendwer muss dann irgendetwas sowieso zahlen. Also braucht auch jeder Mensch noch nach wie vor seine Versicherung." (IP07, p. 14)

[62] "Ja, für den autonomen Modus muss der Hersteller entweder versichern oder garantieren für Schadensfälle." (IP03, p. 16)

[63] "Ja, da möchte ich einfach, dass das ein einheitliches Ding ist, nicht dass ich dann wieder umherdum tun muss. Ich muss nicht zu der Versicherung und die streitet sich wieder mit der anderen Versicherung. Wenn ich eh keinen Einfluss habe auf die Fahrweise, dann soll das einfach, wenn ich einen Schaden mache ja,... dann muss irgendetwas gemacht werden, dass das einfach über eine ganz große Lösung geht." (IP05, p. 15)

7.3.4 Conclusion

As in many other discussed topics, people's opinion on the integration of self-driving cars strongly varies from one person to another. Therefore, a practical solution might be the proposed combination of the "everything somewhere" and the "something everywhere" approach where fully specific fully autonomous vehicles like buses or trucks are coexist with increasingly automated individual vehicles. This way, people will have time to get used to autonomous vehicles and the integration can be done step by step without any undesirable disruptive change. The baseline for different payment approaches considering the introduction of autonomous cars is that people do generally not want to pay for something they are not able to use. Many interviewees are concerned that self-driving cars might be some kind of luxury for rich people which they might not be able to afford for themselves. Therefore, they mostly do not want any tax money to be spent on this technology. On the other hand, if these cars are available for everyone, whether as some kind of mobility service or as individual vehicles, most of the interviewees seem to be in favor of public money being spent on the cars' integration. Unfortunately this state of mind may lead to a deadlock because self-driving cars might be initially very expensive without any public funding. Therefore, investments of third party organizations or companies might provide a solution for the initial potential need for money. Since people mostly wanted cars to be liable in case of an accident they mostly expressed that they want the car to be insured automatically by the manufacturer. This should especially prevent discussions of payment in case of an accident. However, this approach might result in difficulties considering that many interviewees want to maintain the possibility of interference in the driving process. Since in such cases where the driver causes an accident the car will not take over full responsibility, personal insurances will still be necessary. A solution could be, that only people who want to maintain the possibility of manual interference will have to be privately insured.

7.4 Legal and Ethical Issues

During the interviews, different considerations on legal issues and regulations were mentioned. These findings can give important input for law making institutions in order to evaluate their laws and regulations for a beneficial implementation and usage of autonomous vehicles. Moreover, there are also potential issues with the operation of self-driving cars, that have a rather ethical than legal character. In this section we want to elaborate the participant's opinions on different topics in this field.

7.4.1 Liability

Although many interviewees want to maintain the control over their car, most of them are not willing to take the resulting responsibility. The baseline on this question in almost all interviews was, that they want to be able to interfere at any time or situation, but they do not want to be obliged to do so. Observing the traffic and taking over control in case of dangerous situations should be possible but not obligatory. Thus, in case of an accident, the participants

usually see the car to be liable, since it must be able to perform the driving task solely and take full responsibility.

> "Well, actually I don't want to be obligated to interfere. However I definitely want to be able to do it in order to maybe change the behavior in a specific situation. But I don't have to do it." [64] (IP06, p. 7)

> "I want to be able to react, but not obligated to do it." [65] (IP03, p. 15)

But not all interviewees have this opinion. There is also a group, that still sees the human driver to be responsible and also liable in any driving situation. These participants see the autonomous mode as a nice feature, which does not relieve the driver from taking action in case of malfunction or other situations where interference might be needed.

> "I think, that you still do have to observe the traffic." [66] (IP01, p. 14)

> "I would say you are responsible for yourself. You decide to use it [autonomous driving], that's your own decision and therefore you are responsible for it." [67] (IP02, p. 9)

There is also a third group of interviewees who fully trust in autonomous cars and therefore do not see any need for potential intervention. As a consequence, they definitely see the car to be liable in case of an accident. They usually do not care if the car, the manufacturer or the autonomous car technology provider should be blamed as long as they do not have to take responsibility on their own.

> "Exactly. If someone offers such a car, than the car has to be liable." [68] (IP04, p. 8)

Basically the opinions on liability are very diverse and sometimes answers are contradicting each other. It will be difficult to provide people with the demanded possibility of interference at any time, especially in case of critical situations, but make the car responsible for potentially resulting consequences. Engineers as well as lawyers will have to work together in order to find feasible solutions that satisfy the demands on every side.

7.4.2 Driving Permission and License

Another interesting legal aspect is who will be allowed to drive. As a first consideration, there is the current concept of a driving license. The question is, if people will still be required

[64] "Naja eigentlich möchte ich schon dass ich nicht eingreifen muss. Aber auf alle Fälle können, also dass man sagen kann ich möchte das in dieser Situation anders machen. Aber müssen nicht." (IP06, p. 7)

[65] "Ich möchte reagieren können, aber nicht müssen." (IP03, p. 15)

[66] "Ich glaube, dass man dann doch einfach noch mitschauen muss." (IP01, p. 14)

[67] "Ich würde sagen, man ist selber verantwortlich. Man entscheidet sich dafür, das war seine eigene Entscheidung und damit ist man auch selbst dafür verantwortlich." (IP02, p. 9)

[68] "Genau ja. Ja wenn wenn man so ein Auto anbietet, dann muss die Rechtsfrage auch beim Auto sein finde ich." (IP04, p. 8)

to perform a driving exam as it exists at the moment even for a self-driving car? As other aspects, this depends on the actual degree and implementation of an autonomous cars. Many interviewees want the driving license to remain mandatory, however, they could imagine changes in its volume and scope. This could, for instance, result in making them more easy available for young or elderly people. An upcoming issue in this context is the potential loss of driving experience and skills due to the use of autonomous cars. Participants, who still see the need for occasional manual driving, are worried that people may forget how to drive. Therefore the idea of regular practical driving checks was mentioned. However, this approach could eventually lead to rather stricter than weaker regulations concerning the permission to drive, since these checks are currently not mandatory.

> "The driving license in its current form would fall away. Knowing what it is and what is happening with a car, that would not fall away. So it will be a different form of a driving license." [69] (IP03, p. 13)

> "I think you could weaken this [conditions to obtain a driving license]. Yes that would be okay. I would say if you are about 14 or 15 years old, so when you are allowed to drive a moped and you would start working, than there should be some training to obtain a driving license." [70] (IP06, p. 11)

There are also people who believe in fully autonomous cars and therefore do not have issues concerning a lack of driving experience. However, these people mostly sill want some kind of basic driving license too. This license should confirm the basic awareness of the driver considering traffic and basic driving tasks. Furthermore, it should be used for the distinction between adults and children being driven in the car. In this context often some kind of different driving modes were demanded. On the one hand, adults who are allowed to drive manually should be able to interfere, whereas drunken or elderly people as well as children should be traveled in an automatic mode without any possible interference.

> "Yes. If the car can do everything and when he [young person] can not influence it in a way to speed or anything." [71] (IP12, p. 6)

7.4.3 Lose-Lose Situation

An ethically difficult issue is the car's behavior in situations where a negative or possibly even fatal outcome is unavoidable. As already stated in the introductory chapter, this thesis will not focus on how people would decide, since the investigation of this question is rather extensive. The focus in this work was set on the question how this decision should be made. There were different approaches proposed during the interviews. The first group of people do not believe in fully automated cars and therefore always want drivers to be obliged to react in difficult

[69] "Der Führerschein in der jetzigen Form würde wegfallen. Das kennen, was das ist, und was mit dem Auto passiert und so, das fällt nicht weg. Also eine andere Form von einem Führerschein." (IP03, p. 13)

[70] "Ich glaube dass man es dann schon abschwächen könnte. Ja das wäre okay. Ja ich sage jetzt mal wenn man fertig ist mit der Hauptschule, mit 14 Jahren, oder mit 15 Jahren wenn man dann ins Berufsleben einsteigt (Moped Alter), dass man da irgendwie so eine Ausbildung wie einen Führerschein machen kann für das." (IP06, p. 11)

[71] "Ja wenn das Auto alles kann und wenn er das nicht beeinflussen kann, dass er rast oder so." (IP12, p. 6)

situations. In this case, the car does not have to implement any critical decision making algorithm and simply passes responsibility over to the driver.

> "So I would not trust this 1000%. I do want to be able to still control this in any way how the situation turns out in this case for me, I don't know." [72] (IP07, p. 16)

Another approach which is favored by some interviewees is the possibility to personally adjust the decision making algorithm in some way. This might for instance be done during the purchase of the car or at home. The car should provide a simple interface to adjust preferences in case of a critical situation. This preferences could consider number of persons to survive, their age or also the fact if they are passengers of the own car or not. Giving the car owner these options provides them with some kind of control over these situations since for these interviewees the idea of giving away full control appears scary.

> "I think it would be better if you are able to adjust this on your own." [73] (IP08, p. 17)

> "I think everyone has to decide this on their own. I think, if this will be implemented, then it should be programmed in a way that you can say, that in case of this situation, sure, that nobody will be hurt, but that the car isn't damaged too badly either and that it doesn't drive somewhere down in a way that the driver gets hurt." [74] (IP02, p. 10)

The third mentioned approach completely contradicts the former stated possibility to adjust the algorithm for the sake of control. These participants definitely do not want people to be able to decide on their own. They are afraid of people adjusting the car only in their own advantage. Therefore, these interviewees prefer an official solution which is publicly known and has to be followed by every car manufacturer. These participants clearly see a difference between a reaction done in a stressful situation while driving and the opportunity of an adjustable algorithm where you can make your decision in advance. They want the algorithm to be officially supervised and not individually implemented by car manufacturers on their own. Individual implementations might lead to manipulation of the decision making process in order to benefit the manufacturers own car and might cause a dishonest competition. One participant mentioned that these algorithms have to be encrypted an secured. Otherwise illegal adjustments could be done, facilitating a market similar to chip tuning and giving people with money the opportunity to manipulate their car for their advantage. However, the approach of publicly known behavior can also have downsides. One interviewee was concerned about potential frauds if everyone knows the exact behavior of a car. If the car is

[72] "Also so 1000%ig würde ich mich da nicht darauf verlassen. Das möchte schon ich noch in irgendeiner Art und Weise steuern können wie die Situation ausgehen könnte in diesem Fall für mich, weiß ich nicht." (IP07, p. 16)

[73] "Dann fände ich es schon besser, wenn man das selber einstellen kann." (IP08, p. 17)

[74] "Ich glaube, das müsste jeder selber entscheiden. Ich finde, wenn dann müsste man das so irgendwie programmieren, oder so angeben, dass man sagen kann, falls diese Situation wäre, klar, dass ich keinen anderen verletzte, aber das Auto soll nicht zu arg zu Schaden kommen oder soll jetzt nicht irgendwo runter fahren, so dass der Fahrer selber dann zu Schaden kommt." (IP02, p. 10)

known to be programmed to save children, someone could for example push an empty baby buggy on the lane, causing the car to drive off the road.

> "Yes [publicly known algorithm]. I don't want that you can change this or, I mean every car has the same system, enforced by the law so to say. Because this could also be manipulated again, that's the other question. But it should be the same in every car, also if it's a new model, so it should always be implemented the same way, it should always be up to date and every car should behave the same way." [75] (IP06, p. 18)

7.4.4 Privacy and Data Usage

People are already confronted with privacy and data usage issues in their daily lives. The customers' shopping histories in online stores are traced for later evaluation as well as the locations of their smartphones or any kind of personal data that people are sharing on social media. The interviews show that a lot of people a generally aware of this privacy issues, but very few of them have actual knowledge about regulations. Self-driving cars could bring new potential frauds to people's privacy which have to be analyzed and regulated in order to protect people's personal data.

First of all there is the way how data may be collected in an autonomous car and what type of data this may be. People have very different opinions on this topic and there exists a broad variety of answers to these questions. Although there are some people which do not care at all what type of data may be collected, the majority does not like the idea of real-time surveilance. This means, they do not want others to have the possibility to observate their current location at any time. This also applies for personal data as for example who is driving in the car. On the other hand, people are usually fine with the collection of engine data as well as basic routing data of the car. The problem is, that they are not aware, that with daily location data, whether in real-time or not, it is very easy to identify the individual person as well. One would just have to compare the addresses of the daily journeys and therefore might find out the home address and the job's location. Comparing this data with a potential social media account, providing information on the current employment can give away the actual person behind these anonymous trips. As it is already the case for current applications, sophisticated anonymization algorithms have to be used in order to overcome this issue and provide users with the desired degree of anonymity and privacy.

> "Then it would be okay [if anonymized], i just don't want to be supervised." [76] (IP08, p. 20)

[75] "Ja schon. Also nicht, dass man da noch was ändern kann oder dass es halt, ich sag halt, dass jedes Auto dann das gleiche System hat, vom Gesetz vorgegeben so quasi. Weil das könnte man dann natürlich auch wieder manipulieren, das ist ja die andere Frage. Aber dass das bei jedem Auto gleich ist, auch bei einem neueren Modell, also dass da immer genau das gleiche drauf ist, also dass das immer aktuell ist weil jedes Auto soll sich gleich verhalten." (IP06, p. 18)

[76] "Dann wäre das in Ordnung, ich mag nur nicht wenn ich kontrolliert werde." (IP08, p. 20)

For all interviewees the question on which data they would allow to be collected strongly depends on the intended use of the data. None of the participants is worried about the data being used by official authorities for traffic planning in cities. The same applies for technical data of the cars' performance and engine statistics, which can be used by the car manufacturer to optimize and further improve the car's driving performance. Some people would give away this kind of data for free, others would want to be financially rewarded, but almost all of them agreed to give away such information. For criminal persecution, interviewees agreed to provide personal data and most of them would even give away real-time data in this case. People say, that they are not doing anything criminal and therefore do not have anything to hide and no problem with the collection of their data for persecution. In contrast to these mentioned use cases, people are very concerned about their data being used for advertisement. Although some would give away there data if the got financially rewarded, most participants clearly deny the usage of collected data for personalized marketing or similar applications. Despite the individual differences and variations a basic common view on data usage could be examined. As long as the receiving institutions use the data for reasonable and beneficial purposes as criminal persecution, people are generally okay with it. But as soon as they feel exploited, supervised or in any way unnecessarily cut in their privacy they completely deny further data collection.

> "No, for advertisement neither It might be implemented optional. But I would not do it." [77] (IP11, p. 17)

7.4.5 Conclusion

Almost all participants agree on the liability of the car in case of any incident. Regardless if they want to maintain control or not, in the end, they do not want to take responsibility if a self-driving car causes an accident. The crucial task in this aspect will be to give the user the desired amount of control but still provide the autonomous car with enough authority to be able to safely perform the driving task and avoid accidents. It is clear, that car manufacturers can not take over full responsibility if the manually interfering driver causes an accident, but on the other hand, user's do not want to be blamed in case of a technical fault of their car. The exact borderline in this context is very hard to find and still an open issue. It has to be clearly defined especially during the integration phase of autonomous cars, when they are still not capable of driving completely alone, but already take over a majority of the driving tasks. A potential solution might be the exact tracking of which tasks were performed by the car and which by the driver. In case of an accident, this data might be analyzed to find out the cause of the accident and who is to be blamed. However, one can imagine that this might cause tricky situations and has the potential for intense lawsuits. Another approach would be the exact definition of the cars and drivers responsibilities in advance by comprehensive regulations. Considering driving licenses, the majority of the interviewees agrees on the possibility to at least lower the necessary requirements for obtaining a driving license. A possible approach to regulate the requirements for a driving license, a potential lack of driving

[77] "Nein, Werbung auch nicht. Auch nicht für Geld. Man könnte das eventuell auch wieder optional machen. Aber ich würde das nicht machen." (IP11, p. 17)

practice and different driving modes for different persons would be driving modes, that relate to the person's age, driving skills, physical condition and other factors. When entering an autonomous car, the persons license gives information on these mentioned factors and the car switches to the according driving mode, either taking away full control in case of children and drunk people, partially taking control in case of handicapped or elderly people and persons with little practice or providing full interference possibilities. This solution might be the most feasible and beneficial approach in this context. In case of lose-lose situations, the decision making process remains an open issue. People's views on this topic are very contradictory and there are many factors to consider. On the one hand, it is a person's personal right to decide how to behave in critical situations, since this might influence their own life. On the other hand, calmly setting some properties in an algorithm can not be compared with the stress situation right before an accident and decisions might be vastly biased. Last but not least there is still the threat of manipulation of the algorithm, as well as taking advantage from knowing the exact behavior of a car. Because of the very contradicting opinions of the users and the contrasting aspects which have to be considered during the implementation, no comprehensive solution approach can be proposed at this point. Scientist from various disciplines like ethics, mechanical engineering and computer science will have to work closely together in order to find an appropriate solution. Privacy and data collection is already an issue. The interviews show, that people have generally very little knowledge about this topic and react in different ways. Despite different opinions on data collection, the baseline was, that if data is used for reasonable purposes such as improving traffic or safety, people are usually willing to give away data. This might even be the case for personal data and without any financial rewards. On the other side, the participants mostly reacted very negatively with regards to the usage of their data for commercial purposes such as advertisement. Stakeholders will have to invent and implement sophisticated and transparent strategies to protect people's privacy. If they succeed convincing the users, that their data is protected and used for reasonable purposes, people generally do not seem to have serious issues when their data is collected. In case of persecution or emergency help most would even be in favor of according usage of personal data.

CHAPTER 8

Summary and Outlook

Autonomous Driving definitely has potential to revolutionize the way of transport in the 21th century. Because ongoing technical advances might lead to over-optimistic predictions, this thesis shows the importance of taking the user's perspective into consideration in order to find a beneficial introduction.

8.1 Summary

The examination of the current mobility situation shows, that the broad mass of people in the country side do not experience any significant problem concerning their mobility. As a consequence they do not really see any need for a change, at least not in the first place. People in the countryside are very, very used to their way of transport and the convenience that comes with it. They are accustomed to being able to drive when they want and where they want, without any obligations to other people or timetables. Since they often do not have any alternative to their private car, they do not even consider other ways of traveling. As a consequence, people see autonomous cars as an additional luxury, increased convenience or prestige added to a car, rather than a revolutionizing technology providing completely new opportunities. This means, that people are not very excited about this new technology to be introduced, since in their eyes it is mostly just another technical toy. However, when bringing up the topic of missing public transport and the lack of mobility of people that are not able to drive, as well as additional convenience due to the gained free time while driving in an self-driving car, people start getting interested. Although they mostly can not imagine to change their own habits, they do see this technology as an opportunity. This behavior shows, that people do see positive advantages of self-driving cars, but not initially.

8.2 Future Work

The thesis provides profound knowledge about the user's perspective on autonomous cars in rural areas. Explanations and consideration regarding the mobility situation, integration strategies as well as legal and ethical issues have been investigated and analyzed. This information already provides fundamental knowledge in order to support stakeholders' decision making processes. However, there are still open issues and future work to be done.

8.2.1 Comparison to Urban Areas

As already mentioned in this thesis, the analysis of autonomous cars use cases in urban areas is more advanced than that of rural areas. However, there is still a knowledge gap for the user's perspective on self-driving cars in urban areas. A comparison of already examined aspects in rural areas with urban areas might give clues how people's attitude differs, depending on the area they live. Interesting influencing factors to consider would be the availability of public transport as well as the fact that people in cities usually are more aware of car sharing services or maybe even first autonomous mobility implementations. Many participants in the interviews of this study stated, that they expect self-driving cars first to be implemented in big cities. As reasons for this opinion they say, that it would not make sense to start in rural areas because there are too few people and the roads are too bad. An interesting study would be to examine these assumptions and have a look at their validity. Maybe people in cities do not see any need at all for self-driving cars either, because they have public transport and short ways to work. An analysis of this context could bring interesting insights, that might greatly influence integration strategies and uses cases of self-driving cars.

8.2.2 Different Rural Areas

For this study, all interviews have been done in the area of western Upper Austria. Although this region with its infrastructure and population is quite typical for Austria, comparisons with other regions might bring additional findings. Influencing factors on the attitude towards self-driving cars could be the distance to the next city or the work situation with local companies, which reduce the distance for commuters. If people have short distance ways to their working places, the pain for daily commutes might be reduced. This can also be influenced by the quality of the roads, traffic density and the availability of trains. Another factor could be the presence of grocery stores, banks, hospitals and other infrastructural institutions. All these aspects might affect people's need for a car and therefore could influence their desire for additional mobility provided by autonomous cars. Different rural areas show different combinations of these mentioned factors and a comparison could show, which ones are actually influencing people's attitude towards self-driving cars. These results could be used to further examine actual factors that result in a demand for autonomous cars which may help to find out potentially beneficial use cases.

8.2.3 Further Investigation of Ethical Issues

Although ethical issues have been considered in this study, they are still an open problem and have to be further examined. People's attitude towards this kind of problem is very emotional and varies greatly from person to person. Since the topic is very complex and versatile it demands sophisticated, in-depth investigation. Potential future work could focus especially on ethical decisions like liability and decision making in case of an accident and elaborate potential solutions that take care of people's various desires and fears in this context. This includes considerations on how people can be given the highly demanded feeling of maintaining control, whilst also having the potential for the cars' own autonomous control. Further research might find out what the actual reason for people's desire for control is and how this issue can be solved. Another very important consideration is the car's behavior in case of a critical lose-lose situation. Additional research on people's attitudes and reasons for their opinion is necessary to fully understand all different aspects and come up with a potential solution to this very sensitive topic.

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Appendix

Interview Guide

Interview Leitfaden

"Autonomous Driving - Opportunities, Challenges and Risks of Self-driving Cars in Rural Areas from a User's Perspective"

Einführung

Ich werde heute mit dir ein Interview für meine Masterarbeit durchführen. Es handelt sich dabei um ein freies Interview, in dem du so unvoreingenommen wie möglich zu den angesprochenen Themenbereichen erzählen kannst. Lass deinen Ideen und Visionen freien Lauf. Konkret geht es bei dem Interview um Mobilität. Dieses Thema werden wir anhand verschiedener Aspekte bearbeiten, wobei zu jedem Augenblick deine persönliche Meinung von zentraler Bedeutung ist. Die Ergebnisse werden anschließend anonymisiert im Zuge meiner Masterarbeit von mir zusammengefasst, analysiert und ausgewertet.

1. Situationserfassung

1.1. Wenn du an euren Haushalt denkst, inklusive aller Mitglieder. Welche Fortbewegungsmittel nutzt ihr?	
- Wofür?	
- Wie und Warum?	
- Bedeutung?	

1.2. Denke an einen normalen Arbeitstag. Wie sieht euer normaler Alltag bezüglich Mobilität aus? Wer muss wann, warum, wohin?	
- Individuelle Mobilität wichtig? Warum (nicht)? Alternativen	
- Öffentlicher Transport? Möglich? Welche? Warum/Wie (nicht) genutzt?	
- Mitfahrgelegenheiten?	

1.3. Und wie ist das bei besonderen Unternehmungen wie Besuchen bei Verwandten, Amtswegen, Urlauben oder Hobbies. Welche Unterschiede gibt es zum Alltag?	
- Andere Verkehrsmittel? Welche? Warum?	
- Unterschiede im Verhalten?	

2. Problemerfassung

2.1 Wenn du an deinen Weg zur Arbeit/Kindergarten/Schule/Einkaufen denkst, nenn mir doch bitte etwas, was dich dabei so richtig wurmt? Funktioniert da alles so wie du es dir vorstellst oder was ärgert dich dabei? Womit bist du unzufrieden?	
- Verlorene Zeit? Welche Tätigkeiten während Fahrt?	
- Einfluss auf das Design des Auto?	
- In welche Lebensbereiche (Arbeit, Shopping, Urlaub,..)?	
- Individuelle Nutzung und/oder öffentlicher Transport?	
- Mangelnde Flexibilität?	
- Parkplatzsuche?	
- Keine Garage? Auto abscheren?	

2.2. Wie sieht das bei besonderen Unternehmungen wie zum Beispiel Besuchen oder Urlaubsreisen aus? Was geht dir dabei auf die Nerven?	
- Verlorene Zeit? Welche Tätigkeiten während Fahrt?	
- Einfluss auf das Design des Auto?	
- Individuelle Nutzung und/oder öffentlicher Transport?	
- Mangelnde Flexibilität?	

3. Wünsche, Bedürfnisse und Bedenken

3.1 Du darfst dir die perfekte Lösung für deine Fortbewegung ausdenken. Wie sieht diese aus? Ohne jegliche technischen oder finanziellen Hürden.	
- Individuell oder Öffentlich?	
- Welche Transportmittel? Warum? Wofür?	
- Selber fahren oder gefahren werden?	
- Mehrere Fahrzeuge pro Haushalt oder ein gemeinsames (mit Nachbarn)?	

3.2 Inwieweit hast du schon mal an selbstfahrende Fahrzeuge gedacht?	
- Warum (nicht)?	
- In welchem Zusammenhang?	
- Für dich persönlich? Im Haushalt?	
- Welche? Auto, Bus, LKW,...	

3.3 Würdest du selbstfahrende Autos nutzen? Was gibt dir Bedenken? Was gefällt dir an dieser Idee?	
- Warum (nicht)? Was könnte die Einstellung ändern?	
- Wofür?	
- Bis zu welchem Automatisierungslevel?	
- Welches Vertrauen in Fahrzeug?	

3.4 Stell dir vor, dein Auto müsste bei einem Unfall entscheiden wer involviert wird, weil es keinen anderen Ausweg mehr gibt. Wie sollten solche Szenarien gehandhabt werden? Wer sollte diese Entscheidung treffen?	
- Unfälle (Lose-Lose Situation)	
- Bedeutung und Wichtigkeit?	

3.5 Welche zusätzliche Bedeutung hat dein Auto für dich neben einem Fortbewegungsmittel?	
- Statussymbol?	
- Freude am Fahren?	
- Von selbstfahrenden Fahrzeug ersetzbar?	

3.6 Würdest Du in einem selbstfahrenden Auto schlafen oder deine Kinder damit fahren lassen?	
- Schlafen	
- Kinder fahren lassen	
- Auto unbemannt fahren lassen	
- Voraussetzungen für Vertrauen in Sicherheit? Tests?	

3.7 Stell dir vor es gibt selbstfahrende Fahrzeuge, die komplett von alleine fahren können. Wie sollen diese aussehen und wie würdest du sie nutzen?	
- Tätigkeiten während der Fahrt?	
- Mobiles Badezimmer, Wohnzimmer, Büro, Schlafzimmer,...	
- Chaufferdienste?	
- Mitfahrgelegenheit?	
- Wiedererlangte Mobilität?	
- Buslinien, Taxirouten, Platooning, End-to-End	

4. Einführung von autonomen Fahren

4.1 Für die Einführung von autonomen Fahrzeugen braucht man eventuell Infrastruktur (Leitsysteme, besondere Ampeln, Ausrüstung anderer Verkehrsteilnehmer). Wer sollte deiner Meinung nach für die Kosten aufkommen? Wie soll das geregelt werden?	
- Förderungen vom Staat (Steuern)	
- Individuell	
- Automobilhersteller (im Kaufpreis enthalten)	

4.2 Unabhängig davon ob du selbstfahrende Fahrzeuge benutzt würdest, inwiefern wäre es dir unangenehm wenn im Straßenverkehr solche Fahrzeuge unterwegs sind? Wovor hättest du Angst? Wie ließe sich das lösen? Was würde dir daran gefallen?	
- Gesonderte Bereiche (Autobahnlinien, Straßen,...)	
- Automatisierungsgrad? (everything somewhere vs. something everywhere)	
- Würde zusätzliche Sicherheit bringen? (Rasen, Trunkenheit,...)	

5. Rechtliche Aspekte

5.1 Angenommen du hast einen Unfall mit deinem selbstfahrenden Auto. Wo liegt deiner Meinung nach die Verantwortung? Und wer bezahlt den Schaden?	
- Verantwortung im Falle eines Unfalls	
- Wer übernimmt Versicherungen? (Staat, Fahrzeughersteller, Privatperson,..)	
- Autonomes vs. Konventionelles Auto Probleme?	

5.2 Wer sollte deiner Meinung nach für die Versicherung eines selbstfahrenden Autos sorgen und bezahlen?	
- Wer zahlt?	
- Wer sorgt für Versicherung?	
- An Hersteller geknüpft? Staatlich?	
- Unfall zwischen herkömmlichen und autonomen Fahrzeugen	

5.3 Würdest Du auch betrunkenen Personen oder Personen ohne Führerschein das Fahren erlauben? Welchen Personen? Würdest du selber betrunken fahren?	
- Führerschein	
- Alter (Kinder?)	
- Alkohol am Steuer	
- Geistig oder körperlich behinderte Menschen	
- Alte oder senile Menschen	

6. Datenschutz

6.1 Wenn du mit einem selbstfahrenden Auto unterwegs bist, werden Daten gesammelt. In wie fern würde dich das stören? Welche Daten sollten geheim bleiben?	
- Routen	
- Ziele (Geschäft, Arbeitsplatz, Schule, Urlaubsort)	
- Zeit und Dauer	
- Häufigkeiten	
- Mitfahrer	
- Optional oder verpflichtend	
- Anonym oder personifiziert	
- Finanzielle Entschädigung	
- In Echtzeit oder zB. gesammelt einmal pro Woche übertragen	

6.2 Von wem dürfen deine gesammelten Daten verwendet werden? Wofür? Welche Bedenken hast du dabei?	
- Regierung (Straßenplanung)	
- Polizei (Strafverfolgung)	
- Autohersteller (Optimierung)	
- Marketing (Werbung)	

Angaben zur Person

Name:
Alter:
Geschlecht:
Höchster Bildungsabschluss:
Beruf:
Eigenes Auto: