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Investigating the effects of self-driving technology on public transportation in Sweden

A case study on the strategic implications of automated driving systems on the public transportation sector in Sweden

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Abstract

Revolutionizing transportation as we know it, self-driving vehicles have emerged as the frontrunners of cutting-edge technology, promising a future where roads are navigated with unrivaled precision and efficiency. While the adoption of self-driving technology is in an early stage with a few pilot projects underway within the Swedish public transportation sector there is a strong trend and developments ongoing. This study takes an explorative approach towards understanding the standpoint and actions taken by Swedish public transportation actors to gain a deeper understanding of how public transportation companies in Sweden are preparing and what the potential impacts of self-driving technology may be.

Several companies that act as key players within the Swedish public transportation sector were included as case studies where representatives shared their knowledge, beliefs, forecasts and ongoing actions during qualitative interviews. The empirical evidence is also connected and analyzed with regards to literature and previous studies. In the study it becomes evident that there is work to be done, highlighting certain obstacles seen with the technology not up to date. There is also a clear need for strategic actions as the entry of fully self-driving technology requires a well functioning system where actors collaborate.The findings of this research further exhibit that there is a push of self-driving technology as it in correlation with a functioning system could have many potential sustainability benefits.

Keywords: Autonomous vehicles, Self-driving technology, Technology forecasting, ecosystems, Mobility-as-a-service, Public transportation, Artificial intelligence, sustainability.

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1. Introduction:

Self-driving vehicles are ushering in a revolution at the start of a new age in the constantly changing transportation sector. Although completely autonomous cars are still in their infancy, limited partial self-driving technology is already widely accessible (Yurtsever et al., 2020). Furthermore, the timing of a prospective implementation is fraught with ambiguity (Vitale Brovarone, Scudellari, & Staricco, 2021). Nevertheless, it is commonly acknowledged that change will eventually occur (Vitale Brovarone et al., 2021). Furthermore, Agarwal, Chiang, and Sharma (2019) emphasize that the implementation will eventually be upon us.

Once fully self-driving technology is available, it has the potential to drastically change the way we think about mobility, safety, and sustainability in the transportation sector (Howard & Dai, 2014). Through the elimination of the human aspect, it promises to decrease the frequency of hazardous accidents and enhance efficiency on the road (Howard & Dai, 2014). However, even while self-driving technology has the potential to transform the transportation sector, the Swedish public transportation sector is aiming to double its market share (Grönlund, 2017). However, the way that an implementation of self-driving technology will impact the industry specifically is uncertain. There are possibilities of significant expense reductions and efficiency gains but also new competition through the implementation of the technology in the private sector. This presents a highly uncertain future for the industry as they attempt to double their market share and prepare for the implementation of fully self-driving vehicles simultaneously. As such the industry needs to act, lest risk face not just a failure to double their market share but also risk their current market share,

Given this situation, the goal of this thesis is to examine any potential impacts that Sweden's public transportation sector may experience from the adoption of fully autonomous driving technology. In this light, the thesis asks:

How are public transportation companies preparing for the potential entry of autonomous vehicles in Sweden and what are the potential impacts of such technology?

1.1 Outline of the Thesis:

This thesis consists of six chapters. The first chapter, introduction, focuses on the background of the topic and problem whilst providing the purpose and aim of the thesis. The second chapter, the literature review, consists of the analysis of the existing literature available on the subject and the creation of the literary framework which will later be used in the discussion of the findings.The third chapter discusses the methodology of the thesis. Specifically how the data will be collected and the later analysis of the data will be in focus. The fourth chapter, findings, will present a thorough analysis of the collected data and its implications. The fifth chapter will provide a discussion of the findings and what they imply for further research. The sixth and final chapter will consist of the concluding remarks and managerial implications.

1.2 Background and problematization:

With developments towards a sustainable and future with zero-emission cities built on urban mobility a large focus has shifted towards development of autonomous driving technology. As cities are transformed, the road towards an autonomous driving experience within public transportation draws closer (Photopoulos, 2020). While this sort of public transportation does not require a driver, the goal is to further emphasize the impact on the environment by showcasing that autonomous vehicles are in fact a viable and a sustainable solution moving forward for public transportation (Photopoulos, 2020). Furthermore the implementation of autonomous vehicles has an impact on the traffic aspect as it removes the human factor within transportation. Autonomous vehicles are dependent on well functioning systems that can for instance improve the capacity by generating a better flow of traffic by excluding humans as decision makers (Wolf, 2016).

1.2.1 Self-driving technology:

Self-driving technology or automated driving systems (ADS) refers to systems which are able to fully or partially control the drive of the vehicle on which they are installed (Dimitrakopoulos et al, 2021). The society of automotive engineers (2021), showcase and define five different levels of self-driving technology from level one, where there is no driving automation to level five where there is full driving automation (SAE, 2021). At this time though, only level three self-driving technology has been established in production cars

(Yurtsever et al., 2020). Level three self-driving technology refers to conditional automation where the technology is only able to control itself in limited circumstances such as while driving on the highway and the driver does have to be capable and ready to take over control in the event of an emergency (Yurtsever et al., 2020). As for the final two levels, four and five, they represent differences whereby level four self-driving technology can only operate in areas where detailed maps in infrastructure has been put in place whereas level five automation is able to continue control at any point (Yurtsever et al., 2020) The focus of this study will be on level five automation. Estimates for the implementation of level five autonomous vehicles vary greatly, differing from market penetrations of between 7 and 61 percent by 2050 and initial fleet-wide implementations occurring between the early 2020s and 2045 (Vitale Brovarone, Scudellari & Staricco, 2021).

The Swedish transport authority's environmental analysis discusses self-driving technology to an extent (Hårrskog et al, 2022). The report highlights how earlier beliefs of a quick introduction of the technology have been replaced with a more pessimistic outlook where fully self-driving technology is instead expected to be at least 10 years away with expressed doubt as to whether an implementation will happen at all (Hårrskog et al, 2022). This may be partially explained by the statement that of the 23 permits for self-driving initiatives handed out by the agency, only eight remain active at this time (Hårrskog et al, 2022). Furthermore, the report also states that all-encompassing overhauls of the existing infrastructure will not be needed to support the potential implementation and does highlight benefits that the technology may provide in the form of saved lives, increased mobility, and increased accessibility (Hårrskog et al, 2022). However, certain problematic aspects are also discussed such as the need for continuous year-long maintenance of signs and the potential dangers that damage to the infrastructure could cause the software which may cause incorrect actions (Hårrskog et al, 2022). From this, one could argue that while the agency does have a rather pessimistic outlook on the timing and feasibility of the technology, it does seem to have a somewhat positive outlook regarding its potential effects on society if the technology is implemented.

The vast majority of all road accidents are currently caused by human error rather than any other factor, due to this, a potential wide-spread implementation of self-driving technology could potentially deliver a great deal of social value, potentially reaching as high as 800 billion USD globally (Yurtsever et al., 2020). Furthermore, as for public transportation

specifically, the costs associated with the driver of a bus will account for half of the cost associated with driving (Almlöf, 2022).

Some of the presumed benefits of self-driving technology towards wider society is the lowered fatalities after the elimination of human error, energy savings, lowered congestions as well as the use of commute for other activities, and the possibility for those that are unable to drive such as the elderly, disabled or minors to easier transport themselves (Yurtsever et al., 2020). According to the Swedish road authority (2023), during 2022, road accidents in Sweden resulted in 220 fatalities with over 15 000 people injured. As such, if this can lower the rate of traffic-accidents, it would lead to significant benefits to society.

Through this then it can be argued that self-driving technology may potentially lead to a safer, less costly, more efficient, and more inclusive experience on the road. However, some argue that self-driving technology will instead cause increased congestion as they may potentially decrease demand for public transportation and other forms of non-vehicle based transportation (Vitale Brovarone, Scudellari & Staricco, 2021).

Chin-Yao Chan (2017), outlines several key challenges facing the future of self-driving technology as it attempts to transition from the assisted driving technology of today towards fully automated vehicles. The main challenges outlined by the authors are: remaining technical challenges, unit cost in initial production leading to low initial sales figures and potential unsustained investment, consumer attitude towards the technology, and regulatory challenges (Chan, 2017).

Ashley Nunes & Kristen Hernandez (2019) posit that the biggest obstacle facing the initial future widespread adoption of self-driving technology is the cost. This as the price of the underlying systems and hardware necessary for fully automated vehicles will leave many unable to afford them (Nunes & Hernandez, 2019). Even accounting for potential implementation through taxi like services where the cost can be split among a high number of users, it is not expected to be able to compete with ownership of a used car on a per-mile basis (Nunes & Hernandez, 2019). To overcome this issue Nunes and Hernandez argue for government intervention through the use of subsidies (Nunes & Hernandez, 2019). However, given the remaining legal and ethical issues as well as the issues of consumer attitude facing the technology, it may potentially be a challenge for companies to convince government representatives.

One of the most pressing challenges for the potential implementation of fully automated self-driving technology is the legal challenge as there currently does not exist the necessary legislative framework in order for the technology to be implemented (Dimitrakopoulos, Tsakanikas & Panagiotopoulos, 2021). While overtures are being made such as German bill mandating a “black box” so as to be able to determine accountability, the lack of comprehensive framework from which manufacturers can manage their operations causes a massive amount of uncertainty which likely stifles investment and progress (Dimitrakopoulos, Tsakanikas & Panagiotopoulos, 2021).

Another issue facing the implementation is the ethical dilemmas involved. One of the major dilemmas regards the action of the vehicle in the event of a collision (Nyholm & Smids, 2016). Whereas self-driving technology will result in fewer accidents there will still be events where accidents are unavoidable (Nyholm & Smids, 2016). However, given the faster reaction times of the software compared to the human mind as well as the lack of instinct and complete rationality found within these systems they will need to be programmed towards how to act in the event of an unavoidable accident (Nyholm & Smids, 2016). Should the car protect itself and its occupants or act in a way which saves the most amount of people?

Another ethical aspect to consider is that of privacy. With the automation of the activity of driving there will be an extreme amount of data generated about the activities of the people utilizing the vehicles (Dave, R Sowells Boone & Roy, 2019). This includes sensitive data as through analysis of a person's travels one could potentially infer information such as potential medical conditions and it could also potentially open the door for cyber-stalking (Dave, R Sowells Boone & Roy, 2019). As such, manufacturers will need to be able to guarantee the safety of the data of their users in the event of a future implementation.

Additionally, the introduction of self-driving technology will herald significant changes in the job market with a high likelihood of extreme employment disruption within the transportation industry (Nikitas, Vitel & Cotet, 2021). In the European Union alone, 10.3 million people work in the transportation industry with roughly 45 percent of these working as a type of driver (Eurostat, 2021). As such the automation of driving could potentially cause extreme consequences for those affected if preparatory action is not taken before these jobs are eliminated. Furthermore, such a disruption in the labor market could potentially have negative ripples throughout the rest of the economy as unemployment rises significantly.

1.2.2 Public transportation in sweden:

Initially, public transportation in Sweden was organized through private companies which held exclusive rights to their bus lines (Vigren, 2015). The industry would then transform beginning with the establishment of public transportation authority in 1978 followed by the exclusive rights for provision of public transportation in 1989 and a situation by the 1990s whereby services were primarily provided through competitive tendering (Vigren, 2015). The public transportation industry in Sweden is divided between regional authorities which decide on strategic matters such as the scope of services, political decisions, and strategic plans for public transportation within the region (Svensk kollektivtrafik, 2023). As such, each of Sweden's 21 counties has their own regional transport authority which are primarily responsible for the public transportation in that county (SCB, 2023). Thereby the industry is decentralized from a national perspective with only limited oversight from the state government.

With limited influence from the state government, Swedish public transportation is a member of Union Internationale des Transports Publics (UITP) with the goal to unite and make public transportation and make urban mobility sustainable (UITP, 2023). Within UITP the European Union Committee (EUC) can be found in which the European Union regulates laws and directives affecting the member states in regards to public transportation (SVENSK KOLLEKTIVTRAFIK, 2023). Swedish public transportation is therefore related and dependent on decisions made from the European Union working closely with questions from coordination and legislation to passenger rights and payment systems (SVENSK KOLLEKTIVTRAFIK, 2023). With regards to the European Union and their directives Sweden is currently examining and planning for an entry of autonomous vehicles (Trafikverket, 2022). As of now much focus is still aimed towards the manufacturer and developments towards the vehicles, stating that the essential technology resulting in a functioning autonomous vehicle traffic network should be within the vehicles (Trafikverket, 2022). As proposed the main focus is not towards reconstructing the road infrastructure as this would become very difficult. However, composing proper markings for safety issues is a concern and a topic of relevance while acknowledging the legislative aspects of a widespread use of autonomous vehicles (Trafikverket, 2022).

With the public transportation authorities being quite independent, legislation deems them not only responsible for transportation within their region but also transportation which crosses their region (Stjernborg & Mattison, 2016). Furthermore, it was also this legislation which brought about the change that opened the door for commercial actors to enter the industry (Svensk Kollektivtrafik, 2023). However, while it was expected that private actors would enter the industry following the legislative change and compete with the subsidized options of today, that has yet to be the case (Vigren, 2015)

The industry is subsidized on a national level with only roughly half of the funding coming from ticket purchases and other sources such as taxation cover most of the remaining cost (Stjernborg & Mattison, 2016). These subsidies are likely explained by the externalities involved such as the thought they are believed to exhibit scale economies, the decrease in negative externalities found in private transportation solutions, as well as the equity the industry can offer vulnerable groups and between geographically differing groups (Vigren, 2015).

The Swedish transport authority's environmental analysis of trends in the transportation system from 2022, focusing on the long term trends and developments within the Swedish transportation system highlight how the car is still the dominant mode of transportation for within country transportation (Hårrskog et al, 2022). While car travel has decreased somewhat, it still represents roughly 80 percent of transportation with significantly lower proportions for train and bus travel and few signals for significant changes to this dynamic (Hårrskog et al, 2022). As for public transportation, both bus and train travel have seen increases with train travel increasing by 195 percent and bus travel by 45 percent between 2002-2019 (Hårrskog et al, 2022) However, this has come as a result of significant subsidies as from 1999 to 2019, the total subsidies nearly tripled and furthermore the operating costs have more than doubled (Hårrskog et al, 2022). Additionally though it does highlight that while the car is still the dominant mode of transportation for the foreseeable future, public transportation is increasing its market share of domestic personal travel (Hårrskog et al, 2022).

The report also discusses regulation and the importance of regulating so as to create the necessary framework to minimize problems for new solutions but also highlights the importance of not “regulating them to death” and instead focusing on the particular issues at

hand (Hårrskog et al, 2022). This potentially highlights how the Swedish transport authority may have an attitude towards regulation whereby they are accepting of a relatively high degree of regulatory ambiguity for potential new solutions.

1.2.3 Problematization

With the increasing developments towards autonomous vehicles, the private car usage's functionalities are being changed. There will no longer be a need to operate the vehicle nor the time consumption and energy spent on locating parking. Instead other individual tasks can be conducted, which at the current state is what in some sense creates a competitive advantage for public transport (Pakusch & Bossauer, 2017).

It is no longer a case of if autonomous vehicles will enter the industry but rather a race of development and legislation. The real challenge at hand is rather the implementation within a relatively conservative industry of public transportation (Lutin, 2018). As stated, the future with autonomous vehicles is here and the public transportation sector cannot ignore that manufacturers have already started implementing limited self-driving technology (Lutin, 2018).

With society following a trend of a demand for a more sustainable lifestyle, a shift has started to emerge drawing consumers away from vehicle ownership towards a vehicle usage approach (Martínez-Díaz, Soriguera & Pérez, 2019). With this fundamental trend impacting the transportation sector it has a direct connection towards the business behind it. Hence, a shift has been seen towards car-sharing services. There are currently different structures to these services, ranging from ideas based on the individual themselves collecting and leaving the car at a designated location to the person getting picked up and driven to a certain location (Martínez-Díaz, Soriguera & Pérez, 2019). As these services have managed to penetrate the market, the implementation of further automatization of vehicles is expected to boost the services even further (Martínez-Díaz, Soriguera & Pérez, 2019). As mentioned, while private ownership is expected to decline, private car usage is expected to grow (Martínez-Díaz, Soriguera & Pérez, 2019). From this, the competition between public transportation and private car-sharing services will likely stay highly competitive resulting in

strategic actions taken by the public transport sector to potentially be of great importance as society is moving into a new era of transportation (Martínez-Díaz, Soriguera & Pérez, 2019).

While autonomous vehicles are expected to be safer, more efficient and electrical, they are also estimated to come at a lower cost per passenger and mileage especially within a public transportation system. (Martínez-Díaz, Soriguera & Pérez, 2019) However, for a public transportation system to draw its advantages it is in need of a well thought and proper planned structure with adequate pricing (Martínez-Díaz, Soriguera & Pérez, 2019).

1.3 Purpose and Research questions:

It is clear that self-driving technology will present change for the industry. Furthermore, the impacts of the implementation are not entirely known and instead present a great deal of uncertainty regarding its effects on society. Thus, the primary purpose of this study is to gain an insight of how the Swedish public transportation sector is preparing for the future of autonomous vehicles. The thesis' ambition is to investigate how the suppliers, operators and planners of the public transportation system's vehicles in Sweden are adapting to this emerging technology and what actions are being made. Furthermore, a focus will be with regards to the interplay and strategic actions of governmental agencies possessing decision-making influence over the Swedish public transportation sector.

By studying these actors and their preparatory actions the study focuses on an explorative approach in order to gain insight of the Swedish public transportation systems future. From this, the following research question is formulated:

How are public transportation companies preparing for the potential entry of autonomous vehicles in Sweden and what are the potential impacts of such technology?

1.4 Aims and objectives

The aim of this thesis is to investigate the potential effects that the introduction of fully self-driving technology might have on public transportation. For further clarification, the paper will investigate how public transportation companies in Sweden may be impacted as a result of the introduction of fully self-driving technology and what preparatory actions they

are currently taking as a result. The thesis will strive towards this goal through several differing objectives. The first is to provide an overview of the existing literature on the subject. This will be done through analysis of the collected literature. The second objective is to collect such information. This information is collected through interviews with representatives of different public transportation companies, thereby providing information about the plans and outlook of these companies. The third objective is to provide a thorough and rigorous analysis of this data to see the trends among the data. Finally, the last objective is to discuss the findings so as to provide the reader with insight of the theoretical and practical implications of the findings.

1.5 Delimitations:

Given the time constraints and complexity of the issues discussed in this thesis it is necessary to showcase a clear and narrow scope for the paper. The time constraint combined with the complexity involved limited ability to include further data. As such, the thesis is only concerned with Swedish organizations and the Swedish public transportation industry and thereby the interviewed organizations are all Swedish or the Swedish branch of a multinational company. The Swedish market in particular was selected as both authors are Swedish and are therefore more knowledgeable about the public transportation sector within the country. Furthermore, the authors also found sourcing easier as they could utilize reports and studies in Swedish rather than solely material in English. Nonetheless, an effort has been made to utilize english-based studies and report whenever possible. Secondly, the introduction of artificial intelligence will likely have a tremendous impact on many aspects of society and not just the public transportation sector. Furthermore, there are more stakeholders involved which will be impacted by the introduction of self-driving technology such as manufacturers, consumers, and regulators. However, given the time constraints it would not be feasible to facilitate interviews with all of these actors. However, there has still been an effort to facilitate as many perspectives as possible during the data collection phase.

2. Literature review:

This chapter will showcase the existing literature available in the field. It will consist of two primary subchapter: Existing predictive research and management in uncertainty. The subchapter existing predictive research will showcase the current state of the literature regarding technology forecasts of self-driving technology, forecasts on its impact on Swedish public transportation, implications of Mobility as a Service, Ecosystems, and the interplay between self-driving technology and sustainability. This so as to enable the reader to generate an understanding of the current state of the literature available in this field as well as regarding what the potential impacts of the technology may be. The second subchapter, management in uncertainty relates to the other aspect of the research question, how the public transportation companies are preparing for the potential entry of autonomous vehicles by discussing methodologies to employ in situations of high uncertainty.

2.1 Existing Predictive research

To better understand the effects that the introduction of self-driving technology will have upon the market it is important to analyze the existing research on the subject. This will help identify knowledge gaps in the field and enable validation of the future findings of this thesis in comparison to the works of earlier researchers. Furthermore, it can help avoid duplication of research so as to ensure a novel and innovative contribution to the field.

2.1.1 Technology forecasts on self-driving technology

Li, Garces, and Daim (2019) find through an analogy-based forecast on social networks that: “major invention activity in the autonomous vehicle technology is maturing and we should start seeing this industry pick up soon”. However, technology maturity can not solely determine rate of adoption and commercialization but other aspects are needed to enable it (Li et al, 2019). As such, future high degrees of adoption and commercialization are highly dependent on non-technological innovation (Li et al, 2019).

Usman Saeed, Burris, Labi, and Sinha (2020) showcase how there is a disconnect between the general belief that ride-hailing will become the most frequent mode of transportation of the future and the attitudes of consumers in non-large metropolitan areas where ownership of

a personal vehicle was instead favored (Saeed et al, 2020). Beyond this, willingness to utilize self-driving technology at all was lowered in rural areas (Saeed et al, 2020). Furthermore, this forecast also highlights how while general beliefs of enablement of transportation for the elderly through the technology, most seniors are instead uncomfortable utilizing self-driving technology (Saeed et al, 2020).

Bansal and Kockerman (2017) forecast US consumers' long-term propensity to adopt self-driving technology and find that by 2045 level four autonomous vehicles are likely to represent roughly 25-88 percent of the vehicle fleet. However, more than half of the population is not willing to pay anything for advanced automation features (Bansal & Kockerman, 2017). However, this may also change following future adoption of the technology and only represents a current snapshot of attitudes (Bansal & Kockerman, 2017). However, comparatively Liu, Guo, Ren, Wang, and Xu (2019) found that roughly 25 percent of Chinese consumers would be willing to pay for self-driving technology. These differences could potentially indicate that cultural differences affect willingness to pay for the technology and that early adoption rates will thereby vary from country to country.

Ulrich, Frieske, Schmid, and Friedrich (2022) through a forecast of the technological development of self-driving technology indicate that fully self-driving technology, level five, will be ready for market introduction by 2030. However, technological analysis in the same forecast indicates that this may not be entirely accurate and instead represent a too early estimate (Ulrich et al, 2022). This is further supported by Shoettle and Sivak (2014) who find that consumers in China and India are much more willing to pay for the technology when compared with their counterparts in the U.S, the U.K, Australia, and Japan.

From this information one could conclude that the future of self-driving technology is one where the technology will likely mature at a relatively fast pace but the future is still uncertain as it is unclear if consumers will be willing to pay for it. Furthermore, the estimates for implementation also vary drastically as showcased by Bansal and Kockerman (2017). However, it is worth noting that these studies refer to self-driving technology in general and forecast them from this perspective rather than forecast the potential impacts that the technology will have. Furthermore, these studies focus more on other markets than the Swedish one such as the U.S market or the Chinese market. This is especially problematic as

it has been showcased that country differences can be significant in aspects such as willingness to pay (Shoettle & Sivak, 2014).

2.1.2 Forecasts on the effect of self-driving technology on public transportation in Sweden

The realization that self-driving technology will impact public transportation is not a new one and there have been previous studies examining this concept. Erik Almlöf (2022) forecasts the future impacts and finds that self-driving technology will likely have a strong effect in terms of cost savings for public transportation and additionally through the fact that public transportation would no longer be bound by the limitations of human drivers and their schedules, could increase their service level (Almlöf, 2022). It could also potentially expand the areas served by public transport towards ones which currently are not seen as suitable (Almlöf, 2022). These effects could thereby potentially increase the utilization of public transportation (Almlöf, 2022). However, other studies have found more negative viewpoints towards the future utilization rates of public transportation in Sweden. Karin Brundell-Freij, Felix Miranda Thyrén, Moa Berglund, and Martin Klingberg (2020) analyzed the challenges and opportunities of self-driving vehicles and found that usage of public transportation is expected to decrease from 25-75 percent across the country with high differences across geographical areas (Brundell-Freij et al, 2020). This is largely explained by the increased utilization of taxi or taxi-equivalent services which will receive greater savings per trip as the personnel cost per passenger is greater than that found in public transportation (Brundell-Freij et al, 2020). Furthermore, they also find that there is uncertainty regarding the extent of savings which automation brings as it is not sure how much of the staff will have to remain and in what way the public transportation companies intend to utilize the savings (Brundell-Freij et al, 2020).

Erik Almlöf, Mikael Nybacka, and Anna Pernestål (2019) find that depending on how self-driving technology is used and implemented, the effects can vary drastically, especially regarding whether shared ownership of private self-driving vehicles is utilized or not. As such, it is necessary for public transportation companies to utilize dynamic approaches regarding the technology's entry to the market. (Almlöf et al, 2019)

From this it is then clear that there exists a significant degree of uncertainty and disagreement regarding how self-driving technology will impact public transportation in Sweden. As such this thesis seeks to contribute towards this debate by showcasing the attitudes and beliefs of several of the involved stakeholders.

2.1.3 Implications of Mobility-as-a-service (MaaS):

The idea of Mobility-as-a-service has become widely discussed regarding the future of transportation and its implications with regards to an autonomous driving experience. The state of the public transportation industry is currently driven by shared mobility services where companies supply the availability of transportation in order to decrease the general need of vehicle ownership (Arias-Molinares & García-Palomares, 2020). Competition is increasing and more companies are creating ways to enable a shared mobility service through car-rides to rental bikes and scooters. With an increasing number of actors entering the market, consumers have experienced more difficulties navigating through the extensive amount of applications, processes and information sources (Arias-Molinares & García-Palomares, 2020). Hence, the need for a single, user-friendly platform with the characteristics of integrating the different processes has emerged in recent years known as Mobility-as-a-service (MaaS) (Arias-Molinares & García-Palomares, 2020).

According to research done by Wong, Hensher and Mulley, (2019) the decline in vehicle ownership has seen increases both within the urban and suburban areas, meaning that the demand for various vehicle usage services has become more popular. Furthermore, they state that reasons for this include demographic changes with regards to social aspects such as the interpretation of car ownership implicating a symbol of status (Wong et al, 2019). With this trend their research has shown that people using car-sharing services also increased their usage of public transportation (Wong et al, 2019). Perhaps a connection can be created within the community to create coexisting services within a system of Mobility-as-a-service. As further mentioned by Wong, Hensher and Mulley, (2019) the idea of ride hailing such as taxi services offered by Uber not only competes with the public transportation but may also act as a compliment. Ride sharing has evidently become a growing aspect of innovation in many of the world's larger cities as an enhancement of urban mobility. Besides acting as a means of transportation it also acts as a close connection with public transport as a first- or last-mile

connecting means of transportation (Shaheen & Chan, 2016). Again emphasizing the idea of connecting the different aspects with public transportation.

The state of transportation is, however, continuously developing and new means of mobility services arise. With more advanced technologies correlating with mobility such as larger connectivity in an online atmosphere, a universal penetration of smartphones and implementation of autonomous vehicles (Wong et al, 2019). The offerings of transportation services are quickly adapting to generate improvements towards societal needs and customer desires (Wong et al, 2019).

The future is therefore heavily linked to the access to demand, resulting in the creation of the phenomenon of Mobility-as-a-service. The idea behind Mobility-as-a-service aims to meet the transportation needs of users through a single interface that is provided by a service provider (Peraphan Jittrapirom et al., 2017). This approach involves the integration of various modes of transportation to offer customized mobility packages for its users, similar to a monthly mobile phone plan (Peraphan Jittrapirom et al., 2017). This interpretation encapsulates key features, including user-focused service, bundled services, collaboration and connectivity between transport modes and providers (Peraphan Jittrapirom et al., 2017).

With regards to the preface of Mobility-as-a-service, Wong, Hensher & Mulley, (2019) focus on the initial development stages breaking down the future way of public transport into Modal displacement and modal convergence. The former refers to the concept of public transportation with fixed routes becoming replaced by shared mobility modes instead facilitated by Transnational corporations. Here emphasis is focused towards creating a “on-demand-function” as a replacement to fixed routes. The latter moreover refers to the alteration of all public transport modes into an autonomous taxi service. This approach is something that the authors Wong, Hensher & Mulley, (2019) mentions as a potential long term reality and showcase an example of how the process would occur in the realization of a convergence towards an autonomous universal taxi-system.

Furthermore, Wong, Hensher & Mulley, (2019) dives into the potential transport modes associated with the emergence of a Mobility-as-a-service system. While different types of autonomous vehicles such as cars, bus or taxi can be seen as the most impactful towards the development of Mobility-as-a-service (Wong et al, 2019). Public transportation may be the

strongest force of convergence or a shared mode (Wong et al, 2019). Although, there is no clear evidence as to what direction, mainly depending on the policy making and norms associated with different parts of the world (Wong et al, 2019). However, regardless of the driving forces. The idea of Mobility-as-a-service has a general impact of bundling efficiencies of different modes (Wong et al, 2019). Implications of Mobility-as-a-service can however be seen as an enabling factor for collaborations between companies and building blocks of the future of mobility.

2.1.4 Ecosystems:

The importance of ecosystems is increasing, especially as the world is changing for the future with new concepts and disruptive ideas of an emerging autonomous mobility. The idea behind this concept is deeply mounted in fruitful partnerships, potentially spanning across different industries where the collaboration occasionally is based within a shared platform (Jacobides, 2019). The emergence of a new ecosystem often depends on three structural changes: Firstly, ecosystems are often created through an initial unexpected rollback of regulations that previously have acted as a protection for a certain actor serving a niched customer base. Once the protection falls, other organizations start to collaborate with more integrated offerings. Secondly it is due to a complication of separation between products and services due to digitalization or regulatory changes. This structural change often results in new business models emerging through collaboration with multiple value adding components bundled together. Finally, ecosystems often emerge through technological advancements that change how firms serve their customers (Jacobides, 2019).

When building and maintaining ecosystems there are different factors to take into consideration in order to create a well functioning system where each party can thrive. The primary goal is to create an interplay where firms within the ecosystem can generate value for each other. While still competing with one another, the value lies within creating innovations for yourself while also facilitating for companies within the ecosystem (Jacobides, 2019). Moreover, studies indicate that ecosystems act as a source of competitive advantage for the individual firm with the idea rooted in partnerships and value networks that leverage each other's skills and assets (Clarysse et al, 2014). While maintaining and building the firm’s partnership and generating value for one another, it becomes essential to determine each

party's role within the ecosystem and what the terms of participation are (Jacobides, 2019). For well-functioning ecosystems to emerge, the participants must know what role they are playing and what their main objective within the ecosystem is. Not everyone can be the main facilitator and some firms might only act with a complementary product or service to a larger offering (Jacobides, 2019). Furthermore, the idea of participation becomes interesting. Who is allowed access, and how intertwined is the ecosystem and its different participants? These questions are central in maintaining a prosperous ecosystem where each party fulfills a certain need of the ecosystem and the overarching objective. While focusing on who is allowed to enter, it also becomes a matter of how attached and intertwined the participants are with the orchestrating company of the ecosystem (Jacobides, 2019). Maintenance of the ecosystem is highly important and with the constant changes to our world, the members of an ecosystem must be agile and ready to adapt. The idea lies within the fact that one can maintain their relationships and make sure the overall flow can adapt to changing preferences and new strategic business models (Jacobides, 2019).

2.1.5 Self-driving technology and sustainability

As changes occur, building on a new, expanded network of transportation several sustainability aspects are taken into consideration regarding the effect of a widespread use of autonomous vehicles. Focus is aimed at understanding and managing with regards to the emerging technology both on an environmental and social level.

With regards to the effect on environmental sustainability autonomous vehicles depend on the balance between improvements of efficiency and consumer demand (Williams, Das & Fisher, 2020). The net effect is heavily linked towards the idea of a shared mobility as an increased vehicle occupancy is generally seen as a measure of increased efficiency (Williams, Das & Fisher, 2020). Although a shared mobility posing as an opportunity of generating efficiency other aspects are to be taken into consideration. Implementation and widespread use of autonomous vehicles include reduced congestion in traffic leading to less waste of fuel, which was estimated to be 3.1 billion gallons in the United States in 2014 (Williams, Das & Fisher, 2020). Furthermore, Taiebat et al., (2018) argues that a widespread adoption of autonomous vehicles can reduce congestion while simultaneously maintaining road capacity through a shared mobility and right-sizing of vehicles. Other effectivity increasing aspects are

also taken into account such as platooning which increases the number of vehicles that can effectively drive together and reduce drag, while concurrently creating a smoother ride (Williams, Das & Fisher, 2020).

The societal aspect of sustainability with regards to autonomous vehicles is also of great importance as it will have an impact on our lives. It is generally argued that they have a positive impact on sustainability due to the reduction of accidents by eliminating the human factor (Dirsehan & Can, 2020). Traffic safety is considered as one of the greatest influential factors of an adoption of autonomous vehicles as this is currently a significant issue of the transportation and automotive sector due to the influence of human error (Williams, Das & Fisher, 2020). Moreover, an adoption of autonomous vehicles is argued to create mobility for all. Implying that this would provide opportunities for elderly and disabled to benefit from public transport (Williams, Das & Fisher, 2020). Similarly it is argued that the lower income population could see benefits from a cheaper public transport as autonomous vehicle fleets are generally seen as a cheaper option. Hence, also the public transportation companies and governmental agencies benefiting from cost reductions (Williams, Das & Fisher, 2020).

Other studies further suggest that an implementation of autonomous vehicles could have an impact on our land. On average, privately owned vehicles in the United States are used for only 2 hours per day, with the remaining hours spent parked (Kim, 2018). This has opened up for the impact of saving land space by reducing the need for parking space (Kim, 2018). With regards to less parking a reduction in construction of parking space could also amount to a substantial environmental positive impact (Taiebat et al., 2018).

2.2 Management in uncertainty:

This subchapter will describe the existing research for how to manage in a time of uncertainty. As the implementation of fully self-driving technology on a large scale has yet to occur, Chapter 1's discussions on possible ramifications introduce significant uncertainty to the industry.. As such, it is important for companies in the industry to manage their operations as well as make strategic decisions accordingly. The focus will be on exploring differing theories and their proposed managerial actions under such conditions.

2.2.1 Contingency theory

The contingency model of leadership, originally developed by Fred Fiedler (1964), describes a model for how to act as a manager with an emphasis on combining one's natural leadership style with the approach that best matches the particular situation at hand. As such, this model can be argued to represent an example of situational leadership (Fiedler, 1964). Through Fiedler's findings, he finds support for the statement that different group situations require differing styles of leadership (Fiedler, 1964). From this, Fiedler then develops a system for understanding the degree of favorability inherent in a particular situation by analyzing the leader's personal relationship with their subordinates, their power and authority, and the degree of structure inherent in the task (Fiedler, 1964). At the same time, though, Fiedler does recognize that other factors do affect the favorability of the task for the leader but posits that those three are the most important (Fiedler, 1964). Another important variable for the model developed in this work is the least preferred coworker or LPC score (Fiedler, 1964). The least preferred coworker is collected by asking an individual to consider all of the people they have worked with throughout their career and then rank the least preferred of these according to an eight-score scale across three dimensions: pleasantness, friendliness, and how accepting or rejecting they were (Fiedler, 1964).

Through this work, the model argues that leaders either have a task or relationship-focused approach to leadership (Fiedler, 1964). Fiedler describes the task-focused approach as one that focuses primarily on achieving the task or objective at hand, and the relationship-focused approach as one which instead focuses primarily on building and maintaining positive relationships (Fiedler, 1964). The task-focused approach emphasizes setting a clear direction, resource organization, setting objectives, and monitoring progress towards this goal (Fiedler, 1964). In contrast, the relationship-focused approach instead emphasizes providing support and facilitating collaboration with the team while ensuring an environment with strong teamwork, trust, and good communication (Fiedler, 1964). Whereas those employing the task-focused approach tend to be seen as authoritarians, those who employ a relationship-focused approach tend to be seen as approachable and people-focused (Fiedler, 1964).

The model further argues that neither approach is necessarily better than the other but that they instead are better employed at differing times (Fiedler, 1964). Fiedler argues that in

favorable circumstances with good relationships, clear structure, and strong authority, the relationship-focused approach will deliver the best results, whereas in unfavorable situations with poor relationships with their subordinates, an ambiguous task, and low authority, a task-focused approach will instead be the better approach. From this, one can conclude that, according to Fiedler, the approach of the leader under uncertain conditions should be steered by the environment and its degree of favorability.

Ahmed Sakr Ashour (1973) provides an evaluation of the model in his work: "The Contingency Model of Leadership Effectiveness: An Evaluation." Ahmed argues that the model has three main problematic areas: the empirical validity, the methodological rigor, the model, and the theoretical adequacy (Ashour, 1973). Ashour showcases how previous tests of the model's empirical validity had exposed flaws (Ashour, 1973). Furthermore, Ashour also highlights weaknesses in the methodology of the model focusing on the samples employed and the setting for the research, criteria for testing, and the measurement (Ashour, 1973). Here, Ashour finds significant weaknesses, such as the rigidity of the model, where it is found that the LPC score could provide an error variance of between 30 and 69 percent (Ashour, 1973). As for the theoretical adequacy, Ashour argues that it is too simplistic as it does not take several essential linkages into account and only measures static conditions (Ashour, 1973).

In contrast, Roya Ayman, Martin Chemers, and Fred Fiedler (1995) showcase that while there has been strong critique leveled against the model, there has also been strong support for it, highlighting meta-analyses which broadly provided support for the model. They argue that the greatest strengths of the model are the independence of the central constructs, the emphasis on independent and objective measures, low vulnerability to invalidation, and proven predictive validity (Roya et al., 1995). Furthermore, they argue that the model has a high degree of applicability in the real world, given its ease of use and low resource requirement for implementation within an organization (Roya et al., 1995). From this, they argue that the model is still relevant and can help guide leaders towards better performance (1995).

2.2.2 Agile management

Knut Linke (2019) contrasts agile management with the traditional approaches of management, which emphasize following a previously contrived plan. Agile management approaches, on the other hand, emphasize customer focus and results through self-organized work (Linke, 2019). Linke argues that agile management processes, partially due to their lack of strong hierarchies and more undefined processes, are progressively becoming more established due to the volatility, uncertainty, and ambiguity that the world exhibits (Linke, 2019). In an agile environment, Linke argues that there is increased importance given to individuals and interactions, working solutions, cooperation with the customer, and responses to changes compared to traditional methods (Linke, 2019). At the same time, though, agile approaches place less emphasis on processes, documentation, contract negotiations, and following a particular plan when compared to traditional methods (Linke, 2019).

Sven Theobald, Nils Prenner, Alexander Krieg, and Kurt Schneider (2020) posit that organizations which embrace agile methodologies need to do so at every level from a cultural perspective. They define the agile organization as: "...an agile organization unites organizational processes and people with advanced technology to meet customer demands for customized high-quality products and services within a relatively short time frame" (Theobald et al., 2020). Meanwhile, though, there is recognition that in order to achieve this, agility must be embraced as a core value of the organization with support from all levels of leadership (Theobald et al., 2020). Furthermore, it is argued that the rate of change has consistently been increasing over the long term with increased complexity, which creates an environment where managers are required to act under continuous change and through quick action (Theobald et al., 2020).

The authors further critique traditional organizations, which they posit are unable to deal with the quick changes inherent in this new world, as the rigidity in these systems leaves them unable to respond at an acceptable rate (Theobald et al., 2020). The importance of tacit knowledge is touted as an incredibly important catalytic aspect for successfully managing the volatility found within this new environment (Theobald et al., 2020). This tacit knowledge is supported by agile methodologies, primarily utilizing implicit leadership rather than the formal aspects found in traditional organizations, in order to provide the necessary framework for this tacit knowledge to be developed (Theobald et al., 2020). While it is

argued that there is still a place in the future for managers, it is instead a role where they focus on setting the goals and strategies of the organization since agile teams can respond faster and more efficiently when acting in a self-governing manner (Theobald et al., 2020). Thus, the agile organization is able to deal with unexpected events in a faster and thereby better way than the traditional organizations of today (Theobald et al., 2020). However, there is recognition that how the necessary support from leadership and management should be structured is not entirely known at this time (Theobald et al., 2020). Furthermore, Endhita Dhestiana Indiarti and Donald Crestofel Lantu (2022) also find support for the ability of agile leadership to strengthen a company's resilience in the face of uncertainty.

Simona Pontillo, Stefano Di Lauro, and Gilda Antonelli (2022) attempt to characterize the type of leadership required in the agile and remote working conditions which have become more frequent as of late. They find nine different styles or aspects of leadership that this situation requires: directive leadership, catalyst leadership, resonant leadership, servant leadership, transformational leadership, authentic leadership, E-leadership, distributed leadership, and shared leadership (Pontillo et al, 2022).

Directive leadership entails guiding and overseeing the task at hand and is especially important during the first stages of a change process (Pontillo et al, 2022). However, there are long-term difficulties and weaknesses associated with it (Pontillo et al, 2022). Catalyst leadership on the other hand refers to the ability of the leader to successfully impart their ideas towards their employees so as to inspire them to use their talents to successfully reach the objective (Pontillo et al, 2022). As for servant leadership, it refers to the ability of the leader to utilize empathy to influence their team and is argued to have a positive impact on employees' attitude towards change and the firm itself (Pontillo et al, 2022). Transformational leadership relates to the ability of the leader to motivate and encourage employees, in particular in more flexible circumstances (Pontillo et al, 2022). E-leadership is related to the ability to simplify working conditions whilst developing the necessary skills within the team for remote and virtual working conditions (Pontillo et al, 2022). As for distributed leadership, it involves utilizing all members of the team with leadership or managerial skills rather than just the formal manager (Pontillo et al, 2022). Lastly, Authentic leadership can be seen as a foundational aspect for the other aspects discussed and concerns itself with the authenticity of the leader in their interactions with their employees (Pontillo et al, 2022). From this, it is characterized that the leader needs to be visionary, self-aware, able

to create and nurture relationships, an innovator, able to inspire the team, able to perform tasks, ethical, and pursuing continuous learning (Pontillo et al, 2022).

3. Methodology:

This chapter will showcase the way in which this study will be conducted and explain the choices for this. The chapter will consist of seven subchapters: Research approach, Research design, Data collection method, Data analysis, Validity and reliability, Limitations, and Ethical considerations.

3.1 Research approach:

To ensure relevant, precise and valid findings it is important to choose the correct research approach. With two different choices consisting primarily of two options each: Inductive or deductive approach and qualitative or quantitative analysis. The following section outlines the reasoning for why this thesis will utilize an inductive approach and a qualitative analysis.

3.1.1 Inductive theory approach:

Alan Bryman and Emma Bell (2011) showcase two distinct approaches for the methodology to be utilized when conducting academic research: inductive and deductive approaches. While the deductive approach analyzes the relationship between research and theory through hypothesis testing, the inductive approach does not test an existing hypothesis but instead attempts to collect the data first before attempting to identify patterns (Bryman & Bell, 2011). Since there are no clearly defined variables or numerical factors involved as primary study objectives, and the implementation has not yet taken place, it is impossible to test any theoretically existing theories at a representative scale, resulting in invalid results. Therefore, this thesis will utilize an inductive approach throughout.

3.1.2 Qualitative analysis research:

There are two distinct methods available for the thesis to utilize: qualitative and quantitative methods (Bryman & Bell, 2011). Whereas quantitative research focuses on collecting numerical data, statistical analysis, standardized data collection, large sample sizes, and objectivity that is not the case for qualitative research (Bryman & Bell, 2011). One of the main differences is found in the focus of the research, qualitative research generally focuses more on gathering non-numerical data such as interviews and observations (Bryman & Bell, 2011). Another difference lies in data collection. Instead of focusing on standardized

collection methods such as surveys to generate the mentioned numerical data, qualitative research utilizes more flexible and interactive methods such as interviews (Bryman & Bell, 2011). Furthermore, rather than relying on statistical analysis, a qualitative approach instead utilizes qualitative analysis techniques such as thematic coding or content analysis (Bryman & Bell, 2011). Additionally, whereas quantitative analysis utilizes large samples to ensure generalizations and conclusions to be drawn regarding the population as a whole, qualitative analysis instead tends to focus on smaller samples with contextual results that are specific to the studied sample (Bryman & Bell, 2011). Lastly, while quantitative research emphasizes objectivity and minimization of the researcher's personal biases and interpretations, qualitative research is often more subjective, as it emphasizes the researcher's interpretations and understanding of the data (Bryman & Bell, 2011).

Based on this information, it was deemed most suitable to utilize a qualitative approach considering the non-numerical nature of the data, the limited size of the potential sample, the uncertainty involved, and the offered flexibility of the method. Therefore, this thesis will utilize a qualitative approach with the aim to investigate how self-driving technology may impact public transportation in Sweden and discover how the industry is preparing.

3.1.3 Technology forecasting

Kaya Firat, Madnick, and Lei Woon (2008) highlight how technology forecasting at its broadest refers to any and all attempts to purposefully and systematically anticipate the different alternative outcomes of technological change. As such, one could argue that the work of this thesis will therefore be a form of technology forecasting as the focus of this study will be on a systematic and purposeful analysis of the impacts that a future implementation of self-driving technology might have.

3.1.4 Case study

Case studies are a type of qualitative research method that involves in-depth exploration of a single unit of analysis, such as a person, a group, an organization, or an event (Bryman & Bell, 2011). They can provide rich and detailed data about a specific phenomenon, allowing researchers to explore and describe it in depth (Bryman & Bell, 2011). Furthermore, they can provide a holistic understanding of a phenomenon, taking into account the context and the

interplay of multiple factors that influence it and can be used to explore real-world problems and issues, and the findings can have practical applications for improving practice or policy (Bryman & Bell, 2011). Finally, they are a flexible method that can be adapted to suit different research questions and contexts, allowing researchers to tailor their approach to the specific needs of their study (Bryman & Bell, 2011). Considering these factors, it was deemed suitable to utilize a case study as part of the approach of the study. Given the limited number of potential interviewees at each individual company and the desire to see the potential effect across the Swedish market, it was decided to proceed with a multiple case study with the Swedish public transportation sector as the unit of analysis.

3.2 Research design:

This study utilizes a research question which asks: "*How are public transportation companies preparing for the potential entry of autonomous vehicles in Sweden and what are the potential impacts of such technology?"* This research question was selected so as to gain an insight into the future impact of a potential implementation of self-driving technology. In order to answer this research question, data will be collected through interviews with experts who are knowledgeable in both the Swedish public transportation industry and in self-driving technology. Through this, and in particular through interviews with Swedish public transportation companies it is hoped that clarity will be reached regarding both what the potential impact might be but also how the firms are preparing for the implementation of the technology by asking them directly. As such it is estimated that the collected data, in particular about the preparatory actions of the participants will provide insights on the central research question of this thesis.

3.3 Data collection method:

The collection of primary data was carried out through the utilization of semi-structured interviews with six individuals from six different organizations. The interviewed individuals were chosen as they worked in senior positions linked to self-driving technology within their organizations. The organizations consisted of three public transportation companies, one supplier, and one regulatory governmental agency. This mix of perspectives was chosen so as to get as many potential perspectives as possible. Furthermore, secondary data was also

collected, this through the utilization of desk-research. The motivations and methodology of both collection methods is explained in detail in this subchapter.

The interview questionnaire of this thesis utilized semi-structured interviews as they provide flexibility, comparability and high data quality which in turn allowed the ability to thoroughly explore the perspectives of the interviewee's (Bryman & Bell, 2011).

As for the flexibility, Emma Bell, Alan Bryman, and Bill Harley (2019) argue that semi-structured interviews provide a flexible approach to data collection and analysis, allowing researchers to explore the research question in depth while also remaining open to unexpected topics or answers that may arise during the interview. This is especially important given the complexity of the issue and thus the inherent need for a nuanced and open approach. Furthermore, the open-ended questions of the methodology allow the interviewed subjects to introduce unexpected or unconsidered aspects which may deepen the result of the findings (Bell, Bryman & Harley, 2019). As the knowledge and understanding of both public transportation and self-driving technology was much greater among the participants in this study than that of the authors, this was deemed a very positive factor when considering the insights they possess (Bell, Bryman & Harley, 2019).

Regarding the data quality, semi-structured interviews have important benefits related to their comparability and the depth and detail of their findings (Bell, Bryman & Harley, 2019). In semi-structured interviews, participants have the chance to delve deeper into their own experiences and viewpoints (Bell, Bryman & Harley, 2019). Due to this, semi-structured interviews provide data which is generally rich and in-depth, offering a thorough insight of the examined topic (Bell, Bryman & Harley, 2019). Furthermore, the methodology can allow researchers to gain an understanding of the contextual factors that affect the interviewed subjects through their experiences and perspectives (Bell, Bryman & Harley, 2019). This can allow researchers to gain greater understanding of the phenomenon from a holistic perspective leading to more nuanced interpretations of the data (Bell, Bryman & Harley, 2019). Lastly, they also allow for comparability of responses across participants which enables researchers to look for common themes which can enable broader conclusions and more general conclusions on the basis of the collected data (Bell, Bryman & Harley, 2019). As the aim of the thesis was to gain an understanding on the national level rather than among

the actions of individual public transportation companies, this aspect was considered especially important.

The secondary data collection, executed through desk research was carried out primarily in the proceeding chapter, the literature review. This was primarily executed before the primary data collection so as to build a greater understanding of the current state of the available knowledge in the field. However, following the interviews when new data was acquired it was believed that certain aspects were missing from both the background and the literature review and was subsequently added in. This data was gathered through publicly available sources and found primarily through the Lund University search engine: Lubsearch and through google scholar whilst other additional secondary data was provided by earlier course literature from the authors' master program, International Strategic Management.

The sources included peer-reviewed journal articles from scientific journals, earlier coursework from the authors master's program, statistics provided by governmental agencies, news sources, consulting reports, external NGO reports, branch organizations, internal branch organizations, and a master's thesis. These sources were selected based on two criteria: availability and reliability. There was an emphasis placed upon utilization of peer-reviewed sources to the greatest extent possible so as to ensure the reliability of the material except for statistics whereby first-hand sources were prioritized. Nonetheless in certain areas such information was not available through peer-reviewed sources and the next best alternatives such as consulting reports were utilized. This was only done when the information required was not of central importance to the results of this thesis and careful considerations were put on the reliability of the involved sources. Furthermore, while this thesis is written from an international perspective at times Swedish language sources were utilized, this was only done when no English language sources were found. This with the intention of ensuring that relevant information is included but also that non-native Swedish speakers can review the sources as much as possible.

3.3.1 Case selection

The selected participants were chosen through an examination of the required knowledge of the participants in combination with the potential availability of respondents. As they would

need to be able to discuss the potential implementations possible effects on the Swedish public transportation industry it was important that they possessed knowledge of both the industry itself as well as some knowledge of self-driving technology. While certain individuals were found through newspaper articles and contacted directly as a result, the vast majority of respondents instead were chosen following contact with their organization and a request specifically for a contact with someone that might be able to speak on the subject. The participatory organizations were chosen by an analysis of their role in the Swedish public transportation industry. Several public transportation companies of differing sizes and with differing services were chosen so as to get a better understanding of the nation-wide effects of the implementation. However, as there are only a relatively limited number of public transportation companies, suppliers, and regulatory bodies available it was difficult to find a large number of participants.

3.3.2 Design of interview questions:

Once the approach toward the data collection methodology was decided, it became important to create a robust and thorough set of questions in order to attain high-quality data. Furthermore, a secondary aspect was to limit the number of questions. This was deemed important by the authors to keep the total interview time below the customary 60 minutes and instead conduct 30-minute interviews. This choice was made due to the low number of potential respondents who could feasibly provide satisfactory insight. It necessitated a high percentage of positive responses to contact requests, and a reduced required time investment on the part of the participant was deemed likely to partially facilitate this. As a result, only six questions were created. These questions were formulated through an analysis of the research question itself, uncertain aspects, and the gaps in the literature. Afterward, the supervisor of this work was consulted to ensure that the questions were of acceptable quality. Based on this consultation, the following questions were selected:

1. *How do you see that the public transportation sector in Sweden will be impacted by the entry of self-driving technology?*

2. *What preparatory strategic actions are you taking?*

3. *At what point do you believe that fully self-driving technology will be able to be implemented at a large scale?*

4. *What are the most significant obstacles and challenges facing a more widespread adoption of self-driving technology?*

5. *How are you working with the legal and regulatory aspects?*

6. *How do you believe that self-driving technology will impact sustainability aspects?*

The first two questions were created based on the research question to gain an understanding of the actions and viewpoints of the participants. The next two questions were chosen as they represented points of contention within the literature. The fifth question was selected because it highlighted a gap in the existing research that has not been thoroughly investigated. The last question was included to obtain a better understanding of the contextual factors surrounding the potential implementation and its effects on wider society.

After selecting the interview questions, the next concern was conducting the interviews themselves. Before the interviews began, the participants received an email from the authors containing the questions, a request to conduct the interviews in English, assurances of anonymity, and a consent form. It was assumed that some respondents would request the questions in advance, so it was decided to provide all participants with the questions to standardize their knowledge of the factors being discussed prior to the interviews. Furthermore, it was believed that this approach would allow participants who were unfamiliar with certain aspects of the questions to research those topics beforehand or refer the authors to more suitable interview subjects. The consent form and assurances of anonymity were used both to meet the study's requirements and to ensure that participants would feel comfortable sharing a larger amount of information compared to a non-anonymous version, in line with the arguments of Hewson, Yule, Laurent, and Vogel (2003). The request for conducting the interviews in English was made to minimize the probability of mistranslations and misunderstandings of the findings, aiming to standardize the interviews as much as possible. However, one participant requested that the interview be conducted in Swedish instead, and their request was granted. This decision was based on the belief that the potential additional information provided by the interview and the resulting greater understanding of the

phenomenon outweighed the risks associated with a non-standardized approach compared to their counterparts.

During the interviews, the questions were asked in order, and follow-up questions primarily focused on understanding the participants' underlying beliefs. These follow-up questions aimed to explore potential theoretical foundations for their answers to questions 1, 3, and 4. This approach served the purpose of discovering unutilized literature and internal studies or forecasts that might have influenced the participants' judgments and were not known to the researchers. While this constituted the primary approach for the majority of the interviews, there were instances where participants misunderstood a question or failed to provide satisfactory information, leading to non-standardized follow-up questions. This deviation from standardization was deemed necessary to ensure higher quality individual data points, despite its negative impact on the comparability of the data.

3.4 Data analysis:

In order to analyze the collected data the initial step was to transcribe the interviews into text and use a winnowing approach to extract the important data (Creswell & Creswell, 2018). This approach was chosen due to the very dense set of information collected from the interviews as well as similarities between the results. This approach therefore implied that the authors focused on certain information while disregarding other parts (Creswell & Creswell, 2018). The intention regarding the chosen approach is due to the fact of breaking important information from the conducted interviews into themes to generate a base structure for analysis. This is aligned with the Thematic analysis approach mentioned by Bell, Bryman & Harley (2019) as it refers to systematically breaking the data into themes. During the process of analyzing the data has included repetition by thoroughly going over and breaking down the transcript notes. This has included characteristics of coding such as “cutting up” the transcripts as mentioned by Bell, Bryman & Harley (2019). Entailing a systematic approach of breaking down the text file and picking out certain parts and pasting with other relevant information retrieved from the interviews.

To further analyze the structured findings the interpretation and approach was based on summarization of the results, following an analysis with regards to the proposed literature

stated within the paper. The interpretation and analysis likewise included a personal point of view from the authors in which the findings were discussed. As this paper is of exploratory characteristics focus has been aimed towards a discussion and analysis highlighting a comparison between the proposed literature and its implications with the findings and stand point of the case studies. With this approach the analysis acted as ground for the authors to suggest if the proposed findings either aligned with suggested literature or deviated from it (Creswell & Creswell, 2018) while giving an insight into how the Swedish public transportation sector is preparing and behaving with regards to autonomous vehicles.

Furthermore, the analysis of the data will also include a point of where the authors can see a possibility for suggestion of further research as well as limitations towards the conducted research and weaknesses within the findings.

3.5 Validity and reliability:

Throughout the research validity and reliability has been key focus areas as it poses importance in establishing a quality report (Bell, Bryman & Harley, 2019). In order of ensuring validity within the paper the idea of incorporating validity strategies was used. As suggested by Creswell & Creswell (2018) a triangulation approach was taken. This involves checking the findings against multiple sources to establish validity in the research. While the research was conducted on primary data including multiple interviews of companies with similarities in organizational structure and all structured under the Swedish government, other reports were used as well as findings on studied company websites. Furthermore, to emphasize validity and contribute to triangulation the collected data was analyzed with regards to different theoretical angles in order to uncover the ability to view the data from a different perspective (Flick, Kardoff & Steinke, 2004). While the focus of gaining validity was aimed towards the above, peer reviews were also conducted with the presence of fellow students and our supervisor during seminars.

In extension to validity the reliability was also a point of focus with regards to both the internal and external aspects. As mentioned by Bell, Bryman & Harley (2019), the external reliability is to the extent a conducted research is replicable whereas the internal reliability refers to the coordination and agreement between multiple observers. The research was

conducted with attention towards the external reliability through systematically documenting the data collection processes with thorough transcription where the authors went over the text multiple times. Furthermore, the data analysis was in accordance to external reliability with a thorough thematization. The internal reliability was also taken into account with a number of internal check up meetings characterized by a clear communication and a joint thematization and data analysis to ensure agreement of the observed information.

3.6 Limitations:

Another aspect which could have affected the result of the study is respondents themselves. From one side, they may want to present a more positive view of themselves and the activities of their company in the study. However, this is mitigated through the use of anonymity throughout the study but should respondents be unsure of the validity of the promises of anonymity it may influence their responses. Furthermore, while usage of several experts lowers the effects of the researchers' bias upon the thesis, this does instead open up the possibility that the experts' biases instead influence their responses. This may prove especially dangerous should several of the respondents share the same biases. One instance which could point to this is that since all of the respondents needed knowledge of both public transportation and self-driving technology, many of them worked with the technology. Thereby, they may therefore have a more positive outlook than most as they have actively chosen to work with it.

One aspect of limitations of the employed methodology is in the data collection and the semi-structured interviews which were utilized. Once again bias can be at play as there is a possibility that the biases of the interviewers particularly inadvertently affects the questions asked during the interviews. Furthermore, as there was a low degree of direct connection between the interview questions and the theory employed there is also a potential that important information was not asked about. This is especially poignant given the limited number of interview questions which were utilized. Furthermore, as semi-structured interviews are neither wholly standardized nor entirely non-standardized there are limitations involved. This as not every respondent may have been given the exact same potential to provide the same answers nor able to fully customize the questions utilized to the respondent in question. Nonetheless, this was deemed appropriate as this limitation is a lower degree of

each of the limitations of fully structured and fully unstructured interviews and would provide a balanced data collection method. Another limitation of the interviews was that they were conducted in english by non-native english speakers with non-native english speakers as participants. As such there is a possibility that there is a degree of deviation from the intended message and the one that was received during the interviews. Nonetheless this choice was made as there would otherwise be a need to translate the results which imposes the same potential opportunities for misunderstandings and misinterpretations.

Another obvious limitation is that this study concerns an uncertain topic, a future potential implementation of a technology. As such it is impossible at this time to truly validate the results of the study as there is still a high degree of uncertainty as to how the implementation will take place and what the true effects will be. Thereby the core underlying assumptions of this thesis will continue to be uncertain at this time.

Further aspects of limitations are those inherent in qualitative studies. For instance the lack of numerical data lowers the applicability of the findings as it limits the ability to quantify the results and to compare them with other studies or to validate the results. Furthermore this creates a less robust data analysis as it is not possible to utilize statistical analysis of the findings but instead non-statistical analysis. This in turn is especially problematic as the researchers' biases are more likely to affect the findings in a qualitative study given the inherent need for subjective interpretations of data. This then lowers the objectivity of the report which leads to a lowered reliability inherent in this approach. Furthermore, with such a small sample size of six, there is very limited generalizability of the findings, even more so when one considers that the sampling method is not truly randomized. As such the applicability of the findings to the wider population is limited and the conclusions one could draw from this study must be taken more lightly as a result.

3.7 Ethical considerations

The importance of an ethical approach has been mentioned more frequently and is an important aspect when conducting research (Bell, Bryman & Harley, 2019). As the research

revolves around data collected from people about certain organizations, it becomes highly important to protect these parties and anticipate ethical considerations (Creswell & Creswell, 2018). This study has therefore taken ethical considerations into full account during the course of the research. Bell, Bryman & Harley (2019) mention three ethical principles to follow: (1) Avoidance of harm, (2) Informed consent, and (3) Privacy. The research has taken these principles into account to respect the participating individuals and companies involved in the research. To ensure that no harm was done to the participating individuals and companies, a cautious approach was taken with open communication to ensure security and comfort. The interviews were conducted with an approach where the interviewees possessed the power to choose what information to share. Furthermore, the interviewees received information regarding the purpose of the study as well as details about the anonymity of their participation and company representation through a privacy and consent document.

4. Findings:

This section will present the findings obtained from conducting six interviews with employees and managers working with strategy and developments in regards to autonomous vehicles. The interviewed persons all possess a role within companies relevant for the execution and development of the Swedish transportation sector. The empirical data collected will lay as basis in tandem with literature to answer the proposed research question of how public transportation companies are preparing for the potential entry of autonomous vehicles in Sweden and what the potential impacts of such technology are.

First, a description of the case will follow with the intent to outline the studied companies to gain a brief overview. This is based on data collected from the interviews as well information from company websites. The description will be made with a course of anonymity for the companies. Hence, no references will be made to any of the company websites. Secondly, the chapter will follow with the primary data thematized and structured between the different interviewees with similarities and differences.

4.1 Case descriptions

Company A is a major supplier of vehicle fleets and operators to the Swedish transportation sector. They are currently conducting research and developments towards the ongoing trend of autonomous vehicles. This is the major actor of interest as the data collection indicates that company A is working closely with many of the local actors within the Swedish transportation sector.

Company B, company C, company D and company E are all local Swedish transportation companies that are main decision-makers within their respective county but organized under to certain extent governmental control.

The final company included in the study, company F is a governmental body with regards to the Swedish transportation sector. They are working more closely with regulatory aspects and implementation generating a high standard transportation sector.

Lastly, company A, B and C are all undergoing pilot projects with regards to implementing fully self-driving technology within their public transportation fleet. They have projects that are currently being tested on public roads.

4.2 Strategic overview and impact

The overall beliefs for all the interviewed participants are positive towards the developments and adoption of autonomous vehicles. As the trend is moving forward all the companies identified positive impacts and results of an entry of self-driving technology. While all interviewees still possess a sense of uncertainty there are some generally seen benefits to what a well functioning autonomic public transportation sector could mean. As a result of the interviews it becomes clear that there is a strong focus on the cost and efficiency aspects when discussing the impact of autonomous vehicles on the public transportation sector in Sweden.

Much of the focus is aimed towards urban transportation and buses as these constitute most of the public transportation conducted in Swedish cities and rural areas. Company A puts emphasis on the potential cost savings as well as the potential of an increased quality of service towards the end users, pinpointing that a computer is not affected by human factors such as tiredness, monetary compensation or working regulations resulting in a possibility to create a more efficient and larger supply. This argument is supported by the other interviewees. As Company B mentions in the interview:

> "*The day you can drive without the driver, you save a lot more money and could have a bigger supply for the same cost. Because right now the driver's cost is the biggest moving cost we have".*

Furthermore, in the interview, Company B pinpoints the fact that while costs similar to a driver's cost will occur in other areas such as safety surveillance, it can be divided on multiple vehicles. While much focus is being aimed towards the cost side, Company A points out that it is not only about removing costs but also a larger project that may possess certain risks. Stating that:

"It's not necessarily about removing and just cutting costs. It can actually be a way to shift the competence, shift the focus in order to increase or achieve more value, produce more value".

The entry of autonomous vehicles in the Swedish public transportation sector also comes with other benefits mentioned by the interviewees such as social aspects. Company C who are currently running a pilot testing with self-driving shuttles argues that the implementation could result in enhancing the customer experience by introducing a larger network of public transportation routes. This would mean that with a computer operating the shuttle buses could run more frequently and to more secluded areas. There is a strong belief that the entry of autonomous vehicles will generate a larger supply with a strong influence being the idea of first and last mile travel. In the interview with company D, they mention that:

"It's still rather new, but there's still plenty of opportunities … smaller markets will definitely benefit from … what's being tested right now … that opens up a lot of opportunities for last mile transport between kind of a more conventional transit, public transport and major hubs into … areas where it might be harder to serve with conventional public transport".

Company A also highlights this in their interview:

"Autonomous vehicles will actually enable us to provide services that complement and increase the public transport ridership with first and last mile solutions, for instance going out into their local neighborhoods and so on … which is most commonly also the threshold to why people are not using public transport. Normally you would not live on the central station, so you need to get somewhere else".

When focusing on the societal aspects, several companies mention the aspect of congestion, pointing out that the efficiency will arise from multiple factors related to an autonomous riding experience.

Overall, there is a common ground amongst the companies that they see a need for gradual implementation to create a well functioning implementation of autonomous vehicles in the public transportation sector in Sweden. It requires multiple aspects such as monitoring,

technological developments and regulatory aspects to collaborate in an efficient manner. This is something that all companies agree upon will take time to implement before a full scale widespread can be adopted on public roads. As company F mentions it also requires a good transition in role selection, creating for the human to become a complementary role of artificial intelligence. The representative of company A adds to this point as he mentions the future coexistence of artificial intelligence and humans in traffic and that there will become a shift that is needed for humans to adapt towards and accept new roles within a future system.

4.3 Actions and standpoint

With developments and a changing market environment the actions taken by the studied companies possess interest. Many of the interviewed participants have their focus on the privately owned car with the fundamental goal being to gain shares from the privately owned car towards public transportation. This is especially highlighted during the interview with Company A who stated that:

> *"Autonomous vehicles could really come in and be a good opportunity to compete with the privately owned car".*

while emphasizing later in the interview that:

> *"…it really boils down to increasing the volume of shared mobility. The more passengers in a vehicle, the better…"*

The idea as specified by the representative of company A is that the main competitor for the public transportation sector is the privately owned vehicle, not necessarily the car as this might be the perfect size for the future of public transportation. This is further based on forecasts and studies made by company A with a competitive purpose. These studies have shown that public transportation might not be able to be executed the same way in the future and with autonomous vehicles entering the market. For example the representative mentioned that new business models and collaboration could become the way going forward, with Company stating during the interview that

"it does connect also to the trend of aging population, where we see that we, with public funds, cannot do public transport the same way. We need to become smarter, but we also identify that we actually need to be a bit creative and understand how we can combine different revenue streams in the future".

While focusing on the future and actions that might be taken. In the interview with Company ,A they emphasize the idea of a public-private partnership (PPP) by stating that:

"We believe that we need to find new smart hybrid models in order to actually understand what is the value we provide … And in a lot of different places in the world you normally see the PPP model, public-private partnership setups".

The representative from company A even mentions the idea of being open to a change in competitive environment stating that the public and private sectors might rather act as a compliment, something that also company D focuses on. The representative from company A stated during the interview that:

"We believe a lot in the ecosystem, that there is not one size fits all or one solution that is the best for all contexts and so on. We do rather believe that the ecosystem will need different kinds of mobility services and that there is an opportunity for a greater good both in terms of sustainability but also the commercial aspects".

This is further reinforced through company A's additional statement during the interview of:

"*And in the industry we're talking about a lot about the buzzword MasS mobility as a service … But that's one aspect. The other aspect is, okay, so how do we position ourselves? …. And there are of course different approaches to it being that you could see it as a competition, you could also see it as a potential new partnership."*

Furthermore, the representative of company C also discusses the aspect of the privately owned car in regards to a shared environment. He discussed during the interview that it can be seen as a rather good solution with a shared mode emphasizing the efficiency matter. With regards to the autonomous vehicles company C puts the idea of ride sharing in relation to the

current state arguing that with autonomous vehicles there is a possibility to ride at different times also pinpointing the reduction in congestion caused by a driverless vehicle.

The interplay between the public and private sector is highlighted in the interviews multiple times and the representative of company E also points out the impacts. He believes that there will become a growing commercial side and that a collaboration could be of interest. With the adoption of autonomous vehicles he believes that the high capacity routes will be controlled by larger public fleets, complemented with smaller vehicles operating similar to a door to door service. Moreover, company E has focused on creating a pilot project based on enabling a door to door related service where an app is used to calculate and book public travel in real time. As mentioned by the representative, company E views this initiative as an initial action towards creating a quality system with regards to an implementation of automated vehicles in the Swedish public transportation sector as well as a competitive advantage towards the ownership of the car, stating that some routes using the system have seen a major increase in travel.

During the interviews, it was highlighted that there are currently pilot projects ongoing as strategic actions taken by some of the companies operating within the Swedish public transportation sector. Company A and B are working closely together with a pilot project where fully automated bus shuttles are on the road. The representative of company A illustrated in the interview that it gives a good initial view of how it works on public roads while also creating a connected route for commercial passengers. But there is more to the story. The representative stated during the interview that:

> "*But also one very strategic topic for us is of course to understand the transformation of the task that our operational staff is doing. Because today the actual driving takes a lot of focus, but we also see that we have a task beyond that being the host of passengers being able to answer questions, being able to ensure that everyone is getting to the right place and feels safe in terms of both information and security".*

4.4 Obstacles and outlook for the future

Besides a communicated upside by the respondents of the different companies they all mention that it is a long road ahead of a fully developed autonomous driving system with much further development needed. Company A, B, D, E and F all put emphasis towards the safety aspect as one of the main obstacles in need of further development for autonomous vehicles to become fully implemented in public transportation. This safety aspect was referred to from the vehicles safety point of view but also regarding the customers safety aspect given that no driver is present in the bus. The representative from company B emphasized the personal safety aspect, discussing the importance of some sort of controlling mechanism to surveillance the vehicles as people might be alone with someone unknown late at night. He goes on to mention;

> *"Maybe you're going out in the evening, then you sit with a completely unknown person in the same space ... It is so that the driver at least has an overview right now in a normal bus or a tram, someone you can call for ... But this is also a question that you have to think about. How can you get hold of someone? I mean, it's not necessarily insolvable, but if you think about it, you may have a camera, you press a button and then you get connected to a central traffic control who sees what's going on in the vehicle and so on. It's an integrity question too".*

In general the interviewees lift concerns regarding obstacles such as gaining and building trust among the consumers of public transportation mainly with regards to a computer operating the vehicles while also ensuring a high level of safety both inside and outside the vehicles.

The safety aspect goes hand in hand with the obstacle of technological limitations mentioned by company A, B, D, E and F. With the current state of the technology it is simply not developed enough to address for example safety aspects in order to adopt a widespread use of autonomous vehicles. Company B who are currently running a pilot, mentions the flaws that have been observed, stating that the technology is not yet there for autonomous vehicles to run in a larger scale and with a desired quality. He goes on to mention that although the vehicles have never crashed it has caused quite an unpleasant ride within the vehicle, quoting;

"We see a technical problem in that the vehicles we use do not have the image analysis, the image technique that we would like … It has never been in a crash … But on the other hand, it has caused people to fall within the vehicle when it brakes".

However, the representative goes on to mention that they are working internally and with pressure towards manufacturers on the technological developments. Company A further emphasizes the obstacle of technological limitations as the representative mentions that he believes that they have been stuck on the same plateau for a period of time focusing on the project they are undergoing. He states that since they started the pilot a few years back it has not really developed further as they are waiting for the next technological advancements. This aspect is being related by the representative of company A to the emergence of new business models as he mentions the importance of finding the correct structure for a future with autonomous vehicles, stating that for the development to continue there needs to be a strong belief in the fundamental business behind autonomous public transportation in order for investors to contribute with capital. This aspect was further mentioned by the representative of company D as he focused on the importance of planning and investing more with a long-term scope.

The technological advancements also come in close relation to regulations. The representative from company F emphasizes the infrastructure limitations mentioning that the infrastructure is not built for autonomous vehicles but is also not meant to be rebuilt accordingly. Rather, a question of technological developments. The vehicles must be able to adapt towards the current infrastructure. This is an interplay between the market and the regulatory bodies that needs to be highlighted for the development process to run smoothly. Company A, B, C and F all voiced the need for regulations to adapt and the importance of navigating the legal frameworks.

4.5 Regulatory aspects

Regarding the regulatory aspects, the most widely discussed aspect is the need for adaptation of the current regulatory framework. This is especially lifted by Companies A, B, and C. From the perspective of Company A this is done by discussing the need to adapt vehicle regulations for autonomous vehicles, such as type approval and homologation. They mention

the current requirement of mounting side mirrors on their shuttles to comply with existing legislation and the issues that come with this. Company B, who are partners with Company A face the same rear mirror requirement but elaborate further how:

> "*So you have to have a LGF sign on, you have to have rear mirrors, and then you have to decide which one is forward and backward if you are going to put up rear mirrors*.".

Additionally, the respondent from Company B highlights the challenges that are found in applying the existing laws and regulations to self-driving vehicles. Here they mention the need for permits, inspections, and clear guidelines for driving without a human driver. As for Company C, they mention the lag in legislation and permits for self-driving vehicles, which hampers their development and deployment. They mention the need for clearer regulation and the need to provide input through organizations like Svenskkollektivtrafik and Sveriges Kommuner och Regioner (SKR).

Another aspect that is widely discussed is safety and the need for regulation pertaining to safety. This is especially emphasized by companies B and F. Company B does this by emphasizing the importance of security and safety requirements for self-driving vehicles. Furthermore Company B also describes how they have at times needed to educate the regulators by stating:

> "*We have stood for their internal education in some cases as well, because they have laws and regulations, but they have not applied it to anything*"

which is further elaborated on later as:

> *"...after two years a vehicle needs to be inspected. And no one had done that before, so we had to learn the mechanics of how to inspect these vehicles, because they didn't know that."*

Thereby, Company B describes how they are taking part in shaping the future regulatory framework of the technology by teaching the regulators how to apply the existing frameworks. They describe their system of permit approval, route scanning, and using a

cyclist to document the vehicle's behavior on the road. They showcase the level of obstruction this can be by stating:

> "*...if you want to use this on a larger scale, you need a faster system of permit approval.*"

Company F, which is a regulatory agency, mentions the complex and dangerous nature of self-driving systems and the need for regulatory frameworks to ensure safety. They discuss the challenges of harmonizing regulations across different countries and highlight the responsibility of the industry to ensure the safety of their vehicles. Company F further discusses these difficulties by stating that:

> "*… at the European Union, they are talking about harmonization of this regulatory framework. If the function works in Germany, it could also work in Sweden or Brussels or whatever it is. And they are looking into it, but it is a heavy work because we have so much differences between our regulatory framework.*".

The consequences of this are further discussed as:

> "*So you can sell the car, but you can maybe not activate one function or another function or two functions just because you are in a country it is not allowed…*"

As such without regulatory harmonization between different markets there may be a situation wherein self-driving vehicles may only be operational in their home markets and geographically constrained.

One aspect only brought up by Company A is public-private partnerships and business models. This may be as they are the only supplier and only private company interviewed whereas the other participants are public transportation companies or regulatory agencies. Here they emphasize the need for new business models and stakeholder involvement to support self-driving technology. They mention the challenges of combining public and private revenue streams and advocate for smart hybrid business models.
One firm also gave very limited responses to these aspects, Company D, who stated that:

> "*That for us at Company D, we have not really looked at it at this point. We don't really have any kind of sort of program running at the moment, as other municipalities in Sweden have… We're still kind of at the beginning stages of everything, so we haven't really looked into that yet.*"

As such they are assumedly awaiting future work on the regulatory aspects until further developments.

4.6 Sustainability impact

The most common theme found pertaining to sustainability impacts of self-driving themes is related environmental impact and from a positive perspective. The respondents from Companies A, B, C, and D all highlighted the positive effects that self-driving technology may bring through the potential for a more efficient ecosystem with fewer privately owned vehicles, decreased traffic congestion, and improved resource utilization. However, Company F raises the counterpoint of energy usage and highlights the differences in the energy requirements between human brains as decision makers and the high demands of computational systems that are necessary for the technology to function:

> "*When it comes to these computers and all of these sensors and all of this LiDAR, all everything needed, it is 40 kilowatts to 50 kilowatts needed only to operate that way. Can you imagine the differences?"*

Furthermore, several respondents also showcase the difference that fuel choices make. Whereas the general belief is that self-driving vehicles will be electric, Company D does point out fuel choices significantly impact the sustainability of the solution.

Another key theme discussed which is highly related to the environmental impacts is the move towards shared mobility. Companies A, B, and D all focus on this aspect as one which is key to a sustainable implementation of the technology. This by emphasizing the importance of increasing the volume of shared mobility to reduce congestion, improve efficiency, and shift people from private vehicles to more collective modes of transportation. Company D showcases this as

”*...that's kind of the biggest challenge. How do we shift people from driving their own cars into more collective transport? How do we get them into buses? How do we get them onto trains? This might be another step forward. Kind of enticing and persuading people to think that, oh, I don't really need a car for most things that I do. And I think that's another way to keep moving the wheel along in sustainability.*”

As such the aspect of enabling increased shared mobility through self-driving technology is one that is seen as a highly positive one.

Some outlining viewpoints were discussed during the interview with Company A who highlighted the impact of the technology on the workforce and emphasized the importance of managing the transitional period as effectively as possible. While they acknowledge that technological paradigms, like AI and self-driving technology, challenge the status quo and may disrupt traditional roles, they also highlight the need to approach the transition with respect, understanding, and consideration for the different stakeholders involved.
As such Company A believed in self-driving technology as:

“*It's not necessarily about removing and just cutting costs. It can actually be a way to shift the competence, shift the focus in order to increase or achieve more value, produce more value.*”.

Furthermore, they mention the opportunity to shift competencies and focus in order to increase value and productivity. The respondent also mentions the potential risks, such as the need to handle the concerns and worries from individuals who may be affected by these technological changes and to build trust in the technology.

Another viewpoint that was most deeply discussed with Company A was safety and congestion. They discuss the potential for increased safety by removing the human factor, which is the biggest contributor to road accidents on a global scale. However, they also acknowledge the challenge of accepting that accidents will still occur, even with autonomous systems.They also mention the risk of increased congestion if autonomous vehicles are not efficiently managed and increased shared mobility is not achieved. If private car ownership decreases and autonomous vehicles are used for dead runs (i.e., relocating without passengers), it could lead to additional kilometers/miles being driven, potentially resulting in

inefficient systems and increased congestion. Additionally, Company A highlighted how self-driving vehicles can provide solutions for the first and last mile of a commute, making public transportation more accessible and competitive with privately owned cars. It is possible that Company A was the one with the most unique insights given their perspective as a private firm rather than either a regulatory agency as Company F or a public transportation company such as companies B. C, D, and E.

Additionally, a further outlying viewpoint was expressed by Company E who indicated that there may be a possibility of redesigning cities with a focus on pedestrian and cyclist-friendly environments rather than the car focused cities of today through reducing the need for parking spaces in city centers, and creating more space for public use. This follows a potential future wherein private car ownership declines.

4.7 Analysis of the findings

While there is a general agreement amongst the interviewed that a implementation and future with autonomous vehicles incorporated in the Swedish public transportation sector could possess many advantages there is still believed to be further developments needed. As it is clearly mentioned by interviewees, the technology requires further improvements before it will be able to meet with the performance and regulatory requirements. As the legislative information suggests, the infrastructure cannot become adapted towards a widespread use of autonomous vehicles, it is rather a question of the vehicles adapting to a current state of infrastructure. If and when this can be achieved there are advantages to be drawn from self-driving technology. Foremost, cost reduction that many of the interviewees mentions but also generating a more efficient public transportation sector reaching a greater supply in cost effective manners.

4.7.1 Contrasts between the participants

One of the main findings of the contrasts between the different types of respondents is in their core activity related to self-driving technology. Company A, which is a supplier, focuses on research and development of autonomous vehicles whereas Companies B, C, D, and E all act primarily as decision makers within their respective counties and focus more so on their own operations and the implications of the technology for their organization. Thereby Company A

has a wider focus and is not limited in their perspective from one single county but instead has a national focus in their operations. As such Company A works with several different local actors in different municipalities. Comparatively, Company F, in their role as a regulatory agency instead focuses their efforts on assuring a high quality transportation sector with a focus on regulatory aspects and non-operational issues.

Another point of differentiation is the emphasized benefits. Company A as the only private company in particular focuses on cost savings and higher quality of service whereas the public transportation companies and the regulatory agency tended to focus on more societal perspectives first and foremost such as enabling first/last mile travel, enhancing the customer experience, and expanding the public transportation network. All respondents did emphasize that safety is a major concern for the continued development and all respondents did illustrate the benefit of lowered road fatalities.

Other differences appear between the respondents related to current actions in response to potential future implementations of self-driving technology. Whereas Companies A, B, and C all currently have pilot projects running to gain deeper understanding of the technology, Companies D, E, and F do not. In particular, company D has taken very limited steps towards developing further understanding of the potential impacts of the technology. However, they do mention that they are discussing the technology in relation to a future project. Contrastingly, Company E expressed that there had been a will to establish a pilot project in the past but saw no good options for potential project at that time and instead chose to conduct a program focusing on DRT-systems. Company F, in their role as a regulatory agency does not have any pilot programs nor expressed any intentions to start any such programs.

While all the interviewed participants do tend to express relatively positive attitudes regarding the potential effects of an implementation of self-driving technology, the participants with pilot programs tended to be more positive than those that did not. In particular, they emphasize the benefits of potential cost savings and the ability to offer more frequent and extensive public transportation routes more so than those without pilot programs. Furthermore, Companies A, B, and C who have pilot programs in progress are the ones most clearly expressing the need for adaptation of the current regulatory framework so as to accommodate self-driving vehicles. However these differences may be due to the fact

that as participants in a pilot program they are able to access more data and information about what a self-driving future may bring.

Another point of differentiation between the participants with pilot programs those without is of course to be found in the fact that they are utilizing pilot programs and as such taking strategic actions to prepare for a self-driving future by gaining increased insight and knowledge about the technology so as to be better prepared for when the technology potentially becomes implemented. Neither Company D, E, or F mention any as direct actions to gain deeper understanding but do mention it as either an avenue to explore or other actions to gain knowledge and understanding. In particular, Company F does illustrate how they are facilitating dialogues between themselves and other participants so as to ensure that more perspectives are taken into account.

5. Discussion:

5.1 Research aims

This thesis aimed to investigate and investigate the effects that the introduction of self-driving technology might have on public transportation. From the findings of this paper, there is a potential that the implementation of self-driving technology within the public transportation industry in Sweden has the potential to bring about cost savings, increased efficiency, enhanced customer experience, and a shift in the interplay between the public and private sectors. However, challenges remain related to safety, technology, and regulatory adaptation that need to be addressed for a successful and widespread implementation to take place. Furthermore, there is also a potential that the implementation of self-driving technology within private cars may also pose a threat as it may cause an increased usage of private cars in relation to shared mobility.

5.2 Practical implications

5.2.1 Implications for management

The most impactful aspect of the finding for management is with regards to the uncertainty regarding the time horizon. Several of the interviewed companies express concerns regarding when a larger scale of self-driving technology may be developed and ready to be implemented. This is also argued among scholars with Ulrich, Frieske, Schmid, and Friedrich (2022) mentioning that there is quite some time until level five self-driving technology could be available but expressed with uncertainty regarding the accuracy of time estimation. Besides this, Li, Garces, and Daim (2019) express the need of understanding that multiple factors influence the adoption of self-driving technology. Hence, a need for management to understand the underlying processes and structure as this acts as compliments to a future successful widespread adoption of autonomous vehicles.

While it has become evident that self-driving technology is a highly anticipated trend, the evidence also indicates what future benefits a Swedish public transportation sector may see from an adoption of autonomous vehicles. While highlighting the positive aspects, it also becomes clear that much is still to come and that there is a need for further development

before full scale autonomous vehicle fleets may become incorporated in the public transportation sector.

With this in mind much work is still undergoing and strategic actions are being made by companies to transition into the future. Besides the technological aspects of autonomous vehicles, it is generally agreed that the correct systems must be in place and be able to adapt to the widespread use of a more self-driving technology in the Swedish public transportation sector. Many of the interviewed candidates focus on the above, emphasizing the importance of building systems that are suitable for a new structure where humans may take on a more complimentary role in relation to artificial intelligence. The idea behind this can be related to management under uncertainty and especially the contingency theory of Fiedler (1964).

For the organizations to succeed within a new landscape it becomes important to understand the leadership behind the developments and vision. The organizations are in need of understanding the new sphere and adapting the leadership depending on the situation that may occur. While doing so one must also adapt to what the main focus is. Currently, there are expressed concerns among the actors within the Swedish public transportation sectors. There is a technology that is unpredictable regarding when it can be seen as up to date. Moreover, there is a clear need for new fundamental structures dependent on artificial intelligence, regulations and potentially new business models creating concerns regarding how to position and organize for optimal efficiency and competitive advantage. This transition will be consuming and requires correct leadership and focus to succeed.

While there are some general concerns taken up regarding the contingency theory, Roya et al, (1995) still emphasizes the applicability towards the real world indicating that the need for a large base of resources and difficult implementation is minimal. Although the implementation towards a new leadership may seem uncomplicated, the organizations within the Swedish transportation sector must analyze the situation and take actions according to the favorability of the potential outcomes in order to succeed within the transition and during the current developments of autonomous vehicles. Especially in times where the future is uncertain.

In relation to the mentioned sense of uncertainty among the interviewed representatives the idea of agile management raises an interesting aspect going forward. As many of the companies see a potential pivot towards a collaborative industry one may argue that the

organizations will see a need for more agile management focusing on interactions, working solutions and customer collaboration. One must prepare the organization for flexibility and the possibility to adapt. Although the technological advancements may not be here, there is evidently a push towards the new trend which requires more than just new technology. The preparatory work needed has become clear as much indicates that not only is the technology of importance but likewise the fundamental systems behind it with different ways of obtaining and consuming the public transportation.

5.2.2 Sustainability

When discussing the implications of a widespread adoption of autonomous vehicles within the Swedish public transportation sector much focus is aimed towards the sustainable contributions. The collected data suggests that there are many aspects ranging from environmental to social that will be affected and may have positive outcomes based on an implementation of self-driving technology. Both the literature and interview respondents pinpoint the upside of possible efficiency gains being a core driving force of the positive impact of self-driving technology. While the technology behind it may enable society to draw efficiency gains, the idea emphasized both in the literature and amongst the respondents further suggests that a suitable and well developed system must be in place. Hence, much focus is aimed towards a solution of shared mobility where collaborative actions are seen as potential outcomes. As Williams, Das & Fisher (2020) points out, the net effect of efficiency gains are heavily linked to the aspect of shared mobility. To fully draw the desired and potential benefits much revolves around gaining a mass adoption and winning over the public perception. The idea behind autonomous vehicles clearly establishes an interesting discussion as it shows that multiple actors must collaborate with clear goals and actions to fully draw the proposed advantages of self-driving technology. The correct management will evidently become crucial in order to generate efficiency and to steer the developments of both systems and technology in the right direction. Although there are many sustainability benefits to be achieved compared to the current state of the public transportation sector in Sweden, there are still developments and long-term investments needed while creating a new fundamental system.

Once the proper systems, actions and technology has fallen into place there are many benefits that can be seen. It has become clear that it is generally agreed amongst the interviewed that autonomous vehicles within the public transportation sector could have an environmental impact primarily by a simple reduction of emissions as these vehicles are deemed to be only electric and efficient. While doing so some of the environmental aspects will much be impacted by a correlation with societal impacts. An implementation of self-driving technology can be seen to have the biggest impact on the societal aspects. As mentioned by Company A and C, the adoption could have an impact on congestion as computers will run a more dynamic operating experience. This is also emphasized by Taiebat et al., (2018) who pinpoints the fact that perhaps more vehicles could fit while maintaining the congestion due to a more optimal fundamental scheme when the human factor is excluded. This is further connected to a less energy or fuel consumption as a more smooth traffic flow can be achieved.

Moreover, conversations are made regarding the possibility of increased supply with interviewees mentioning the possibility to expand with more routes and an increased service. The social impacts stretch with regards to a potential of increased supply to enable the possibility to further satisfy the public, with Williams, Das & Fisher (2020) stating that an implementation of autonomous vehicles could increase the benefits and possibilities of transportation for elderly and disabled.

Finally, research also suggests that an impact on the land could occur, with literature indicating that a adoption of autonomous vehicles could mean a flowing transportation where vehicles are operating regularly rather than as for the private car, idle in a parking lot. This would consequently disembarrass space for further urban development. However, this benefit is closely related to the concern of the interviewed company representatives, emphasizing the competition and importance of shifting from a privately owned car scheme towards a shared mobility.

5.3 Theoretical implications

5.3.1 Ecosystems

As the empirical evidence suggests the companies are currently acting within a collaborative stage with the developments with regards to autonomous vehicles within the Swedish public transportation sector. Furthermore, many pinpoint the idea of a new way of conducting public transportation where the implications result in an interconnected ecosystem rather than independent actors. The collected data suggests that perhaps even a collaborative sphere between governmental actors and commercial companies could arise. As the literature suggests, ecosystems have gained more traction and awareness as new technological developments are being made (Jacobides, 2019). With the main goal of ecosystems consisting of generating a larger collective scale of value, meaning that the participating actors can generate value for each other.. The idea mentioned by Jacobides (2019) becomes very interesting in relation to the outlook of the Swedish public transportation industry. Ecosystems may generate prosperous relationships across sectors resulting in a more extensive service provided for the end users. As it is argued that the private and public sector may act as compliments it becomes evident that analysis must be made with regards to how to properly structure and maintain a well functioning ecosystem. As for the strategic implications of the Swedish public transportation companies, importance lies within understanding the role one might have to embrace within such an ecosystem and adapt accordingly. This could indicate that preparatory work may be of great importance in order to gain a competitive advantage with a certain developed resource or process that can act as a contributing factor of value creation within a potential ecosystem. A lack of strategic preparatory actions may result in difficulties entering the ecosystem and consequently becoming outcompeted by multinational private actors.

5.3.2 Mobility-as-a-service

While only one participant directly mentioned Mobility-as-a-service during the interviews, Company A, several key themes aspects to the concept were discussed throughout the other interviews as well. One such aspect is the discussions of shared Mobility where it was mentioned in the discussions with the participants that there is a need to increase shared Mobility compared to the current status. Furthermore, self-driving technology is seen as having both competitive and complementary aspects attached to it. While ride-hailing

services like Uber can be argued to partially compete with public transportation, the findings also indicate that they can also act as a first- or last-mile connecting means of transportation, in line with the views of Shaheen & Chan (2016).

A less positive implication is the difficulties in converging legislation discussed by Company F, which is especially poignant considering the need for converged policy making discussed by Wong, Hensher & Mulley (2019). Without a convergent legislative framework there may then be difficulties associated with integrating self-driving vehicles into a MAAS platform.

Additionally, Company A also discussed public-private partnerships which may, if implemented, be a potential avenue to advance towards a fully developed MAAS platform. If such a partnership is struck between a public transportation company and a ride-sharing service this could enable greater connectivity and competitiveness for shared mobility. Furthermore, the emphasis on cost savings and efficiencies found in the results, one could potentially argue that the respondents do perceive positive aspects that could be found within a MAAS platform. Another positive aspect towards the concept of a potential MAAS platform could be found within the similarities in the responses from the participants. With relatively similar outlooks on self-driving technology, it is possible that the conditions for collaborative efforts may exist. However, that was not the focus of this study and further research would need to be done to ascertain the degree of likeness on a statistical level. From the findings then one could imply that there is some potential for a future development towards a MAAS platform in the Swedish market, however, uncertainty persists and more research is required to investigate this fully.

5.3.3 Implications of the findings for the forecasts

While all participants did generally agree somewhat on certain key aspects of the technology there were others yet where there was disagreement. This is mirrored in chapter 2 where while there were areas of agreement, there were others yet where the outlooks differed. Thereby, there still seems to be a high degree of uncertainty regarding self-driving technology and how it will be implemented.

Li, Garces, and Daim (2019) argued that the technology was close to maturity but this was not a sentiment that was shared by the findings which indicated a relatively long lead time for

self-driving technology to be implemented. However, whether this is skepticism of the development in the eyes of the respondents or optimism in the eyes of the researchers is difficult to ascertain. If the participants are to be believed there may be an over-optimism clouding certain forecasts produced by researchers and if the predictions of Li, Garces, and Daim (2019) hold true it could potentially indicate that the public transportation industry in Sweden is responding too slowly.

Another aspect which was only briefly discussed by the participants was consumers' attitudes towards self-driving vehicles. As Usman Saeed, Burris, Labi, and Sinha (2020) pointed out, there is a high amount of individuals who are uncomfortable utilizing self-driving vehicles which may impact the firms should they choose to integrate the technology within their vehicle fleet. If this is not taken into account during a roll-out of the technology, either through attempts to convince consumers of the benefits of the technology or non-automated transportation then self-driving vehicles may cause shared mobility to lose market shares.

Pricing is another area of potential concern as Bansal and Kockerman (2017) found that consumers are generally unwilling to pay extra for self-driving technology which may impact the future benefits of the technology. However, this is assumedly counteracted over the long term as participants foresaw a great degree of cost savings which could counteract the inability to heighten the prices to pay for the implementation.

As referenced in chapter 2, there is still some uncertainty regarding cost savings. However the findings of this thesis indicate that a large degree of support for long-term savings as even Company B who indicated that there will be new costs associated with the technology acknowledge that these costs will be able to be split between multiple vehicles (Brundell-Freij et al, 2020).

Furthermore, the findings of this thesis fully support the arguments in the forecast of Erik Almlöf (2022) in that self-driving technology will be able to facilitate not only cost savings but also increased service levels as human capital is no longer a restraining factor. Additionally, the participants generally seem to share the perspective of Erik Almlöf, Mikael Nybacka, and Anna Pernestål (2019) in that the way the technology is implemented will ultimately impact its effects. In particular, the respondents highlighted the need for an increase in shared mobility to come as a result of the implementation. However, the findings

did not seem to indicate sufficient support for dynamic action taken by the public transportation companies although this may simply be as a result of them viewing the technology's implementation as a long-term issue and therefore do not have dynamic responses developed yet.

5.4 Suggestions for further research

For future researchers, one potential avenue of research to explore may be a thorough exploration of the transitional period of the transformation of the transportation sector. Whereas studies such as this one explore the potential long-term effects of the technology, less research seems to have been directed towards the initial phases of the implementation and what the consequences may be in the short term.

Another avenue is to explore the same questions from a different cultural perspective to see whether the general trends hold true in another cultural context and whether the cultural context of a study focusing on the Swedish market impacted the respondents or whether the result may see some applicability in other contexts as well.

Another potential avenue to explore further is the public-private-partnerships mentioned by Company A and what kind of a potential role they may play in a future implementation of self-driving technology in the Swedish market. Additionally, exploration of the conditions and attitudes towards Mobility-as-a-service could be beneficial as well.

Furthermore, the social aspects may be another perspective to explore more thoroughly, in particular how self-driving technology may impact mobility for those that currently are less able to utilize the mobility solutions of today due to disabilities or other factors.

Additionally, research could also be done so as to ascertain the views of Swedish consumers in response to an implementation of self-driving technology within the public transportation sector in Sweden. Would Swedish consumers be willing to utilize self-driving buses to the same degree or would such buses see lowered utilization rates?

Lasly, a study could be done with the aim of further investigating the cost and benefits associated with an implementation of the technology within the vehicle fleets of the Swedish public transportation sector. Will the massive cost of upgrading all of the buses in Sweden to a level where they are capable of utilizing self-driving technology be able to be outweighed by the associated benefits in the short and medium term?

6. Conclusion:

This thesis aimed to investigate the effects that the introduction of self-driving technology might have on public transportation. It did so by asking: *How are public transportation companies preparing for the potential entry of autonomous vehicles in Sweden and what are the potential impacts of such technology?* From the information presented throughout this thesis it is argued that public transportation companies are preparing for the potential entry of the technology by gathering knowledge and increasing their understanding of the technology. It is clear that the technology has the potential to reshape the transportation industry. The study indicates that strategic action regarding the creation and structuring of a future system of public transportation is of importance. However, the companies view the technology as a long-term issue and therefore do not prepare through particularly carefully constructed strategies at this time. As for the impact, the findings of this thesis indicate that self-driving technology may lead to significant cost savings, increased efficiencies and increases to the service level.

However, the findings also indicate that this is all dependent on how the technology is implemented and the need for an emphasis on shared mobility instead of private cars. As such, while self-driving technology may prove a beneficial innovation for society, uncertainty still remains and the only way to truly and fully dispel that uncertainty though is to wait and see how the implementation plays out. Self-driving technology paves the way to a future untold, be it a utopian or dystopian one.

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Appendices:

Appendix A: Interview guide:

1. How do you see that the public transportation sector in Sweden will be impacted by the entry of self-driving technology?

2. What preparatory strategic actions are you taking?

3. At what point do you believe that fully self-driving technology will be able to be implemented at a large scale?

4. What are the most significant obstacles and challenges facing a more widespread adoption of self-driving technology?

5. How are you working with the legal and regulatory aspects?

6. How do you believe that self-driving technology will impact sustainability aspects?

Appendix B: Informed consent

Informed Consent

Concerning the participation in an interview and the analysis of the resulting data for reports and academic publication

The primary purpose of this study is to gain an insight of how the Swedish public transportation sector is preparing for the future of autonomous vehicles being implemented on the road. The thesis ambition is to explore how the supplier and operator of the public transportation system's vehicles in Sweden are adapting to this emerging technology and what actions are being made.

I consent to the interview being recorded and transcribed. All data will be handled strictly confidential.

I am aware and consent that quotes from the interview may be cited in publically accessible reports and academic publications, however only in strictly anonymized form. My identity will not be revealed.

I can end the interview at any point in time during the interview. In this case, the recorded file will be destroyed and not used for analysis.

By signing this form, I consent to participate in an interview within the framework of the project "Investigating the effects of self-driving technology on public transportation in Sweden" conducted by Fredric Idmark and David Jevinger, for the purposes of publication in an essay to be examined at Department of Business Administration, Lund University.

Name of the participant: XXXXX XXXXXXX

Date of the interview: XX-XX-XXXX

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Signature of the participant Signature of the interviewer

Signature of the interviewer