Developing an interface for bus drivers

Simplifying complexity through usability and user experience

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Preface

This report is the result of a master's thesis carried out at the Industrial and Materials Science department at Chalmers University of Technology. The scope of the project was 30 ECTS and it was done by two students during the spring of 2019 for the public transport information company LTG Sweden AB.

Acknowledgements

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Finally, the biggest of thanks to the bus drivers all the way from Malmö to Kristinehamn who have generously taken of their own time to participate in our studies. Your job is demanding, and to get an insight into your daily tasks have truly opened our eyes to the complexity of public transportation!

Terminology

Public transport authority: An organization or a company which is responsible for creating public transport in a specific region (TRANSMODEL, 2016). Examples of Swedish public transport authorities are Västtrafik or Skånetrafiken.

Public transport operator: A company which owns buses and hires bus drivers. This company is offering various transport services for the public transport authority upon contract (ibid.). Examples of public transport operators acting in Sweden would be Nobina or Keolis.

Route: A specified journey for a vehicle which goes between two end stations. The same route can be driven multiple times a day (ibid.).

Vehicle journey: A specified route designated a specified time. A vehicle journey can only be driven once a day (ibid.).

Block: The vehicle's journey starting from its parking point and ending when coming back to its parking point. One block can contain several different vehicle journeys and be manned by different drivers throughout the block (ibid.). A block is designated a specific number, e.g. 1234.

Line: A group of route patterns which together is known to the public under a specific name or number (ibid.).

Line guide: A chronological ordered list of bus stations for a specific line.

On-board computer: A computer that supports the driver in a vehicle. In the context of a bus, an on-board computer can show e.g. a line guide and the current time in relation to the schedule.

Timing point: A bus stop where the driver is not allowed to leave too early. A timing point is a regulating bus stop.

Abstract

The aim of this project was to facilitate Swedish public transport bus drivers' daily work tasks by developing an interface with relevant functionality, good usability and good user experience. The project was based upon user-centered design. Interviews, observations and usability tests were conducted together with drivers.

It was found in the user studies that the current solutions do not consider the complexity of the drivers' work tasks. The currently used technology is either too utilitarian or too complex. Based upon the gathered data, a solution called MobiLity was developed. MobiLity improves the usability and user experience through presenting information in a simpler way, suggesting actions and connecting different systems.

An interactive prototype of MobiLity was evaluated in user tests, where it received positive feedback. The drivers liked the simple design and found that receiving suggestions of actions was efficient and would be useful in their daily work.

The conclusions made during this project was that the functionalities that bus drivers need are complex, which makes good usability even more vital. Humans still need to take the final decision in the system, as the traffic environment is complex and dynamic. Lastly, a solution based on user-centered design stand out from currently available solutions both in terms of usability and functionality.

Executive summary

The public transport sector is a growing market in Sweden today, as it is an efficient way to transport people from the perspective of environmental sustainability. Bus drivers are a vital component of public transportation, and they need to perform a multitude of work tasks in a complex and continuously changing environment. Not only do they need to drive the bus, they also need to keep an eye on passengers and other road users, orient themselves along the route and adapt their driving to weather conditions and reroutes due to e.g. traffic congestion. The supporting technology in buses today utilize outdated solutions and complicates rather than facilitate the drivers' work tasks. There is great potential to improve the bus drivers' work situation through technology. This master's thesis project aims to develop an interface that facilitates the drivers' work tasks while providing the drivers with good usability and good user experience. The final deliverable of the project was an interactive prototype that has been evaluated by bus drivers. The project was carried out together with the public transport information company LTG Sweden AB. LTG Sweden AB produces destination signs for public transportation environments and destination sign control units. Throughout the project LTG Sweden AB has contributed with valuable feedback and information.

User-centered design has served as the basis for the development of the interface. To find and fulfill user needs has been the focus of the project. The user needs were found through interviews with bus drivers, study visits at bus depots and observations of drivers while they drove buses in actual line traffic. Bus drivers from different parts of Sweden, from both rural and city backgrounds, participated in the study. The user needs found in the study pointed to that the two currently available solutions studied are either too simple or too complex for the drivers' work situation. They are also not adapted to the changing and complex conditions of e.g. traffic congestion, weather or number of passengers. One of the most vital functionalities that a driver needs is relevant, updated and quick information from the traffic management, something that is not provided today. Bus drivers are also a diverse group where e.g. age, technology skills and Swedish language skills varies greatly.

The solution developed in this project was based on the pre-study and was developed through brainstorming and discussions within the project group. The result was then compiled into an interactive prototype, where the focus of the first iteration was to develop relevant functionality and good usability. The first iteration of the prototype was evaluated by bus drivers, and the functionality and usability were confirmed to be good. For the second iteration of the prototype, the focus was on user experience. This stage mainly entailed developing the aesthetics and making sure that the interface fit the context while being perceived by the drivers as a support. Adjustments were also made in accordance to the results of the first usability tests. The second iteration was also compiled into an interactive prototype which once again was evaluated by drivers. The interface was found to provide the intended user experience while still maintaining the good functionality and usability of the first iteration.

The final result of the project is the smart interface MobiLity. MobiLity aims to facilitate the bus drivers' complex work tasks. This is done by dividing and simplifying the tasks to their most necessary elements, and by connecting and utilizing other systems already in place in the bus to

suggest relevant actions to the driver. It will also provide simple, quick and easily updatable ways to exchange information between two bus drivers or between the traffic management and the bus drivers. This exchange of information can be messages and an updated GPS map in case of e.g. traffic congestion.

To be able to provide the driver with simple and easily readable information, MobiLity's included functionalities are divided into sub-functions that are accessible through a main menu. The sub-function Current route provides the information that the driver needs while driving a route. This is the function that the drivers will use the most during a work day. The view in Current route switches automatically depending on whether the vehicle is in motion or standing still at a bus stop, to provide the driver with only the information that is the most relevant for each instance. When moving, a GPS map navigation view with relevant information such as route, bus stops and locations will be displayed. When standing still at a bus stop, the driver will see the line guide, the message function, connections and the SmartInfo functionality. In each view, as much information as possible is combined so that it is easily accessed without cluttering the view.

SmartInfo is a function that will notify the driver of relevant information, and it is connected to the other systems in MobiLity and within the bus. For instance, SmartInfo will be connected to the driver's schedule, and will remind the driver when it is time for a driver change. It will also be connected to passenger counter sensors, and it can suggest informing the traffic management and changing exterior destination signs when the sensors indicate that the bus is full of passengers. Every SmartInfo suggestion needs the driver to accept or deny it. The power to decide which action to take therefore remains with the human in the system.

MobiLity is designed to provide the experience of being like a colleague to the bus driver, to suggest actions and to help the driver to perform automatable tasks. It is also designed to fit the context of vehicles, and to give the drivers the experience of that little bit of "extra something".

The conclusions made during this project was that the bus drivers have to be able to perform complicated actions through the interface. Their work environment is complex, which makes good usability even more vital. Automating some functions is a good way to decrease the cognitive load of the drivers, but humans still need to take the final decision in the system due to the complexity involved. Finally, a solution developed through user-centered design stands out in terms of usability and functionality when compared to currently available solutions.

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1 Introduction

In this chapter the background of the project will be described, as well as the aim, objectives and demarcations of the project. Lastly, the report structure will be described.

1.1 Background

A brief description of the background of the project is given in this section. For more details on the topics introduced here, please go to the chapter 3. Understanding the context (page 29 - 34).

1.1.1 A growing and changing industry

The public transport sector is growing in Sweden today, and the average amount of travels done by public transport per person per year have increased by 28 % from 2000 to 2016 (Sveriges Bussföretag, 2018). Furthermore, public transport is good for the environment since people travel together which decreases greenhouse gas emissions compared to traveling individually by car. The public transportation drivers are the ones that makes these journeys possible, but their work situation is often neglected, and the tools they have are not adapted to the needs of today's complex traffic situation. Thus, it is more relevant than ever to investigate and redesign the tools that a driver uses for their daily work tasks, to facilitate and increase the efficiency of their work tasks so that they can fully focus on driving safely.

This master's thesis project was carried out in collaboration with LTG Sweden AB, a sub-brand of Luminator Technology Group (LTG). LTG Sweden AB is a company working with destination and information signs on buses, trains, airports and other public transport systems. They also produce control units for interior and exterior destination sign control in public transportation vehicles. These control units are still used by public transport authorities in some areas in Sweden today, but have been replaced by automation or on-board computers in many regions. Because of this, LTG Sweden AB is now moving towards also developing interfaces aimed at the driver.

1.1.2 The current situation

A bus driver's primary task is to transport passengers from point A to point B along a specified route. During this route, the driver is supported by various tools to help them with everything from serving customers, communicating with traffic managers and navigating through the route, see figure 1 below for how these systems can be placed in a driver cabin.

Figure 1: How the on-board computer and other systems are placed in a driver cabin

One of these tools is an on-board computer, where different variants are used in many regions in Sweden today. An on-board computer typically utilizes a touch-screen interface. The functionalities vary depending on variant, but it typically contains information about the time in relation to the timetable, a line guide which lists the upcoming bus stops of the line, and data of the bus' current block, vehicle journey and line. The last three factors are used by the public transport authorities and operators to organize the bus fleet. The vehicle journey is a route that has a specified time. The block is the bus' journey from its starting point to its ending point at a certain day. The line is a collection of route patterns, that is called by a certain name, e.g. line 16 or 55. A visualization of the difference between block, line and vehicle journey can be seen in figure 2 below. These factors are important, since the information displayed on the destination signs, the announcements in the bus, the ticket machine and the line guide depend on these being filled in correctly. These are filled in either automatically or by the driver at the beginning of each block or vehicle journey. Today, the on-board computers sometimes lose the connection to underlying system, leading to the block, vehicle journey and line data not being displayed correctly.

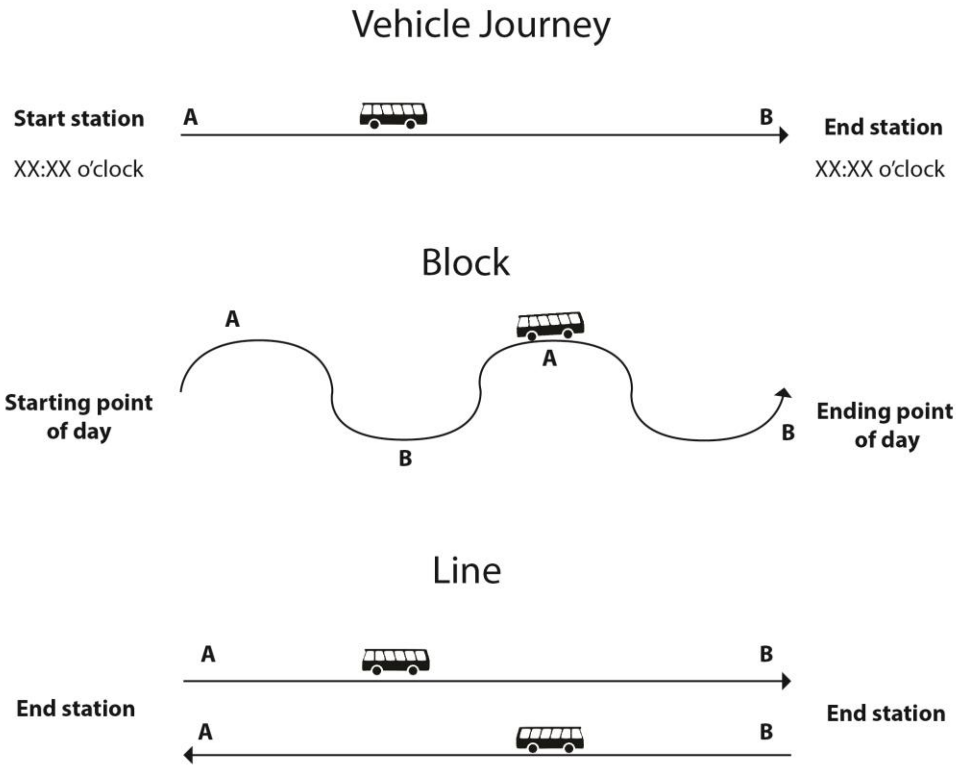

Figure 2: A visualization of vehicle journey, block and line, where A and B are end points

The on-board computer is primarily used to help the drivers navigate through their route, provide them with information to help answer passengers' questions. Other functions such as changing the bus' signs and sending messages to traffic managers are primarily used when something goes wrong. The drivers are not allowed by Swedish law to use any handheld systems while driving. Many of the on-board computers are therefore locked to interaction while the vehicle is in motion.

As the bus goes along the route, the driver will stop at the designated bus stops and open the doors. When passengers board the bus, the drivers might need to sell tickets and answer questions. While driving, the bus driver needs to keep track of the surroundings both outside and inside the bus to provide a safe journey for the passengers. However, the traffic situation is often complex, and traffic congestion is common. This complicates the driver's work tasks and they might need to change interior and exterior destination signs, inform passengers of the current situation and drive a different route than the planned one. Traffic managers informs the drivers of any congestions, reroutes or other issues. If the driver feels uncertain, the traffic managers are there to help them. The traffic manager's instructions must always be followed. During rush hours or traffic disturbances there are often many drivers trying to get in contact with traffic managers, resulting in long phone queues. Information might also be sent to the traffic managers from the drivers. An example of this is when the bus gets full. A driver might have to inform the traffic managers that an additional bus should be sent as they do not have the possibility to pick up more passengers. When a driver gets a full bus, they might avoid stopping at a bus stop in order to save time.

A driver's schedule often contains multiple vehicle journeys and blocks on the same day. Driver changes are common. The information about time and place for these is on the drivers' schedule, which is printed out on paper every day, or accessible through smart phone applications. Drivers sometimes forget that they have an upcoming driver change, which leads to logistical complications. During a driver change, each driver has to log out respectively into several systems such as energy-efficient driving, the tachograph and the ticket machine. These are all separate systems that are tied to a specific driver and therefore require logging in.

Energy-efficient driving evaluation is a common functionality in many buses. Different operators use different systems, but they all measure fuel consumption in some way. The existing systems measures against an idealized reality, where drivers are always punished for braking. This is regardless if it is due to an external factor such as bicycles, other vehicles or weather, which the system does not take into consideration when evaluating their driving. If a driver performs a hard brake to avoid hitting a bicyclist, their energy-efficient evaluation will suffer.

Apart from the systems that relates strictly to the driver's work tasks, there may also be other sensors and systems in place collecting data depending on which operator is in charge of the bus. One example of this is a passenger counter sensor, which counts how many people are boarding and alighting the bus. Today, this data is used as an analytical tool for administration only, and the system is not used for the benefit of drivers while driving the bus.

1.2 Aim

The aim of this thesis project is to design a digital touch screen-interface that facilitates the daily work tasks of public transport bus drivers while providing them with good usability and good user experience. The interface targets the context of Swedish public transport line-based bus traffic.

1.3 Objectives

In order to achieve this aim, the following objectives were set:

- To research and conduct user studies regarding the current situation of bus drivers' daily work tasks and needs
- To develop an interface that facilitates the drivers' workday while providing good usability and user experience
- To evaluate the solution with drivers and improve the solution in accordance to the results from the evaluation

1.4 Demarcations

This project had the following demarcations:

- The ticket sale systems and machines will not be included in the interface and surrounding solution, since these vary too much between different regions to be able to make a solution that fits all
- The tachograph will not be included in the solution since it is strictly regulated by laws and is required to be a separate system
- The solution will be an interactive prototype and not a functional coded product

1.5 Report structure

In chapter 1. Introduction (page 1 - 6) a brief overview of the use context for MobiLity and the details of this project such as aim, objectives and demarcations are presented.

In chapter 2. Result (page 7 - 27) the result of the background studies, how the developed solution works and the evaluation of it will be presented. For details on how theory was applied when creating the solution, see chapter 7. Design motivations (page 50 - 61).

Chapter 3. Understanding the context (page 28 - 34) will provide the background information needed to understand the context of public transport in more detail, e.g. who the users are and what systems they use today.

This is followed by chapter 4. Theoretical framework (page 35 - 39) which describes the design theories that the solution is based upon.

After this, chapter 5. Process and method descriptions (page 40 - 43) describes and motivates the methods used in the project.

Thereafter, chapter 6. Project process (page 44 - 49) describes which phases the project were divided into, how the selected methods were applied in practice and what the goals of using the methods were.

This is followed by chapter 7. Design motivations (page 50 - 61), where the results are presented in the abstraction levels used in the ACD^3 method, going from general to detailed. In each abstraction level the design decisions are presented and motivated based on the user studies and the theories presented in chapter 4.

In chapter 8. Discussion (page 62 - 65), the result is discussed in relation to whether it achieved the aim and objectives or not. The methods and other aspects of the project are also discussed.

The report will be concluded with chapter 9. Conclusions (page 66 - 67) which presents the main takeaways from the project.

2 Final results

In this chapter, the findings from the user studies, how the final solution works and the results from the evaluation of the solution done together with users will be presented.

2.1 Main findings from the user studies

Here, the main findings from the interviews, observations and study visits will be presented. In this section, the drivers' needs and the problems with currently existing solutions are described. For more details on each activity, see chapter 6. Project Process (page 44 - 49).

2.1.1 Communication and current technology

Drivers need to receive information that is relevant, meaning that it concerns the route that the driver is currently driving, and updated, meaning that the information is the latest and still applicable. This is to ensure that the drivers are able to adapt and feel confident regarding where to drive in case of a redirection. Today it is common for traffic managers to announce all traffic information to all of the drivers, both written and oral announcements. The drivers then have to filter this information in order to find what is relevant to them specifically. Some drivers even lower the volume of the announcements so that they cannot hear them in order to avoid getting annoyed. The redirections are typically the same at each specific point. For example, every time the traffic is stuck at bus stop Brunnsparken, the redirection will be to drive via bus stop Nordstan instead. For an experienced driver, this is easy since they know the usual reroutes, but for new drivers it may be difficult to understand where to go with only a bus stop name.

A problem found regarding the written messages was that it was hard to read them while driving due to drivers having limited resources to spare but also due to poor placement, small text size and too much text, see figure 3. This led to the drivers only being able to read it when standing still at a bus stop, even though the information it contained might have been relevant before reaching the stop. An example of this is the intercity buses, where it is far between the bus stops and the drivers might get stuck in traffic congestion since they were not able to read the announcements about it and therefore not able to act accordingly. What was concluded from the issues with communication was that the information delivered to the drivers must be quick, relevant, easy to read and easy to process into actions. The current announcements are also temporary, and in case of driver changes it is up to the disembarking driver to relay the relevant information to the new driver. If the disembarking driver forgets to mention some relevant information, it may cause trouble for the new driver.

Figure 3: How an on-board computer is placed and its text size

One of the main findings is that the current technology is not well adapted to the usage situation or the tasks of the drivers. The systems are quite rigid and utilitarian, and are not a good fit for the complex and changing context that public transport is. The two on-board computers that was studied in this project were iTID, used by the public transport authority Västtrafik and OBIS, used by Skånetrafiken. iTID was deemed as too complicated by the drivers, and OBIS as too simple. Neither of the systems are efficient at performing their included functions. iTID also loaded slowly, resulting in many drivers not performing the actions they should due to time restrictions, as time is of the essence in the public transport context. Another related finding was the fact that the drivers had to log in and out of multiple systems. This was especially precarious during driver changes, where it takes a lot of time for the driver in an already very stressful situation with tight time margins. From this, it could be concluded that the interaction with on-board technology must be efficient and take the shortest amount of time possible.

Today, the only support that the drivers have regarding their route is the line guide which updates automatically according to the GPS position. An example of how it looks like in the iTID system can be seen in figure 4, to the right in the image. A driver has to manually update the GPS position if the system loses connection to the GPS. Experienced bus drivers are very proud of their knowledge about the routes and the fact that they do not need extra support. A less experienced driver or a driver that drives many different routes may however need more support regarding the route. It was concluded that more support would therefore be useful. However, it needs to speak to both the experienced and inexperienced drivers. The information provided should be presented as supporting previous expertise, and not as ordering the driver around.

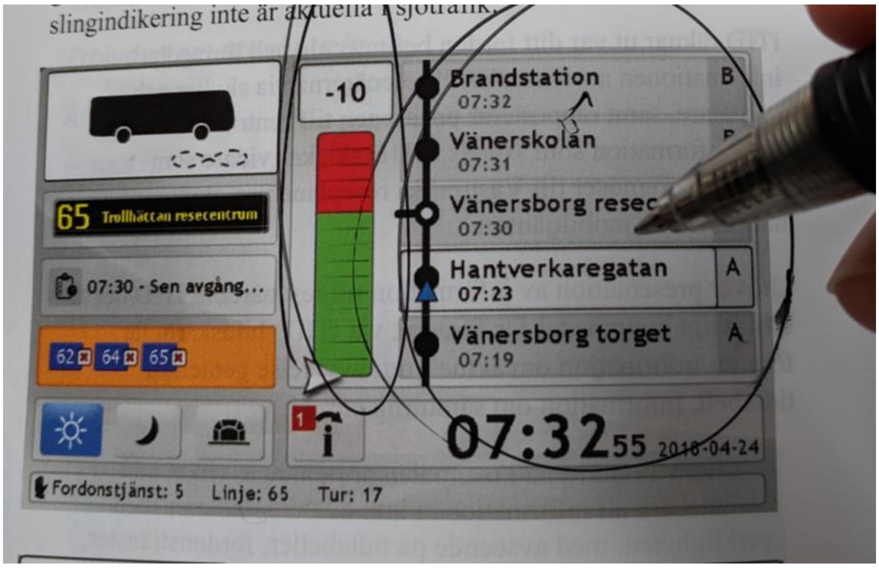

Figure 4: The iTID start screen

Furthermore, the drivers are already occupied looking at the road while driving. Having to spend a lot of time looking at an interface to acquire information is therefore not optimal, especially if it is as complicated to understand as the current solution iTID.

2.1.2 Stressors for a bus driver

Stress was something that many drivers experienced. The stress was caused by many different factors and one of these was being late while driving a route. In the systems today, the driver's time relation to the timetable is shown. In figure 4, this can be seen circled to the left. The drivers have little control over the external factors that often makes a bus late, and some drivers felt that seeing this in the interface could be stressful, which may result in some drivers driving less safely to try to catch up. Other drivers did however feel that knowing their time in relation to the schedule was supportive. A developed solution therefore needs to balance how to display time related information.

Another stress factor that some drivers experienced was having to make announcements in the internal speakers of the bus. Some drivers were uncomfortable, especially if they were not fluent in Swedish. A solution should therefore provide a way to present information to the passengers that does not require the driver to make announcements.

The last major stress factor found in the user studies was the energy-efficient driving functionality. Drivers said that it was an unfair system, because external factors that they cannot control impacts their evaluation. It was concluded that the developed solution therefore should take external factors into consideration in some way.

2.1.3 Individual conditions and preferences

Some of the drivers, primarily the older ones, mentioned that they had a hard time reading what was displayed on the screens of the current on-board computers. The drivers thought that the text was too small, and that the screen was either too bright or not bright enough depending on the external lighting conditions. It was therefore concluded that all text needs to be big enough to be read by people with minor visual impairment, and that brightness and contrast settings are necessary in the developed solution.

One function that the drivers that used the iTID system appreciated was the function of a day and a night mode, used for the bright and dark hours of the day respectively. Having a too bright screen during the dark hours causes difficulties to see the road, and a too dim mode would not be readable in bright sunlight. The developed solution should therefore have these two modes to facilitate good visual ergonomics.

The drivers also mentioned that the user should not have full control over the settings in the bus. They gave examples of other drivers lowering the volume of the internal announcements all the way down, resulting in the passengers not getting any auditory information. Other examples included lowering the brightness of the screen of the on-board computer all the way down so that the next driver was not able to see anything. The next driver then has to spend time adjusting these settings back to readable levels. What was concluded from these examples was that the degree of control the users should have should be somewhat limited. It should allow for individual preferences but prevent misuse.

2.1.4 Varying needs

The needs of the bus drivers vary depending on the public transport authority or organization they work for, if they drive rural, city or intercity routes and the intensity of the traffic in the context that they drive in. Driving a city bus in a small town may for instance be comparable in intensity to driving the intercity routes between two bigger cities. The type of information that needs to be communicated also varies. In bigger cities, traffic congestion is a major topic, whereas in rural areas it may be more relevant to spread information regarding wild animals on the roads. The solution should therefore facilitate some level of customization to facilitate communicating whichever information is relevant to the specific context where it will be used.

It may also vary who the driver needs to be able to contact. In smaller cities and areas where the buses depart only a few times a day, there may be an agreement between certain buses to wait for each other. The public transport authority or operator decides which lines and at which bus stop such waiting agreements are in place, as well as for how long the drivers are allowed to wait for another bus. If the connecting bus is late, the connecting driver needs to be able to contact the other driver to arrange that they wait. In bigger cities however, there is no need for the drivers to contact each other since the buses depart so frequently, meaning that there is no need for an agreement to wait. There are however some intercity routes that goes through both urban and rural areas, where there may be waiting agreements in the rural areas. The solution should therefore provide a way to contact other drivers that are included in the agreement to wait, but this functionality should not complicate the system for those drivers that do not use it.

There are many drivers that are not fluent in Swedish, which must be taken into account when developing a solution. It was also found in the studies that depending on the expertise of the drivers, their needs relating to supporting functions varies greatly. There are many new drivers, and many drivers that changes jobs between public transport authority or operator. There are also drivers that work as reserves, filling in for other drivers that are absent. There are therefore many drivers that are new to driving their specific routes. Lastly, many drivers work in other cities than they live in, so their knowledge of the area is limited which may cause trouble in case of reroutes. The solution should therefore support the drivers regardless of whether or not they are experts of the route they drive or the area that they drive in.

2.1.5 Summary of problems with the current situation

As described earlier there are many existing problems that needs to be solved in order for the solution to better facilitate the driver's work tasks. Here is a short summary of some of the most important problems that the final solution aims to solve.

- Insufficient support to new drivers, or drivers unfamiliar to a route, especially during redirections
- Systems cannot adapt to the changing conditions
- Irrelevant information is sent to the drivers during mass announcements
- Hard to find information in the systems due to too much information displayed
- Tasks in the systems takes too much time to perform

- Language barriers can create problems when a function requires spelling or extensive Swedish skills
- Logging in and out of several systems during driver changes takes a lot of time
- Energy efficient driving systems have unfair judging criteria

2.2 Aesthetics of the vehicle context

A design format analysis was performed on car interiors and vehicle related interfaces, to make sure that the solution fits the context. For more detail on the conducted design format analysis, see chapter 6. Project process (page 44 - 49). The most common design features are presented below.
Car interiors vary in color, but the most common ones are gray, black and beige. The instrument panels often have a matte surface finish with glossy metallic details. Seats also have a matte surface finish and are typically leather or textile materials. A distinguishable feature in car interiors is the curvature of the instrument panel. The design of the instrument panel utilizes a mixture of curves and straight lines to create a dynamic expression. These curvatures are often used together with colors and material finish to communicate the brand. One curvature found in many cars is the one around the car's radio.

The studied vehicle interfaces typically followed the same design cues as the rest of the interior, and the most commonly used colors were black or grey. The interfaces combine the dark color scheme with an accent color, typically turquoise, red or teal. GPS navigation maps are a common function found in the interfaces. They either follow the rest of the color scheme, or the standard set by Google Maps; a gray-beige background, white roads and a blue route. When it comes to the buttons in the digital interfaces they typically adhere to one of the three following styles:

- The button is designed to look like the physical elements of the instrument panel
- The button consists only of outlines with no body
- The button looks three-dimensional through the use of shading and color

2.3 The MobiLity interface

The final solution, MobiLity is a smart touchscreen interface that will incorporate the functions available in on-board computers today as well as functions from separate systems such as the energy-efficient driving evaluation and the schedule. It therefore requires only one personal log in by the driver to access all the functionalities. A rendered image of MobiLity can be seen in figure 5 below. In this report, the images from MobiLity will primarily show the night mode unless otherwise stated. For an example of the day mode, see chapter 2.2.3 Making it personal. All the figures of MobiLity in this report are in English although the prototype was originally in Swedish. The drivers will also not be able to interact with MobiLity while the bus is in motion, to not tempt them to focus their attention on the interface rather than on the road. This is also in accordance with Swedish law about not interacting with handheld devices while driving.

Figure 5: The MobiLity interface

MobiLity is designed to make the bus driver's workday easier. It does so primarily in two ways; delivering and performing suggested actions and decreasing the drivers' cognitive load. It is a system that is designed to alleviate the complexity of the driver's work situation. This is done by simplifying many of the tasks so that the driver can focus on their most important task; driving the vehicle in a safe way. MobiLity does this by collecting data from various sources such as sensors and other systems such as the schedule system. The size and placement of MobiLity can be seen in figure 6 below. The placement may vary a bit depending on which bus model it is placed in, but it should be placed so that it is easily reached and that the driver can see it clearly from the driver seat.

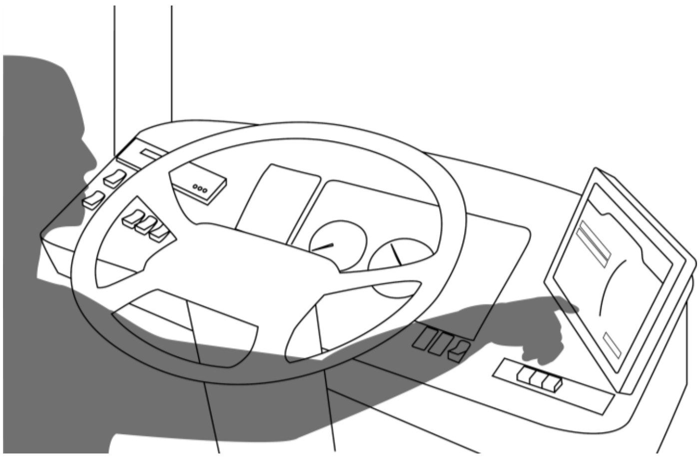

Figure 6: The size and placement of MobiLity

The information flow of MobiLity has been constructed around a main menu, as seen in figure 7, where each button then leads to a relevant function. To not place all functionality in the same view makes the interface easy to read and understand. In this chapter, the sub-functions will be thoroughly described. The most used sub-functions are all connected and easily accessed through the Current route button, which is the function that will be used most by the drivers, and the less frequently used functions are placed in the main menu. In the main menu, each function is clearly displayed in order to avoid cluttering the view.

Figure 7: The main menu of MobiLity

When logging in, the current vehicle journey, block and line is automatically loaded as these are tied to the driver's employee number. The top information panel, as seen in figure 8, will always show vehicle journey, block, employee number, date and time in relation to timetable regardless of view since these are relevant to the driver while they are on duty. This information is placed here to act as a confirmation to the driver, so that they can be sure that they are correctly logged in and that the correct vehicle journey and block is active. The line, i.e. what is shown on the exterior destination sign, will be shown in every view except the GPS map view, since it would clutter the view in that instance, but is otherwise relevant for the driver to see.

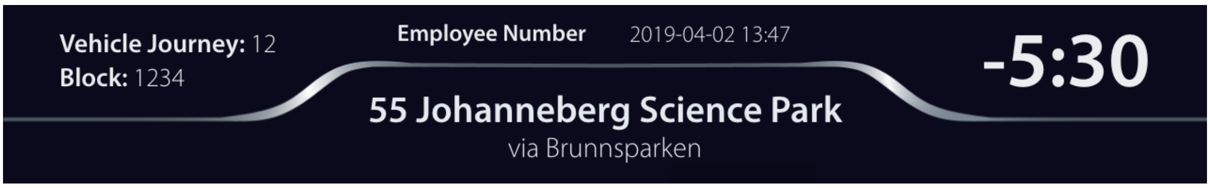

Figure 8: The top information panel

2.3.1 The right information at the right time

Current route is the function that will be used when the driver is driving on a route. It actually consists of two views, since the information that the driver needs differs depending on if the vehicle is in motion or standing still at a bus stop. As soon as the bus leaves a bus stop, MobiLity will display a GPS map navigation view. This view is shown in figure 9 and contains the following information; a map of the surroundings, the bus' position (the arrow symbol), the correct route (the orange line), the bus stops (red map pins), the stop names (e.g. Regnbågsgatan) and the stop locations (e.g. A). This way, the drivers will know the distance to and location of the upcoming stops, which is the most relevant information for this particular task. When driving, the drivers are not allowed nor permitted to interact with the interface, and they should focus mainly on the road. This view is therefore designed to provide as much relevant information as possible, but accessible through only a quick glance.

Figure 9: The GPS navigation view

When the bus comes to a halt at a bus stop, MobiLity automatically switches to the view shown in figure 10. Here, a function called SmartInfo (to the left in the figure) and the line guide (to the right in the figure) are displayed. The line guide is scrollable, so that the driver can check stops further down the line.

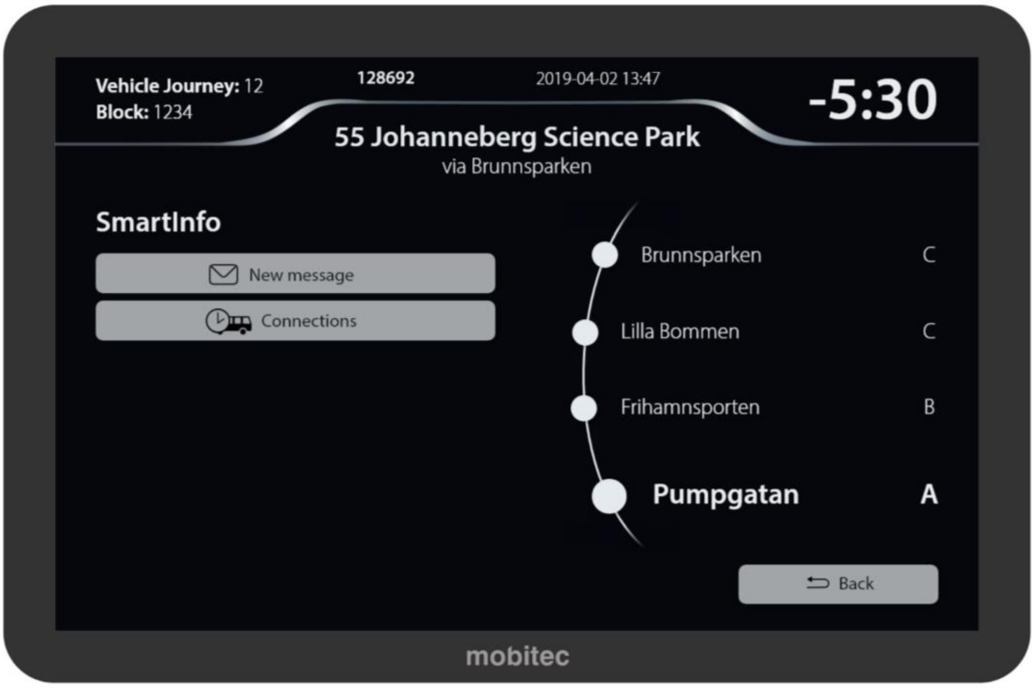

Figure 10: The bus stop view

The line guide helps the driver plan their driving and can be used as a support to help the driver answer passengers' questions about whether or not the bus is going to a certain stop. The current stop is at the bottom, bolded, and the upcoming stops are above it. This direction was chosen to make it more intuitive for the driver when used as a complement to the GPS map view, since the order the stops are presented in is the same.

2.3.2 Introducing SmartInfo

The SmartInfo is a system that will notify the driver of relevant information, as well as suggest actions to the driver and is located in the Current route's bus stop view. The displayed messages are either from traffic managers, other drivers or automatically generated messages that are based on e.g. information collected from sensors placed in the bus or other relevant sources such as the driver's schedule. Whenever SmartInfo delivers a new message, it does so together with a sound notification that is loud enough to be heard in the noisy bus environment. SmartInfo is designed to be the system that collects most of the functionalities needed when the journey does not go as planned, e.g. when the bus is running late or when the bus is full of passengers. Other situations where the SmartInfo reacts includes redirections and information from traffic managers, issues with the bus, driver changes and connections with other buses. SmartInfo can suggest a course of action as well as provide the driver with an easy way to perform said action, which typically involves sending a message to the traffic management or changing the bus' destination signs. An example of this can be seen in figure 11, where the SmartInfo has detected that the bus is likely full of passengers through the sensors placed in the bus. It then prompts the driver to confirm this, and when confirmed it automatically contacts the traffic management and changes exterior destination signs. The power to decide is always placed with the driver, since the situation often is complex as well as the fact that sensors may measure incorrectly. It is also always in the hands of the driver to revert the action, e.g. change the signs back to normal again. The reason why

SmartInfo was designed to give these suggestions is because these unplanned events happens often, but the required action to take for the bus driver is typically cumbersome and complicated today. To have the system perform the "heavy labor" alleviates the cognitive load placed on the driver.

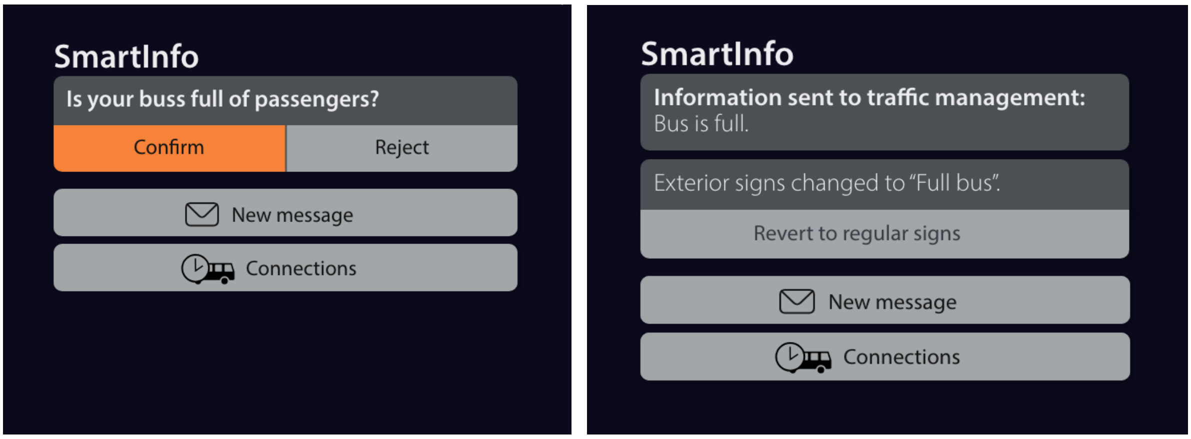

Figure 11: SmartInfo suggestion and action

SmartInfo may also be connected to the line guide and the GPS map view. One example of this is that it can be used to remind the driver of daily tasks. In figure 12, the reminder of an upcoming driver change is displayed in the SmartInfo as a message, as well as the fact that the letter D (for "driver change") is also displayed in the line guide and in the GPS view at the designated bus stop. Information regarding timing points, i.e. bus stops where the driver is not allowed to leave early, can be shown in the same way.

Figure 12: Displaying information about a driver change in both views

2.3.3 Simplifying communications

Communications is an important factor for bus drivers since their work is impacted by many external factors. The drivers may need to contact traffic management about reroutes, congestions or being late, or contact other drivers to request them to wait where there is an agreement of connecting buses. Naturally, the driver also needs to be able to receive information about these topics as well. MobiLity does not aim to replace oral based communication tools but rather complements them with visually based communication tools. In MobiLity, sending messages to the traffic management and connecting buses are located in the SmartInfo function, see figure 13. It is placed in the view that is shown when the bus is standing still.

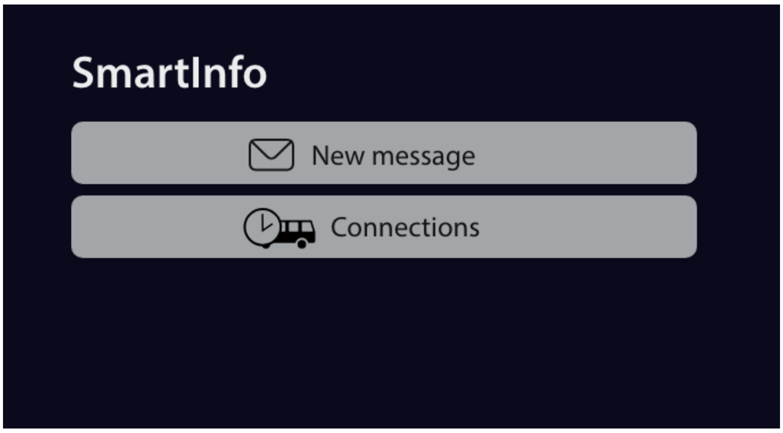

Figure 13: Message and connections functionality

When accessing the “new message” function through the SmartInfo, it will open a screen where the driver will be presented with a few select options to choose from where the selected message is sent to the traffic management. These options will be customizable for each public transport operator, so that they will reflect the most relevant messages for their company, depending on e.g. if they operate in a big city or in a more rural area. An example of messages can be seen in figure 14 below. One message that however always needs to be present is the Call me button, since it is impossible to cover all relevant subjects in a short list. This message will then notify the traffic management to call the driver, so they can discuss the problem in more depth.

Figure 14: Sending messages to the traffic management

The Connections function is where the driver can send a message to other drivers requesting them to wait. This function is only available for drivers in areas where waiting agreements are in place. In MobiLity the driver can scroll through a list of bus stops where a waiting agreement is in place, while at the same time see their own approximated and live-updated arrival time. When a stop is selected, a new list appears where the connecting buses are listed together with their approximated departure times. This way, the driver can also see whether the connecting driver is late or not. When the desired stop and bus is selected, the other stops in the list is greyed out, see figure 15. To send a request to wait, the driver presses the “Send request” button.

Figure 15: The process of sending a message to a connecting bus

It is already pre-determined by the public transport authority or operator how long connecting buses are allowed to wait for each other. It is therefore not relevant for the drivers to request a specified waiting time for the connecting driver. The connecting driver will receive the request in their SmartInfo, where they can either confirm or reject the request, and will get a confirmation of their choice in their SmartInfo. This procedure can be seen in figure 16. Likewise, the requesting driver will get the answer from the other driver displayed in their SmartInfo.

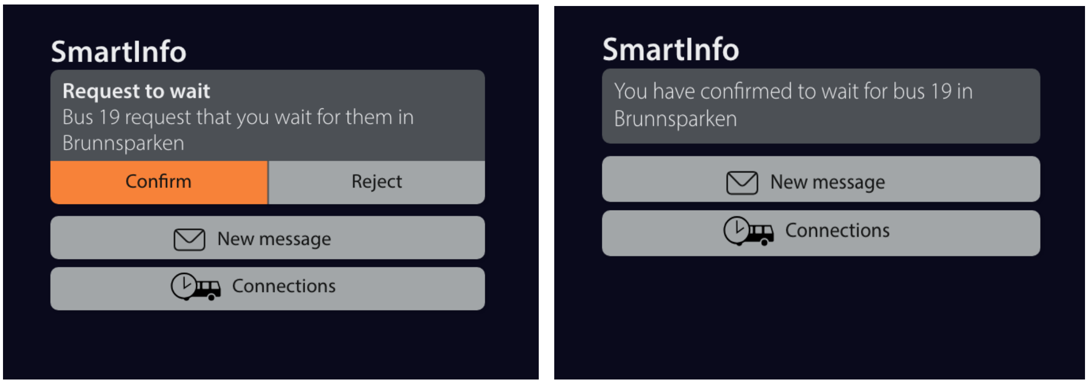

Figure 16: A request to wait and a confirmation of the answer

There are also times when the bus driver will receive information that is relevant for the driver while the vehicle is in motion. The most important example of such information is reroutes sent in from the traffic management. The traffic management will input the point of interest and where to drive instead from their end of the system, and MobiLity will use the bus' GPS position, the block, vehicle journey and line to determine which information affects which bus and only show the relevant information to each driver. In figure 17, it is shown how the view changes when the traffic management updates the route. The line drawn in the GPS map view changes to the new route, the newly added bus stops appear and a message relaying that the route has been changed appears. The old route will still be there, in gray, to show the driver where the original route would have been. To alert the driver of the change, the auditory notification will also sound.

Figure 17: reroute in the GPS map view

It is however important that the driver confirms that they have acknowledged the change of route. Therefore, they are presented with an option to confirm or to call traffic management when they reach the first stop after the change is implemented. There is no option to decline, since the traffic management's instructions always needs to be followed. In figure 18, such a message is exemplified.

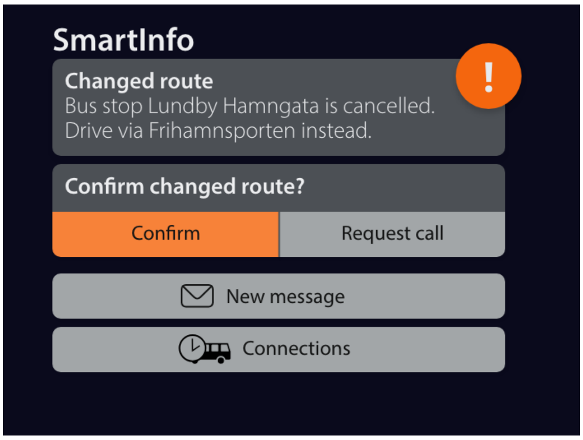

Figure 18: Confirming the reroute

When the driver has confirmed the changed route, the alert message regarding the change will remain in the SmartInfo, which can be seen in figure 19. The message will remain until the traffic management removes the point of interest in their end of the system, i.e. when the route is back to normal or until a newer message replaces it. SmartInfo also automatically changes the bus' signs and announcements so that the passengers get information about the updated route, without the driver having to make the announcements themselves. This removes a stress factor as described above in chapter 2.1.2. The driver can also once again revert the signs and announcements back if they want to.

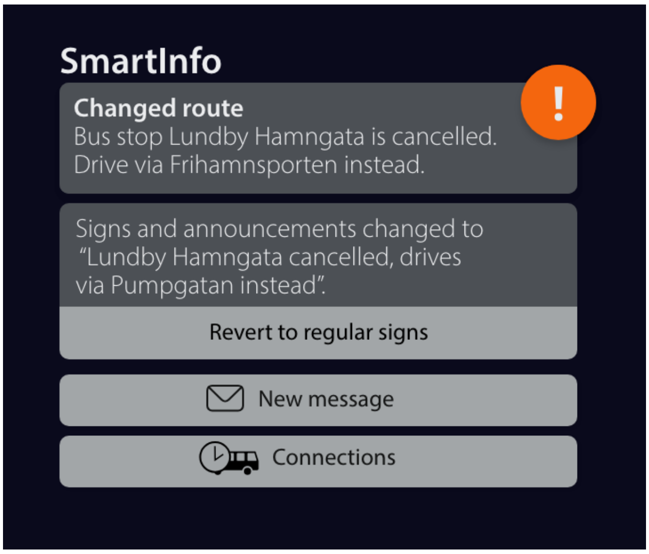

Figure 19: The remaining notification and sign change

The fact that the most recent notification will remain until the traffic management removes it is also advantageous when there is a driver change. With this functionality, the new driver will know directly about any route changes, and there is less pressure for the disembarking driver to have to remember which information to relay to the new driver. There may however be days when the driver has many simultaneous notifications where there is not room for all in the SmartInfo. In cases like these, it is also important to have an inbox functionality, so that the drivers can check all active messages. Just like in the SmartInfo view, messages only remain there until they are marked as finished by the traffic management in order to only give the driver updated and relevant information, compared to today where messages are stored until a driver deletes the messages. The inbox is accessed through the main menu of the interface, and how the messages looks like is shown in figure 20.

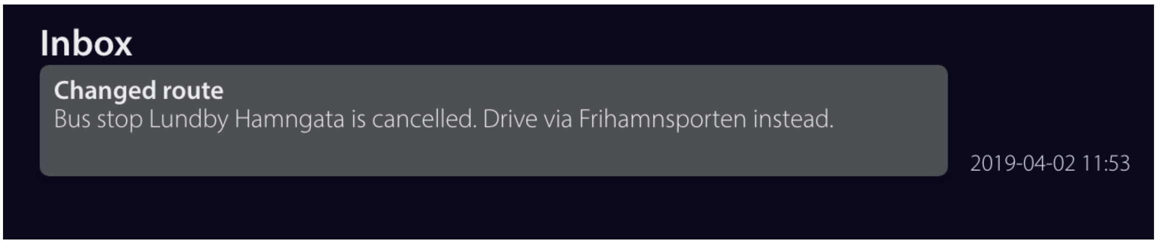

Figure 20: A message in the inbox

2.3.4 Making it personal

To use MobiLity, a personal login is required. Because of this, functions tied to a specific driver can be utilized. The first of these functions is the schedule, as shown in figure 21. The schedule is accessible through the main menu and shows the driver's daily tasks, e.g. which block they will drive or when they are on break. Each task has block number and start time and finish time together with their respective location displayed. The driver can then choose to press the orange arrows to expand more detailed information such as start and finish time and location of partial tasks during a route, line, vehicle journey or the vehicle number of the bus. The detailed schedule covers the task of the day, as well as the starting time and location of the next day so that the driver knows how long their rest until the next day is, which is beneficial for drivers with irregular schedules.

Figure 21: The driver's daily schedule

The next personalized function of MobiLity is the energy-efficient driving functionality, which is accessed through the main menu and that is illustrated in figure 22. Fuel consumption is measured through aspects such as soft braking and rolling, and the grading is affected by which type of route it is and what time it is. This means that if a driver goes on a highly trafficked route during rush hours the system would have higher tolerances compared to driving at a rural road at night. This is to create a fairer system, since the driver's driving style is impacted by external factors such as pedestrians, bicyclists or cars. At the end of each work day, the driver will get a score depending on how they have driven. This score will be visualized in a graph, as seen to the right in figure 22. This graph also contains the drivers average score. The lowest level in the graph is Acceptable, since it is designed to make the drivers feel motivated instead of judged. In addition to the graph, the driver can choose to compare their results to other drivers that has had similar conditions as themselves. This function is optional, and the drivers that has opted in for this will also receive a message of their score in comparison to other drivers. This is once again to provide a fair comparison, so that the drivers will know how they rank in reality and not just compared to some idealized conditions that are not possible to achieve. Both of the scores (placement among other drivers and comparison to their own performance) creates a competitive aspect to energy-efficient driving. The drivers can either compete against others or themselves. But, in order to help the drivers improve they will also receive some tips if MobiLity notices any recurring errors in their driving, which can be seen to the bottom left in figure 22 below.

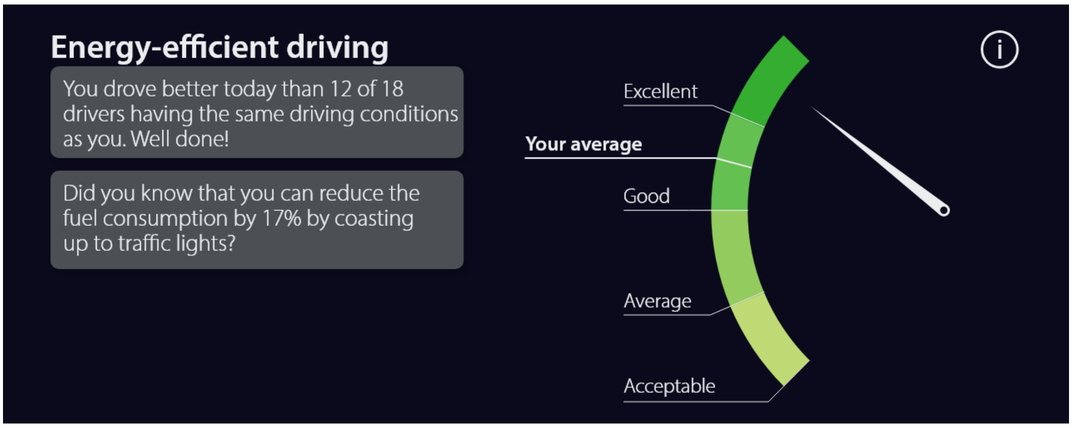

Figure 22: Energy-efficient driving

Lastly, all drivers have individual preferences, thus they have the possibility to change the audio and display settings. These can be accessed through the "Settings" button in the main menu. In the audio settings, the volume for exterior and interior announcements in the bus can be adjusted between a chosen interval. The driver cannot completely turn off the volume since the announcements will need to be heard by the passengers, but the volume can be adapted to e.g. if it is early in the morning and the driver does not wish to disturb the passengers more than necessary. The driver can also test the volume of both the internal and external speakers in order to confirm whether the volume have an appropriate level or not. The volume is adjusted by sliders, as exemplified in figure 23.

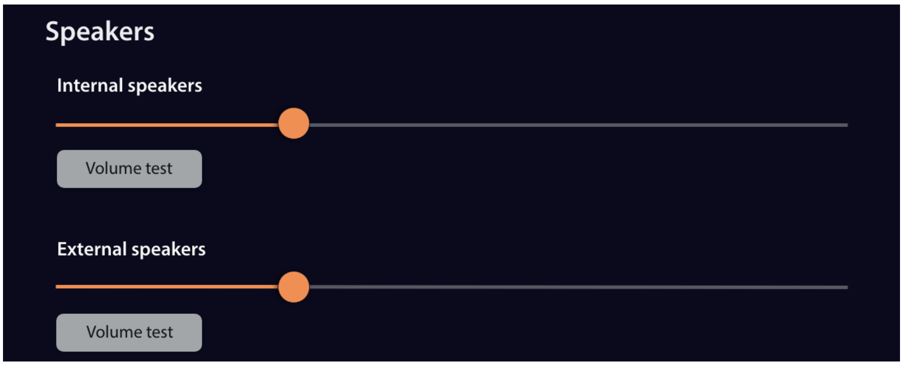

Figure 23: Volume control sliders

In the display settings, the driver can change the brightness and contrast of the interface, as well as switch between day and night mode. Having two different modes facilitates reading the interface in dark respectively light surroundings. An example of day mode can be seen in figure 24 below. This allows the driver to change settings according to context and individual preferences.

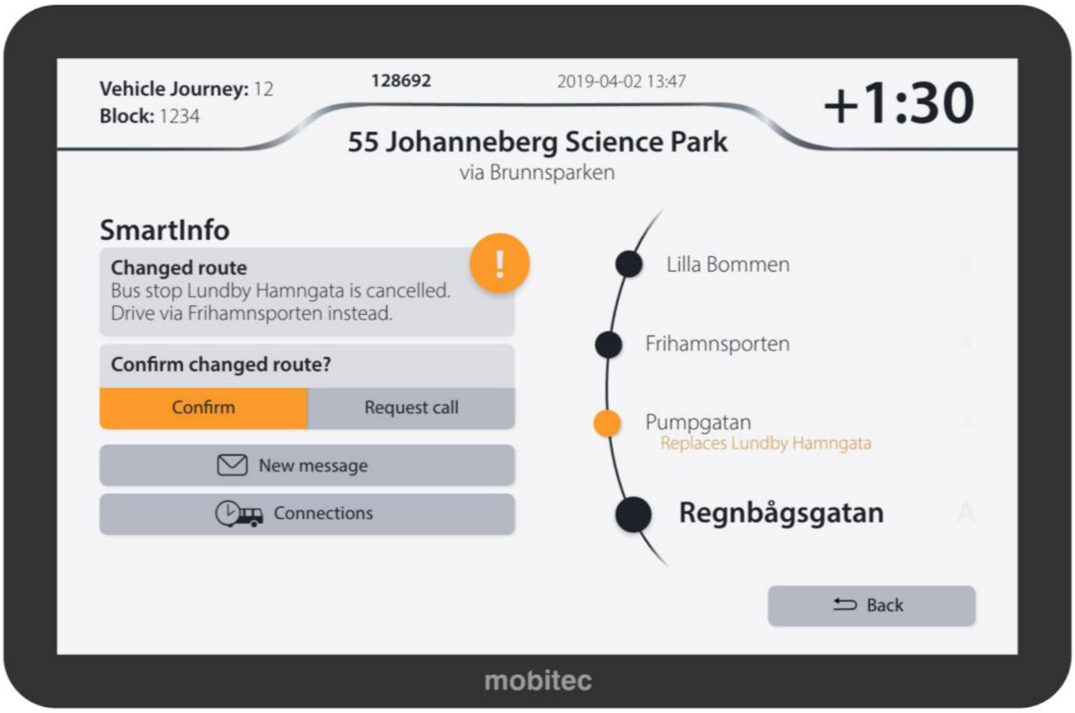

Figure 24: The bus stop view in day mode

2.3.5 Simple solutions when uncommon situations arise

Since the bus drivers' job is impacted by many factors outside their control, unexpected things happen quite often. It is important that MobiLity is a system that is designed to help the driver solve these problems quickly and easily, especially since the driver most likely will already be stressed when an unexpected situation arise.

As mentioned earlier, the block, line and vehicle number should load automatically when the driver logs in. These needs to be correctly filled in, or else the bus will display the wrong destination signs and the bus stop announcements and the line guide will also be incorrect. If these does not automatically load, the driver needs to manually fill in the block in the "Manual block" function found in the main menu. There are two ways to input the block; selecting in a list of recent blocks, or search for one through inputting numbers. The two ways of selection can be seen in figure 25 below. The first option is a more efficient way to find the block, especially in the case where the system has dropped the current block that should still be active. The other option is for when the desired block is not within the list of the last used blocks. When a block is selected, the system will compare the block to the time and fill in the details regarding vehicle journey and line by itself.

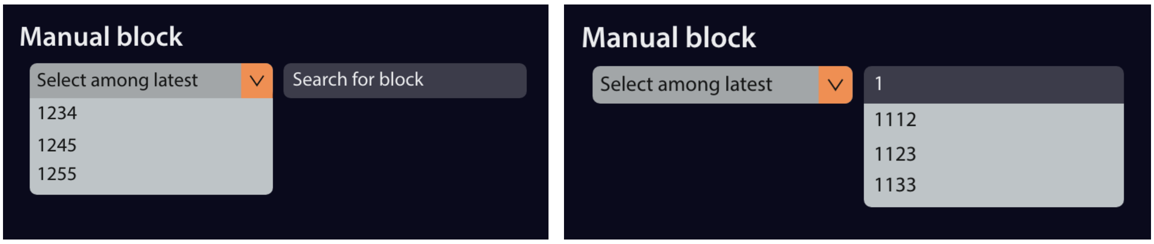

Figure 25: Manual block selection

There may also be an issue with the current position in the line guide, which once again will cause the destination signs, announcements and the line guide to be incorrect. To set it manually, the driver will find the manual positioning under the Sign control button in the main menu. Here, the driver is presented with a list of the stops included in the current vehicle journey, in the same order as they appear in the line guide. When the driver selects one, the others are greyed out, and they can confirm the selected stop as seen in figure 26. At the top and bottom, previous and upcoming vehicle journeys are placed, so that the driver may go into them if the system has selected the wrong one.

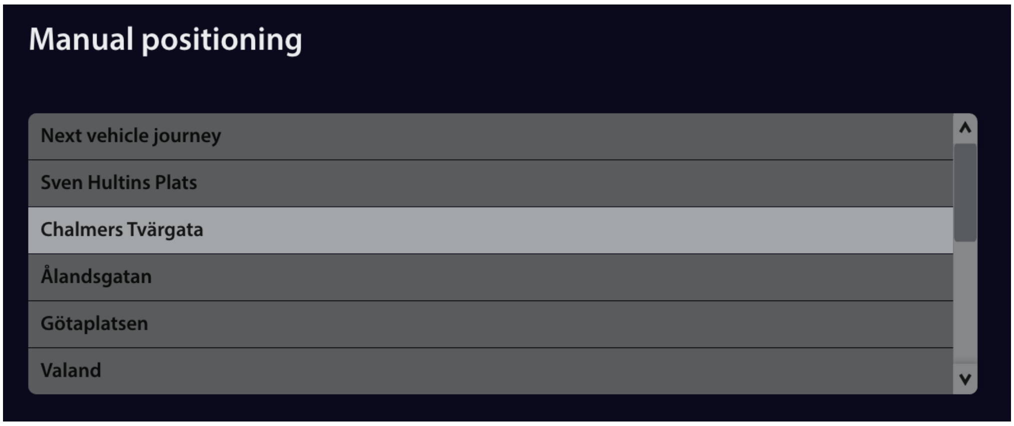

Figure 26: Manual positioning

Finally, there is the option for the driver to manually select special signs. The content of these signs is set by the public transport authority or operator, and some common examples are "not in traffic", "chartered" and "full bus". The driver finds this function under the "sign control" button in the main menu. In this section, the predetermined signs are shown, and the driver can select one of them. When one is selected, the others are grayed out and the text on the button changes from "select" to "revert" for the actively selected sign, which is illustrated in figure 27. This is so that the driver may quickly and easily change the special signs.

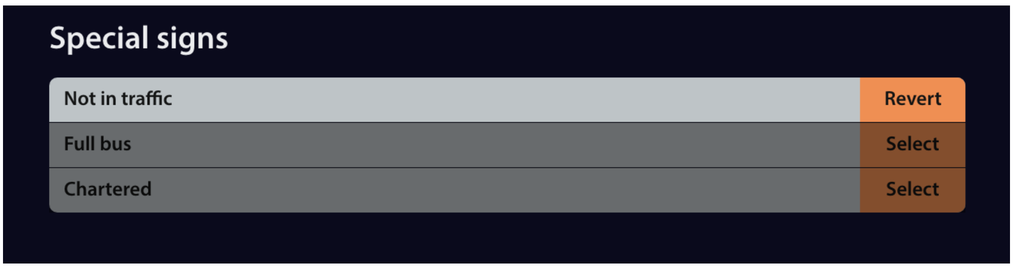

Figure 27: Selecting special signs

2.4 Evaluation

MobiLity was evaluated in two usability tests throughout the development process. All of the participants were bus drivers currently active in the public transport sector. The first usability test was done to evaluate the included functionality and the usability of MobiLity. The second usability test was done to evaluate the user experience. For a more detailed description of how each usability test fit into the development process, see chapter 6. Project process (page 44 - 49). In general, MobiLity was very well received by the drivers in the two usability tests.

2.4.1 MobiLity's functionality and usability

The drivers thought that MobiLity included relevant functionalities for them to perform their daily work tasks. This included both the functionality available in current solutions, e.g. sign control and the line guide, as well as the unique functions for MobiLity, e.g. the SmartInfo and the schedule. The drivers also liked the fact that MobiLity is divided up into several sub-functions, so that only the information relating to each function is provided in each view. This made the information easy to read and understand. The participating drivers felt that the relevant information was displayed in each view, and they generally liked the fact that as much information as possible was expressed through as few elements as possible. Many of the drivers also commented positively about how nice it was to be able to easily scan each view for information. In general, the drivers expressed that MobiLity is constructed in a logical way. Some drivers did however comment on the fact that it is very different from the solutions available today, but they all believed that it would be quite easy to learn how to use MobiLity with a bit of education. All of the drivers were able to solve the tasks in the usability tests, and only a few needed hints during the tests. The symbols used were perceived to adhere to the standard and the drivers generally understood them. Overall, they were able to easily navigate through MobiLity, and found the correct functions quickly.

The SmartInfo functionality was also very well received by the drivers. They appreciated that the system did the "heavy labor" in terms of executing all the actions after the driver had approved the suggestion. This was seen as a great way to save both time and effort, where they would be able to focus on e.g. the passengers instead of performing tedious tasks on the screen. The drivers also liked the fact that the system comes with suggestions, but that the human has the final say. Many drivers gave examples of situations from their work lives where they argued that an automated system would make the wrong decision. The suggestions and resulting actions that the drivers got to see in the usability tests were also generally seen as relevant and suitable to the context. The drivers also appreciated that the systems and sensors that are not connected today were brought together. This was seen as a possibility to get more relevant and updated information.

However, there were some drivers that raised concerns regarding removing or replacing systems that they think works well today. The most common such complaint was that they did not want to get rid of their schedules in paper form, where the motivation was that you cannot trust that technology always work. They liked the possibility to have the schedule digitally in the interface, but they still wanted to have it printed out to be on the safe side should something go wrong. This is likely related to the fact that the currently available systems break down so often. The drivers also liked to be in control and on top of what is being done in the system. Because of this, they also liked the fact that MobiLity gave feedback on each action that it took.

2.4.2 MobiLity's user experience

When it comes to the user experience, all of the participating drivers felt that MobiLity fit the context of vehicles and that it felt like a tool used for work. The drivers experienced the SmartInfo functionality as helpful and supporting, and not nagging or condescending. MobiLity was described by one driver to be like a reliable person that can step in when something goes wrong.

All of the drivers felt that MobiLity was a modern interface that looks like it belongs in the present day. One of the drivers said that an interface like this would be able to last many years in the public transport context with its functionality. When asked to describe MobiLity with words other than those relating to its physical appearance the drivers used descriptions such as smart, wise, helpful, reliable, grown up, good looking, clean and flexible. This was in line with the goals set by the project group, which are described in more detail in chapter 6. Project process (page 44 - 49).

3 Understanding the context

In this chapter the background of the project will be presented in depth. This includes a description of the context that MobiLity was developed for, as well as the design premises relevant for the developed solution.

3.1 Mobitec

LTG Sweden AB has been the collaborative partner of this project and has assisted with information and steering of the project. LTG Sweden AB has been designing and manufacturing passenger system technologies for mobile passenger information for the public transport industry since 1987. LTG Sweden AB's systems are used in more than 60 countries around the world today. They aim to deliver intuitive, safe, dependable and multifunctional products which meets the needs for mobile passenger information (LTG Sweden AB, 2019).

LTG Sweden AB belongs to Luminator Technology Group since 2012. Luminator Technology Group consists of several brands which delivers solutions towards the aerospace and mass transit markets. The product range includes signs, lighting, CCTV and passenger information systems (Luminator Technology Group, 2019). However, even though LTG Sweden AB belongs to Luminator Technology Group it continues to be its own brand. Since LTG Sweden AB is a company that has been in the business for many years, their knowledge and expertise as well as their brand values have impacted the project in terms of the direction of the solution. It was also LTG Sweden AB that set many of the initial conditions, e.g. that the interface will be aimed at the Swedish market and that it will be a touchscreen-based interface, which also impacted the solution.

3.2 Public transport in Sweden

In Sweden, public transport is governed by strict rules and regulations that the final design needed to be adapted to. The solution also needs to fit the context of public transportation in Sweden to be attractive for the purchasers of such technology.

The lines which all passengers use in public transport are decided by the public transport authority, which is the organization running all public transport systems in a region (Sveriges Riksdag, 2010). These lines are divided amongst several public transport operators which provides the buses and drivers for their contracted lines. In order to keep track of all the routes within a region there is a system where each block is attributed lines and vehicle journeys. The block, line and vehicle journey are then used to control the interior and exterior destination signs, the announcements, the line guide and the ticket machine.

The public transport authorities are responsible for the ticket systems and also decides the requirements for the vehicles in terms of which equipment is mandatory. The public transport authority or organization are also the ones that decide on whether connecting buses should have waiting agreements between them, and at which stops such agreements should apply. In this project, the public transport authorities that have been benchmarked are Västtrafik, Skånetrafiken and Värmlandstrafiken. The public transport operators studied in this project were Nobina Kungälv, Göteborg Spårvägar Buss, Keolis Göteborg, Nobina Kristinehamn, Nettbuss Lund and Trandsev Malmö.

3.3 Tasks and technology

MobiLity was developed to fit bus drivers' tasks and utilizes the existing technology as well as implements other relevant and upcoming technologies. In this chapter, the drivers' tasks as well as the technology they currently use will be described. A schematic view over the most common technology in a driver cabin can be seen in figure 28 below.

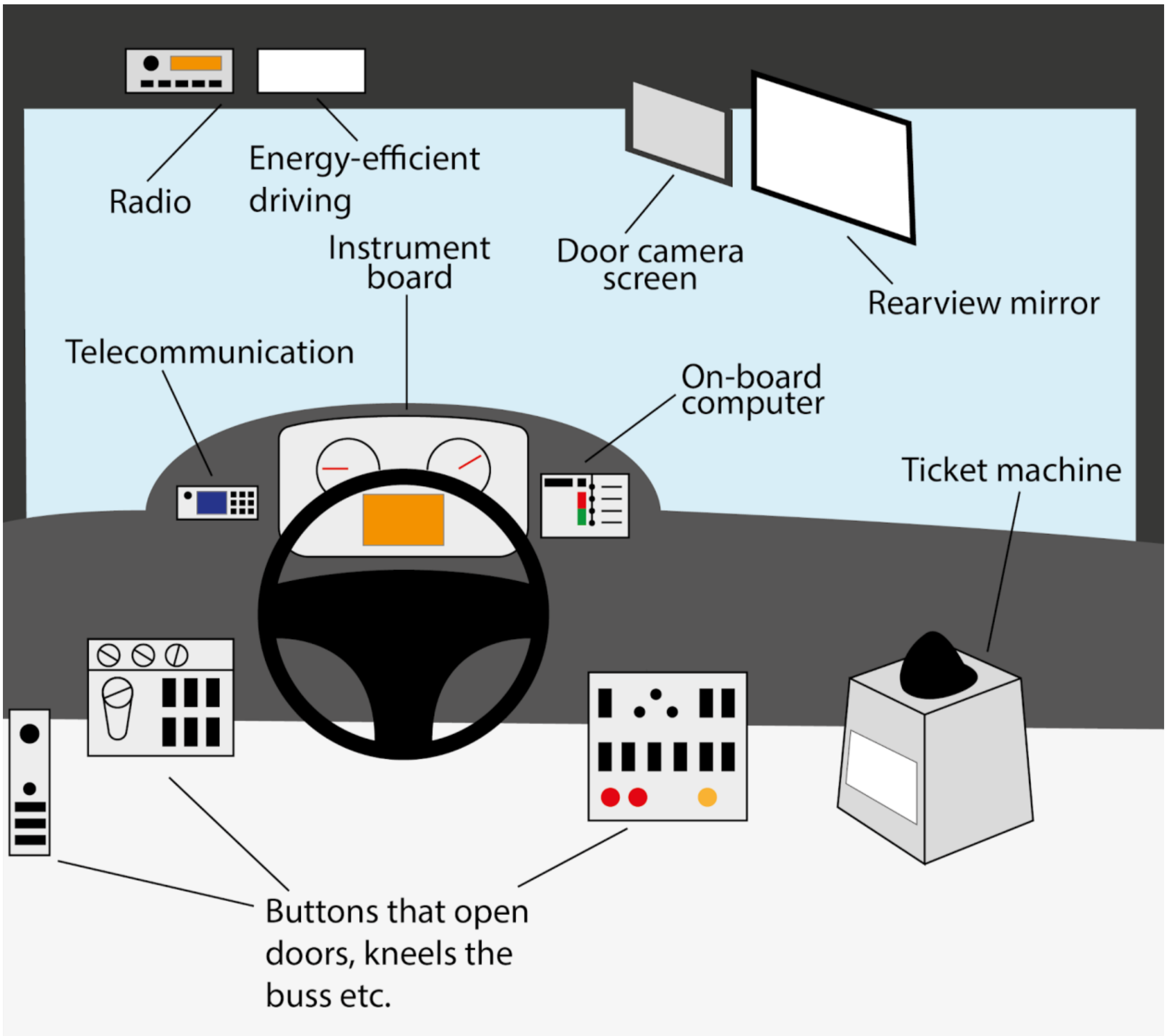

Figure 28. The driver cabin's systems

A bus driver has a wide variety of different tasks that they perform daily. Driving a bus can be briefly explained as driving the bus safely while transporting passengers from A to B along a specific route. The route a bus goes is determined by the vehicle journey as there might be several routes within the same line. A driver receives education on the route by a coach when they start working for the operator, and the driver has to remember the route by heart when driving. As a support, some public transport authorities and operators offer an on-board computer which contains information on e.g. time in relation to the timetable and a line guide (a list of the upcoming bus stops). The line guide is automatically updating itself via GPS position and can be manually calibrated if it loses connection. This is to ensure that announcements and signs are correct at all times. Although the on-board computers utilize GPS data it is not used for

GPS navigation. On-board computers are also used to manually change interior and exterior signs and send messages between traffic managers and drivers.
The two on-board computers that has been benchmarked in this project are iTID used by Västtrafik and OBIS used by Skånetrafiken, see figure 29 below. iTID and OBIS looks like they originate from the 90s and 00s from an aesthetical point of view.

Figure 29: iTID (left) and OBIS (right)

The bus drivers need to constantly monitor the surrounding traffic, including cars, bikes and pedestrians, as well as keep an eye on the passengers within the bus. Beyond driving the bus, the driver has a multitude of side tasks. This includes selling tickets, answering questions, making sure the destination signs display the correct information, checking for passengers getting on and off, kneeling the bus for elderly and passengers with baby strollers, putting down the accessibility ramp for passengers in wheelchairs and much more. The bus driver has to keep a lot in their mind at the same time, and the cognitive load on the driver is quite high. For a schematic overview of the driver's work tasks see figure 30 below.

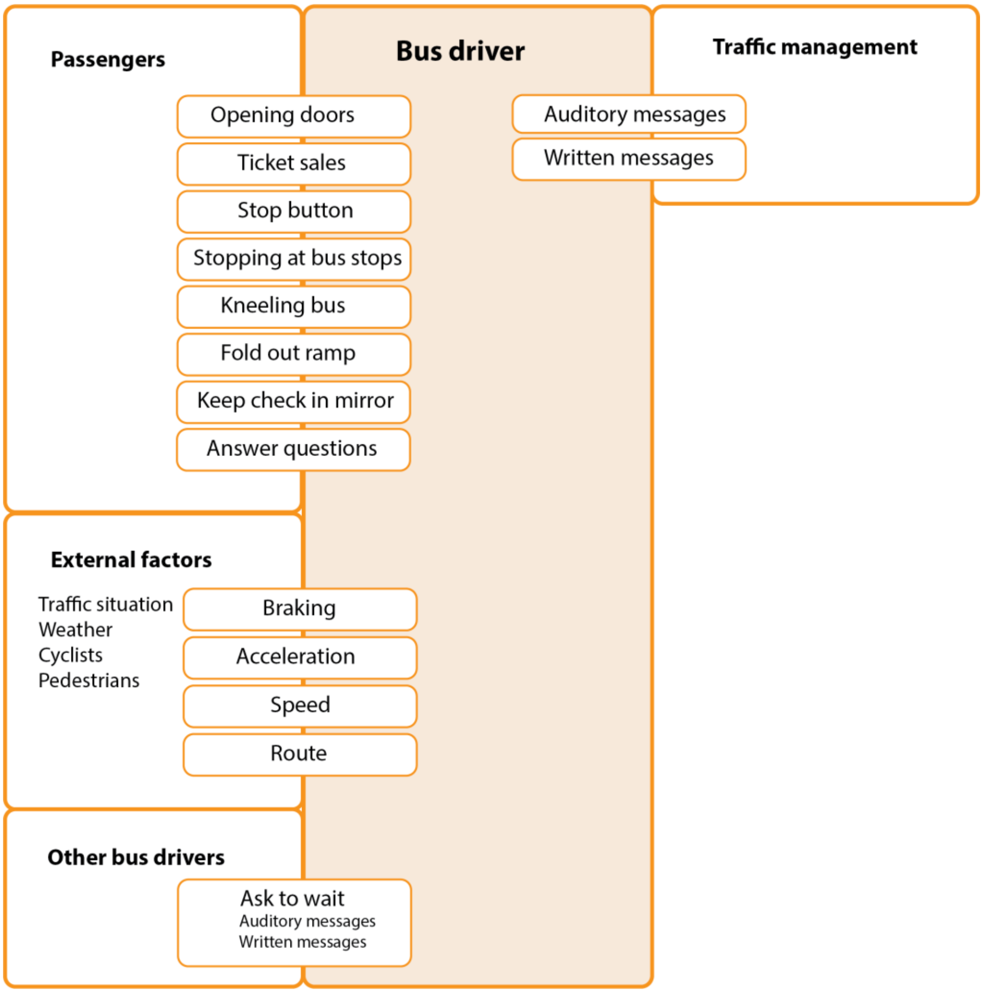

Figure 30: A schematic overview of the driver's work tasks

Driving a bus is a task that is impacted by external factors such as the weather, other road-users, road construction work and more. To support the drivers and give them updated information about the situation, each public transport operator has a traffic management. The traffic management is responsible for rerouting the traffic when needed, and drivers typically need to wait for confirmation from the traffic management before they are allowed to diverge from the predetermined route. When giving redirections, the traffic managers typically give the same information to every driver within their responsibility. The bus driver then informs the passengers of the redirection through the interior speakers.

A bus contains many systems that the driver has to interact with when beginning and finishing a shift. Examples of such systems are the alcoholic interlock, the tachograph, the ticket machine, the on-board computer and the energy-efficient driving system. Most of these systems typically gathers data on the driver's actions and thus requires the driver to log into them. Energy-efficient driving was present in all but one of the studied traffic operators' vehicles. How the efficiency of the driver was measured varied between the different operators. For instance, Nobina's system Gröna Resan did not measure if a driver jump-starts their vehicle or if they accelerate in curves, it only measures how much a driver uses the brakes. Common for all of the systems is that they compare the driving to an idealized version of reality, where the best way to drive would be to not brake at all.

There are several different ways of how communication is conducted for the bus drivers, which varies depending on public transport authority or operator. The communication can either be between the bus driver and the traffic managers, or between two drivers. Communication is a vital aspect in the bus drivers' daily work and is only between two actors unless a traffic manager sends out a mass announcement. The first system, utilized by Västtrafik and Värmlandstrafiken, is the Rakel system. This is a digital radio communication system that requires the speaker to hold down a button while speaking, and the button needs to be released before the other speaker can reply. The second voice message system, used by Skånetrafiken, is VOIP. This is a technology used for voice communication over the Internet, comparable to telephone, and people can therefore speak to each other freely during the call. Lastly, there is the case of the drivers using their own private cellphones to call the traffic management via handsfree. There is also the case of text messages via the on-board computer systems, which is available in both iTID and OBIS. These may be either free text, typically sent from traffic managers and displayed to the driver, or a selection of given messages for the drivers to choose from to send to the traffic management. In OBIS, this list had options such as "5 minutes late due to congestion", "10 minutes late due to congestion", "15 minutes late due to congestion" and so on, resulting in a long list with little variation between the options. Messages can also be sent to other buses requesting them to wait.

There are also other types of technology installed in the vehicles depending on the public transport authority or organization. An example of such technology is passenger counters, that are installed in Västtrafik's buses to count the numbers of passengers getting on and off the bus. What all of the technologies have in common is that the driver is not allowed to interact with them while driving, which is regulated in Swedish law.

3.4 Bus driver demographics in Sweden today

Drivers in Sweden are a diverse group with large differences in age and ethnicity. This was an important factor when designing MobiLity, as the interaction and information in the final design needs to be adapted to the target user group.

The average age of a bus driver in Sweden is 48 years old, and over 35% of the drivers are above 55 years of age, while less than 7% of the drivers are below 30 years old. 46% of the drivers are born outside Sweden while out of all drivers, 86% are male (Sveriges Bussföretag, 2018).

The education levels of the drivers may also vary. Common for all is that they have a bus driver's license. The internal education that a driver receives varies in length and content depending on the public transport operator. The internal education typically includes customer service, coaching on energy-efficient driving, education about the technical systems and guidance to remember their routes. The number of routes a driver has to learn depends on the organizational structure of a public transport operator as well as the contracted lines from the public transport authority.

3.5 Summary and implications of the context

LTG Sweden AB is a company offering traffic passenger system. In this project LTG Sweden AB have been a support through providing information and has helped with feedback on ideas throughout the project.

In Sweden there are several laws and regulations shaping today's public transport. The public transport authorities and operators are the ones that set up the routes and lines, but they are also the ones deciding what equipment is provided to the bus drivers. The regulations and equipment have a big impact on MobiLity's functionality as it needs to be integrated into these systems.

A driver has a wide variety of tasks they need to perform while working. These tasks consist of everything from driving the bus to serving the passengers by selling tickets, informing about redirections and more. To the driver's help are the systems implemented by the public transport authorities and operators, such as the on-board computer, energy efficient driving and tachograph to name a few. MobiLity aims to facilitate the drivers' work tasks, and in order to achieve this it must fulfill the drivers' needs.

Lastly, the target group of bus drivers consist mostly of men and has diversity regarding ethnicity and age. The user group's demographics has implications on the design of MobiLity as it needs to be adapted to the actual users.

4 Theoretical framework

In the following chapter the theoretical framework used in the project will be described. These are the theories of which the design decisions were based upon, and helped the project group to design the interaction and visualization based on the found user needs.

4.1 Usability

Usability has been the most fundamental theory used in this design project. The usability theory was applied to make the final product functional and useful for the drivers' daily tasks.

The ISO definition of usability is "the extent to which a product can be used with effectiveness, efficiency and satisfaction by specific users to achieve specific goals in a specific environment" (ISO, 2018). Effectiveness is further defined by ISO as how accurately and completely that the user can complete their goal. Efficiency is defined as how much resources, e.g. time or effort, was used in relation to the achieved results. Jordan (1998) bases his definition of usability on ISO's, and divides it into the following five components:

- *Guessability*: How good the usability is for a first-time user.
- *Learnability*: How good the usability is for a user that has completed the task once before.
- *Experienced user performance*: How good the usability is for an expert user.
- *System potential*: The optimal level of usability in a product needed to complete a task
- *Re-usability*: How good the usability is when the user has not used the product for quite some time.

Furthermore, Jordan also defines the following principles of usable design, which he recommends the designer to follow in order to create a product with high usability:

- *Consistency*: To design a product in such a way that tasks that are similar are performed in similar ways.
- *Compatibility*: To design a product in such a way that the method used for operation corresponds to the users' prior knowledge of the world and other product types.
- *Consideration of user resources*: To design a product in such a way that the method used for the operation is adjusted to the demands that are placed on the user's resources.
- *Feedback*: To design a product in such a way that the user's actions are recognized and that the product produces a meaningful response regarding the result of the actions.
- *Error prevention and recovery*: To design a product in such a way that the risk of use error is minimized. If errors however do occur, the product should be designed in such a way that the errors are possible to recovered from as quickly and as easily as possible.
- *User control*: To design a product in such a way that the user's control of the product and its actions and states are maximized.
- *Visual clarity:* To design a product in such a way that the information displayed on it can be read in a quick and easy way, while at the same time minimizing the risk of confusing the user.
- *Prioritization of functionality*: To design a product in such a way that the information and functionality that is the most important is accessible in an easy manner for the user.
- *Appropriate transfer of technology*: To appropriately use technology that was developed for other contexts to increase the usability when designing a product.
- *Explicitness*: To design a product in such a way that it gives cues to how it is operated and what its functionality is.

Jordan's principles were used in this project to evaluate both the current solutions as well as the developed solution. MobiLity has therefore been created to fulfill Jordan's principles where it was deemed relevant, and the principles were used as guidelines in the development process.

4.2 User experience

Bussolon (2016) argues that the definition of user experience remains vague among researchers and practicing designers, but that it generally boils down to "a holistic, multidisciplinary approach to design, where information architecture, interaction design, information design, graphic design, usability, accessibility, content management converge to the final product or service." In this report, the phrase user experience will be used to describe the aspects beyond usability that impacts the user's experience of the solution, e.g. aesthetics, the perceived adherence to the context (e.g. professionalism, used in a vehicle) and the user's emotional response to the interface, both in terms of the included functions and the interaction with it. The use of this definition of user experience is what took the final design from being a purely functional solution to be a design that aesthetically fit its purpose and that could generate a more positive experience for the drivers.

4.3 Wickens' multiple resource theory

Wickens (2002) has developed a model explaining why performing some tasks simultaneously will increase the cognitive workload drastically, whereas other tasks can be performed simultaneously with low cognitive workload. Wickens argues that this is because different tasks place different demands on the different information processing stages and perceptual modalities. For these stages and modalities, various senses are used such as the visual, auditory and spatial senses among others. To minimize the cognitive workload as much as possible, different senses and modalities should be used when designing a product. The further away the tasks' required modalities and senses are in Wickens' multimodality model, the better it is for the cognitive workload. For example, driving a car and listening to the radio is typically doable at the same time, but it is more difficult to read a text and speak simultaneously.

4.4 Levels of automation

Sheridan and Verplank (1978) proposes their thoughts on automation by structuring the division of human labor and automation into ten different levels. These were useful for the project as they helped communicating as to what level of automation MobiLity should act within. The ten levels of automation are as follows:

- Level 1: The human makes all the decisions and actions themselves.
- Level 2: The computer helps determining different actions and decisions.
- Level 3: The computer helps narrow down the selection to a few actions and decisions.
- Level 4: The computer suggests one action or decision.
- Level 5: The computer executes suggested action upon confirmation from the human.
- Level 6: The human is allowed to intervene within a set time frame before the computer executes the action.

- Level 7: The computer executes the action and informs the human if necessary.
- Level 8: The computer executes the action and informs only if the human asks the computer.
- Level 9: The computer executes the action and informs the human if the computer decides to do so.
- Level 10: The computer executes the action and ignores informing the human.

4.5 Gestalt principles

In order to increase the usability of MobiLity, selected Gestalt principles were used to help shape its layout and aesthetics. The Gestalt principles are a set of laws of which explains how the human mind tries to seek order in what we see (Interaction design foundation, 2019).

The Gestalt principles used in this project are the following:

- *Law of common region:* Objects which are enclosed within the same region are grouped together.
- *Law of proximity:* Objects placed close to each other are grouped, and objects farther away are separated into different groups.
- *Law of similarity:* Objects' similarities and differences are linked. Objects that are different compared to other objects stand out instead.

4.6 Summary and implications of the theoretical framework

For this project, the ISO definition of usability was used together with Jordan's usability components and design principles. Jordan's framework was the basis for every step in the design process; evaluating the current technologies, developing the new solution and the usability tests done together with users. This framework was used as guidelines to fulfill the aim set in the beginning of the project.

When it comes to user experience, it was defined as the aspects that goes beyond the previously defined usability. Aspects such as aesthetics and adherence to the context are examples of this. The user experience has been a vital part of the project and has taken a supporting role to the usability framework.

Wickens' multiple resource theory states that tasks should be divided among different modalities. This theory has been used in the project to find ways to relieve the drivers' overloaded visual sense.

Sheridan and Verplank's levels of automation compiles the different levels of labor division between human and automation. This was used to decide the level of automation for MobiLity and its included functions. This theory was also used as a means of communication within the project group and in the report, to describe the desired level of automation of the solution.

The Gestalt principles are principles explaining how humans interpret different visual elements. Selected Gestalt principles were used when developing MobiLity to better communicate how different elements are connected and ordered.

5 Process and method descriptions

In the following chapter, the overarching process and methods used in the project will be described.

5.1 ACD^3

The ACD^3 process divides the product development process into various dimensions; design activities, design levels and design perspectives (Bligård, 2017). This process can be further separated into five or seven phases depending on how extensive the project is. For less extensive projects the five phases are needfinding, design of use, general design, detailed design and construction. What the ACD^3 process promotes is to work on several design levels, in an iterative process throughout the phases.

This project's process was loosely based upon the ACD^3 framework, in terms of how the project was structured and organized. Consequently, chapter 7. Design motivations (page 50 - 61) are divided into the five abstraction levels described in ACD^3. The abstraction level Effect describes the desired outcome/effect of the product on the use context and presents the needs of drivers and stakeholders on a general level. Use describes how the solution is intended to be used, and how its use fulfills the desired effects. Architecture describes the functionality the solution consists of, and how these functionalities fulfills the desired effects. Interaction describes the interaction in detail and why the interaction was designed in this way. Elements describes the technical elements of the solution in more detail.

5.2 Benchmarking

Benchmarking is the process of a business looking at other businesses to measure and compare their products with their own to find ways to improve (Coers, Gardner, Higgins and Raybourn, 2001). In this project benchmarking has been used for three main purposes. It was used to find the solutions that exists on the market today and evaluate the positives and negatives of existing solutions. Benchmarking was also used to find which currently unused or upcoming technology that could be implemented in MobiLity. Finally, benchmarking was used to find other vehicle related technology to develop suitable aesthetics for MobiLity.

5.3 Interview

In the context of product development, interviews are conversations with users with the purpose to find out their opinions, experiences, attitudes or motivation in relation to products or services (Wikberg Nilsson, Ericsson and Törlind, 2015). Interviews may also be used as a means of information gathering when the interviewees are experts. Interviews in the design process can be used either to gather information about the use of current products, or to get feedback on developed prototypes.

The interviews can be carried out in three different ways; structured, semi-structured or unstructured. A structured interview follows the interview guide strictly, which makes it consistent but rigid. An unstructured interview is more like a conversation between the interviewer and the interviewee, where the interviewee more freely talks about the topic. Lastly, the semi-structured interview is somewhere in-between the structured and unstructured interview, where an interview guide is used but with more room for spontaneous turns in the interview. In this project, semi-structured interviews were used to find user needs as well as to evaluate concepts and ideas.

5.4 Observation

Observations are used in product development to identify user needs in specific situations as well as to discover potential areas for innovation (Wikberg Nilsson, Ericsson and Törlind, 2015). The observations gives the designer an understanding of important factors to take into consideration such as the user's attitudes, goals, or relations between different factors. Observations are conducted through the designer observing and experiencing the user's situation, and may be complemented by asking questions to the user. Observations were carried out in this project to find user needs and to understand use context.

5.5 KJ method

The KJ method is used to analyze and compile data (Bligård, 2015). The method consists of writing down collected data on notes, that are then organized into groups depending on the theme. The method goes from a detailed view to the more overarching analysis, and is used to sort collected data into relevant categories. The KJ method was used to structure the data collected during the interviews and observations in this project and to distinguish important factors in the context.

5.6 Use cases

Cockburn (1999) defines a use case as "a description of the possible sequences of interactions between the system under discussion and its external actors, related to a particular goal." Use cases are used to further enhance the understanding of a system by detailing how the interaction works, what the possible outcomes are, and what triggers certain outcomes. Use cases were used in this project to create relevant scenarios that could be used as a base for ideation as well as in the usability tests to evaluate whether the final solution improves the usability or not.

5.7 Personas

A persona is a representation of a fictional user belonging to the target group (Wikberg Nilsson, Ericsson and Törlind, 2015). This representation is based on the research made into a user group and its context. Using personas can help product development by having a concrete user to test concepts against. In this project, personas were used during the design process to discuss what different users may like or dislike about different concept or ideas.

5.8 Brainstorming

Brainstorming is a method used to ideate and generate a large quantity of ideas. The brainstorming sessions are normally conducted around a certain problem. It is common to set a time where each participant is allowed to sketch or type down their ideas freely. Afterwards the participants discuss their ideas, typically followed by another session (Ibid.). Brainstorming was used in many stages of the project to come up with solutions that could fulfill the user needs.

5.9 Prototyping

A prototype is a model which purpose is to test a concept (Ibid.). A prototype is also used to learn about any eventual problems, and if the functions work as intended. Prototypes can come in all shapes and sizes, both physical and digital. The prototype can be used in user tests or it can simply be tested by the development team to test dimensions or other aspects. In this project, prototypes were used both as a way for the design team to test and discuss ideas internally, as well as a medium to evaluate the concept together with users.

5.10 Usability testing

Usability testing is done to evaluate an interaction between a user and a product (Hanington and Martin, 2012). The test typically consists of tasks that the user has to complete with the product, and the purpose of the test is to find eventual issues that frustrates the user. Aspects that are examined are e.g. whether or not the user is able to complete the given task, if they understand the product or if they express positive or negative comments. In this project, usability testing was used to evaluate prototypes in two different stages; one with the focus on functionality and usability, and one with the focus on user experience.

5.11 Design format analysis

Warrell and Nåbo (2001) describes the design format model as a way to discern distinctive visual form factors of the same product family within a company. Several products from the same product family are compared, and their different visual form elements are listed. The form elements are then weighted depending on relevancy in comparison to the overall product family. The most relevant form elements are compiled in a table together with the products in the product family. Each product is then ranked depending on how many of the visual form elements it has. By doing this it is also possible to rank which form elements are the most important to signify belonging to that specific product family. A simplified version of design format analysis was used in this project to find the aesthetic expression of MobiLity.

6 Project process

In the following chapter, the process of the project will be presented briefly. An overall description of the process structure is followed by a more detailed presentation of the activities done in order to gain understanding of how the interface should be designed to facilitate good usability and provide good user experience.

The process has been focused on a user-centered design approach, to create an interface that fulfills the drivers' needs in their daily work. Because of this, input from users has been vital throughout the process. A total of 21 drivers has participated in the project. They have had both urban and rural driving experience and worked the cities Gothenburg, Kungälv, Lund, Malmö and Kristinehamn. Both men and women participated, and the participants had various ethnic backgrounds. The project was loosely based on the ACD[3] framework, where the final solution was developed through working with the abstraction levels Effect, Use, Architecture, Interaction and Elements. For a more detailed description about the detailed design decisions made at each level, see chapter 7. Design motivations.

The process has been iterative, where each iteration allowed for new information to be processed. All the design decisions are based on data found during user studies. Thus, various methods have been utilized in order to find the drivers' needs. In this project the process can be described in three major parts; the needfinding stage, the first iteration of the interface and the second iteration of the interface. Each of the two iterations of the interface consisted of several smaller iterations. For a graphical representation of the process, see figure 31 below.

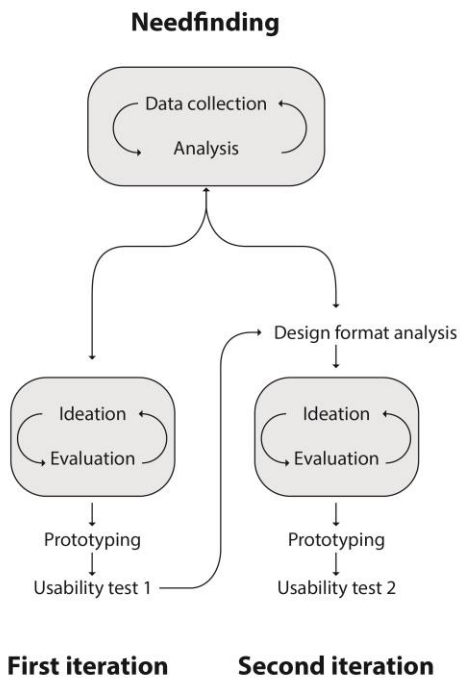

Figure 31: A general process description of the project

6.1 The needfinding stage

In the needfinding stage, the user studies were conducted and compiled. Methods such as interviews, observations and study visits were used to collect data. These methods were conducted together with drivers from both urban and rural areas, as well as with drivers from different public transport operators since their needs differed depending on the operator and the traffic environment. Some of the participating drivers also worked as traffic managers or educators to new bus drivers, and thus had a broader perspective. Three study visits to different bus depots were conducted to understand the context and surrounding factors of driving a bus.

Five complete and one incomplete in-depth interviews were also conducted, to find the needs of the drivers. To read the full interview guides used, see appendix I. Furthermore, two observation sessions of a bus in real traffic were conducted, where observations and loose interviews were combined to complement the in-depth interviews.

Benchmarking was also conducted. It was performed to look into currently existing solutions which were evaluated with Jordan's usability principles. Benchmarking was also done on current and upcoming technologies within bus related technologies and other related fields, to find if there was anything relevant for this project. For a description of the benchmarking results, see appendix II.

The data found during the pre-study was analyzed using the KJ method in order to find requirements and common problems, which were later used as a basis for the ideation sessions. The data was compiled into four use cases describing the most relevant situations of use, which were used as a tool for ideation and evaluation. These can be found in appendix III. The data was also used to create personas representing the most common driver types. These were used as a tool of ideation as well as for evaluation in both of the iterations. A full description of the personas can be found in appendix IV. The information gathered in the needfinding stage was the cornerstone which the two other stages were based upon.

6.2 The first iteration

When the data from the needfinding stage had been compiled, the first iteration of MobiLity was developed. The focus was to solve as many of the relevant problems found in the needfinding phase as possible. The ideation process for designing the first iteration consisted of several smaller iterations, where brainstorming sessions were mixed with discussions on the ideas' advantages and disadvantages. The personas and use cases were also used to make sure that the solution fit the users and the context. This was repeated several times where the functionality of the concept was improved in each iteration. The first iteration focused on usability, and the focus was therefore on which functions to include, how these functions should be designed, and how to organize these functions within the interface in such a way that they facilitates the drivers' work. Aspects such as Sheridan and Verplank's levels of automation, the size of graphical elements and workflow were developed during this stage.

6.3 The first usability test

In order to verify the concept's usability, it was compiled into an interactive prototype which was tested together with drivers. A frame from the first prototype can be seen in figure 32.
The prototype was constructed around the use cases compiled in the needfinding stage. Nine drivers participated in the first usability test, where four worked in rural areas and five in urban areas. Domain knowledge was a necessary prerequisite in the selection of participants, meaning that the concept could only be tested by drivers.

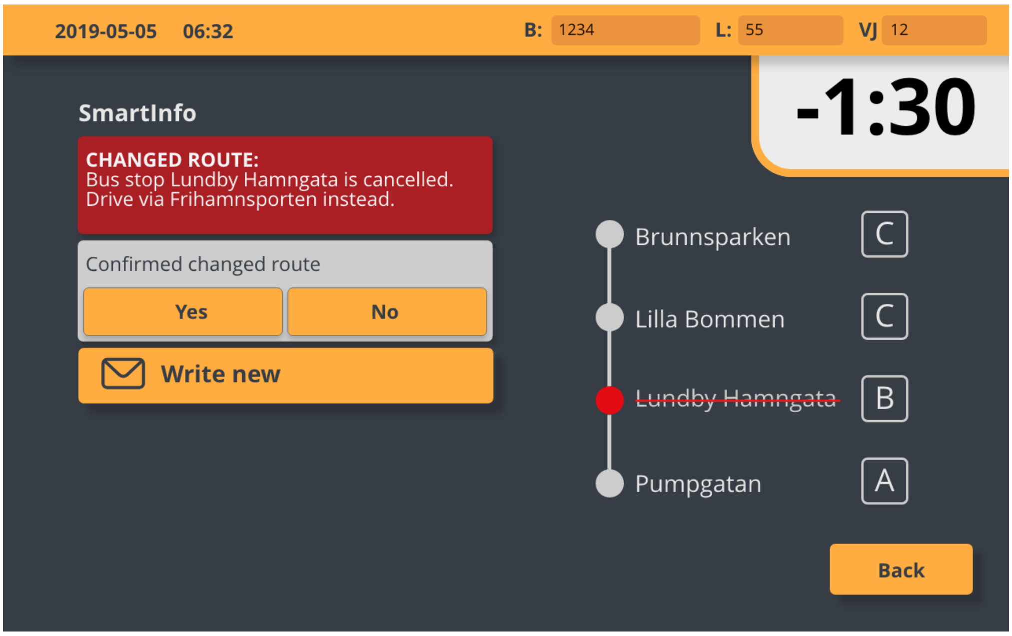

Figure 32: A frame from the first prototype

The first usability test focused on finding out whether the right functions had been included in the interface, and if it was understandable. To evaluate if the interface fit the context, a driving situation was simulated. The drivers got to watch a movie shot from the front of a bus, which matched the route in the scenario as displayed in the interface. To make sure that the drivers did not interact too much with the interface, a model of a steering wheel was also used so that the drivers could hold on to this, as seen in figure 33 below.

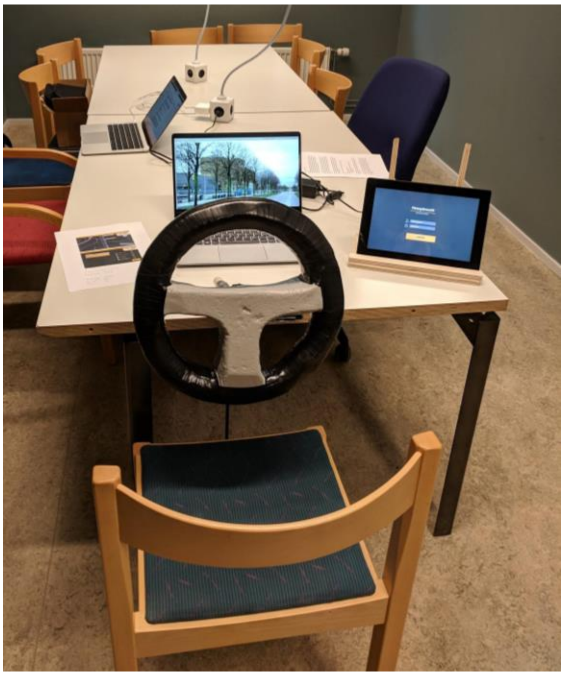
Figure 33: The setting for usability test 1

Since the focus was usability, questions such as "how certain are you that you did it correctly?" were asked frequently, to evaluate if the interface was easy to understand. The drivers also got to answer questions about if the functions are relevant or not. The drivers got to “drive” through three scenarios; a day where everything goes as planned, a scenario where they need to contact the traffic management, and one scenario of a traffic reroute. The full interview guide can be read in appendix V.

The results of the usability tests of the first iteration were mainly positive. The included functions were appreciated and deemed relevant by the drivers, and they understood how to use it with only a few minor errors.

6.4 The second iteration

The main focus for the second iteration was the user experience, since the usability had been proven to be good in the first usability test. The solutions to the issues found in the first usability tests were also ideated during the second iteration. Much like for the first iteration, the development of the second iteration was iterative with brainstorming sessions and discussions.

An important part of improving the user experience was to improve the aesthetics. Hence, benchmarking and a simplified design format analysis were performed on car interfaces in order to adapt the aesthetics to the vehicle context while giving a professional look, and the results can be found in chapter 2.2 Aesthetics of the vehicle context (page 12). A benchmarking was also performed on car interfaces, to find eventual relevant or interesting functions to apply in the solution. The result of this benchmark can be found in appendix VI. In order to express the LTG Sweden brand, another design format analysis was done on a few of their applications, where the results can be found in appendix VII. The results from these two methods were combined and brought into the ideation phase, where various visual concepts were tested and evaluated through looking at how well they fit the context and the personas. After several small iterations, the result was compiled into a new interactive prototype which once again was centered around the use cases. A frame from the second prototype can be seen in figure 34.

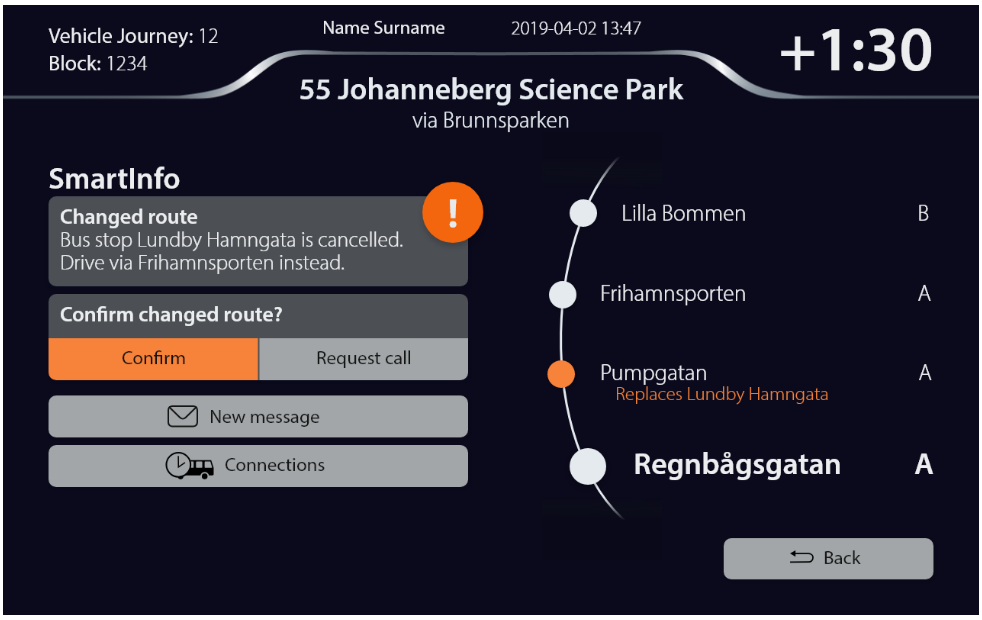

Figure 34: An excerpt from the second prototype

6.5 The second usability test

The second iteration of the prototype was also tested in a usability test. The focus of this test was to find if MobiLity fit the context of vehicles, if it expressed professionalism and if it was perceived as a support to the drivers and their expertise rather than being annoying or condescending. The project group also wanted MobiLity to communicate the little bit of extra luxury since the driver's work very hard with oftentimes little appreciation. The second evaluation of MobiLity was also done to see if it still had the same good *guessability* and *learnability* as the first iteration, after having been reworked aesthetically. The construction of the test was similar to the fist usability test. The drivers got to "drive" through the same three scenarios; a day where everything goes as planned, a scenario where they need to contact the traffic management, and one scenario of a traffic reroute. In this test, questions such as "How did you feel like…" or "How did you experience…" were frequently asked. Compared to usability test 1, this was performed quicker than real-time. There were also several new questions at the end of the test, to find out the driver's feelings for the interface, and to find out how they perceived it on a more emotional level. The full interview guide can be found in appendix VIII. Four complete and one incomplete test were performed together with drivers. After the second usability test was done, some minor adjustments were done to the solution in accordance to the feedback received.

7 Design motivations

In the following chapter, the way the results of the background study impacted the design decisions will be presented in the five abstraction levels used in the ACD^3 method, going from more general to more detailed. In these sections, the design decisions of each level will be motivated.

7.1 Effect

In this section, the effect that MobiLity aims to fulfill will be presented and motivated. The Effect is the foundation of the other levels, describing what should be fulfilled by the developed solution. The other sub-chapters motivate how these aspects are fulfilled by MobiLity.

7.1.1 Making a complicated situation as simple as possible

As described in chapter 3. Understanding the context (page 28 - 34), the drivers work in a very complex and dynamic environment and they use multiple systems simultaneously. Because of this, MobiLity needs to be clear and simple. Only relevant information should be displayed in each situation, as opposed to today's systems where the driver must filter through a lot of information. Furthermore, as the drivers are pressed on time, the interaction must be quick, efficient and intuitive. By achieving these needs, the already complex situation can become simpler and less cognitively demanding. Usability factors such as *visual clarity, prioritization of functionality* and *prioritization of user resources* were therefore vital when developing MobiLity. It was also found in the user studies that many drivers have recently changed jobs, are new to driving or are not well acquainted with the area or routes. For these groups, easily understood and clear information is even more important.

MobiLity will also simplify the complex situation through providing updated, quick and relevant information to the drivers, from both the traffic management and from other bus drivers. It is important that this information is easily accessible for the drivers. Furthermore, since drivers have varying technical skills, MobiLity should be intuitive to use. *Guessability*, *explicitness*, *consistency* and *compatibility* were relevant usability factors to achieve this. MobiLity should also be usable by drivers even if they are not very proficient in Swedish.

7.1.2 Replace or complement the current systems

The public transport authority and operators are the ones deciding which technical equipment that are placed in their buses. Therefore, MobiLity needs to be compatible with other systems in the bus. The most notable are the spoken communication channels. Mobility should complement the spoken communication by providing the possibility of written communication. This will optimize the way the drivers communicate.

To simplify the drivers' work environment, many of today's separate systems are integrated into MobiLity. It is important that the usability and the cognitive ergonomics of the integrated systems are preserved or improved. Examples of such systems found during the background studies are the energy-efficient driving system, the printed-out paper schedules, internal and external destination sign control, GPS map navigation, line guide and the input of traffic data. It is important that the integrated functions in MobiLity has good *compatibility* compared to how each system was designed when they were separate. They should however still fit well together with the rest of MobiLity through good *consistency*.

7.2 Use

In this section, the way that MobiLity fulfills the factors described in chapter 7.1 Effect will be presented and motivated.

7.2.1 Suggest and confirm

MobiLity utilizes automation of level 5 as defined by Sheridan and Verplank, meaning that the system suggests and performs actions when the human has confirmed them. The system analyzes data collected from e.g. sensors in the bus to give suggestions to the driver of an action to take, as well as perform the action when it has been approved by the driver. This is to provide the driver with quick and easy usage of MobiLity, as well as to lessen the cognitive load of the drivers. However, since the situation is often complex, it is important that the power to decide will always lie with the human in the system and the level of automation should therefore not be higher. This will therefore be the optimal level of *system potential* and *user control*. The experienced drivers have much prior experience of many different situations, and the course of action that they want to take due to their expertise may be different than what can be concluded by only measurable data. An example of this brought up during the usability tests was the situation where a whole school class always goes one stop by bus at the same time every day. It would then be unnecessary to change the exterior destination signs to "Full bus" since the class will get off at the next stop. It is important that the driver's expertise is the foundation for the action. There may also be instances where the sensors are broken, and the provided data is incorrect. Utilizing automation of level 5 will also increase the efficiency of the interaction. The drivers are able to do as much as possible with as few clicks as possible, which can save both time and cognitive effort. *Feedback* is also readily provided, so that the driver can be sure which action has been taken. This provides the driver with *user control*, which aims towards making them more relaxed and in control of the situation.

MobiLity never requires the driver to spell correctly, e.g. when choosing the current bus stop in the manual GPS positioning functionality. This is because many drivers are not fluent in Swedish, and scrolling through a list and selecting a stop is therefore easier than spelling the stop's name, which is an example of *error prevention*. When selecting a stop from a bus stop list, the list is ordered in the same way as the stops appear in the line guide. This may also assist a driver who is unsure of the name of the upcoming stops. When the driver inputs numbers, e.g. for the manual block functionality, the driver can only input blocks that are previously registered in the system. This is also a form of *error prevention*.

7.2.2 Simple and updated communication

The drivers are in need of updated and simple information, both from the traffic management and from other drivers in areas where there is an agreement to wait for connecting buses. The drivers are pressed for time, so the communication needs to be both quick and easy to perform, both when receiving and sending information. MobiLity provides written communication, to complement the existing oral communication tools that are used in buses by several public transport authorities in Sweden today.

Written communication fits the context well, as it was found in the user studies that spoken announcements were easily missed as it is a noisy environment, and that it is not always repeated. Written communication is advantageous since the message is there for the driver to read whenever they have time, which fits with the *consideration of user resources.* For drivers who has difficulty understanding Swedish, written messages also give them more time to interpret the meaning. It was also found in the user studies that spoken messages can be problematic in driver changes, where the driver getting off their shift has to remember to forward the relevant information to the driver getting on, something that was sometimes forgotten. Written messages therefore acts as a way of *error prevention,* since they can also be displayed to the new driver. Written messages can also be stored in the inbox as a form of *consideration of user resources* in case many messages are sent out at the same time, since the driver cannot read everything at once.

7.2.3 Motivate and encourage

MobiLity's energy-efficient driving function aims to motivate drivers through providing a fairer evaluation than the current systems while also introducing an element of competition or gamification. In a study conducted by Liimatainen (2011), bus drivers in the city of Tampere in Finland were divided in different groups depending on what type of route they were driving and at what time of the day. Drivers with similar conditions were ranked within their respective group. It was found that this ranking motivated the drivers, and that the they appreciated being evaluated in more realistic conditions than against idealized conditions. The energy-efficient driving functionality in MobiLity has taken inspiration from Liimatainen's study. It was however found in the usability tests of the prototype that some drivers were not comfortable with being compared to others. Other test participants liked the idea, and this functionality will therefore be optional.

7.2.4 Provide support while driving

It is important that the drivers are not overloaded by information while they are driving. In MobiLity, *consideration of user resources* has therefore been taken when designing the view displayed while the vehicle is in motion. It is however also important that drivers that are new to the route or beginner drivers get support regarding where they should drive. This is extra important in the case of traffic reroutes, where inexperienced drivers may not know where to drive. MobiLity therefore provides a GPS map view when the vehicle is in motion. This will support the drivers that are unsure, while the experienced drivers do not need to look at it if they do not want to. The GPS map view can also be quickly updated in the case of reroutes. GPS map navigation is already common in other types of vehicle contexts, and can therefore be seen as *appropriate transfer of technology.*

7.3 Architecture

In this section, the way that MobiLity's information structure is constructed will be presented and motivated.

7.3.1 Dividing and connecting functionality

In MobiLity, the functionalities have been divided into different sub-functionalities, and the information presented in each view is strictly tied to that specific function. One of the major design decisions was to not present all functionalities on the same screen, which some existing on-board computers do today. Putting them all together would only result in poor *visual clarity* and poor *consideration of user resources*. By dividing the functions into different views, the drivers are able to quickly find the function or information that they are looking for while not being cognitively overloaded. The drivers are not able to, nor allowed, to interact with MobiLity while the vehicle is in motion. To present all information to the driver while driving would risk distracting or tempt the driver to look at the interface instead of the road. When the bus is standing still at a bus stop, the driver needs to perform many different tasks and the timeframe is short, making efficient interaction relevant here as well.

The driver may have to perform a few more clicks to reach their desired function compared to if everything was presented on the same screen. However, this division leads to each function having enough room to be presented in an easily read and easily understood way. Furthermore, MobiLity connects the most relevant functions to each other, which will lessen the number of clicks needed to reach the functions most commonly used together.

7.3.2 Multifaceted information

To be able to include as much information as possible in an easily understood way, MobiLity presents as few different elements as possible while maximizing the amount of information that can be communicated through each element. By minimizing the number of elements, the *visual clarity* will naturally increase. Many of the existing on-board computers presents the same information in several different ways, or irrelevant information which makes them bad from a *visual clarity* standpoint. For instance, in the GPS map view, there is no need to present the distance in meter to the next stop since the bus' and the stop's position is clearly understood by looking at the map. Likewise, there is no need to show the expected arrival time and departure time at a bus stop when the time in relation to the timetable is shown at the top right corner. Knowing their time in relation to the timetable lets the driver know the relevant information; if they are behind, on, or before the scheduled time. Not spreading this information out in different places but instead collecting it in one single element makes it much easier for the driver to receive the relevant information through only a quick glance.

7.3.3 Accommodating varying conditions

The physical conditions of the driver's cabin vary depending on the time of day and the season. The interface should therefore be readable in many different lighting conditions and should not interfere with the driver's sight during dark hours. MobiLity will therefore have a day mode and a night mode, as well as the possibility for the driver to set brightness and contrast according to their preferences.

The needs may also vary between rural and urban areas, and MobiLity will be adaptable to these differences. For example, the messages in the New message function will be set by each public transport operator. The six preset messages are supposed to reflect the most common messages that the driver may need to send, and these will naturally vary depending on the area and traffic environment (e.g. urban, intercity or rural).

7.4 Interaction

In this section, further details relating to the interaction between the driver and MobiLity will be presented and motivated.

7.4.1 Adapted to the use situation

The interaction needs to be quick and efficient since drivers are constantly pressed on time. With the SmartInfo, many of the time-related issues are solved as it gives a suggestion and executes said action when the driver confirms it. All of the functions are designed to only require a few clicks. For example, sending a message to the traffic managers can be done with two clicks. Furthermore, by integrating several systems into one interface there are less systems to log in and out from during driver changes. This saves a substantial amount of time and effort for the drivers.

When driving, drivers need to keep constant attention on their surroundings. MobiLity therefore takes on a supporting role when driving, by showing the drivers the route if they are uncertain of where to go, as well as showing how their current time is in relation to the timetable. It is only when there is urgent information that MobiLity will call for the driver's attention through auditory notifications. By using sound, a new modality is introduced into the usage situation, which increases the chances of the driver noticing the notification as per Wickens' multiple resource theory.

The situation when driving can quickly change when e.g. traffic accidents happen. In these situations, it is important to allow for good communication between drivers and traffic managers. Good communication is best achieved by utilizing both spoken and written communication, i.e. delivering information through two modalities. The interface will complement the currently used radio or telecommunication by providing the possibility of written communication. Messages are generally only displayed when standing still at a bus stop, but can during urgent reroutes be shown while driving. Furthermore, during redirections the GPS map navigation will automatically update the route that the driver should follow, which help the driver take part of the information faster and easier when there are sudden changes in their route.

7.4.2 Easy to read and find

Many drivers are older, and the lighting conditions can be far from optimal which means that the information displayed must be easy to read and easy to find. This becomes even more important when things go wrong and the drivers get stressed since their ability to find information decreases, i.e. it needs to consider the *user's resources*. These needs have been accommodated through large font sizes where letters are always bigger than 25 pt. and an easily read sans-serif font, Myriad Pro, has been used throughout the interface. MobiLity also has high contrast between text and background, minimizes the amount of content displayed during certain situations through *prioritization of functionality* and utilizes design theories such as the Gestalt principles to further communicate what the buttons do. Buttons are also larger to make them easier to find and easier to use by drivers with large fingers, since the majority of the drivers are men.

The colors chosen for both night mode and day mode are selected so that it is high contrast between text and background. All text and background combinations have AAA rating according WCAG standards, meaning they have the highest contrast rating (W3C, 2016). The colors chosen for both the day mode and night mode can be seen in figure 35 below. Buttons have two different colors and some of the prioritized buttons have an orange color to draw attention to them by utilizing the *law of similarity*. For example, when the driver needs to confirm an action. Having high contrast makes it easier to read and increases the *visual clarity*. The GPS navigation also uses contrast to highlight the active route and bus stop pins. The inactive route during redirection is grayed out to draw less attention from where the driver should go. The inactive route is still displayed since during usability test 1 drivers mentioned that it helped them see when they are back on their original route.

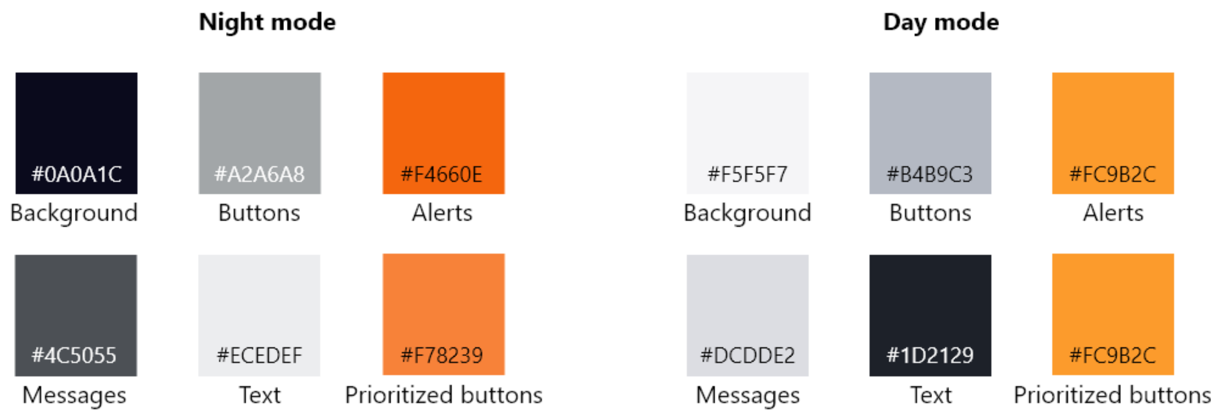

Figure 35: The chosen color codes

Most of the buttons uses both text and symbols to increase their *explicitness*, which makes it easier for the driver to understand what each button does. The symbols are useful for those that are not fluent in Swedish, and by using standard symbols where possible the *compatibility* increases. Furthermore, by combining text and symbols, the *guessability* and *learnability* will also increase. Examples of standard symbols can be seen in figure 36 below, where e.g. Schedule and Settings use standard symbols. In the cases where standard symbols were not available, new ones were created with the focus to provide as much information as possible about the function it describes. Examples of this can be found in figure 36 below, where Current route and Sign control are two non-standard symbols. In some cases, similar functions calls for similar symbols. It is therefore important that they are easily distinguished from each other. An example of this is the Inbox and New message, where both are tied to messages. To make sure that the distinction between them are clear, Inbox is visualized with an old school mailbox, and the Message function is symbolized by a letter.

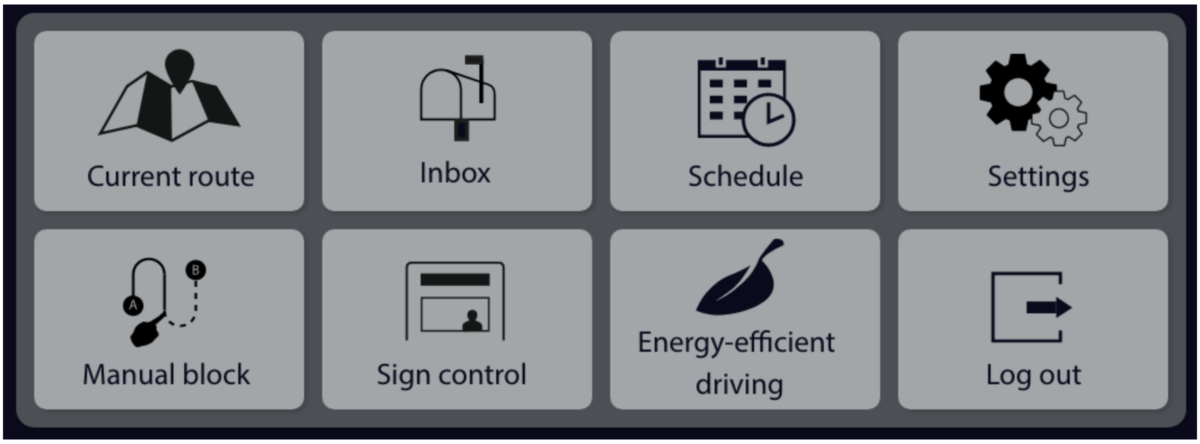

Figure 36: Examples of symbols

In order to make the content more sensible, the Gestalt laws *proximity* and *common region* have been used. These laws help the drivers to understand how objects are grouped and what specific buttons do. For example, in the SmartInfo there are messages that contain buttons, as seen at the top of figure 37. All of these are part of the same rounded rectangular shape, which shows which message that the buttons are responding to.

Figure 37: Common region

In a similar way, *proximity* helps to connect several separate but related messages together. An example of this is the way the two top messages and the two bottom buttons are placed closer together in figure 38 below.

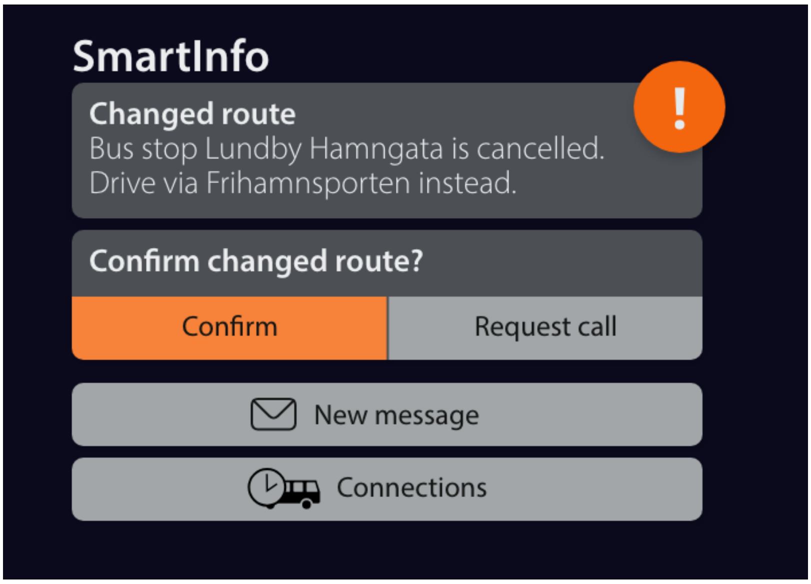

Figure 38: Proximity

Furthermore, *hierarchy* has been used to highlight certain content. For example, the current bus stop in the line guide have bigger and bolder text to make it stand out from the other bus stops, see figure 39 below.

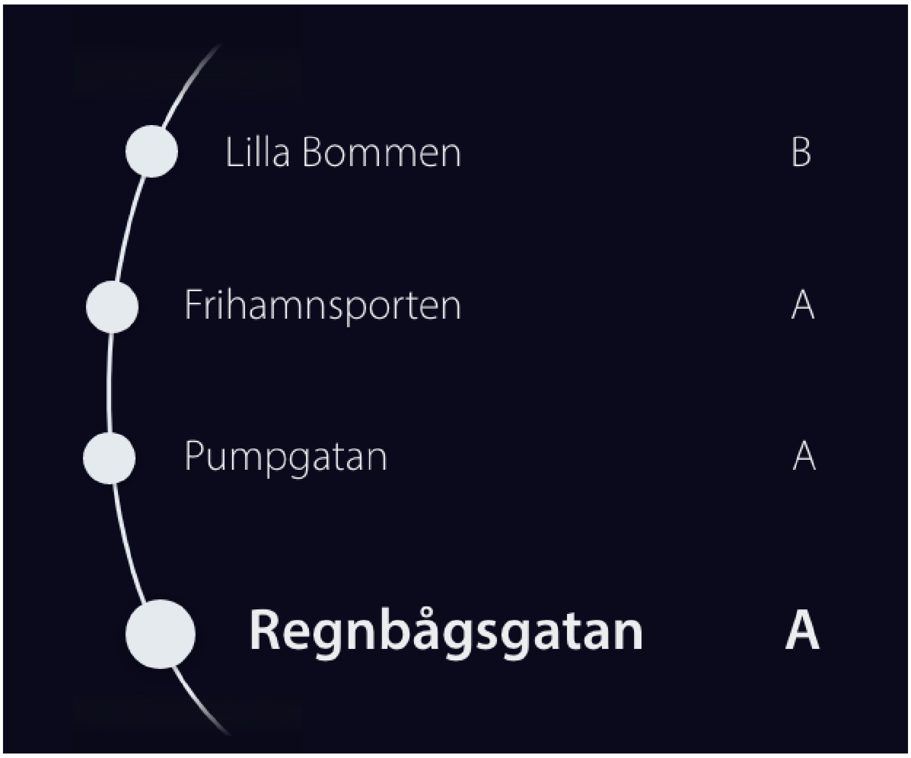

Figure 39: Hierarchy in the line guide

Another important aspect that makes it easier to find information is the *explicit* and *consistent* interaction, which also increases the *learnability* of MobiLity. A large part of the interaction with the interface is through the SmartInfo function, which is designed to be as simple to use as possible while maintaining the fact that the final decision lies with the human in the system.

Furthermore, many of the functions are executed similarly to each other, creating a good inner *consistency*.

7.4.3 Utilizing the medium's advantages

A touchscreen interface allows for many functions to be implemented and optimized to create intuitive and efficient interaction. Common touchscreen functions such as a keyboard popping up when filling in fields, or swiping up and down to scroll was implemented to allow for a *compatible* interaction in relation to other touchscreen interfaces. Scrollable lists in MobiLity have a scroll progress indicator to the side, as seen to the right in figure 40. For expandable fields an arrow will indicate interactivity, see the arrows on the orange background in figure 40. These two types of indicators increases MobiLity's *guessability, explicitness* and *compatibility*. However, the screens used in buses are typically less responsive than commercial tablets and smartphones. Because of this, more complicated interaction gestures such as e.g. pinching to zoom will not be implemented in MobiLity. Furthermore, having a digital interface allows data to be transferred between the functions in MobiLity, e.g. connecting the SmartInfo to the schedule, or connecting the energy-efficient driving to the sensors in the bus. The collection of data is what allows the SmartInfo to provide intuitive and easy interaction for the drivers, and this utilization of data can be seen as an *appropriate transfer of technology*.

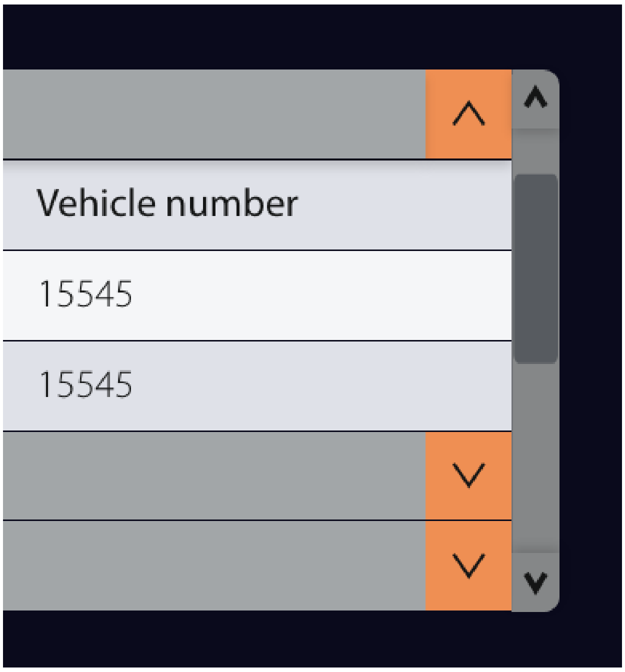

Figure 40: Scroll bar and expandability

7.4.4 Creating the experience

MobiLity was designed to fit into the context of being used for work while at the same time fit into the context of driving a bus. In order to achieve this, MobiLity utilizes common features used in car interiors and car interface design. The sense of professionalism is mainly communicated through the use of toned-down colors in combination with an orange accent color. The border of the information panel, see figure 41, was influenced by the curvature around the radio in a car interior to communicate the context of vehicles.

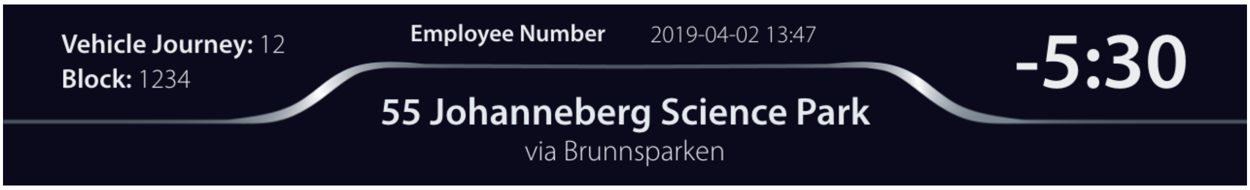

Figure 41: The top information panel

The SmartInfo should be perceived as helpful, and complement the driver's knowledge. The project group set a goal that MobiLity should be perceived as a helpful colleague, always willing to step up to help out. It was very important that MobiLity was not perceived as nagging or condescending. To produce this experience, the automated functions always give only relevant information for the situation, and they are phrased in such a way that the driver feels helped instead of told off. Another way to make the driver feel that they are the one in charge is to always give *feedback* regarding the performed actions. It is important to inform the driver of changes in the system as it improves their self-confidence, which then improves their user experience. Another example of making the driver feel confident is to always show the current vehicle journey and block, as well as the employee number, in the top information panel. This is to show that the drivers have logged in correctly and that MobiLity has the correct data. However, the driver should always feel safe, which is why it is the employee number instead of the name that is displayed in the information panel. It was pointed out in the second usability test that drivers may feel unsafe having their name visible in case of aggressive passengers, but employee numbers were seen as neutral and therefore safe to display.

The interface should also have a modern and contemporary look, and give the drivers that "little extra something". To express a modern look, the buttons have a flat color with a small shadow against the background to make them stand out and read as interactive. All buttons also have slightly rounded corners. To further create the experience of a thought through and coherent interface, the spacing between square-shaped elements and headings and elements are always the same.

The interactive prototype was also designed to enhance the user experience. Transitions and animations did not just switch flatly, but instead transitioned in various ways. These transitions are quick enough not to register consciously by the user, but are still readable as a motion. For example, between the GPS map navigation view and the bus stop view the information panel remains stationary, while the lower segment slides up and down between the transitions. More developed transitions gives the impression that all details have been thoroughly planned while giving a seamless experience. Some of these transitions were also made to accentuate that a change was made or to confirm that a result is up to date. An example of this is the indicator in the energy-efficient driving evaluation, which always starts from 0 and then moves up to the given score. This way, the driver can feel certain that this is their current score, and not something "stuck" from an earlier evaluation, thus, once again delivering *feedback* to the user.

7.5 Elements

The hardware that MobiLity has been designed to fit was provided by LTG Sweden AB, and can be seen pictured in figure 42. The resolution of the screen is 1280 x 800 pixels, and the screen size is 175 x 260 mm. The software in the actual solution will be based on the Android platform. As described in the demarcations, the scope of this project did not include coding a functional prototype. The actual interface will however require to be coded to be fully functional. The hardware must be able to withstand cold, humidity and vibrations since this is part of the environment where it will be used.

Figure 42: The hardware

8 Discussion

In this chapter, MobiLity will be discussed in relation to whether it fulfills the aims and objectives of the project. The project process, sustainability, ethics and further development will also be discussed.

8.1 Does the solution meet the aims and the objectives?

MobiLity can be argued to fulfill the aims and objectives described in the beginning of the thesis. Research of the current situation was done by conducting interviews and study visits around different locations in Sweden, as well as at different traffic environments such as urban, intercity and rural. Insights were made by looking at various aspects of the drivers' work day and interviewing the drivers about topics such as how they work, what problems they have, and what in the currently available solutions works well today. All of these insights were analyzed and used as a basis for ideation, which resulted in an interactive prototype that was evaluated together with drivers.

In the usability tests, MobiLity was confirmed to have relevant functionality, good usability and good user experience. The participating drivers gave positive feedback about the functionalities and their experience, and the error frequency was low in the tests. The relevant functionality was achieved by compiling and selecting the most relevant user needs from the background study. MobiLity simplifies the driver's work tasks by utilizing data from various sources such as sensors in the bus, the scheduling system and the traffic management. It creates suggestions which with a single click results in various relevant actions within the system. These suggestions save both time and cognitive resources compared to the current solutions, e.g. Västtrafik's iTID and Skånetrafiken's OBIS. The final solution also collects and connects many other tasks such as removing the need to log into several different systems, improving the energy-efficient driving system and controlling destination signs.

It can also be argued that MobiLity fits the Swedish public transport context, as the usability tests were conducted together with drivers from different traffic environments and the responses were in general positive for all participating drivers. However, it cannot be concluded that it fits every single driver in Sweden, since all drivers have their own needs and opinions on the current and upcoming technology. A total of 21 drivers participated in this study. Since participation was voluntary and conducted outside of working hours, the type of drivers that participated were typically of the more motivated kind. This may have impacted the result, as the solution may be more adapted towards the motivated drivers. However, during the usability tests and interviews the participating drivers also mentioned what they thought that other, less motivated, drivers would have thought. This input was also considered throughout the project. Since the final solution is designed to facilitate the driver's work tasks and alleviate the cognitive load as much as possible, it should fit even the more unmotivated drivers. Thus, it could still be argued that MobiLity meets the aims of the project.

Finally, it is also worth noting that MobiLity is a modular solution, connecting different functions such as e.g. the driver's schedule and data from passenger counter sensors. While it is not strictly necessary to implement all modules, MobiLity will be more effective the more of its functions are included, since the basic idea of MobiLity is to connect and utilize as much data as possible.

8.2 Discussing the project process

The project process followed a semi-structured design methodology with an iterative process consisting of two major iterations, where each iteration in turn consisted of several smaller iterations. The two major iterations of the project developed naturally. The first iteration focused on usability, functionality and finding solutions that facilitates the drivers' work tasks. When this was confirmed to be good in the first usability test, the second iteration focused more on the aesthetics and the experience. Focusing on the functionality first allowed for a smooth transition between the iterations, where the first iteration laid a solid foundation for developing the experience. Furthermore, working in iterations allowed the project group to evaluate and improve the concept for each iteration, creating a more thorough final design.

The methods used in the project were generally well-suited for gathering the intended data. The most difficult aspect throughout the project was to test the experience and the emotions of the drivers. This could partially be attributed to language barriers, as some of the drivers in the second usability test had a hard time understanding the questions related to emotions and experience and were not able to formulate their answers. However, these drivers did still explicitly express their more general thoughts during the usability test, which could be analyzed and used to draw conclusions from. It would have been possible to utilize methods relating to extracting emotions from interviewees such as Geneva Wheel of Emotions (Scherer, 2005), PrEmo (Desmet, 2003) and SAM (Lang, 1980). However, the project group decided against using these, as they were deemed to not fit the target group and the use context. Whether these methods would have elicited additional emotional responses or not is hard to determine.

8.3 MobiLity and sustainability

MobiLity can be argued to have a positive impact on sustainability, primarily the environmental and social aspects of it. The environmental aspects might be the more obvious of the two, as drivers will get feedback on their performance in the energy-efficient driving functionality and can use this as a tool to monitor and improve their driving. This decreases fuel emissions and wear on the bus. But the MobiLity interface also has the potential to improve public transport as a whole. The better and more punctual the public transport becomes, the more people will want to use it, which in turn decreases the amount of people travelling by themselves in cars. This will then lessen greenhouse gas emissions and pollution of the environment.

It can also be argued that the social aspects of sustainability will be improved. MobiLity creates a better work environment for the drivers, since many tasks can be performed easier and more efficiently. This decreases the stress and the cognitive load placed on the drivers, which improves the drivers' general well-being. Furthermore, redirections become safer as the drivers have support from MobiLity to navigate. The drivers can then navigate more calmly and go by safe routes, which should minimize the risk of accidents. This increases safety not only for the driver but also for the passengers and other road-users.

8.4 Ethical considerations

When it comes to MobiLity and ethical considerations there are three points of interest. The first aspect is the collection and storage of data, and the monitoring of drivers. Energy-efficient driving is a function that requires personal data to be stored and gathered. Today there are strict regulations on data storage regarding personal data, and monitoring has always been a sensitive topic. What is important in this case is to inform the drivers of what the data is used for, and that it does not have any implications on their integrity or their employment.

The second aspect of interest is that MobiLity may allow drivers that are not educated on a specific route to drive it, by providing them with the detailed GPS map navigation. From a safety perspective, the driver should always receive education regarding their route beforehand. MobiLity is meant to act as a support to the drivers, and not as a replacement to the education. It is therefore important that the public transportation operators act responsibly and makes sure to still educate their drivers, even if there is GPS navigation available, to ensure a safe journey.

The final ethical aspect is the optional possibility for a driver to compare themselves to other drivers in the energy-efficient driving function. This was found to be a bit of a sensitive topic for some drivers, and was therefore remade to be an optional functionality. This way, only those who want to compare themselves to others will be able to do so.

8.5 Further development

The natural next step in the development process of MobiLity would be to construct a properly coded prototype. This could then be used for testing in an actual bus in real line traffic. This prototype could then be used to verify that the results found in the usability tests conducted in this project are valid in an actual traffic environment. This prototype could also be used to test the usability and user experience after prolonged use, to see if it would change or not.

As mentioned in the demarcations, this project did not focus on the ticket sales machine, but it would be possible to integrate this functionality into MobiLity. This would decrease the amount of time and effort it takes to log in and out of different systems during a driver change. As mentioned in chapter 1.4 Demarcations, the ticket sales systems varies much between different regions and it would be difficult to make a general solution that would fit all. It would however be possible for MobiLity to be compatible with third party solutions, where each public transport authority could develop their own app for ticket sales fitting their own system. This app could then be added to MobiLity. It would however be important that these third-party solutions would be developed with MobiLity in mind so that they fit well with both the way MobiLity is used and the way it looks to not detract from the overall usability and user experience.

9 Conclusions

The driver's work tasks and work environment are complex, and it is therefore extra important that an interface that is used in such a context is easy to use and understand. The interface should provide the driver with all the functions that they need in their daily work, in such a way that it facilitates and simplifies their work tasks.

The technology should be designed to decrease the cognitive load on the drivers. There is great potential in connecting sensors and systems that exists today, and use the information they provide to simplify the driver's work tasks.

The human in the system should always make the final decision, as the traffic context is complex. The automated part of the systems should be used to support the drivers through suggestions, but it should be the drivers that makes the final decisions due to their expertise and experience.

MobiLity stands out from the other currently available solutions, since it is the only one that is clearly based on the drivers' needs. Since the drivers work in a very domain specific context, only they will know how the functions are actually used. To base MobiLity on their input therefore created a unique solution that is placed far ahead of competing solutions in terms of both usability and user experience.

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Appendices

Appendix I: The interview guide used in the needfinding stage

For Gothenburg:

Hello!
We are Rebecka and Markus, and we are last year students from the Technical Design program at Chalmers. It's an engineering education for product design, where the focus lies on the user's needs, and we therefore always want to interview actual users to get input in the projects we do. All opinions found in the study will be anonymous. This project is our master's thesis, and it is about technology that bus drivers use during their work day, for instance iTID and Rakel, and how this technology potentially could be improved.

It is the technology that we evaluate and not you! We hope that it is OK that we record the audio in this interview, to be able to remember it better. And you will get coffee as thanks for your help!

We start with some initial questions:

- What is your name?
- How old are you?
- For how long have you been working as a bus driver?
- What kind of education have you been taking to become a bus driver?
    - Did you get any specific education relating to the technology in the buses you drive right now, or did you teach yourself after you started?
- Which line do you typically drive? Always the same or different?
    - If different: Is it difficult to remember the way?
    - Does the technology in the bus differ between different lines?
- Have you worked as a bus driver for other companies or in other cities?
    - If yes: did it differ from driving here?
- What would you say are the most important traits for a bus driver?
    - Good at handling stress etc… Why is it an important trait?
- Are there any specific rules about how much you are allowed to interact with technology while you are driving?
    - Talk in the phone/handsfree, interact with the buttons on the instrument panel etc?

Let's get into the more specific questions regarding your daily work:

- Please describe your usual work shift. If we divide it, please start with describing your work tasks at:
    - The start of the day
        - (they tell first, we then ask the questions)
        - The first thing when you get in the bus: do you manually put in block number or is it automatic in iTID?

- While you drive
  - (they tell first, we then ask the questions)
  - When someone has pressed the stop button, where do you see that?
    - Big indication lamp, small yellow symbol in the bus button in iTID, the small yellow indicator in the line guide or the indication on the instrument panel?
  - Open/close the doors: What do you look for, and where? (rear view mirror, door camera screens?)
  - What different factors do you keep in mind while driving? Time in relation to schedule, traffic congestions etc?
  - Prioritization:
    - What do you prioritize when driving? (time in relation to schedule, energy-efficient driving, driving softly…)
    - How do you learn to prioritize these things?
      - Does it differ how you drive in reality to how you "should" be driving?
- End of the day/when you have finished driving

We would now like to ask you a bit about the technology that you have by your driver seat.

- Could you describe in general terms what kind of technology is there? Buttons, lamps, screens…
  - Generally about the different things: iTID, door cameras, speedometer, buttons to open/close the doors, tachograph… Everything you use during your work day!
  - Is something especially difficult to understand and use?
    - Why/why not?
  - Is something especially easy to understand and use?
    - Why/why not?

We have also looked deeper into the iTID system, since many of the functions are collected there, so here comes some questions regarding that:

- How do you feel in general regarding iTID?
  - What works well?
  - What works less well?
  - Do you see the whole screen from where you sit? Is the readability good, can you read everything that is on the screen?
  - Are you able to reach it when you want to change settings? (including the setting buttons below the screen)
  - Is the button size good?
  - How often do you need to manually calibrate the GPS function?
    - Have you ever needed to change signs manually?

Then there's some general questions about communication between you and various recipients.

- Contacting traffic management:

    - How is it done?
        - Rakel/other way? Keyboard shortcut in Rakel?
    - What type of info do you give to/get from the traffic manager?
    - How often are you in contact with the traffic management? Every day or more seldom?

- Contact with passengers:
    - Internal/external speakers: sake microphone or different?
    - How often do you do announcements?

- Contact with other bus drivers:
    - Does it happen?
        - If yes: how do you contact them? Through iTID? Rakel?
        - If no: Do you feel a need for it? Would you like to be able to send messages or call them? For e.g. connections?

Then we have some general, shorter questions about the technology in general in the bus.

- Bus camera (if applicable): When you close the door, do you look mostly in the camera screen, rear view mirror or both at the same time?
- Do you listen to the radio while driving?
- Where is the radio placed in the bus that you most frequently drive?
    - If it's hard to reach, is that bad or is it good so that people don't interact with it while driving?
- What is still done manually?
    - E.g. the buttons placed on the instrument panel…
- Are there any technical systems that you use at the same time as you're driving?
    - E.g. the buttons placed on the instrument panel, Rakel…
- Is there any function in iTID (or other, e.g. Rakel) that you would like to access while you are driving?

Lastly, we have a bit of an open question:
- Is it something that you feel is missing that would facilitate your work?
    - Please think freely! It can be totally crazy ideas!

That was the questions that we had for you! Thank you very much!

For Malmö:

Hello!
We are Rebecka and Markus, and we are last year students from the Technical Design programme at Chalmers. It's an engineering education for product design, where the focus lies on the user's needs, and we therefore always want to interview actual users to get input in the projects we do. All opinions found in the study will be anonymous. This project is our master's

thesis, and it is about technology that bus drivers use during their work day, for instance OBIS, and how this technology potentially could be improved.

It is the technology that we evaluate and not you! We hope that it is OK that we record the audio in this interview, to be able to remember it better. And you will get coffee as thanks for your help!

We start with some initial questions:

- What is your name?
- How old are you?
- For how long have you been working as a bus driver?
- What kind of education have you been taking to become a bus driver?
    - Did you get any specific education relating to the technology in the buses you drive right now, or did you teach yourself after you started?
    - Do you have some sort of brochure about the technology that we might look at?
- Which line do you typically drive? What kind of traffic situation is that; rural, urban..? Always the same or different?
    - If different: Is it difficult to remember the way?
    - Does the technology in the bus differ between different lines?
- Have you worked as a bus driver for other companies or in other cities?
    - If yes: did it differ from driving here?
- What would you say are the most important traits for a bus driver?
    - Good at handling stress etc… Why is it an important trait?
- Are there any specific rules about how much you are allowed to interact with technology while you are driving?
    - Talk in the phone/handsfree, interact with the buttons on the instrument panel etc? The OBIS system?

Let's get into the more specific questions regarding your daily work:

- Please describe your usual work shift.If we divide it, please start with describing your work tasks at:
    - The start of the day
        - (they tell first, we then ask the questions)
        - The first thing when you get in the bus: do you manually put in block number or is it automatic in iTID?
    - While you drive
        - (they tell first, we then ask the questions)
        - When someone has pressed the stop button, where do you see that?
            - What kind of indicators do you have available?
        - Open/close the doors: What do you look for, and where? (rear view mirror, door camera screens?)
        - What different factors do you keep in mind while driving? Time in relation to schedule, traffic congestions etc?
            - How to you get to know timing in relation to schedule? Do you get automatic notifications on e.g. congestion?

        - Prioritization:
            - What do you prioritize when driving? (time in relation to schedule, energy-efficient driving, driving softly…)
            - How do you learn to prioritize these things?
                - Does it differ how you drive in reality to how you "should" be driving?
    - End of the day/when you have finished driving

We would now like to ask you a bit about the technology that you have by your driver seat.

- Could you describe in general terms what kind of technology is there? Buttons, lamps, screens, on-board computer?
    - Generally about the different things: on-board computer, door cameras, speedometer, buttons to open/close the doors, tachograph… Everything you use during your work day!
    - What is manual? What is automatic?
    - Is something especially difficult to understand and use?
        - Why/why not?
    - Is something especially easy to understand and use?
        - Why/why not?
    - Do you see the whole screen from where you sit? Is the readability good, can you read everything that is on the screen?
    - Are you able to reach it when you want to change settings?
    - Is the button size good?
    - How often do you need to manually calibrate the GPS function?
        - Have you ever needed to change signs manually?
    - Do you have GPS functions in your systems?
        - Do you get any help from the GPS, e.g. support for where to drive? (maps etc)
    - Does it happen that the GPs loses its position and you have to fill in things manually?
        - Have you ever had to change signs manually?
    - Do you have door cameras by the doors?
        - If yes: When you close the door, do you look mostly in the camera screen, rear view mirror or both at the same time?
    - Do you listen to the radio while driving?
        - Where is the radio placed in the bus that you most frequently drive?
            - If it's hard to reach, is that bad or is it good so that people don't interact with it while driving?
    - Do you feel like you know what all your equipment do?
    - Are there functionality in some of the technical systems that you tend to use while you are driving?
        - Are there any functions(s) that you would like to be able to access while driving?

Then there's some general questions about communication between you and various recipients.

- Contacting traffic management:
    - How is it done?
        - Rakel/other way? Keyboard shortcut in Rakel?
    - What type of info do you give to/get from the traffic manager?
    - How often are you in contact with the traffic management? Every day or more seldom?

- Contact with passengers:
    - Internal/external speakers: sake microphone or different?
    - How often do you do announcements?

- Contact with other bus drivers:
    - Does it happen?
        - If yes: how do you contact them? Through OBIS? Rakel?
        - If no: Do you feel a need for it? Would you like to be able to send messages or call them? For e.g. connections?

Lastly, we have a bit of an open question:

- Is it something that you feel is missing that would facilitate your work?
    - Please think freely! It can be totally crazy ideas!

That was the questions that we had for you! Thank you very much!

For Kristinehamn:

Hello!
We are Rebecka and Markus, and we are last year students from the Technical Design programme at Chalmers. It's an engineering education for product design, where the focus lies on the user's needs, and we therefore always want to interview actual users to get input in the projects we do. All opinions found in the study will be anonymous. This project is our master's thesis, and it is about technology that bus drivers use during their work day, and how this technology potentially could be improved.

It is the technology that we evaluate and not you! We hope that it is OK that we record the audio in this interview, to be able to remember it better. And you will get coffee as thanks for your help!

We start with some initial questions:

- What is your name?
- How old are you?
- For how long have you been working as a bus driver?
- What kind of education have you been taking to become a bus driver?
    - Did you get any specific education relating to the technology in the buses you drive right now, or did you teach yourself after you started?

        - Do you have some sort of brochure about the technology that we might look at?
    - Which line do you typically drive? What kind of traffic situation is that; rural, urban..? Always the same or different?
        - If different: Is it difficult to remember the way?
        - Does the technology in the bus differ between different lines?
    - Have you worked as a bus driver for other companies or in other cities?
        - If yes: did it differ from driving here?
    - What would you say are the most important traits for a bus driver?
        - Good at handling stress etc… Why is it an important trait?
    - Are there any specific rules about how much you are allowed to interact with technology while you are driving?
        - Talk in the phone/handsfree, interact with the buttons on the instrument panel etc? The OBIS system?

We would now like to ask you a bit about the technology that you have by your driver seat.

- Could you describe in general terms what kind of technology is there? Buttons, lamps, screens, on-board computer?
    - Generally about the different things: on-board computer, door cameras, speedometer, buttons to open/close the doors, tachograph… Everything you use during your work day!

Let's get into the more specific questions regarding your daily work:

- Please describe your usual work shift.If we divide it, please start with describing your work tasks at:
    - The start of the day
        - (they tell first, we then ask the questions)
        - The first thing when you get in the bus: do you manually put in block number or is it automatic in iTID?
    - While you drive
        - (they tell first, we then ask the questions)
        - When someone has pressed the stop button, where do you see that?
            - What kind of indicators do you have available?
        - Open/close the doors: What do you look for, and where? (rear view mirror, door camera screens?)
        - What different factors do you keep in mind while driving? Time in relation to schedule, traffic congestions etc?
            - How to you get to know timing in relation to schedule? Do you get automatic notifications on e.g. congestion?
        - Prioritization:
            - What do you prioritize when driving? (time in relation to schedule, energy-efficient driving, driving softly…)
            - How do you learn to prioritize these things?
                - Does it differ how you drive in reality to how you "should" be driving?
    - End of the day/when you have finished driving

Let's talk more about the technology by the driver seat:

  - What is manual? What is automatic?
  - Is something especially difficult to understand and use?
    - Why/why not?
  - Is something especially easy to understand and use?
    - Why/why not?
  - Do you see the whole screen from where you sit? Is the readability good, can you read everything that is on the screen?
  - Are you able to reach it when you want to change settings?
  - Is the button size good?
  - How often do you need to manually calibrate the GPS function?
    - Have you ever needed to change signs manually?
  - Do you have GPS functions in your systems?
    - Do you get any help from the GPS, e.g. support for where to drive? (maps etc)
  - Does it happen that the GPs loses its position and you have to fill in things manually?
    - Have you ever had to change signs manually?
  - Do you have door cameras by the doors?
    - If yes: When you close the door, do you look mostly in the camera screen, rear view mirror or both at the same time?
  - Do you listen to the radio while driving?
    - Where is the radio placed in the bus that you most frequently drive?
      - If it's hard to reach, is that bad or is it good so that people don't interact with it while driving?
  - Do you feel like you know what all your equipment do?
  - Are there functionality in some of the technical systems that you tend to use while you are driving?
    - Are there any functions(s) that you would like to be able to access while driving?

Then there's some general questions about communication between you and various recipients.

- Contacting traffic management:
  - How is it done?
    - Rakel/other way? Keyboard shortcut in Rakel?
  - What type of info do you give to/get from the traffic manager?
  - How often are you in contact with the traffic management? Every day or more seldom?

- Contact with passengers:
  - Internal/external speakers: sake microphone or different?
  - How often do you do announcements?

- Contact with other bus drivers:
    - Does it happen?
        - If yes: how do you contact them? Through OBIS? Rakel?
        - If no: Do you feel a need for it? Would you like to be able to send messages or call them? For e.g. connections?

Lastly, we have a bit of an open question:

- Is it something that you feel is missing that would facilitate your work?
    - Please think freely! It can be totally crazy ideas!

That was the questions that we had for you! Thank you very much!

Appendix II: Benchmarking current and upcoming technologies

In this benchmarking, the systems used today and upcoming technologies will be described.

iTID

iTID is the on-board computer used by the public transport authority Västtrafik and was developed by Consat. The main screen consists of a line guide, relation to the timetable (as a number MM:SS and a red-green vertical scale), information centre, day/night/tunnel mode, connection with other buses, manual control of signs, menu button and traffic related information; block, vehicle journey, line, destination, date (YYYY-MM-DD) and time (HH:MM:SS).

A lot of the functions on the main screen can also be found in the menu button (the bus shaped button). Under the menu button there are also additional functions such as settings for the volume for the interior and exterior speakers and diagnostics. Diagnostics can however only be accessed by technicians. Visual indicators can be found on the menu button. Examples of such indicators are; warning for faulty systems within the bus, priority signals, stop signs and the status of whether the doors are open or not.

Furthermore, there are other buttons in the interface which changes appearance depending on certain factors. One of these is the controls of the signs, which shows the active exterior sign, in the figure down below, it shows ”Ej i trafik” (“not in traffic”) for example. Other examples are the messaging function and the connections with other buses. The message button lights up when there is a message. Connections with other buses shows which lines the driver have requests from, and which lines the driver have requested. For each request there is also a status indicator of whether the request have been accepted or not.

A driver does not normally interact with iTID and the interface is locked when driving. It’s position in the bus depends on the bus model and the public transport operator, but is generally placed in proximity to the ticket machine.

The iTID interface

OBIS

The on-board computer used by the public transport authority Skånetrafiken was developed by Fältcom and Sweco. It is an app based solution where the user can switch between apps depending on their current need. The standard apps which all of Skånetrafiken's operators use are the communication system VOIP (verbal and written messages) and the OBIS app itself, see the figure below, which includes line guide, manual sign control and relation to the timetable. In Lund, Nettbuss uses a third app in the on-board computer for coordination between buses.

The line guide displays the two upcoming bus stops, the end station and the previous station. Each station's location is displayed and the distance to the next station is also displayed. In the main menu the driver can control the signs, change light and audio settings, and update the GPS position for the line guide. In order for the signs and line guide to work properly the driver inserts the block number before departing.

The OBIS interface

Värmlandstrafiken's ticket machine

In Kristinehamn there is no on-board computer used today. On the other hand, the ticket machine acts as a line guide for the bus drivers. In this ticket machine the driver has to manually enter the line number as well as the vehicle journey number at each final station. Signs are done manually for intercity routes, but for city routes it follows the block number, i.e. no need to change at each final station.

When going onboard, or during a driver change, the drivers have to manually log in and out of the ticket machine. They log out by registering their specialized card at the ticket machine and then enter their password. This is similar to how it was done at other ticket machine systems in Sweden, for example Västtrafik and Skånetrafiken.

Upcoming on-board computers

Various concepts of upcoming on-board computers have been analyzed but cannot be described here due to confidentiality. However, MultiQ has developed an on-board computer (or as they call it, DCU). The functionality in MultiQ is about the same as iTID and OBIS. It allows you to change signs, send messages and get an overview of the line guide. The difference between MultiQ and the current solutions is that MultiQ has a more modern design.

Energy-efficient driving

Energy-efficient driving, or eco driving as it is also known as, is a way to drive a vehicle so that the fuel consumption is minimized. As such, the fuel cost is reduced as well as being beneficial to the environment. Driving energy-efficiently also increases the comfort of the passengers. The most common factors of measurement are fuel consumption, harsh braking and idling.

Examples of systems used in buses today that promotes energy-efficient driving are "Den gröna resan", developed and used by Nobina, SMART used by Transdev in Malmö, and Sparsam körning, developed by Vehco and used by Keolis in Gothenburg. These typically have a screen of their own. There is also the alternative that the fuel consumption is measured but not displayed to the driver and is only accessible to the fleet management, as it is done by Göteborg Spårvägar Buss in Gothenburg. Finally, there is also an option to measure the fuel consumption but have it accessible to the drivers only remotely by computer, after the drive is done, as is done by Nettbuss in Lund.

Appendix III: Use cases

The use cases used in this project are the ones which have been used during the usability tests and consists of four different scenarios. (1) When everything goes as planned + driver change, (2) Communication with the traffic managers, (3) Receiving redirections from the traffic managers and (4) Connections with other drivers. These four use cases were used to create the most essential interaction flows.

When everything goes as planned + driver change

In this use case the driver has no immediate issues and the journey through the route goes as planned.The driver starts their day at the bus' parking point where the driver fetches the bus which is planned to be used for the driver's first block. The exception to this is when the driver starts their shift at a driver change. After that the driver will go along their designated route, pick up and drop off passengers until they reach the end of the route. Repeating this until it is time to change drivers.

The primary actor for this use case is the driver and the passengers are the secondary actors. The goal of the driver is to transport passengers safely along the route and if possible have as minimal difference in relation to the timetable as possible. Drivers need information of the current traffic situation and how they relate to the timetable when driving.

Communication with the traffic managers

In this use case the driver will have to communicate with the traffic managers regarding a full bus and a traffic disturbance, i.e. vehicle issues, queueing, accidents among other disturbances. After a lot of passengers have boarded the bus the driver needs to change the exterior signs to full bus and send a message to the traffic managers about this. When a few stations have passed there is a congestion ahead and the driver is forced to wait. The driver needs to inform the traffic managers about this congestion in order to allow other drivers to avoid the congestion if possible.

The primary actor for this use case is the driver, the traffic managers and passengers are the secondary actors. Drivers requires the information from their surroundings and how this might affect them on their route. The goal for the drivers and traffic managers is to keep the situation at control and minimize delays and inconveniences for the passengers.

Receiving redirections from the traffic managers

In this use case the driver will be informed from the traffic managers about a redirection needed as a traffic disturbance have occurred further along the driver's route. The driver has to confirm that the information has been received and then drive according to the redirections.

The primary actor is the driver with the traffic managers being the secondary actor. Drivers require this information in order to transport the passengers safely and minimizing inconveniences.

Connections with other drivers

In this use case the driver is late and therefore requests another bus to wait for them in order to allow passengers to switch between the buses. The driver will continue driving after sending the request and will then receive a request from another driver which needs to be confirmed.

The primary actor is the driver and the secondary actors are the other drivers and passengers. In order for a driver to send a request the driver needs to know how late they are and how the other drivers relates to the timetable. The goal is to allow passengers to switch between the buses and minimize their waiting time.

Appendix IV: Personas

In the following paragraphs, the three personas created and used in the project will be described.

Yussuf
Yussuf is 49 years old and immigrated to Sweden 22 years ago. He has worked as a bus driver since he was 23 years old, and he is very passionate about his job. He is currently driving the city busses in Malmö. Yussuf is interested in technology and environmental sustainability, and likes to check out the latest tech. He likes the eco-driving interface since he wants to drive in an environmentally sustainable way, and to get to see the results makes him feel likes he gets proof of his hard work. Yussuf is a soft-spoken and calm person. He is skilled at speaking Swedish, but he is a bit uncomfortable speaking in front of a crowd. Therefore, the only part of his job that he does not love is to make announcements in the inner speakers to the passengers since it makes him self-conscious.

Erik
Erik is 36 years old, and got the training to become a bus driver via Arbetsförmedlingen's employment service after many years of unemployment. He is not particularly fond of his job, but he likes it well enough and is not motivated enough to look for something else. He is therefore not prepared to go the extra mile when it comes to deepen his understanding of the available technology in the bus. He hates the energy-efficient driving interface, since it makes him stressed. He feels that it is more important for him to be on schedule than to drive energy-efficient, and that factors such as aggressive cyclists and the traffic situation are the major factors to the results - not his skills. This makes him even more unmotivated to even try to get good results. Today, Erik is driving busses in the Gothenburg area.

Vivianne
Vivianne is 51 years old and has driven busses all her working life. She currently drives busses in and around the small city of Filipstad. She loves interacting with her passengers, and often makes announcements in the inner speakers about the weather or other fun topics. She needs to be able to contact other bus drivers, since the density of buses are not very good in the area and there is a waiting agreement between most of the buses she drives. She also needs to be able to contact the traffic management, but she gets tired of the constant announcements about moose walking in the middle of the road in areas far from where she is currently driving since the traffic management is responsible for a very big area.

Appendix V: Interview guide for usability test 1

Hello!
We are Rebecka and Markus, and we are final year students from the Technical Design programme at Chalmers. It's an engineering education for product design, where the focus lies on the user's needs, and we therefore always want to interview actual users to get input in the projects we do. All opinions found in the study will be anonymous. This project is our master's thesis, and it is about technology that bus drivers use during their work day, and we have developed an interface - kind of like the iTID system.We need your help to evaluate if this system is good or not. This interface is a result of interviews and observations of bus drivers. What we have tried to create is an interface that is easily understood and that gives you a good experience.

You will first get an overview of how the system is constructed, and then you will get to interact with it. This is just a prototype, and because of that you may not be able to do all the things that you would be able to do in the finished system. The final result will be on a screen that looks like this one. As you can see, there is a steering wheel and we will also run a movie on the computer to make you feel like you are in an actual driving situation.

Please think aloud about what you are thinking and feeling! It is the technology that we evaluate and not you! We hope that it is OK that we record the audio in this interview, to be able to remember it better. And you will get coffee as thanks for your help!

We start with some initial questions:

- What is your name?
- How old are you?
- For how long have you been working as a bus driver?
- Which line do you typically drive? Always the same or different? Worked for other bus companies?
    - Urban or rural routes?

Let's look at the interface! First, let's look at the two views that will be shown when you are driving the bus. When the bus is in motion, you will see a GPS map view, where the line you drive will be marked in blue, and the box in the top right corner shows your time in relation to the schedule. When you stop at a bus stop, you will see another view. Here, you will see the line guide and eventual messages. We will look further into the message function later! What are your spontaneous thoughts about dividing the information up like this?

We will try 3 different scenarios. Before we do that, you will get to see what different functionalities there are and how it looks like.

- Menus and settings.
  - First step - log in. Your employee number is 1234 and your pin is 456.
    - How certain are you that you did it correctly? Why?
    - Was something difficult?
  - Next step. Normally, the block, vehicle journey and line number be connected to your employee number and they would have loaded automatically. But, something in the system went wrong and you will need to input these manually. Your numbers are: B: 1234, L: 55, VJ: 12
    - How certain are you that you did it correctly? Why?
  - You have now input the numbers for your current route. We will quickly look into the different functions in the interface. Let's start with the settings. At first glance, what do you think you can do in these two sub-menus?
    - Sound - was it like you thought? Do you understand how to change the sound? Is it easy to understand?
    - Screen - was it like you thought? Do you understand how to change the sound? Is it easy to understand?
  - Let's look at the schedule function. Is that something that you think is useful to have in this interface? Is is some specific information that you think would be good to have in the schedule? Something that is here today that is not needed?
  - Let's look at manual sign control. As you can see, it is quite similar to iTID. Could you set a special sign - not in traffic?
  - Can you manually change the GPS position to Lindholmen?
  - Energy-efficient driving. We think that energy-efficient driving is a functionality that is good for both the environment and the passenger's experience. But we have come to understand that it is frustrating the way it works today since it does not take into account many of the things that happens in traffic such as bicyclists, walking people and other road users that may cut in front of the bus. The thought behind this concept is to measure during a whole day how smoothly you drive. It will then take into consideration the background conditions and not punish you for avoiding bikes etc. What is your opinion on such an approach to energy-efficient driving?
  - In general, are the functions here that you imagined?

    - Something that's lacking that is important to your work?
    - Something that was included that you appreciated?

- Scenario 1: The route goes as planned. In this scenario the bus is going along the route as planned. You will see what the screen looks like when you drive. Since we are not in a real bus, we have to pretend that you have now stepped on the gas pedal. (click on the screen)
    - When you are in motion, you can see that you have a GPS map navigation, where you will see your position and which stops are upcoming next. When we have stopped at the bus stop, the view changes to the line guide and messages view.
    - (driver change appears) Do you have any opinions about this screen?
    - It is now time for a driver change. To prepare for the new driver, it is time to log out. Please log out of the interface.
    - As you saw, the energy-efficient driving functionality popped up quickly. What is your opinion about that?
    - How certain are you that you logged out correctly? Why?
    - Do you think that this will take too much time when it is time for a driver change?

- Scenario 2: messages. It is time to test the message functionality in the system, that we have called SmartInfo. The information shown is either from the traffic management, or it has been automatically generated by the system, through e.g. using sensors that count the number of passengers that has boarded the bus. Let's start by pressing the gas pedal again. There are many passengers on the bus currently, since many passengers boarded the bus ta the last stop.
    - Your task is to tell the traffic management that the bus is full.
        - How certain are you that you did it correctly? Why?
        - How did it feel like to get such a message and choice? Is it helpful or annoying?
    - Your task is to change the exterior destination signs to "Full bus"
        - How certain are you that you did it correctly? Why?
        - Did it feel good to change signs in this way?
        - Is it good that you are able to revert the signs yourself?
    - We continue the ride. You see that it will soon be traffic congestions and want to tell the traffic management. Your next task is therefore to tell the traffic management about the congestion.
        - How certain are you that you did it correctly? Why?
        - How did it feel like to send messages in this way? Practical or laborious?
    - And now that you have sent this message, we are done with this scenario.
        - What are your thoughts in general about these two different kinds of messages?
        - Do you think it is relevant to change the exterior signs in this way?

- Scenario 3: traffic reroute. In this scenario we will see what happens when a traffic reroute is happening due to traffic congestion.

- We start going. As before, everything is as it should.
- (reroute message appear in the GPS map view) Did you see that you got a message regarding traffic congestion in the GPS map view?
    - What did you think about that message?
    - Did you see it well? Did it give relevant information? Do you think that it is easy or difficult to miss?
- (reroute message appear in the line guide view) Did you see that you have a message about traffic congestion in the line guide view?
    - What did you think about that message?
    - Did you see it well? Did it give relevant information? Do you think that it is easy or difficult to miss?
- Confirm the route change!
    - How certain are you that you did it correctly? Why?
    - Is it relevant that the announcements and the destination signs are changed by the system?
    - Is it relevant that it is the driver's responsibility to revert back to the actual information?
- (The new route appears in the GPS map view). How do you feel about receiving information about the reroute in this way?
    - Can you see any pros or cons with receiving information in this way compared to how it is today?
    - Do you like to get the information right in the GPS view?
    - Is there any other way that you would like to get the information?
    - Do you think that it is relevant to still get to see the actual route in grey?
        - If yes, is it a good color or should it stand out less/more?

That was the test, thank you very much for your participation!

Appendix VI: Benchmarking car interfaces

In this benchmarking of car interfaces, functions included in car interfaces were investigated. What functions are common and how they are integrated into the car. There was no selection criteria when finding functions.

The most typical function found in car interfaces was the GPS-navigation. This navigation could include various features such as voice instructions, picture depicting on what lane and how one should drive and text based instructions found in the top.

Other common functions are the integration of a microphone which allows the driver to talk without picking up their phone. This is often combined with the possibility to connect ones smartphone to the car through an AUX cable or via bluetooth. Android and Apple have also created their own interfaces where one can use some of the apps on ones smartphone. Examples of such apps are music, messages, calls etc. There are also products which allows the phone to be mounted close to the radio in order for easier access.

In some cars there have been functions related to eco driving. These are either placed in the interface or in the instrument panel. If eco driving is placed in the interface it normally allow access to more detailed information while the instrument panel shows their driving performance in a more simple way.

Appendix VII: Design format analysis LTG Sweden

In order to better communicate the LTG Sweden brand a design format analysis was done based on their website and a web application produced by LTG Sweden AB. Common characteristics was written down and compiled.

Characteristics of LTG Sweden website
LTG Sweden's website uses a color palette with grays and whites for background elements, and blue and orange for accent colors.

For typography LTG Sweden uses san-serif fonts for both headers and body text. The headers are larger and have dark blue color with regular style. The color for the body text varies, it is white when placed on a background with an accent color and a dark color when placed on a neutral background (white or gray). See figure below for what colors are used.

There are no bodies for the buttons, it only consists of a text label. In some cases there are expandable symbols, and these expandable elements uses either arrows or a + / - as a symbol. Lastly, buttons have no 3D effects or any drop shadows.

Characteristics of LTG Sweden's web application
The application uses a dark background and a wide variety of accent colors. The accent colors are used for grouping content. There is however, one primary accent color (green) used for some interactive buttons.

For typography the application uses san-serif fonts with gray and white color. There are slight differences in size between the text elements. However, there are no clear distinction or use of headers.

Squares and lines are frequently used for buttons or to separate content. A signature shape is the square with a faceted corner used for each category. Corners are slightly rounded. Buttons and text are flat with no drop shadows. In lists, the application uses a toned shadow to signalize that the list is scrollable.

Appendix VIII: Interview guide for usability test 2

Hello!
We are Rebecka and Markus, and we are final year students from the Technical Design programme at Chalmers. It's an engineering education for product design, where the focus lies on the user's needs, and we therefore always want to interview actual users to get input in the projects we do. All opinions found in the study will be anonymous. This project is our master's thesis, and it is about technology that bus drivers use during their work day, and we have developed an interface - kind of like the iTID system.We need your help to evaluate if this system is good or not. This interface is a result of interviews and observations of bus drivers. What we have tried to create is an interface that is easily understood and that gives you a good experience.

This is the second version that we are testing. In the test of the first version, the focus was on which functions are relevant to include and how they should be used. In this test, we would also like you to focus on the experience. It's more about the aesthetics, how it looks like and how it feels like to interact with the interface. This may sound a bit imprecise, but it is an important factor in using a product and we therefore need your help in evaluating it!

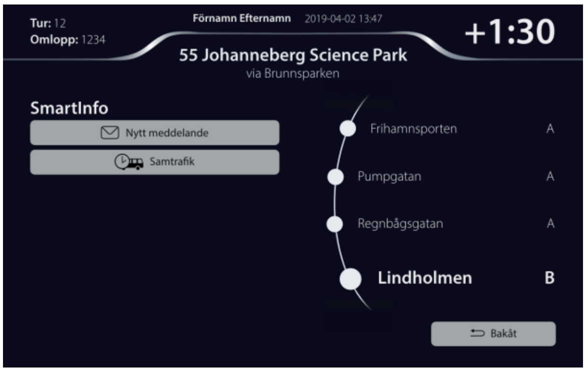
You will first get an overview of how the system is constructed, and then you will get to interact with it. This is just a prototype, and because of that you may not be able to do all the things that you would be able to do in the finished system. We will also play some sounds sometimes, and the idea is that these sounds should come from the interface. Unfortunately, it did not work out to make it sound from the screen, which is why we play them separately.

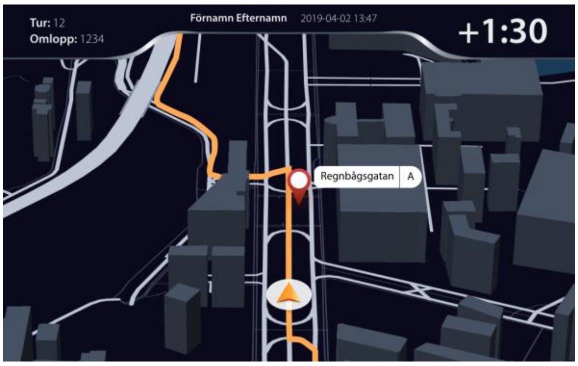
After you have gotten to test to use the interface, we will ask you some questions and ask you to tell us how you felt using it. There are no right or wrong answers when it comes to these things, so please just try to think about how you felt! It is the technology that we evaluate and not you! We hope that it is OK that we record the audio in this interview, to be able to remember it better. And you will get coffee as thanks for your help!

We start with some initial questions:

- What is your name?
- How old are you?
- For how long have you been working as a bus driver?
- Which line do you typically drive? Always the same or different? Worked for other bus companies?
    - Urban or rural routes?

Let's look at the interface! First, let's look at the two views that will be shown when you are driving the bus. When the bus is in motion, you will see a GPS map view, where the line you drive will be marked in blue, and the box in the top right corner shows your time in relation to the schedule. When you stop at a bus stop, you will see another view. Here, you will see the line guide and eventual messages. We will look further into the message function later! What are your spontaneous thoughts about dividing the information up like this?





We will try 3 different scenarios. Before we do that, you will get to see what different functionalities there are and how it looks like.

- Menus and settings.
    - First step set block number. Normally, the block, vehicle journey and line number be connected to your employee number and they would have loaded automatically. But, something in the system went wrong and you will need to input these manually. Your numbers are: B: 1234
        - How did it feel to do this?
    - You have now input the numbers for your current route. We will quickly look into the different functions in the interface. Let's start with the settings. At first glance, what do you think you can do in these two sub-menus?
        - Sound - was it like you thought?
        - Screen - was it like you thought?
    - Let's look at the schedule function. Can you control check that the block that you input is the same as in the schedule?
    - Let's look at manual sign control. Could you set a special sign - not in traffic? How did it feel like to change the sign?
    - Can you manually change the GPS position to Chalmers tvärgata? Thoughts and opinions?
    - Energy-efficient driving. It works slightly different in this system compared to how it is today. If you want more information about what and how it measures, where would you click? (hint if they do not find it: i-symbol). How did it feel like to be compared to other drivers that has the same conditions instead of the way it works today where it only measures number of times braking etc?

- Scenario 1: The route goes as planned. In this scenario the bus is going along the route as planned. You will see what the screen looks like when you drive. Since we are not in a real bus, we have to pretend that you have now stepped on the gas pedal. (click on the screen)
    - When you are in motion, you can see that you have a GPS map navigation, where you will see your position and which stops are upcoming next. When we have stopped at the bus stop, the view changes to the line guide and messages view.

    - (driver change appears + sound notification) Do you have any opinions about this screen?
    - Thoughts about the GPs navigation? How do you like it's looks? The content?
    - How do you feel in general about getting this kind of messages?
        - Helpful? Nagging?
    - (arrives at stop) That's how a driver change looks like. Any thoughts?

- Scenario 2: messages. It is time to test the message functionality in the system, that we have called SmartInfo. The information shown is either from the traffic management, or it has been automatically generated by the system, through e.g. using sensors that count the number of passengers that has boarded the bus. Let's start by pressing the gas pedal again. There are many passengers on the bus currently, since many passengers boarded the bus ta the last stop.
    - There are more passengers boarding. (notification sound)
    - Your task is to tell the traffic management that the bus is full.
        - In general, what is your opinion on this function? The fact that it measures automatically and you get to confirm?
        - Does it feel like a support or like it's nagging?

- Scenario 3: traffic reroute. In this scenario we will see what happens when a traffic reroute is happening due to traffic congestion.
    - We start going. As before, everything is as it should.
    - (reroute message appear in the GPS map view + sound notification) Did you see that you got a message regarding traffic congestion in the GPS map view?
        - Do you understand which way is the new one, and which one is the cancelled one?
    - (reroute message appear in the line guide view) Did you see that you have a message about traffic congestion in the line guide view?
    - Confirm the route change!
        - Does it feel like you know enough from this message?
        - Does the combination of written info and GPS map view feel relevant?
        - Any other thoughts?
    - Let's go the final stop so that you will see the last view!

Now we're done with the part where you get to interact with the interface. We have a couple of final questions, but before that, do you have any general thoughts concerning what you have tested today? How has the experience been?

- Do you think that this interface fits the context of driving a bus? Why/why not?
    - Or does it feel like something else, to use on an airplane, a bike..? Or something completely different?
- Does it feel like a work tool?
    - Or more like something to use in your free time?
- If you were to describe the interface with three words without using words that describe its physical appearance (e.g. black or square), which words would it be and why?

- Which personality traits do you feel like the interface mediates?
    - E.g. serious or playful..?
- If this interface had been a car brand, which would it have been and why?
    - E.g. “It would have been a Volvo, because everyone has one of these”
- Which time period would you say that this interface fits in and why? Is that positive or negative?
    - 80’s, 90’s, present time, future, timeless…?

That was the test, thank you very much for your participation!