MASTER THESIS PROJECT

AUTONOMOUS BUS PASSENGER EXPERIENCE

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ABSTRACT

Time keeps on changing our perception of what is possible in our personal life and around us. Over time, jobs such as elevator operator was essential to make the elevator keep its speed, stop parallel to the floor and keep passengers safe in case of emergency. Nowadays elevator passengers just have to enter their destination and wait to be transported there. An operator would be superfluous for this, today, simple procedure.

This paper aims to create a set of interaction strategies to provide an efficient and pleasurable journey for the passenger traveling with an autonomous bus, as well as evaluate concepts where these strategies have been applied. The strategies and concepts will be developed from an extensive user- and literature research where the situation of today will be analysed and looked upon with the eyes of tomorrow, to find challenges and needs.

Findings shows that passengers have to trust the vehicle and service. At the same time vehicle and service providers have to provide a reliable and consistent service. Four design directions were created to establish this trust between the user and vehicle and service.

To enable control and give passengers an efficient journey, passengers have to be provided with adequate and reliable information. The information regarding the bus’s behaviour should be communicated in a transparent way so the bus’s intentions and actions are understandable from a passenger point of view. Also, passengers have to be enabled to stay safe when using the bus, during commuting and emergency, through giving them cues in how an emergency should be handled.
INTRODUCTION
As time goes on and future becomes a more natural part of our passing days, we amongst technology keep evolving. Tasks that once belonged to a factory worker might nowadays be conducted by automated industrial robots. Today, this overtaking of work tasks might not seem as controversial as it once did when the robots came to replace us and take our skills and jobs away [1].

Today we see sophisticated technology such as artificial intelligence replaces the human mind in many sectors, for example in medicine and, as in this paper, vehicles [2]. The research topics on how people perceive automation varies from the different applications of it.

In this paper the author will try to create a passenger interface in the context of an automated bus. How does the new driver-less context affect the passenger? What is important and how do passengers value the different parts of the trip? These questions among others has to be answered to be able to design an extraordinary commuting experience.

PROBLEM STATEMENT
Autonomous buses are being developed to perform tasks such as driving, pick up passengers at stops and mastering complex traffic situations. These tasks will be performed by the vehicle itself, without any involvement from a driver, in direct proximity to passengers and other road users. So, how will the automated bus and passengers communicate?

ASSIGNMENT
Design a bus passenger human-machine interface (HMI) for an automated bus creating an experience that makes the journey efficient and pleasurable.
The assignment is to try to define future needs and challenges of the future automated bus passenger, benchmark products, look into different markets and scenarios that might be relevant to the project.

The result of this project will partly be a framework supporting the design of an enhanced user experience when traveling with an autonomous bus. The focus is on making the experience efficient and pleasurable. Four scenarios create the fundament of the research project:

- Bus stop at bus stop
- Passengers exit from bus
- Passengers embark bus
- Bus departs bus stop

DELIVERABLES

- Create a set of interaction strategies that could provide a framework on how to communicate with an autonomous bus.
- One or more evaluated concepts for a passenger on an automated bus in city traffic environment.

RESEARCH QUESTIONS

- What factors are important when designing for a pleasurable bus experience?
- What does bus passengers value when choosing to travel with bus?
- How will bus riding of tomorrow be different from the situation of today?
- How can intentions be conveyed from one side to another in the autonomous bus – passenger relationship?
SCOPE

CONTEXT

STOCKHOLM 2025

The concept will be developed for Stockholm in 2025, which will be an inner-city environment, where people and vehicles has to coexist. Accordingly, the design has to be intuitive and easy to use for users with different backgrounds and experience. The roads will be mixed with vehicles driven by humans and autonomous vehicles. The vehicles will be able to exchange information about position, heading, intentions and speed through vehicle-to-vehicle communication. In the bus there will be no driver nor ticket collector.

DELIMITATIONS

There will be no notice taken to what the passenger has to do before getting to the bus stop and after leaving the bus. This project is only considering the passengers n autonomous buses, individuals and other road users acting in vicinity to the bus are also very interesting research topics, but it will not fit within the scope of this project. The concepts developed will not be tested on detail level, because of the wide scope of this project the tests will be evaluated. Because of already existing best practices when it comes to map and system design. The concepts will be limited to visuals and therefore will no other mediums such as sound be explored. This limitation is made because of the broad scope of the project, there would not be enough time to explore different mediums to convey information.

This paper paves the way for further work and therefore the perspective will be broad. Unfortunately, there is no or less focus
on challenges that arise in connection to a mentally or physically disabled person’s journey.

TARGET GROUP
The target group in this project is primarily tourists and thereafter commuters. This prioritization between these two groups was made because of the greater support needed from the tourist as a novice user in a new transport network. This persona will cover a wider range of users instead of designing for the commuter, which already is used to travel with the bus. Commuters know where the bus will depart and what bus could be used to get to their destination, they know how they should behave to embark as smoothly as possible.

The focus during this project will be on tourists which constitutes a user new to the environment and in need of support to be able to find right bus and exit at right stop.

ASSUMPTIONS
Trust in automated vehicles is at this time important to establish, without trust it will be a challenge for passengers to feel comfortable and use a self-driving service. Concepts developed within this thesis project is aiming for a product that will be on the market in 2025 so the stance is that essential trust between an automated bus and the passenger is already established by then. However, because of the unavoidable nature of the subject trust, it will still be touched upon.

In the process of developing prototypes and concepts, all technological necessities that are required for the concepts are seen as solved. Some concepts are only to be partly developed, the concepts will be designed where issues for passengers can be found.

As of today, we can assume that tourists are traveling connected with a smartphone. If nothing unforeseen will happen until 2025
it will be assumed from now on that persons traveling by then also carries a personal connected device. However, the bus service has to be just as usable with or without a personal device. It could be seen as if the passenger carries a personal device, the bus experience could be personalized and customized to the specific need of the individual.

**BACKGROUND**

**SCANIA CV AB**

Scania CV AB is one of the leading transport solution companies in the world, within the Scania product family one can find trucks, buses, engines, marine engines and service solutions [3].

**RCDI**

Research Cab Driver Interaction, is the group at Scania where the project is conducted. RCDI, which is a part of Scania’s design department *styling and ergonomics*, are designing the interaction between the vehicle and the driver in Scania’s trucks and buses. RCDI’s vision is to enhance the driver’s, and to some extent also passenger’s, performance by designing an HMI that is best in class and supports safe, efficient and pleasurable driving.

**PUBLIC TRANSPORT**

Riding together is smart, there are several positive impacts such as improvement of health, urban environment [4], wage equality [5] and of course on the climate in general when people choose to use public transport instead of cars. There are still trends that indicate that people tend to choose private motorized transport instead of public transport. This leads to 6.2 billion private
motorized trips are made every day in the cities of the world [6]. With an increasing income in low- and mid-income countries, cities have been experiencing a raising motorization trend where the increasing income and population lead to a deficient capacity of urban transport. This results in a lower quality of life in urban areas with air pollution, traffic congestion and accidents [7]. This on the other hand can be seen as an excellent opportunity to stay awake and be a part of the change towards better urban transport policies in the developing cities in the world.

By 2050, approximately 66 percent of the world’s population will have moved in to urban areas. This is a remarkable change from the 30 percent who lived in urban areas in 1950 [8]. Until today we have managed to meet this increasing need of urban transport, but we can see the consequences in increasing congestion, air pollution and health issues. This increasing demand of mobility in urban areas is best solved by public transport, not only because of the positive impact on people’s health, traffic congestion, urban environment and economic growth, but also for poverty alleviation and democracy in the end *to whom do the streets belong* [7].

**BUSES AS MEANS OF TRANSPORTATION**

Buses as the choice of public transport is amongst the most economically effective alternatives when it comes to implementing new public transport in cities [9]. There are several solutions when it comes to buses, there are systems such as Bus Rapid Transit (BRT), autonomous buses and manually driven buses. The advantages of choosing bus as means of transport is that it might not necessarily have to come with big investments in infrastructure as most cities already have functioning road networks. This makes the implementation phase quick and efficient.
THEORY

The following section contains a summary of existing research and literature relevant to the project’s scope.

URBAN TRANSPORT

From 2000 until 2015, the public transport journeys increased with 18 percent in 39 of the world’s countries. In China alone, 85 billion journeys were conducted in 2015, followed by Japan and Brazil [10]. World-wide, a majority, 63 percent, of the journeys each day are done by bus. The average journey is done by bus, but the main mode of transportation differs between countries and cities.

SAFETY

Each year, in Stockholm alone, more than 100 persons have to seek emergency medical care due to bus related accidents. Personal injuries are most common among women 65 years or older [11]. Women are to a wider extent affected by these accidents, 3 out of 4 injured are women. About 40 percent of the people injured stood up inside the bus before the accident occurred. Accidents of this kind are often a product of hard break manoeuvre [12]. 12 percent of the injuries occurred when passengers were in the process of sitting down in combination of hard acceleration from the bus. The fourth biggest cause of injuries, 7 percent, was due to closing doors, where the passenger either got squashed or pushed over by the closing doors.
TRANSPORT PROVIDERS

To be a passenger is not limited to riding a bus, as the market of mobility is expanding from today’s personal transport such as taxis to services such as Lyft and Uber. Today, you as a passenger can get much more tailored experiences depending on your need, preferences and will to pay.

The emerging mobility as a service (MaaS) sector will change the way we look upon transport. In metropolitan areas the need for a personal car will drop drastically in the near future. In a report released in November 2017, the professional service company KPMG (Klynveld Peat Marwick Goerdeler) predicts a 50 percent decrease in sales of sedans until 2030, in United States alone [13].

In this report KPMG foretell a future where larger metropolitan areas in the world are adopting autonomous transport solutions to such an extent that they become islands of autonomy. This paradigm shift from human-driven vehicles towards an autonomous vehicle fleet will demand a broad array of vehicles which will be applicable for the different needs of transport [14]. There will be no one solution to fit all these needs. However, there will be the smaller sized personal pods that could provide transport for shorter commutes, larger shared vehicles for lines that are more crowded, moving offices for longer commutes and different kinds of delivery vehicles [15]. Here are adaptable and customizable vehicles that could change their behaviour and application depending on task and user needs, as Toyota’s e-Palette, something that is frequently pointed out as a game

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1 https://www.lyft.com/

2 https://www.uber.com/en-SE/ride/
Bus Passenger Experience

This concept showcases the possibility of having a vehicle with the possibility to change accordingly to the user’s intended activity, i.e., to an office or workshop.

![Image](image_url)

**Figure 1. Toyota e-Palette concept**

KPMG also predicts the MaaS will create a multitrillion-market for mobility services. Car manufacturers of today have to be ready to transform their businesses to approach this market.

**CONNECTIVITY**

To be able to provide an efficient service with self-driving buses for the masses, there has to be some way of communication between vehicles and between vehicles and infrastructure. This is referred to as either vehicle-to-vehicle (V2V) or vehicle-to-infrastructure (V2I).

**VEHICLE-TO-VEHICLE**

V2V connectivity enables the possibility for vehicles to talk to each other. This makes it possible for vehicles to react to other vehicles in matters of fractions of a second. Braking could be communicated even though the brake lights are obscured. Turns and intentions could also be communicated making the traffic run much smoother [16].
VEHICLE-TO-INFRASTRUCTURE

V2I connectivity enables the different components of the infrastructure to communicate with the vehicle. These components could be anything from traffic lights, magnetic sensors to cameras surveying the traffic situation. This information of driving conditions, traffic congestion or safety issues is communicated to the bus who according to this, can make decisions in relation its current assignment and destination [17].

USER-CENTRED DESIGN

User centred design (UCD) is a design strategy which believes that the user who possesses the problem also somewhere has to solution for it. To find them, extended user studies is needed. The needs of the user are the centre of the design process and the solutions should be developed from these needs to address them as good as possible [18].

Goals are of real importance in UCD, these goals are defined by the user from what the user want to achieve in the end. These goals can be hard to define when they sometimes are nested inside each other. Because of this, it is important to keep the user in the loop during the design process and include the user from the beginning to gather more information and test early concepts and thoughts [19].

COGNITIVE LOAD

When designing products that in some way will deliver or contain information for users it is important to keep the user’s needs in mind. Too much information will demand cognitive processing power from the user and important messages could be lost. It is of great importance as a designer to understand that you have the
power to use a lot of different technologies that deliver information. Human are only able to process a limited amount of information, and users could sometimes be helped with the importance of the information. Where to look when and how the information be ordered depending on its importance should be ordered in an intuitive way to be able to handle an emergency or stressful situation [20].

If we as humans are provided with more information than we can process it will take more time to process, we will have trouble to interpret it, miss important details or abandon tasks [21].

The definition of cognitive load within the field of user experience design is: the cognitive load imposed by a user interface is the amount of mental resources that is required to operate the system. To avoid overloading the human brain with information we have to try to minimize the cognitive load within the application we are designing [20].

HUMAN TRUST IN AUTOMATION

One essential ingredient to make the passenger choose to travel with public transport in general and with bus in particular is trust. Trust will make the passenger feel more comfortable while traveling. Trust is multi-layered and will not only concern how passengers feel about the absence of a driver in an automated bus. Trust will also affect concerns of in-vehicle safety, as well as the feeling of traffic safety and personal security on board [22].

TRUST

Meyer et al. [23] Describes trust as follows: It is the willingness of one party to be vulnerable to the actions of another party based on expectations that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party.
This definition is putting the user in the centre which, in this case, depends on the bus to take the passenger from A to B. If this action can be performed in a satisfactory way the autonomous bus will gain in trust from the passenger’s perspective. On the other hand, the downside is that it is much easier to destroy trust than it is to build. An asymmetry like this is due to the case that negative events, seen as risks, get much more attention and are more visible than positive trust building events [24].

Because of this, media coverage has a vital role when it comes to the reputation and construction of trust regarding new technology. News that portraits failures and convey a negative reflection of the new technology make the trust and the willingness to adopt new technology much lower. It will also increase the perceived risk from the user’s perspective.

The willingness to adopt new technology, such as automated buses, will change accordingly to how new and how familiar the prospective user is with the product. If the user has been familiarized with a product, through media coverage, if it is positive, it will be more prone to adopt the new technology [25].

BUILD TRUST

To build trust, which is of great importance to be able to become a brand of the future automated bus industry, the development of autonomous buses has to be done alongside with the potential user. This to not introduce a brand new and unknown technology to the market, which many times is received with scepticism and
distrust. Trust is developed alongside three pillars: predictability, dependability and faith [26]. The authors’, Rempel et al., model of trust is built on interpersonal relationship and how the trust is built within a relationship between two persons. This can be applied and has been applied [27], to understand the adoption of new technology in general. In the paper, Hengstler et al. argue that the adoption process in early phases is driven by predictability, i.e. how the user can predict coming actions by the technology.

Building initial trust is key when introducing a new technology. If there is no trust from the user’s point of view, an adaptation of the technology is very unlikely [28].

If the automated technology can be seen as predictable from a user perspective, the continuous building of trust will be dependability, which can be described as whether the autonomous behaviour is perceived as consistent or not. Next step in the relationship is faith, where the user’s trust and rely on the technology.

However, it is important to distinguish interpersonal trust from human-automation trust.

Adoption of new technology depends on the willingness and attitude of the user. Their stance regarding new technology is affected by media, news, social media, trends, brand status etc. Especially when knowledge about an emerging technology is low, at this time the trust is driven by how predictable the technology is perceived by the user. Persuasion of technology is not objective. How new products are received by users and markets depends on the quality of communication from the company, if it is seen as open, closed or a two-way-communication where the company signals an openness. Reputation of the company and the quality of earlier products also plays a crucial role. Introducing new technology to a market with the help from earlier successful
products and a good reputation will help the company, as people judge the messenger before they judge the message [29].

To build trust in the system there has to be a consistency of the service. If there is a problem from the beginning with the rate of trust in a system, there will be a much slower adoption rate of the technology.

TRUST BUILDING METHODS

Trust is built upon different pillars. First there has to be a market which is ready for the introduction of a new technology to make people start using it. The next step is to make them keep on using it. Here the feeling of safety, trust and efficiency is essential. These words have multiple meanings to themselves. Safety can be regarded as personal in-vehicle safety towards other travellers, perceived traffic safety and emergency handling. One aspect could also be integrity when personal data is handled by automated systems, safety as in integrity is becoming a more important factor [22].

To be able to build trust, Hoff et al. [30] Describes the three main points of trust, which are the human operator, the situation and the automated system. These three blocks of trust are further defined as dispositional trust, situational trust and learned trust [31]. Dispositional trust represents one individual’s tendency to trust automation. Situational trust is dependent on in which context the interaction takes place and also the human relation to the context influencing the experience. Learned trust is related to expectations and earlier experiences relevant to the current system of use.
Dispositional trust

Dispositional trust is affected by personal characteristics such as self-confidence and mood among other things. The main factors that impose change into this brick of trust building is culture, age, gender and personality (Figure 2). These four factors are those who affect the trust the most. Culture is shown to affect us in different ways, in previous research, trust varies depending on nationality, religion etc.

There are several studies showing the tendency to trust automation differs between age groups. In a study from 2017 it is shown that older participants rated an agent as more trustworthy than younger participants [32]. Several papers suggest that this is because individuals of different age use different strategies to make up their mind, if an application is trust worthy or not.

Gender has not been the focus of a study regarding trust in automation, yet. The existing research touches upon the perception of trust depending on the gender of the agent. A study performed to investigate the power of stereotypes found that adoption of automation could be affected by the gender of the automation, depending on the user’s tendency to apply stereotypes to the computer [32].

Personality has a lot of different factors in itself, whether the user possesses an open attitude, is neurotic or are agreeable it correlates different with the trust in automation [33]. Among
findings a person with higher overall trust from before also tend to trust automation in a broader perspective. In contrast to this, persons with general lower trust seems to accredit automation higher trust, if the aid perform badly [30].

Figure 3. Situational trust

Situational trust

The two ingredients in situational trust (Figure 3) is internal- and external variability. Internal variability could be described as the individual’s self-confidence when it comes to a certain task and if the person feels experienced. Other factors such as mood, expertise and attention also influence the dispositional trust. If the person is familiar with the task to be achieved, the person is less likely to use automation for help. In previous research, is has been shown that if a person’s self-confidence was low but trust for automation was high, automation was utilized to a higher extent [34].

What kind of factors that impact the trust and usability of a system varies over time, depending on workload, type of system, complexity of system and task. Together these factors are the external variability that will affect the user’s trust of an automated system. For example, during a heavy workload, operators tend to use automation to a higher extent, which also has a positive effect on the trust in automation.
Learned trust consists of dynamically and initially learned trust (Figure 4). Dynamically learned trust is *built* during interaction with the technology. Initially learned trust is trust that the user brings from earlier interaction with, in this example, automation and attitudes towards the application or understanding of the system. Dynamically learned trust depends more on the current state of the application such as system performance and design features that have an impact on how easy the system is to use [30].

To translate this to the introduction of automated buses today, it could be said that the test pilot in Kista⁴ is trying to give the passengers some kind of initial learned trust where the reputation, understanding and expectations of the service is built.

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⁴ [http://www.urbanictarena.se/autopiloten-kista/](http://www.urbanictarena.se/autopiloten-kista/)
So, in the future when passengers will use Scania’s buses, they will bring their experience from this pilot in Kista in the form of initial learned trust and this will be mixed with the dynamically learned trust which will be built while interacting and using the buses. Here, design features such as appearance, feedback, ease-of-use and communication style i.e. is the automation communicating through voice or text etc will play a crucial role in the trust building.

The performance of the system also plays a crucial role here. If the system is predictable, reliable and useful among other factors it will be perceived as good and the experience will affect the users in a positive way [30].

PERSONAL IN-VEHICLE SAFETY

In conventional public transport the general feeling of personal in-vehicle safety is dependent on the trust in other passengers. In a study performed in United Kingdom regarding personal safety, the perception of personal safety has a significant influence on whether people choose to use public transport or not [35]. Personal safety is subjective and what affects it differs from person to person.

In general, according to research, personal safety is negatively affected by a physical space that is perceived as closed, dirty and has bad lightning. Other factors could also be unwanted social
interaction with intoxicated persons and situations where there is less social control [36]. This factor is more significant on means of travel with a low density of personnel. Gaps in the information flow is also a negative factor affecting the overall feeling of personal safety. If there is a delay in service, the user might be stranded for an unknown period of time in an inhospitable place.

Personal safety is also related to social context, age and gender. According to a study performed in Stockholm, 53 percent of the female passengers and 72 percent of the male passengers felt safe. In general, 69 percent felt safe during travel with Storstockholms Lokaltrafik (SL) [36].

PLEASURE

Scania’s own definition of pleasure is: [...a product which is/has/ incorporates] stimulating, enjoyable, quality feeling, inspiring, feeling of control. With this stated, it is not possible to just put a well-designed and amusing screen in a bus and then you have a pleasurable ride. As the goal of the project is to create a pleasurable ride, pleasure has to be explained. Pleasure is dependent of other feelings that together contributes to a feeling of pleasure.

In this project, pleasure is seen as dependent of the user’s state of mind. Whether the user feel safe or not will affect the experience to a great extent. If there is no sense of safety nor relaxation, an enjoyable and well-designed interface would probably not invoke any pleasurable feelings towards the journey anyhow. The first task to create pleasure is to establish trust for the system and anchor the trust, through making the system predictable, transparent and easy to understand from the passenger’s point of view. Note, that this reasoning for pleasurability is a multi-layered nexus, trust has to be established between the user, system, vehicle and service.
TRAFFIC SAFETY

The perceived traffic safety of an automated bus might first seem to be worse than in a manually driven bus. In this case, the gap between statistical proof that automated buses are safer than regular buses, might be overshadowed by the public perception depending on a lack of trust [24]. In a study performed in Finland 2015 [22], where data was gathered to analyse passengers’ perception of personal safety, traffic safety and emergency handling in driverless autonomous buses. According to this study, 37 percent of the travellers experienced the traffic safety in a driverless bus as better or much better, 36 percent perceived the safety as the same as in a traditional bus and 27 percent assessed the traffic safety as worse or much worse. This study was performed where the bus travelled a designated route without any other traffic, this did of course affect the perception of safety.

EMERGENCY HANDLING

Emergency handling refers to unexpected events that might constitute danger to the passengers, such as fire or collision with another vehicle or road user. When emergency handling is perceived as good, travellers can relax and enjoy the ride. This feeling comes from clearly communicated and easily detected ways of managing emergency situations, as in where to find emergency exits, how to contact emergency services or report something suspicious [22].

How these systems should be designed depends on how the bus system is used. Is there a lot of people on board the bus? Is the bus running in a complex environment such as dense traffic where it is not suitable to open doors right away? Depending on this, it is important to develop systems to support the passenger mental emergency handling model [37].
TRANSPARENCY

To give the passenger a sense of control in an autonomous environment where human interaction is less needed to control the vehicle, the system has to be transparent. This means that the vehicle should communicate its intended actions, so the individual’s impression of the action corresponds to the situation [38]. All actions do not need to be communicated, this would only result in an information overload for the passenger. If there are sudden changes from normal or expected behaviour there should be an explanation, to make sure that the passenger understands why this deviation occurred. Through this, user will accredit even higher trust for the system [39]. Studies have shown that systems that are capable of communicating flaws are gaining trust [39].

ANTHROPOMORPHISM

Applying human characteristics to a non-human object has long been frequently occurring in the human culture [40], the first example could be the Löwenmensch figurine. This sculpture, found in a cave in Germany, is made out of mammoth ivory and was made by homo-sapiens 40000 years ago [41]. It could be argued that this might not be thought to be anthropomorphism from the beginning. But the use of human characteristics is the same.

In automation, anthropomorphism is used to apply automation human characteristics to automation such as gender, voice and facial expressions. This has been shown to be effective to gain trust from users of automated systems, where the researchers have given the AI human characteristics such as a gender and an ability to express emotions through the pitch of the voice [42].
AUTONOMOUS DRIVING

There are some challenges left to deal with before the majority of the vehicles traveling our streets are autonomous. On the way towards the goal of having autonomous buses, cars and other vehicles there is for example, the problem with having a mix of autonomous vehicles and vehicles with human chauffeurs. Meanwhile the autonomous vehicles can share information between each other about their intentions and next moves, there will be harder to predict the intentions of human-driven vehicles.

LEVELS OF AUTOMATION

The most frequently used description of autonomy today is a scale defined by Society of Automotive Engineers (SAE). The scale consists of six levels, which each represents a level of autonomy for vehicles. The scale ranges from 0, which constitutes no autonomy where every task is handled by the driver, to 5 which representing a fully automated ride, where every driving task is handled by the system [43]. This scale is used by the majority of vehicle manufacturers to describe what level of autonomy their vehicle is capable of.

AUTONOMOUS TRANSPORT

Autonomous buses and cars have many similarities, but they also have clear differences in how the passengers will use them. Buses will be used as a shared space, which is not the case of the personal car. There it will also be possible to take over the control of the vehicle, which is not the case when it comes to buses. In buses, it will not be expected for passengers to be prepared for handover, the procedure when passenger and vehicle exchange the control of the vehicle between each other. The handover procedure in an AV with a person behind the steering wheel requires quite extensive information to enhance the driver’s situational awareness in the handover moment [44].
BENCHMARKING

Today, autonomous buses are already traveling some of our streets in the world. This up-and-coming market of future mobility services and transport solutions, consists of a wide range of companies which are trying to take the lead, as Toyota’s E-palette for example. To achieve this, companies are now starting to team up with other companies, not limited to the auto industry [45]. Already established companies team up with mobility start-ups and tech companies. One recent example among other alliances is the computer component maker NVidia\(^5\) and Volkswagen, together they will develop a new generation of smart vehicles with the power of deep learning and artificial intelligence [46]. There are common denominators to be found when it comes to autonomous buses.

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\(^5\) http://www.nvidia.cn/

LAST MILE

The majority of today’s buses aims being a service for the last mile. As well as most of them have a capacity around 12 passengers. This notion for the last or first part of the trip, which might be too far to walk and too short to deploy conventional public transport in. This could also help to bring down the dependency on cars in less populated suburbs for example [47]. The idea of last mile concepts was coined within the business of telecommunication but has now been taken over by the transportation sector. Here, the concept provides a solution for the last part of the journey between the main transportation hub and the office, for example, or one major transportation body to the addressee. One of many interesting last mile concepts is Mercedes-Benz Vision Van (Figure 6), which uses drones to deliver parcels the last mile.
One of the most prominent and used vehicles on the market today is manufactured by Ligier called *EZ10, or easy mile*. EZ10 was presented in 2014 and is now running on multiple places around the world. The purpose of EZ10 is to take the passenger the last mile, as in a *last mile concept*. It is capable of transporting 12 passengers at the same time, six people standing, and six people seated, it could also cater passengers with reduced mobility thanks to the built-in ramp. EZ10 can run up to 14 hours with a cruise speed at 25 kilometres per hour [48].

**BLINK**

Blink is developed by Humanising Autonomy to make the interaction between people and automation easier and more natural. Through analysing body language, posture and situation the team behind blink are trying to create a way for communication between pedestrians and autonomous vehicles. In *Figure 7* below, one example is shown, where a pedestrian is communicating with blink through gestures and gets feedback in the shape of a green light and a low-resolution picture of the user itself. This means that the vehicle knows your presence and it is safe for you to cross the street [49].
Figure 7. Blink system

acoustic capabilities to distribute warnings or specific spoken messages.

The LED displays could deliver messages to cars behind it showing intentions and activities. For example, letting a pedestrian cross the street in front of the vehicle [50].

The display also shows that the car has noticed the pedestrian and it is safe to cross. The laser could at the same time for example, project a crossing in front of the car.

MERCEDES F 105

Mercedes concept, Figure 8, car for their driverless future features different kinds of interactive elements which both communicate within the interior with passengers and outside with other road users. The car has two LED displays distributed on the front and rear of the car. One laser in the front, capable of projecting shapes on the ground in front of the car. It also has
Among the autonomous buses of today the interaction elements are quite standardized, most of the buses has some kind of display with the route and a communication interface to contact traffic management or rescue. What makes Olli, *Figure 9*, stand out from the crowd in this manner is that it is utilizing *IBM Watson*\(^6\) as an interface for the passenger. This feature makes it possible to ask the vehicle about attractions, such as restaurants, nearby. The efficiency of voice interfaces in shared vehicles is debatable. It is possible in less passenger dense environments such as Olli for example. If the vehicles grow in size it will be more of a challenge to ask questions and deliver answers in a sensible manner in vicinity of other passengers [51]. Olli does as well serve as a last mile concept, so the application is mainly done within campuses or smaller areas rather than covering whole cities.

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\(^6\) https://www.ibm.com/watson/
Waymo is Google’s contribution to the autonomous vehicle race. Their vehicles are smaller than the both Local Motor’s Olli and EZ10, Waymo’s approach is to implement their technology in already existing vehicles. So far, they have driven around 8 046 720 kilometres, mostly on city streets. Waymo’s goal is to design for the passenger’s experience instead of the driver experience. Therefore, Waymo has researched this area as one of the pioneers where they have focused on how passengers would like to interact with the vehicle and how the experience differs from driving. From the research, Waymo has added a range of features. Inside the vehicles there are displays which show the destination, arrival time and visualizes static road elements and other road users [52].

Passengers can also find a button to start the journey, so they are prepared when the vehicle start moving, there is also a pull over button, Figure 10. Waymo interior interaction for the passengers to push. If they want to end the trip before the destination is reached. If this is pushed, the vehicle will pull over at the closest safe place. In case of a safety critical event, screens and audio will guide the passengers to respond to this and stay safe [53].

Waymo has also, from research, found that passengers need to know what and why the vehicle is taking specific actions and what
it reacts to. The screens inside the vehicle therefore display what the vehicle sees and explains its actions *Figure 11*. Waymo explaining vehicle actions.

*Figure 10. Waymo interior interaction*
METHOD
The aim of this project is to create an interface through a user-centred design approach.

LITERATURE RESEARCH
To get a deeper understanding of theories that some parts of this subject is founded upon, a broad literature research was made in the beginning of the work. Subjects regarding anthropomorphism, trust in automation and factors that affect passengers’ perception of public transport were researched. Articles regarding autonomous shared vehicles were researched but this subject has so far had a very limited number of publicised articles.

USER STUDIES
Following sections are describing the methods of how the user’s perspective was captured and then later used in the development of concepts and design strategies.

PRE-STUDY
To get a clue of the nature of bus traveling and about who is the typical bus passenger a pre-study was performed. During the study, which lasted for a day, observation were done as well as unstructured interviews with passengers, service personnel and with bus drivers.

The aim of the pre-study was to prepare for observations and interviews. Through a deeper understanding of the problems that affect the everyday traveller, the main study could be designed in a more efficient way with this pre-gained knowledge about the situation.
The pre-study took place during November 14th 2017 between 09:00-16:00.

OBSERVATIONS
During the observations, the method fly on the wall [19] was used to get an idea about how passengers of today are using buses and how they behave in relation to each other. This method suggests the observer to take a step back to observe the user in an unobtrusive way, which reflects the passenger’s natural behaviour. The observations were made during three different occasions, 24th, 28th and 30th of November 2017. Observations were also performed in shorter sessions multiple times during the project.

CONTEXTUAL INTERVIEWS
Contextual interviews are a good tool to understand why, in this case, passengers behave or do things in a certain way when you observe it. It is also good to incorporate the feeling from the context when using the product to get answers that reflect the user’s true feeling about things. The interviews were performed briefly when there was an opportunity or something interesting was found during the observations. Questions were held short and asked to understand a certain behaviour or action.

SEMI-STRUCTURED INTERVIEWS
Semi-structured interviews are one of the most useful interview techniques to get deep in to the user’s perception of the bus experience of today. The format of the interview is also flexible and makes it possible to explore topics that arise during the session to find underlying factors affecting the interviewee. The format of the interview is relaxed, but it has two principles to follow. The first one is that the interviewer should not be leading the interview through the formulation of questions or with body language. The second rule is to create a comfortable atmosphere.
where the interviewee can express themselves without judgement [54].

To give the interview subject a sense of the project before the interview, they obtained an interview brief which they got sent to them. This was to try to make them more aware of the bus riding procedure and to make them think about how they behave and how they perceive things.

From interviews with passengers with an appropriate background, similar to the personas different, in-depth insights was found. The interviews differed in length. The shortest one was 34 minutes and the longest lasted for 1 hour and 45 minutes. The mean was 1 hour and ten minutes. Before the interview sessions participants had been given a project and interview brief where they could read about the intention of the interview and that their participation was voluntary. In total, six persons were interviewed. Three commuters and three tourists were represented in the study. Four males 20, 27, 29 and 31 years of age and two females 31 and 33 years of age. All interviews were recorded with the consent of interviewees. The interviews were analysed, and insights were boiled down to sentences to get a better view of what passengers need, worry about, think and like. Insights were gathered in themes found during the analysis of the interviews.

**QUESTIONNAIRES**

To get a broad picture based on a bigger sample of people’s opinions and habits questionnaires were used. A questionnaire was created regarding passenger’s general perception of buses. Also, habits and how passengers found information in the different steps during the bus travel were explored through this form.
FIELD RESEARCH

During the time this project was proceeding there was a pilot test with autonomous buses in Kista, north of Stockholm, called Autopiloten with the transport service provider Nobina\(^7\) as a driving force. Here two buses of earlier mentioned model EasyMile (EZ10) were deployed as a test to transport passengers between Jan Stenbecks Torg and Scandic Victoria Tower, with one stop in between. The route is stretching a distance of 800 meters one way. The buses are at all times manned by an official Nobina operator which can overtake the control of the vehicle at any time and the maximum speed is 20 kilometres per hour. The research methods that was used were *fly on the wall* and also to interact with other passengers and ask them questions about their impressions of the trip.

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STRATEGIES

One of the deliverables of the project was to create a set of interaction strategies between the bus and passenger. This part of the project is thought of as a support for future bus projects at Scania to give designers a brief intro to user values when it comes to bus riding.

The framework (*Figure 12*) is built up by user insights, design strategies and how to use these to design for pleasure and efficiency. The strategies are based on findings in interviews and observations and also from previous research.

The user insights are presented as a user journey to show how our tourist persona is perceiving the bus journey of today. The insights can be used to see what parts of the journey that are important...
Bus Passenger Experience

to take in consideration when designing for the bus passenger experience and can be studied closer in Appendix F.

Figure 12. Strategies for passenger - bus interaction

CONCEPT GENERATION

The concepts generated were to a beginning broad and sprung out of the user studies’ wide range of needs connected to bus transportation. The four decided scenarios of the trip were considered until the moment of exiting the bus. To be able to approach the broad range of different applications of design. The concepts were divided in to personal, external and interior concepts.

The ideas were generated through ideation sessions all alone but also with the help of other persons during co-creation workshops where material already created was brought and used as reaction concepts or scenarios.

WORKSHOP ONE

As part of the process to get to know the passengers and their needs a bit deeper workshops were hosted. One workshop was
held at Scania CV AB in Södertälje, where four different scenarios were explored. Here the participants were employees at RCDI and at the same time also bus passengers from their everyday lives. The aim of the workshop was to explore different ways of communication between the bus and the passengers. At the workshop the participants were divided into four different teams, each with a specific need reflecting the persona they were handed e.g. tourist or blind. From this they had to come up with ideas connected to the four different scenarios wait, board, ride and exit.

Workshop number two was conducted together with two tourists in a public transport context. Here the aim was to explore their way of using public transport in a new context as a tourist.
Participants were handed a leaflet (Appendix A) where the workshop and the aim of the study was explained. On the leaflet they were asked to map their experience and to put down sentences that for them were related to a good and a bad journey, as well as the difference between bus and other means of transportation. The workshop was conducted with two persons visiting from Singapore who had never travelled with bus in Sweden before this workshop.

**Figure 14. Tourists finding their way**

**PERSONAL**

This category of concepts is designs applied within the personal space, where the information obtained by the user is tailored to fit its need. The possibilities of this kind of applications is really interesting, especially when new ways of communication between vehicle and passenger is made possible by faster
networks and infrastructure. We could potentially see a solution where a passenger running late for the bus, and the bus automatically notice this, and the bus knows that the traffic situation allows it to wait for an additional 20 seconds for the passenger.

INTERIOR
The interior concepts are designed with the aim to deliver information about the journey and enable for the user to feel comfortable, be efficient and stay safe in case of an emergency. The passenger should be able to know where one are located on the route and when it is time to exit without feeling distress of not knowing where one is. Information for the passengers traveling inside the bus should also make one feel safe and comfortable showing the passenger what is planned and what is not.

Not all passengers want the same kind of information, commuters for example, need less affirmatory information. For commuters it is more important to convey deviations from the normal procedure. Because of this one have to take the user’s need in consideration, how communication for passengers with different need should be met. Information about stops, times, route and connections and deviations from this and the expected bus behaviour is something that should be accessible during the commute.

EXTERNAL
These concepts are to be found outside of the bus. These concepts are made to communicate bus intentions, warnings and information about what is about to happen to inform other road users and passengers.
These concepts was developed to guide boarding passengers to first leave way to exiting passengers before they start to board. This concept were questioned how well it will work when the bus stop is crowded. Though it could still be claimed that the lights will catch boarding passengers’ attention and hopefully make them leave way to others.

REACTION CONCEPTS

As a part of the process to include the user and their thoughts in the process and concept development, reaction concepts were developed in the beginning of the concept generation phase. The concepts was made more as an overview to trigger the passenger’s own thoughts and make them suggest other ways of approaching the passenger need. This research method is effective to use to evaluate the ideas in an early phase of the conceptualization and getting input from the potential users fast.

The method was used during workshop three together with three tourists.

WORKSHOP THREE

In a try to spark opinions from users the first partial concepts (Appendix B) were created to get user input on placement, information content and interaction elements. This workshop, where three tourists participated, brought some interesting insights from the user perspective.

In an attempt to meet the need of reaffirmation and to let passengers know where the bus is going, a concept where the bus’s door has an integrated screen which clearly shows where the bus is heading and stops along the route. There is also a map on the door where the passenger can see one’s location and near surroundings.
FIRST ITERATION

There were some changes based on suggestions from workshop participants. Among them, to move the interactive map from outside to the inside because to not risk a prolonged boarding procedure.

CONCEPT EVALUATION

After the concepts had been refined from the first co-creation workshop with the tourist group, another evaluation was held with six participants, three RCDI-employees and three thesis workers. During this session the refined concepts were explained and discussed, based on this, the workshop participants could come with ideas, tweaks and critique. The use of this kind workshop was used so the more experienced designers could give feedback and reflect about the concepts and their adequacy.
SECOND ITERATION

In the first concepts, a big screen would be placed in the roof of the bus to show the route as clear as possible. This was opposed in the workshop and the question whether how a really big route map is easier to read rather than four smaller for example was raised. With this input, the big screen, as seen in concept in the roof was moved away and replaced by smaller maps in the corner where inner wall meet the roof of the bus (Figure 16. Second iteration of map placement).

EXPERT EVALUATION

Expert evaluation was chosen as method to evaluate the concepts. This method was chosen because of the way the concepts were designed, the concepts were not implemented on a physical bus, instead they were made digitally. Because of this, is expert evaluation a good method to get input from more experienced
designers with experience from being bus passengers as well. Seven RCDI employees were tested, each test took one hour to conduct.

The final concept was first modelled in a computer aided design (CAD) software, Rhinoceros 5\(^8\), and then later rendered with the 3D rendering software KeysShot\(^6\). This model were then animated with Adobe After effects\(^10\) to show how the different concepts work in the four scenarios.

The scenarios were walked through from the bus approaching the bus stop, the passenger embarking the bus, then riding and last exiting the bus. After each scenario the participant had to fill out a form (Appendix D) to evaluate how the design responded to the design directions. After the session, the participants had to fill out a form for the whole scenario to evaluate the concepts applicability to the created design direction, which could be found in the strategies.

\(^8\) https://www.rhino3d.com/
\(^9\) https://www.keyshot.com/
\(^10\) https://www.adobe.com/products/aftereffects
RESULT

This section contains the main findings from the user studies, framework and the developed concepts for the bus passengers traveling with an autonomous bus to make the journey pleasurable and efficient. Extended findings from interviews can be found in Appendix C.

PLEASURE

Within this project the trust for the vehicle and system is of main importance to create a pleasurable sensation. The building bricks (Figure 17) for creating a pleasurable ride is trust, control, safety and efficiency.

TRUST

Trust is critical to make people become passengers of autonomous vehicles. Today, trust is the biggest obstacle to sell the concept of a self-driving vehicle [55]. During the research, one of the findings was that trust connected to the bus experience is multi-layered. It is hard and not especially necessary, as a passenger, to distinguish between the trust for the service, vehicle and the driver. If the trip is perceived as bad, the whole picture of traveling by bus will be affected negatively, not only the source e.g. the transport supplier.

Vehicle

Figure 17. The author’s idea of generating a pleasurable experience
The vehicle has to be predictable for passengers to trust it. They have to understand what is about to happen to be able to plan their response to this. To the trust equation we add reputation as a brand, here, Scania could try to create good reputation which could affect the trust for the vehicle from the user.

Service

If passengers do not trust the service provider to be able to keep times and run a reliable service, then the experience will be affected by this and also cause the bus brand to be blamed. Therefore, it is important to keep passengers informed with information that are met up to. If there is a delay it is of great importance to communicate it and to be transparent about the reason why.

CONTROL

Control for passengers means to be on top of the majority of thinkable situations. To be on top, passengers need to know what is about to happen, and be sure that they can respond to this, e.g. see the closing doors or have enough time to exit the bus at your stop. Something that feels as basic as knowing that you are on the right bus is hard for a first-timer, and through enabling and making it possible for passengers to have this room for response we give them control.

“I have no attention span, I want to be in control, I go mad when there is no information” – Niklas, 29, commuter

SAFETY

The impression of safety during emergency situations and how these situations should be handled when there is no authorized personnel in the bus is a reoccurring concern brought up by
participants in this study. In the, so far, limited research [56] [22] regarding the passengers’ perception of autonomous buses, passengers have been shown to be positive towards the technology and the use of it, but the biggest concerns are regarding safety and emergency handling.

**Personal**

For the individual it is important to feel safe while commuting. Especially in situations when riding alone. Research has shown that passengers feel the most insecure for their own personal security when there is one other passenger inside the bus.

**Traffic**

To be able to have a pleasurable journey, the behaviour of other road users will play an important role. If there is no respect for the autonomous bus and other road users are taking advantage of its collision preventive systems to either cross the street in front of it because you know the bus will stop, then the service will not function.

**EFFICIENCY**

**Service**

Passengers want to transport themselves from A to B. It is a negligible part who just rides for the pleasure of riding. The majority wants to get from A to B without any unexpected lag or surprises. The biggest stressor connected to bus riding is waiting time, especially when users have to wait without any information. Therefore, it is important to keep the passenger updated about times and why the service might be delayed if that is the case.

Second to this is the absence of relevant information to the situation. Where is the bus? What is your location? When is the bus arriving? Where do I find the connecting service? And so on.

**Vehicle**
Efficiency in the vicinity of the bus is also important, mainly for commuters where as little lag time as possible should be spent waiting. The boarding and exiting procedure could be disturbing for commuters when people are standing in their way. Here it is possible to guide more unfamiliar passengers where it is preferred to stand to make this procedure smooth.

**PASSENGER VALUES**

**USER JOURNEY MAP**

From the state of today a lot of conclusions about what to focus on tomorrow can be drawn. The situation of today was mapped out in a user journey, *Figure 18*, where the relevant scenarios to the project are described from the passenger’s perspective. A bigger version can be found in *Appendix E*.

**VALUES**

Passengers value the reliability of the bus service as the most important factor. If the bus service is impossible to trust, then there will not be any pleasure what so ever. If the service is running and it is reliable, tourists want easy accessible

“I want to know where I am heading and feel comfortable, I do not want to feel as a stranger. I want to look like I know what I am doing.”  - participating tourist about her vision of travel
Bus Passenger Experience

information, somewhat easy-to-understand maps and some way to keep track of the journey to be able to alight at the right stop.

Commuters on the other hand know their journey and what stop they should alight at. For commuters it is important to have a punctual service with frequent departures and minimal waiting time. For commuters’ reliable information is important too and also to know in advance if the bus is late for example.

Figure 19. Passenger values and ways to collect information in connection to bus travel
TOMORROW’S SITUATION

Based on the behaviour of today

The most prominent change tomorrow will bring, is the absence of a driver. Therefore, it is important to take the driver’s role into consideration when designing the interface for an autonomous bus. Today, a driver is not only the person behind the wheel. The driver also constitutes a source of knowledge for unfamiliar users as well as the person that will coordinate an emergency. Drivers do also act as the ambassador for the bus and service. It is to this person passengers often turn when they feel unhappy with the service. Passengers also judge the driver’s capacity by first impression.

Today, passengers utilize the fact that there is a human behind the steering wheel. Passengers take contact with the driver during different occasions. From findings in both observations and interviews, passengers wave to the driver if they want the bus to wait for them. Drivers can also see the running passenger and choose whether to wait or not. Passengers can also wave buses by, so the driver does not have to stop at all bus stops. If passengers accidentally press the stop button one can simply tell that to the driver if there is no one else alighting. Other, more insecure passengers, often ask the driver where the bus is bound and if it is passing by their destination. Sometimes the driver notifies the passenger of their stop.

This interpersonal relationship between the driver and the passenger is really dynamic and passengers read the driver’s body language to know what will come next. Passengers can also see if the driver is preparing to depart or whether there still is time to board the bus without hurrying. This is possible by judging the drivers posture and activities. Cues in shapes of sound and lights are also available when passengers are in vicinity of the vehicle.
Every answer to each question passengers ask the driver is possible to find fast, if the passenger has the tools to find it. Passengers either find it easier to ask the driver or too complicated to find the answers in an app or an information map in the bus stop.

The absence of a driver will increase the demand for reliable and easy accessible information. Figure 20 contains and presents the important and requested information during the different steps of the project scenario.

**CONVEY INFORMATION**

There are multiple ways of conveying a message in this area. As of today, the use of signs and speech is already wide spread and established among passengers. Therefore, it is a good and efficient way to keep on using these ways of communication in cooperation with other techniques that are possible with new technology and also in some cases needed. Projections could for example, be a way to inform passengers about danger or that someone is standing in the bus’s intended path. The possibilities that our connected society brings are interesting, with these more personalized experiences can be achieved. In Figure 21 below, different ways to communicate messages between a vehicle and a human can be studied.
### VISUAL / AUDITORY MODALITY

<table>
<thead>
<tr>
<th>SPEECH</th>
<th>PROJECTION</th>
<th>PERSONAL DEVICE</th>
<th>LED DISPLAY</th>
<th>LED STRIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>No need for visual contact</td>
<td>Direct addressability</td>
<td>User specific</td>
<td>Possible to reach out to many people</td>
<td>Visibility from all sides</td>
</tr>
<tr>
<td>Regardless of weather conditions</td>
<td>Multiple direction</td>
<td>Clear</td>
<td>Possible to reach out to many people</td>
<td>Possible to reach out to many people</td>
</tr>
<tr>
<td>Straight forward</td>
<td>2-way exchange</td>
<td>2-way exchange</td>
<td>2-way exchange</td>
<td>2-way exchange</td>
</tr>
<tr>
<td>Good reach</td>
<td>Supplement: smart glasses</td>
<td>Supplement: smart glasses</td>
<td>Supplement: smart glasses</td>
<td>Supplement: smart glasses</td>
</tr>
<tr>
<td>Not optimal for direct addressability</td>
<td>Visual contact necessary</td>
<td>Distraction</td>
<td>Visual contact necessary</td>
<td>Angle of sight</td>
</tr>
<tr>
<td>Noise level</td>
<td>Weather dependent</td>
<td>Integrity</td>
<td>Complexity</td>
<td>Inconclusive</td>
</tr>
<tr>
<td></td>
<td>Complexity</td>
<td>Terminal needed</td>
<td>Inconclusive</td>
<td>Visual contact necessary</td>
</tr>
<tr>
<td></td>
<td>Glares</td>
<td></td>
<td>Complexity</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 21, Possible ways of communication, source: Volkswagen group research*
**DESIGN DIRECTIONS**

The design directions were derived from the user insights. The directions are made to bridge the challenges that exist today and those who will rise tomorrow. The user insights are four main directions which, if they are met, will make the experience more pleasurable and efficient within the scope and limitations of this project.

- **Provide passengers with adequate and reliable information, to enable control and give passengers an efficient journey.**
  - Information about time, information about traffic and delays, connections and stops. This both before, during and after the trip. This information is made for the passengers, so they can plan their trip.
  - Make different stages of the trip differentiable.
  - Create a way for passengers to feel in control during waiting time.

- **Provide passengers with enough information and enable them to know what is to happen.**
  - When are the doors opening and closing and when is the bus arriving? Information like this could today be gathered from the driver’s position, engine sounds or how crowded it is in the vicinity of the bus. This should also be possible to see in the future.
  - This is to make passengers able to anticipate what is next.

- **The information regarding bus behaviour should be communicated in a transparent way so the bus’s intentions and actions are understandable from a passenger point of view.**
  - This is to build an understanding and trust from the passenger towards the bus. This point is not saying that every little turn should be communicated and make passengers ready for it.
  - Passengers will learn the bus behaviour in common situations and expect it to behave accordingly.
- Important to communicate unexpected events, errors and/or flaws.
- Intention to turn is today communicated by blinking, this should also be the case for future driverless vehicles.

- Enable the passenger to stay safe when using the bus, during commuting and emergency.
  - This point has to be explored more extensively, as already stated, the passenger’s perception of personal security and safety is of great importance.
  - Emergency handling and contact with personnel is among the most frequent worries described among passengers in driverless vehicles.
  - It is important to give passengers cues on how to contact authorized personnel and evacuate.
  - It is important to give guidance throughout the emergency situation to guide passengers to safety.

**FINAL DESIGN**

The design directions were used to evaluate the final design of the bus-passenger interaction in the four scenarios. The resulting design of each scenario was evaluated in an expert evaluation and compared with the four design principles.
SCENARIO 1: WAIT

The waiting scenario was designed to try to ease the passengers mind in the waiting moment, to give them a feeling of control and certainty. The scenario is that a person named Lo is on vacation in Berlin. The city of Berlin has just chosen Scania to provide the city with an autonomous bus service. First Lo opens the app and gets welcomed to Berlin (Figure 22). Our passenger Lo, wants to travel to Warschauer straße, Lo gets a notification that the bus is approaching and arriving in 10 seconds (Figure 23).
Figure 23. Notification and the approaching bus
SCENARIO 2: BOARD

The bus has now stopped, and the doors are opening. This is done to give passengers a possibility to anticipate what is about to happen and what is expected from them. In Figure 24. Bus arrived and letting passenger exit the bus is telling passengers to stand back to let other passengers exit before the boarding starts. This is done to make the procedure more efficient. Thereafter (Figure 25) the screens of the doors change, and arrows projected on the ground tell passengers it is time to board. Passengers can also see on the doors what stops that are coming up as well as the time to departure. When the time to departure has less than six seconds left the screen switch to doors are closing to inform passengers about this. Thereafter, when doors are closed, time to departure are shown (Figure 26).
Figure 25. Bus letting passengers board
Figure 26. Bus closing doors and departing
SCENARIO 3: RIDE

While riding, the bus should be able to convey what is happening and why it is reacting in a certain way. The top image in Figure 27 is communicating an unexpected event that happens suddenly and is noticeable by the passengers. The image below is showing the moment when the doors are closing.

Figure 27. Passengers are being informed about pedestrians in front and doors closing
SCENARIO 4: EXIT

In the last scenario, our passenger gets a notification that the stop is approaching and that Lo should exit the bus at the next stop (Figure 28). Lo can thereafter, when doors are opening, see above the doors where she could head and where she can find connecting services and interesting places in the area.

Figure 28. Passengers are informed of an approaching stop and doors opening
FEEDBACK FROM TESTS

During the test, the participants came with many interesting insights from both a design and passenger perspective.

One insight was that the timer counting down to departure will stress passengers standing in line to enter or have reduced mobility. They might think that they will not be able to board the bus before departure and get stressed instead. Here it is better to show some kind of procedure instead of a fixed countdown, which also risks being cause distrust if the bus is not able to depart at the designated time. It is better to show an estimated time of departure instead.

It is also better to remove the next stop or change the layout of them from text to a route map, to not make passengers think that they have to read it. This might slow down the boarding procedure if uncertain passengers think that they have to read it.

Another suggestion was to move the countdown to the front and rear of the bus (Figure 29) to show this to passengers approaching from a far, to let them know if they have to hurry or not.

The suggestions were applied to a final concept (Figure 30) to show how these suggestions could look if they were applied.
Bus Passenger Experience

Figure 29. Departure time on front

Figure 30. Bus with suggestions from test applied
USER INSIGHTS

During the research, interesting insights in bus traveling was found, this section contains the findings of main importance to the project and for the design of autonomous buses.

TRANSPARENCY

Passengers and other road users should be aware of the bus and its attentions and whether it will stop or start moving. Individuals in its vicinity should know what it will do. Letting passengers and other road users be aware of the bus’s intentions enable them to prepare and decide how to respond to this. Information is again key to make passengers know what is happening and what is needed from their side.

CONSISTENCY

A theme through user interviews was the lack of consistency throughout the bus experience of today. Passenger use different platforms to find buses to their destination. When they later want to use available information at bus stops or inside the bus, the information they find does not match the information they have obtained inside for example, Google Maps. Therefore, consistency something that would make the bus passenger experience much better, a consistent graphical layout of maps, showing connecting services in a consistent manner is as well very helpful. Network maps, connecting services, an app and interactive screens inside the bus should have elements that are recognizable and invites the user to interact and use the interface.

GUIDANCE

Passengers want to be able to exit without squeezing through a crowd of passengers which refuse to move. Passengers also want
to embark and exit in the smoothest way possible. We want to make passengers aware of others to be able to co-exist easier during crowded times such as rush hour.

**ONE DEVICE**

Public transport users want to be able to use public transport without relying on their own personal device. If they have a device, information could be customized and made personal. But, with the situation of today, losing a personal device in a new city where you cannot speak the language could put you in a tricky situation. Therefore, it is important to make information accessible without using a smartphone.

**TRUST, TRUST & TRUST**

Findings suggest that passengers need to be able to rely on something. Whether it is on other passengers, the service or in case of an emergency the situation will be administrated or that the bus will not run over other road users. Trust is crucial to make passengers feel safe and comfortable while using the buses. Trust could be built through showing bus intentions, error transparency and communicating delays, so passengers understand why something is happening. Every action should spark a, from the user’s perspective, expected reaction [39]. This could be distinguished into three kinds of trust, first the passenger has to trust the service provider. Today it is mainly SL within Stockholm, to make the service run smooth and on time. The passenger has to trust that the vehicle and technology will not behave in an unpredictable way. This trust, today, do some passengers attribute to the driver. The driver tomorrow is the technology, e.g. the image recognizing algorithms who keeps the bus from running into objects. It is of main importance to get the passenger to trust the technology and the vehicle.
INFORMATION

Not surprisingly, information is the backbone of using public transport. Information is a broad term. Within this project the information is regarded as gathered by the user from devices, timetables and signs. To some extent, information is also an entity that the passenger carries within as a mental representation or as an experience from earlier use of public transport.

During the user studies, information made itself stand out as an important missing key for passengers to use the bus service to a sufficient level. Passengers often experience that it is hard to know basic things such as when the bus should depart, exit or what bus to take.

Other studies [57] have shown a lack of easy accessible information such as network maps, stops, terminals and schedules will make it hard to adapt to and use a transportation system. This is also a problem for existing users who want to make new trips to other destinations that they are used to. This causes used passengers to choose other easier-to-understand transportation options, such as urban rail. Here, up to 40% of the passengers are irregular transportation users [57].

THE ABSENT DRIVER

It also has to be taken in to consideration what will be lost in connection to the absent driver. So far in observations and interviews, passengers do not fear the fact that there will be no driver. Many say that they are worried about emergency handling. On the other hand passengers also see the consistency of the bus behaviour as something positive. Insecure passengers in need of reaffirming their information will lose the easily accessible source in the boarding area. Though, in general it is known what kind of questions that are occurring. Information about the route, stops, destinations and connections could be more accessible to make these questions arise less frequently.
RESPECT

Bus traveling is traveling tight, the bus space demands people to co-exist, let others exit and embark, not disturb with loud conversations and it requires passengers to sometimes help each other. Passengers have during the research period pointed out the importance of taking other passengers into consideration. People want it to be easy to exit even though the bus is full, taking notice of exiting passengers or keeping a phone conversation quiet is existing codex.

WAITING

Passengers do not like to wait. Waiting time is seen as much more negative than riding time and the most prominent stressor. The hardest part of waiting is not knowing whether the bus will arrive to the stop or not. This is something that can be solved and, in the future, helped by better connectivity between devices, bus stops and buses.

OVER-PLANNING DUE TO DISBELIEF

Findings in the user studies reveal that passengers could experience stress during all of the different stages of the trip. The source of stress differs, through the user studies, passengers have mentioned that the first encounter of stress is already at the planning stage, where passengers do not know whether the bus will depart at accurate hours. This stress causes the passenger to “over-plan” which could make the passenger choose another way of transportation or plan for an earlier departure than needed just to be sure to be on time.

This buffer time is time that could have been spent on other, more important, activities for the passenger. It has to be kept in mind, that even though we are trying to create the best buses, a majority of the passengers want to spend as little time in them as it is possible. The stress while riding bus is peaking when passengers are trying to find the right stop and when they have to exit the bus.
Here, many passengers stress over the inconvenience of squeezing through a crowd to get off at right stop. This concern is present for both commuters and tourists. For tourists the new context where the behaviour of co-passengers might be hard to predict in this situation causes stress.

“Do not know if I am late for the bus, because the bus will not follow the time table anyhow” – Niklas, 29, commuter

Feeling in control is important to be able to relax and enjoy traveling by bus. The passenger wants the necessary information, such as when and where stop should be pressed. How do they find their way back if they miss their stop and go too far? In this situation it should be clearly communicated how a passenger should do if this occurs.

There are also moments when information that is meant to give passengers control instead makes the situation feel even more out of control. It is when reality does not match with what is communicated to happen. This could be demonstrated with the real time time-tables that can be found at bus stops in Stockholm. Here, the information is supposed to be updated in real time, quite often the information is misleading and says that the bus soon will arrive. Though this is not the case, the bus might just have passed or the number of minutes that the display shows could be shown for three minutes. This distrust is quite common
Bus Passenger Experience

among interviewed commuters travelling within Stockholm. The persuasion of real time updates is widely appreciated among travellers.

BUS VS. RAIL
Throughout the interviews, subjects described how they preferred the subway before the bus as their first encounter with public transport in new cities. The reason was that with subway they do not have to focus where they should push stop, they know that the train will stop at every station without their own engagement.

In the subway system the station is much more noticeable with a clear name and the station is easy to differentiate when the subway have reached the station and when it is travelling between stops. If passengers would go one station too far, it is easy to find the way back. Many times, the signage at the station is sufficiently made and rail systems are quite standardized with one platform designated for each direction.

Bus routes are harder to figure out. There are a lot more roads than there are rail lines. The layout of subway maps are also a reason that makes people choose subway before bus. These maps often have the stops printed out along the different lines, lines which also often are a lot fewer than routes on a bus route map. This often makes the bus network map messy and hard to read.

The Stockholm bus map has a lot more routes and it does not show any other stops than bigger hubs where a lot of different lines merge. To use a map like this to orientate yourself is hard. It gets even harder when you know that the routes on the map itself is simplified, otherwise it is not possible to draw it. This demands passengers to either have an experience from using buses in the
city or have a secondary source of information, such as a smartphone or a physical time table.

Passengers emphasized the importance of intuitive maps, stops and departure times to feel sure enough and able to see the bus to a greater extent, instead of other means of transportation.
Orientate while riding

Passengers experience it hard to find the right stop while riding the bus. Though it should be mentioned that tourists were positively surprised by the information that could be found on board Swedish buses. This kind of information was, among tourists, seen as one of a kind and really helpful. Passengers want information about when the next stop is approaching, what the next stop will be, name and connections at it. They also want to be sure they will be able to exit at right stop. This problem concerns passengers traveling during rush hour, people with function variations and elderly.

Passengers want to be able to plan their trip on board the bus. They want to see if their stop is approaching, to be able to prepare themselves to exit. Others pointed out how vague it is when the bus is approaching stops, they rarely have enough information to be sure to exit at right place.

Reaffirm information

The majority of passengers asking questions want to reaffirm the information they have at hand. This is because they feel insecure when embarking a new bus, but research suggests that passengers are asking the driver today because of the accessible information that the driver imposes when embarking the bus. One approach would be to enable confirmation through personalized and more accessible information. Another way is to make the reputation of the service better, which would make the passenger approach towards bus riding more confident. Though, this has to be made from the service supplier point.

Altering devices

Throughout research, whether it is observations, workshops or interviews, passengers pointed out that they want to manage to travel with bus without a personal device, such as a smartphone. Tourists described in interviews how they use their phones to
keep track of the bus and their movement towards their stop. This is an appreciated tool in a new environment, but at the same time it is easy to rely on and if the battery is out, they do not know how they should behave.

**INFORMATION EQUALITY**

During the observations and interviews, passengers of different age and background had problems making use of information that could be found either inside the bus, in apps or at the bus stop. Depending on how used the individual is to technology, a different amount of information is available. Elderly, tourists and other passengers not used to use personal devices to find information e.g. smartphones, often struggled with the quite sparingly information available at bus stops. During the observation, one elderly man, going to *Kungsgatan*, had to be helped by the interviewer to find his stop and bus. He said that it had become harder to use buses when almost everybody else relies on mobile devices.

In the bus stops in town, there is a very limited amount of information in other languages than Swedish. Exclamations and other kind of audial information is mainly made in Swedish. Signs have to some extent a section with an English summary pointing out the most important parts of the message. Other languages than English and Swedish are almost non-existent. It is also important to take passengers with disabilities in mind, some might have a hard time to understand spoken language, read signs or logical steps etc.
Today there is a trade-off between trust for the technology and vehicle and the trust for the service. People have to be confident enough to travel with the bus and know that they will reach their destination safe and sound. But at the same time, there is no point in riding a bus that is unpredictable and will not get to the designated destination. For Scania, the most important, is the latter, this is here Scania can make the biggest impact on the passenger.

In buses, information about both the service, such as route, stops and times is important, but also, information about behaviour, why is the bus braking or turning [39]. Another case might be that passengers do not interpret the intentions of the vehicle in the right way and try to override the system instead [58]. In the case of autonomous buses this could for example be an unsustainable use of the emergency brake.

This thesis work did not take variation in functionality among passengers into consideration. Though it is something that would have been interesting and important to research. The future holds lots of interesting possibilities which could enable public transport for a diverse passenger crowd. It might be easier to learn how the bus will react and e.g. that it will wait for the passenger if the passenger has made itself noticeable for the bus.

To give the passenger a pleasurable and efficient journey, it has to be kept in mind that the perception of the bus experience does not start and end with the bus. The bus experience starts with a need of getting from A to B, where a potential passenger has to find a connecting service from location A. Today, it is hard to find
a consistent system to use. Passengers often use Google Maps\(^\text{11}\) to find bus stops and their destination. Passengers have to know which way they should be heading in this stage. Many of the interviewed passengers pointed out the difficulty of knowing this. The part of the trip before embarking the bus is surrounded with doubt and a feeling of uncertainty. This is because there is no indication of in which direction the bus will be heading, and it is hard to distinguish buses heading different ways from one another.

It is important to take different parts of the journey into consideration and to see how they are affecting the whole bus experience for the passenger. It will be impossible to create a good experience from only providing the buses without knowing how they will be used.

**HOLISTIC SERVICE PROVIDING**

Scania is today manufacturing buses and trucks which are sold to e.g. SL. Scania does not have any finger in the game when it comes to the use of the vehicles. Nowadays, the majority of passengers do not know what brand of buses they are traveling with.

**AFFECT THE PASSENGER**

It should be of main interest for Scania to create a credible brand when it comes to the autonomous vehicle sector. Therefore, it could be good to have a showcase of projects to let the bus passengers of today know that Scania is in the game and developing the next user experience when it comes to driverless buses. In research it has been shown that reputation and

\(^{11}\) https://www.google.com/maps/about/
expectations from earlier use of a brand and news coverage, if it is positive, makes the adoption much easier.

**LIMITATIONS**

With this broad approach, a specific solution for a specific challenge within the scenarios would have been really hard to solve. After discussing the scope with my supervisor at Scania the project scope was limited further. The time before passenger arrives at the bus stop was cut away from the project, even if it is of interest in a driverless bus scenario when bus and passenger can utilize another connectivity between one another. Though this was still a really big scope and made the project quite hard to grasp.
CONCLUSION

The difference is clear between the future and today. It has been shown that it is a complex task to try to design for something that is not present today. When designing an HMI for an autonomous bus, which would make the journey pleasurable and efficient, it is of main importance to include the user perspective. However, this has in this project been hard to find, when the perception of buses is based on the user’s situation today. How passengers behave in the vicinity of an autonomous bus is still not known to a great extent. Small scaled pilot tests are currently running in many places around the globe, which can give us a hint of how this relationship will work. These tests are mainly running smaller shuttle buses and that which also affects the user’s behaviour. This project was however, concerning larger city buses which will run in a city context with everything that includes. Passengers will be stressed, drunk and maybe misbehaving which will affect the whole procedure. Therefore, it is hard to predict what is needed to please the passenger. Will passengers get used to the new driverless service fast and think that information about bus behaviour is redundant and disturbing instead of soothing and helpful?

More research has to be done within this field, right now a lot of the research is focused on making the self-driving technology safe. However, it is important to not forget about the passengers when researching how this interaction should be done and how services emerging in relation to this technology could be used in the best way for the most of us.
FUTURE/ WORK

It would be interesting to find a group of users already past the first impression of use when it comes to autonomous buses. This would be done to find out what kind of information that is important when it comes to the bus behaviour. It would also be interesting to see what is needed to make other road users start respecting the driverless bus. Because it would not be sustainable to have pedestrians not respecting the vehicle. At the field research in Kista, pedestrians showed not to care about the bus and were walking out right in front of it, knowing that the bus will always stop. This is an interesting are to research. How could we create mutual respect in the bus – road user relationship? Also, extended research within the area of anthropomorphism could be made together with this, to try to establish a sustainable relationship based on respect and understanding through the possibility to give the vehicle an ability to express emotions.
REFERENCES


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APPENDIX A

WORKSHOP 2

The following document was used for tourists in the workshop to document their trip.

Figure 32. Journey perception from tourist workshop
HI AND THANK YOU FOR PARTICIPATING!

In this folder, I would like you to describe your perception of bus travel. This exercise is made to make you think about your journey that you might be doing for the first time or is a part of your everyday life. Think about what kind of needs, challenges and information you require to have an good experience from the journey in the different stages. I am interested in your thoughts, emotions, what you feel and what kind of activities you engage in in the different stages as well as problems or unclarities. It could be done as in the example below, or something else that you find annoying, something that is in need of a new solution or troublesome procedures. It could of course be something you experience as positive along the way as well. Maybe something that works really nice.

The time line to the right is made for you to take notes during the trip, each number represents a step in the journey. Feel free to sketch or write your thoughts. Mark out positive and negative events through a plus(positive) or a minus(negative).

The different stages, but not limited to, are:
1. Standing at the bus stop finding information
2. Bus coming in, as in see the bus approach the bus stop
3. Enter the bus
4. Ride bus

Figure 33. Time line from tourist workshop
APPENDIX B

Reaction concepts

Figure 34. Interior reaction concept from concept evaluation 1
Figure 35. Exterior reaction concept from concept evaluation 1
Figure 3b. Map layout reaction concept from concept evaluation 1
APPENDIX C

USER STUDIES

This project is user-centred, user studies constitutes an important part of the procedure. To get a sense of how the situation is today, a wide range of different methods were used, as described in Method. From the study needs, challenges and behaviour related to bus traveling was identified.

OBSERVATIONS

Inattentiveness, information equality, uncertainty, relax

One of the most common behaviours found among passengers were to ask the bus driver about certain stops along the way, where the bus was going or where to change to another bus. During the field research, drivers confirmed in in-context interviews the frequent questions from insecure passengers. Drivers also expressed their concerns regarding how this group of passengers will find information and whether they will feel relaxed during travel with driverless buses.

Passenger’s questions are mainly of a confirmation kind, as if they want to make sure that the information they have at hand actually is right. Passengers who ask for route information or for certain stops along the way are mostly elderly people or people new to the context, such as tourists. When it comes to tourists asking for help, it is mainly regarding how they buy tickets and location of stops. One bus driver pointed out the language barrier as a problem. With this in mind, information access is not equal between the different groups of passengers. Passengers who are able to use smartphones and computers or master the language will have access to more information which give them more freedom. Others who cannot make use of this information have
to ask for help, interpret maps and information tables to try to find their way. This causes many passengers to choose other means of transportation, where information is more accessible and easier to utilize. This phenomenon is from here called information inequality.

Furthermore, passengers and road users use their bodies to communicate with drivers, this makes today’s set up with a human driver behind the steering wheel very dynamic. If passengers were late and wanted to catch the bus, they simply block the way of the bus by running in front of it and stop it from departing. Some passengers also waves the bus by, when they do not intend to ride, so the bus do not need to stop.

While observing passengers embarking and exiting, many are helped by the fact that passengers only embark through one door and the rest of the doors are designated for exiting. During the observation, a couple of tourists tried to open the back doors to embark the bus, though this is not possible.

To observe passenger behaviour in scenarios where embarking and exiting are made through same doors, observations were made at Liljeholmen tram station. Here it could be seen that people squeeze together when it is time for boarding and all passengers do not wait for other passengers to exit before they started to embark themselves. This causes irritation and a prolonged boarding procedure and stresses exiting passengers.

Passengers who use their commuting time to stare in to their phone, which the majority does, is less attentive for moving co-passenger. This causes passengers to walk in to each other and at the same time it makes it harder to exit for deliberate passengers that have to squeeze through a crowd. Smartphones also make some passengers distracted and lose track of their trip which makes them miss their stop.
From the field research made at Autopiloten in Kista, the result was mainly positive. Passengers were not afraid nor worried about the behaviour of the bus. A majority of passengers spoken to were positive about the use of autonomous buses, they thought it was comfortable and useful too. Though some of them found it hard to see how it could be scaled up so all buses were autonomous. A couple which were interviewed said that the use of smaller buses would be very helpful to get transport for shorter distances, though they could not see how bigger buses was supposed to interact with human drivers. The overall feeling was very positive, and people who rode the bus was very open towards the autonomous future and the possibilities it will bring.

It is worth mentioning the special case these buses constitute, when it comes to comparing the experience between them and the experience in a bigger inner-city bus which is driven autonomously. There are factors that could skew the passenger experience in Kista, among these the speed is limited to only 20 kilometres per hour which could affect the feeling of safety. During the trip there will be an operator from Nobina present, which is ready to break in if something happens. Also, the smaller size of the bus which make it easier to overlook and see objects and other road users around the vehicle. The bus will also keep to a fixed route which makes the path of the bus predictable and easy to follow as a passenger. All of these factors probably skew the perception of the trip away from what it would really have been, and what it will be like inside an autonomous bus in an inner-city traffic environment. Early studies [22] [56] in passenger experiences from automated shared vehicles have shown that acceptance for this technology, under the circumstances of a strict route, present operators and an upper limit speed is good. Passengers opinion is positive about the use of the concepts as last mile transport and the convenience the buses would contribute to in their daily lives. Passengers also agreed that their
perception of safety would change if the buses were bigger and faster and did not have any operators aboard [56]. One finding from the pilot in Kista was that the buses was perceived as too slow by passengers [59].

**CONTEXTUAL INTERVIEWS**

*Distrust (service), Reaffirm information, Information inequality*

From unstructured interviews performed with bus drivers and passengers while observing, drivers confirmed that the questions they receive from passengers were mainly regarding connecting services, the bus route or how to buy tickets. Quite a lot of passengers also asked for the way to hospitals.

Drivers pointed out that from their perspective, passengers tend to distrust the timetables that can be found at bus stops. Especially when buses do not show up and passengers will not be notified about it, passengers tend to become really upset and passengers do not perceive the service as reliant. However, in most countries passengers do not perceive public transport service as reliant [60], even though service reliability is the most important factor for the perceived quality of public transport [61].

One driver pointed out that passengers seems to trust the technology much more these days than before since it is actually have become more precise.

Conclusions from the observations and contextual interviews were:

- Passengers and chauffeurs communicate through body language, eye contact and gestures to know what the bus is doing and the passenger’s intentions such as flagging the bus or waving it by.
- Passengers are nowadays entering through the front door which gives a perfect opportunity to greet drivers and ask questions.

- Passengers use the driver as a source of knowledge. Asking for stops, connections and other bus related topics.

- Drivers find it hard to see that autonomous buses will be able to handle the unpredictable behaviour of other road users and wary passengers. (Distrust towards the capability of the technology)

- Boarding is slow, mostly depending on the fact that everybody is forced to enter through one door and blip their card.

- Entering and exiting from the same door is sometimes challenging because people are not interested in waiting for exiting passengers.

- Younger passengers rely on their phone, while older passengers rely on maps and physical time tables. Which causes older passengers to use the driver as a source of information to a greater extent, i.e. there is an information inequality between passenger groups.

- Passengers are inventive, if they are in a hurry they can run in front of the bus to make sure they will be able to catch it.

- Passengers who use their phone are more inattentive towards their own trip and to other passengers.

- If the bus is late, the bus service will get the blame for this, even if the problem lies at another place.

- Passenger unused to traveling with bus are uncertain and need to reaffirm the information they have.

### INTERNET SURVEY

*Inconsequent service, Waiting in vain, Out of control, Crowdedness, Distrust*
The online questionnaire generated 54 unique answers. Out of 54, 25.9% said that the biggest reason to travel with bus was the proximity to a bus stop. 18.5% said they choose to travel with bus because of the comfort and being able to see the surroundings.

When people travelling with bus, the most frequent way to find stops and connections was through their smartphone. However, many passengers requested a way to get this kind of information from the bus instead, making the passenger less dependent on a personal device. Some suggested solutions as interactive screens, personal notifications or better route maps. Out of 47 answers on how people would like to have this information presented 44 wanted some kind of screen with customizable interface.

When passengers was questioned to rate the importance of different information about the route inside the bus. 48 rated the next stop as quite- (7) or very important (41), 47 rated the destination as quite- (25) or very important (22). Today 56.6% rated it as 3 on a scale of 5 on how accessible the information is.

When interviewees were asked to write down what they think is the most annoying or confusing part of traveling with bus the overall theme was lack of information regarding different parts of the journey.

- Most frequently, passengers pointed out how annoying it is to not have information and feel out of control when waiting for the bus. There might be real time updates, but this information might not be accurate enough to give passengers a sense of control.
- Passengers also pointed out that they find it stressful to look for their stop while traveling. Either because there is no or little information inside the bus about next stop or because they do not know if the bus will stop.
- Bus routes are confusing, passengers want to know where the bus is going. Today it is very hard to understand which bus goes where from the route maps. Also, passengers think it is confusing with buses that go opposite direction but still have the same number.

- Other passengers are sometimes stress-triggers, having to squeeze through a crowd to exit or find a seat is perceived as stressful and inconvenient.

- Information about traffic situation is something that passengers ask for, people do not want to embark a bus trip that soon will be stuck in traffic, if there are alternative ways of getting from A to B passengers would like to know.

- Indifferent drivers are annoying, some might be nice, others bad drivers and some are rude. This causes the trip to be different each time and passengers do not know what to expect.

- Passengers pointed out the convenience of bus commuting, many said that the ability to do something else than driving and being able to enjoy scenery are some of the best things.

**SEMI-STRUCTURED INTERVIEW FINDINGS**

The semi-structured interviews identified underlying challenges of the current state of bus transportation. Most significantly was the lack of information which causes passengers to choose other means of transportation. Lack of transparent information caused passengers to feel stressed, in situations when buses did not show at designated times.

Common challenges for tourists were finding the right bus, bus stop, where the bus was heading and to exit at right stop. Riding
on crowded buses are stressful for both groups of passengers. For
commuters the main cause of irritation was delayed buses,
crowded buses and the traffic situation that could affect travel
time.

Passenger fears, challenges, needs, wants

- Not finding your way and to get lost,
- relying on uncertain information,
- Travel on a crowded bus,
- Try to exit from a crowded bus,
- Being able to reaffirm information,
- Difficulties when trying to orientate yourself,
- No information to build knowledge from,
- Lack of information which implies difficulties to plan,
- Orientation is hard due to bad information inside bus and
  on bus stops,
- Non-transparent information causes frustration.

Bottom line is that passengers want to have control over the
situation they find themselves in, and if there is no control, there
is no pleasure nor efficiency. The interviews were analysed and
were divided in to headlines containing the different areas they
touch upon.

INFORMATION AND INTERPRETATION

- Buses that do not stick to time table makes passengers
distrust the service and choose other locomotion.
- Passengers want to know where the bus is while waiting.
- Without information about stops, route, connections
passengers do not feel in control.
- “Bus numbers, names of stops and route names are totally
  unhelpful for people unfamiliar with local streets and
  geography” – Mary, 34, tourist
- Passengers want important information at hand, such as next stop, connections, time-to-destination. Quality of life-information should be limited or at least separated.
- Passengers try to use available information outside and aboard the bus to reaffirm the information they have gathered.

ORIENTATION DURING TRAVEL
- Passengers stresses the need of more intuitive representation of maps, bus lines and connections inside the bus.
- Passengers have to alter between apps and the bus’s information system to find their correct stop.
- Passengers have to focus and stay alert to be able to exit at right stop, this brings the whole experience down.
- Passengers find it hard to know when to push stop and whether it is really needed.

- Passengers need a possibility to reaffirm their information they have at hand. Did I just embark the right bus?

REACHING DESTINATION ON TIME
- Passengers want information to be presented instead of being forced to hunt information.
- Passengers does not want to change between different information devices to obtain information during different parts of the journey.
- Passengers appreciate when they know if they have to hurry to catch the bus, or if they can take it easy.

EXITING
- “...I find my bus stop] by frantically comparing the horrible bus app UI with whatever information about the bus whereabouts I can find through the windows...” - Anonymous interviewee
Passengers adapt their exiting-behaviour depending on crowdedness.
Passengers find it stressful to not know whether they will be able to exit at right stop or not.
Depending on how much luggage the passenger carries, it affects how the passenger position itself during the trip. This can sometimes result in an uncomfortable journey and passengers can find themselves in tricky situations.

BUS PERCEPTION
Passengers appreciate traveling with bus, however a common point is that the space inside the bus is quite dark and it easily feel crowded.
Passengers want a reliable bus service with a consistent time schedule and with reliable information, they do not want any extra stuff.

The best part is the convenience, price and not having to drive.
Passengers are to some extent worried how emergency situations will be handled without a driver that could coordinate the situation.
Acceptance Scale of Passenger Support Tech

Mina åsikter kring detta system är … (kryssa i en ruta på varje rad):

1. Användbar
2. Trevlig
3. Dålig
4. Rolig
5. Effektivt
6. Irriterande
7. Behjälplig
8. Önskad
9. Uppmärksamhetshöjande

Meningslös
Otrevlig
Bra
Träkig
Ineffektivt
Angenämt
Usel
Önskad
Sövaende
<table>
<thead>
<tr>
<th>Pästacende</th>
<th>Håller inte alls med</th>
<th>Håller med helt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Jag tror att jag skulle vilja använda detta system regelbundet</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2. Jag tyckte att systemet var onödigt komplicerat</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3. Jag tyckte att systemet var lätt att använda</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4. Jag tror att jag skulle behöva hjälp av en manual/teknisk dokumentation för att använda detta system</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>5. Jag tyckte att de olika funktionerna i systemet var samspela (integrated)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6. Jag tyckte systemet var inkonsekvent och betedde sig oväntat</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>7. Jag skulle tro att de flesta personer skulle lära sig att använda detta system väldigt snabbt</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>8. Jag tyckte att systemet var väldigt trög och svår att använda</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>9. Jag kände mig väldigt ståke/trygg i att använda</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>10. Jag behövde lära mig mycket innan jag kunde komma igång att använda systemet</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>11. Jag tror att designförslagen ger användaren tillräckligt med information för att möjliggöra en effektiv resa</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>12. De olika designförslagen ger användaren tillräckligt med information så att hen vet vad som händer när näst</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>13. Jag tycker att informationen förmedlas på ett sådant sätt att man förstår bussens intentioner och handlingar och ingar förtroende.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>14. Jag tycker att informationen hjälper mig att använda bussen på ett säkert och effektivt sätt, under de flesta scenarien. (pending &amp; nödsituation)</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

PARTICIPANT ID: _______  
SUS AutoBusDATE: _______
APPENDIX E

User journey mapping the situation of today which is relevant to take into consideration when taking the user in mind for the next experience.
Lundquist Martin

Passengers appreciate greet the driver
First impression of safety and measure trust
Passengers would like to be able to board through all doors
Boarding time is slow, could be made better and more smooth
Passengers find it hard to relax while in transit, when in an unfamiliar context
Passengers feel stressed when bus is crowded
It is hard to know where you are on the route
Passengers position themselves considering where and when they get off to minimize stress
Passengers would like to have relevant information about stops. Can I change here or when?

Passengers want to reaffirm they boarded correct bus
Passengers need a way to reaffirm their information
Passengers need to know trip duration to be able to plan connections and if they have time to sit down
Passengers need to know next stop, stops along the route and connections
Questions from passengers to driver mainly is of a reaffirmation kind
What will the next stop be?
The amount of passengers stresses me
I still need to know if we will be on time
What was the name of my stop? Is the bus stopping there and is it on time?
It is a tough job to stay alert in transit

Passengers find it hard to know when to push stop
Passengers find annoying to always rely on more than one source of information (personal device + bus information) to reach destination
Passengers distinguish between information that is “important” and “quality of life”
Passengers find it inconvenient to press stop
Passengers is annoyed of people standing in the way as well as being in the way of others
Passengers experience the boarding moment as stressful
Passengers often find themselves distracted by personal devices

How will the doors be opening
Will I have time to alight?
People are standing in my way
Keep alert on where to get off
Compare app with route info, to confirm stop
Where will I be able to find connections?
The strategies were developed to give designers a fast recapitalization.
Bus Passenger Experience

PROPERTIES OF THE EXPERIENCE

Four main factors are affecting the passenger bus experience. All can not be changed, but can affect the overall experience. For that reason, the four areas: Availability, information and perceived safety, ease of use, and perceived value can be prioritized as the passenger experience.

TO DESIGN FOR PLEASURE.
FOUR MAIN INGREDIENTS

Trust
Control
Convenience
Safety

These are the four main ingredients for designing a passenger bus. They are essential for creating a pleasant experience for the passenger. These factors can be addressed in the design of the bus, making it a more enjoyable journey for the passenger.