CHALMERS
UNIVERSITY OF TECHNOLOGY

Drivers' Needs while reversing with a High Capacity Transport Combination

Master's thesis in Product development

AIME VESMES

DEPARTMENT OF INDUSTRIAL AND MATERIAL SCIENCE

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2023
www.chalmers.se

Master's thesis 2023

Drivers' Needs while reversing with a High Capacity Transport Combination

AIME VESMES

CHALMERS

Department of Industrial and Materials science
Chalmers University of Technology
Gothenburg, Sweden 2023

Drivers' Needs while reversing with a High Capacity Transport Combination
AIME VESMES

Supervisor: Fellow Product Architect Lena Larsson, Volvo GTT
Professor Johan Malmqvist, Industrial and materials science, Chalmers
Examiner: Professor Johan Malmqvist, Industrial and materials science, Chalmers

Master's Thesis 2023
Department of Industrial and Materials science
Chalmers University of Technology
SE-412 96 Gothenburg
Telephone +46 31 772 1000

Cover: Long link combinations reversing in Gothenburg harbor, annotated screenshot from Oryx simulator.

Typeset in LaTeX
Printed by Chalmers Reproservice
Gothenburg, Sweden 2023

Drivers' Needs while reversing with a High Capacity Transport Combination
AIME VESMES
Department of Industrial and Materials science
Chalmers University of Technology

Abstract

The greenhouse gas emissions are today a global problem and the transportation sector significantly contributes to these emissions. By improving the energy efficiency of transports, the emissions can be reduced. To use High Capacity Transport (HCT) combinations a truck can transport larger volumes of goods while the emissions per transported tonne of goods reduces. However, difficulties with driving HCT combinations have arisen, particularly while reverse driving. The thesis aims to recommend solutions to decrease the reversing time for HCT combinations by investigating the drivers' needs while reversing with an HCT combination.

In order to fulfill the aim, three primary activities were accomplished. Firstly, a drivers' needs study was conducted to identify drivers' opinions and needs while reversing with an HCT combination. The result from the study led to four main insights; an HCT combination must acquire the correct specifications to suit the specific transportation mission, drivers should be given sufficient time and opportunities to practice before driving an HCT combination, external aids are essential for enabling efficient reversings when the visibility is impaired, and the layout of terminals significantly affects how efficient a reversing becomes. Secondly, a market analysis was performed to study existing support systems available on the market. Lastly, a usability test with a cab simulator was carried out to investigate to what extent a simulator could be used for training, compared to real life driving.

Findings from these three activities resulted in nine recommendations aimed at reducing the reverse driving time for HCT combinations. These recommendations are directed toward three receivers: Volvo GTT, haulers, and terminals. The most prioritized recommendation calls upon Volvo GTT to inform the sales personnel about HCT combinations and ensure that they possess sufficient knowledge to sell the most suitable combination for the customers' transport mission. Haulers need to provide time for drivers to practice and invest in external aids. Terminals should adapt the area for longer vehicle combinations, and perform regular maintenance on the terminal area. For future research, potential areas of investigation could involve comparing the use of rearview mirrors versus camera systems used instead of mirrors when reversing with HCT combinations, or exploring why people are influenced differently in a cab simulator.

Keywords: High Capacity Transport (HCT), reverse driving, customer needs study, usability testing, simulator.

Acknowledgments

Throughout the thesis, I have received help from many people and I would like to express my gratitude to all of them.

Firstly, I would like to thank the project group at GTT who has been by my side for the whole thesis time. Particularly my supervisor Lena Larsson, for your guidance, knowledge, and support during the thesis, and for the time you dedicated to me in your otherwise full schedule.

Secondly, I would like to show my gratitude to my academic supervisor and examiner professor Johan Malmqvist for the feedback and support along the thesis. I also want to thank my opponents, Arvinth Kumar and Hugo Löfgren for your questions and feedback.

Further, I would like to express my gratitude for the support from additional employees at GTT who helped me, whether I got hold of the right person or not.

Lastly, I would like to thank everybody participating in my thesis, both during the interviews or driving in the simulator. Without you and the received information from you, the thesis would not have been possible to complete.

Aime Vesmes, Gothenburg, June 2023

Contents

List of Figures

List of Tables

List of Terminology and Abbreviations

Driver	A driver in the report refers to a truck driver or a driver with a truck driver's license.
GCW	Gross combination weight
HCT	High Capacity Transport
PiP view	Picture in Picture view
Regular combination	In this report a regular combination is the today legal combination with the highest capacity, namely a combination max 25.25m long and with a GCW of max 74 tonnes
Reversing actions	In this report, reversing actions stands for reversing with a longer HCT combination (longer than 25.25 m), as well as coupling and decoupling the combination.
Volvo GTT	Volvo Group Trucks Technology

1
Introduction

In this chapter the problem of reversing with HCT (High Capacity Transports) combinations will be presented along with the background and the identification of the problem. Further, the purpose of the thesis is presented together with the intended research questions, objectives, and demarcations to achieve the purpose. Lastly, the outline of the report will be specified.

1.1 Background

Today there is a global problem with CO_2 emissions and the negative aspects which arises from them. A third of the greenhouse gas emissions, in Sweden, come from domestic transport (Naturvårdsverket, n.d). Heavy trucks accounted for approximately 20% of these emissions, that is 6% of the total, year 2021. A way to reduce the emissions from these trucks is to make the transports more energy efficient. There are many solutions for making a transport more energy efficient, and one of them is by using HCT combinations.

An HCT combination is a longer or heavier vehicle combination using several cargo vehicles, trailers, together at the same time. One type of HCT combination can be seen in figure 1.1 (Fröjd et al., 2021). When cargo vehicles are connected it leads to a fewer number of trucks on the road as well as a lower energy consumption per transported tonne of goods.

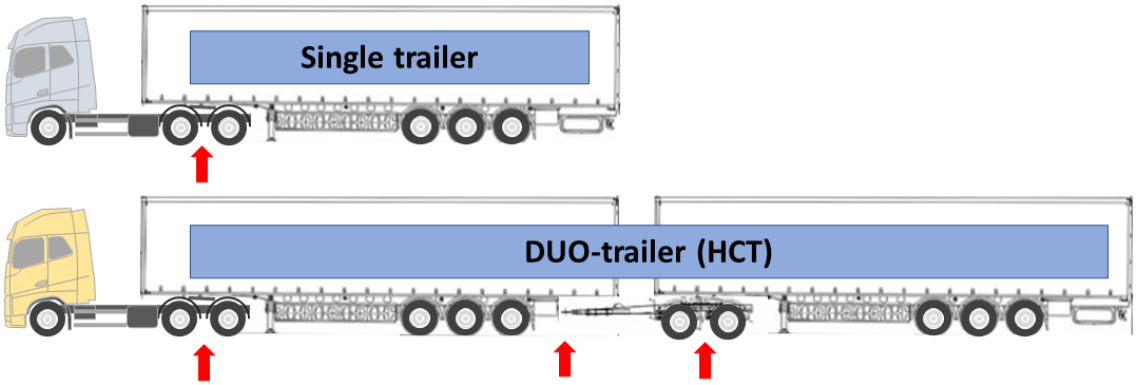


Figure 1.1: *Above is a tractor with a trailer (one joint), and below is a tractor with three trailers, type DUO-trailer (three joints). The placement of the joints are shown by the red arrows.*

However, some challenges with using longer HCT vehicles have been identified, one problem being a more time-consuming reversing and coupling of the vehicle combination (Larsson et al., 2022). Due to the increased number of joints, from zero or one to two or three joints, and the length of the combination the reversing of an HCT combination is more difficult than with a standard combination. A more time-consuming reversing may hinder a hauler from choosing to use an HCT combination, and by that do not gain the more energy-efficient transport. Consequently, there is a need for making the reversing with an HCT combination more time efficient.

1.2 Problem identification and analysis

Volvo GTT has had many projects with HCT combination between year 2007-2023. During these years problems have occurred in the projects, which later have been solved, for example traction problems that arose due to the increased GCW (Gross Combination Weight). However, many of the projects have had combinations that mostly have been driven forward, without a need for reverse driving in the daily work. Problems identified from the reversing actions are presented below in figure 1.2 (yellow boxes). The problems have arisen from two main factors (red boxes), which are presented more thoroughly below.

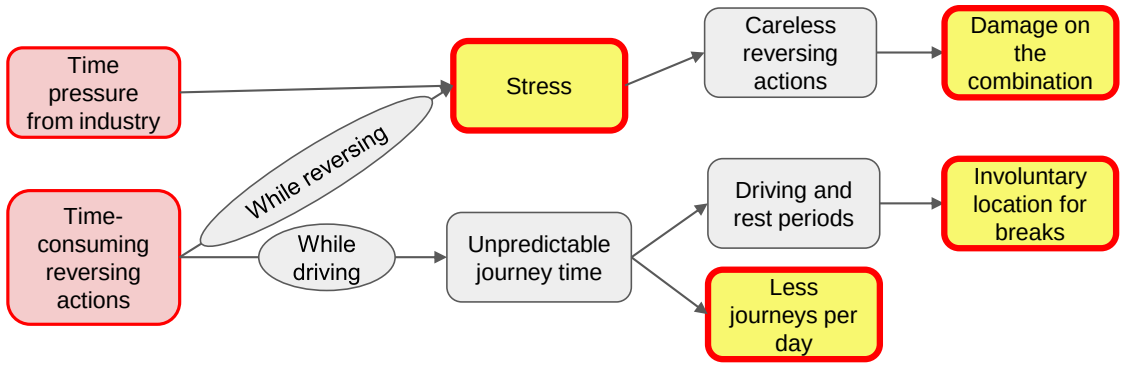


Figure 1.2: *Downstream problems from the time pressure and the time-consuming reversing actions.*

1.2.1 Problems that have arisen from the time-consuming reversing actions in previous HCT projects

In one of the latest projects, Highly Automated Freight Transport, also called Autofreight-1 (Vinnova 2016-05413 and 2016-05415), the problem with reversing with an HCT combination occurred and affected the result of the project negatively (Larsson et al., 2022). In the project, an HCT combination (type DOU-trailer as seen in figure 1.1) was driven back and forth between the Gothenburg harbor and Viared industrial area. At the two endpoints of the journey reversing actions were

needed and some of the drivers had difficulties with this. Especially drivers who were unfamiliar with longer vehicle combinations had these difficulties and needed more time for the reversing actions. The longer, but also unpredictable, time in the endpoints led to negative results for the project. It was one of the reasons why it was not possible to drive three journeys a day, which was predicted before the field test started. Further, the unpredictable time for the reversing actions together with the Swedish regulation of driving and resting periods, and the need of taking a break after 4 hours and 30 minutes (Transportstyrelsen, 2023a), made it difficult for the drivers and haulers to plan the day ahead. Another problem that has arisen from other HCT projects is that the difficulties with the reversing actions have led to damage on the used vehicle combinations when the reversing actions are not correctly done. These damages can be costly to fix and may lead to downtime for the combination.

These three main problems led to the question being raised about what the drivers' needs are while reversing, and what support or training systems there are on the market that can solve those needs and decrease the reversing time.

1.2.2 Time pressure in the haulage industry

During an ordinary workday, more than a third of the workers in the haulage industry in Sweden are stressed. In 2020, Länsförsäkringar released a report on the *Challenges on the road for the transport and haulage industry* where they address, among other things, the problem with the time pressure that leads to a stressful work environment for both drivers and haulers (Länsförsäkringar, 2020). As mentioned above, the reversing actions in Autofreight-1 were extra time-consuming and were increasing the stress even more for the drivers (Larsson et al., 2022). Although the main problem came from the fact that the project results were not met within Autofreigt-1, one may also see the possibility to reduce the stress for the drivers and haulers and therefore contribute to a better working environment for them by reducing the time for the reversing actions.

1.3 Purpose

The thesis aims to recommend solutions to decrease the reversing time for HCT combinations by investigating the drivers' needs while reversing with an HCT combination. From those findings, the project will further recommend solutions or support systems to fulfill the needs and lead to a less time-consuming reversing action.

1.4 Research questions and objectives

To achieve the expected purpose of the thesis five research questions were formed to more clearly understand what information needs to be collected before a recommendation can be done.

1. What are the drivers' needs when reversing with a longer HCT combination?
2. What external environment aspects (for example weather conditions) may affect the reversing actions?
3. What support systems for reversing (mounted after production) are available on the market today?
4. To what extend can training in a simulator fulfill drivers' needs as compared to practicing in real life?
5. Which solutions can fulfill the drivers' needs and decrease the time for making a reversing action?

From the purpose and the research questions a objective can be presented.

- Based on the gathered information derived from the research questions, recommendations should be presented aimed at decreasing the time spent on the reversing actions.

1.5 Demarcations

In order to fulfill the project some limitations have been established to frame the process. Below is a list of the selected demarcations:

- The time of the project is restricted and due to this some planned activities may not be as completed as intended. Some activities in the time plan was more important and needed enough time to be fulfilled. Due to this, some activities was less prioritized that what was originally planned.
- HCT combinations can be both heavier or longer than the legal combinations used on the roads today. However, in this project, the focus will be on the longer HCT combinations (longer than 25.25m).
- The project focuses on HCT combinations and support systems used for HCT combinations. It will not be taken into account how the systems affect reversing with a standard combination or how haulers can use the support systems on other non-HCT combinations in their fleet.
- The project is limited to the Swedish market and the recommended solution should operate in Sweden and on Swedish road conditions.
- Within the project, many drivers were involved. It was aimed to only use drivers who had driven longer HCT combinations in daily work. However, in parts of the study, this limitation was exceeded due to the limited amount of HCT drivers close to Gothenburg. However, all used drivers within the thesis had CE-drivers license.
- Within the project, recommendations will be presented aimed at decreasing the time for reverse driving. The recommendation will not focus on which solution or recommendation generates the fastest reversing time.

1.6 Outline of the report

The report is built up of six chapters, with additional appendixes. The study, however, has five main stages, which are explained further in chapter two.

1. Introduction - The first chapter in the report describes the background of the thesis, along with the purpose, research questions, objectives, and demarcations for the project.

2. Methodology - The second chapter presents the methods used in the thesis and explains the five main stages of the project: Prestudy, Identify drivers' needs, Market analysis, User experience study, and Data synthesis.

3. Prestudy - Thirdly the results from the prestudy are presented. The prestudy is represented by relevant theory for the reader to better understand the project.

4. Results - The fourth chapter presents the results from the remaining four stages presented in the methodology. The main results here are: insights from the drivers' needs study, SWOT analyses of products on the market, results from the user experience testing using a simulator, and finally a final recommendation of how to decrease the time for reversing actions for HCT combinations.

5. Discussion - The fifth chapter is discussing aspects of the project, for example changes from the original plan and unpredicted events that occurred.

6. Conclusion - Lastly, a summary of the result is presented in the concluding chapter.

Appendix A - Interview guide - The first appendix presents the used questions in the interviews.

Appendix B - Affinity diagram - The second appendix presents the complete affinity diagram.

Appendix C - Feedback grid - The last appendix presents a feedback grid containing all mentioned opinions.

2
Methodology

During the project time, many different methods have been used and these methods are presented in this chapter. The project was divided into five different stages, as seen in figure 2.1. The different stages will be described more thoroughly below along with the used methods for each stage.

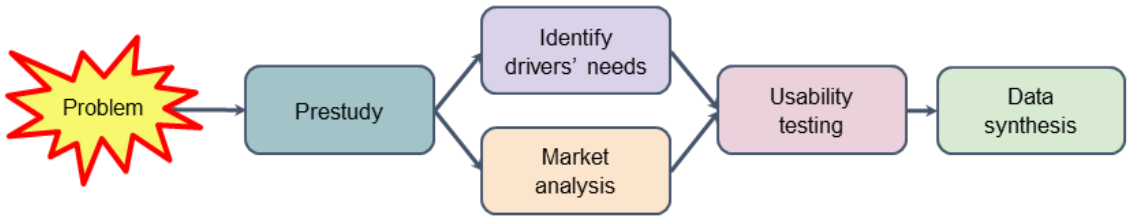


Figure 2.1: *Overall process chart of the project.*

2.1 Prestudy

The first stage of the project was to conduct a prestudy. The study was made to increase the knowledge of the subject and the problem. Further, the study also generated information that supported the selection of methods for the project. The information for the prestudy came mostly from internal documents, while the information on the methods came from different sources, for example educational books or websites.

2.2 Identify drivers' needs

The second stage was to identify customer needs, namely the drivers' needs. The identification of customers' needs is important when developing products, or in this case, to map what needs a driver have to fulfill a reversing action. The identification of customer needs helps with, for example, ensuring that a solution solves the customers' needs and that no important needs are unnoticed (Ulrich et al., 2020).

This stage was divided into seven steps, as seen in figure 2.2, and each step is described further below. The seven steps are built up on each other and need to be fulfilled in order. However, from the data collection to the empathy maps the

Figure 2.2: *Process over the identification of the drivers' needs.*

methods are done for each interviewee. This means that the steps will be done once for each interviewee, shown by the multiple arrows in figure 2.2 and not all at once.

2.2.1 Plan the drivers' needs study

Before a customer needs study is conducted a plan needs to be made. For the interviews, an interview guide was important to structure the interview and to ensure that the right information is collected (Ulrich et al, 2020).

During the planning stage, the participants for the study was selected. Since the study was decided to be qualitative, the result may differ depending on who participates. Ulrich et al. (2020) mention that with the help of lead users the customer needs can be established more efficiently. Lead users are advanced users and they have used the product more than the average. The lead user is usually one step ahead of the normal user and has insights the usual user does not gain at the same time span. For this project, the lead users were the drivers of longer HCT combinations. However, it is also argued that at least 10 interviews should be conducted to prevent the result to be inadequate. The study aimed to have at least 10 interviews with HCT drivers and additional drivers were aimed to be used if it was not possible to interview 10 HCT drivers. The study was able to obtain 5 HCT drivers, 3 non-HCT drivers, and 2 drivers who had driven HCT, but who do not drive it on a regular basis.

2.2.2 Data collection using semi-structured interviews

Interviews are a data collection method used to gather for example user experiences, behaviors, or opinions to name a few (Wikberg Nilsson et al, 2021). Interviews can have different aims depending on when in the process the method is used. In this stage, it was used as a data collection method. Namely, the goal of the interviews was to gather information and later use the information to establish drivers' needs. The interviews were semi-structured, meaning that some questions were stated beforehand, however, the interviewee had flexibility when answering the questions and the interviewer was able to ask supplementary questions if needed. Additionally, all questions were not asked to each interviewee, since the interviews could be adapted along the way. An example was if the interviewee already answered a question in an earlier answer, then the question was not included or rephrased. Due to this, the interviewer had to focus on the interview and select which questions to ask during the conduction. Leading to difficulties of taking notes at the same time as the interview was conducted. By recording the interviews it gave the interviewer the possibility to focus on the interview, rather than taking notes.

The interviews were approximately 30 minutes long and consisted of 36 questions with additional supplementary questions which were asked if the answer from the driver was not informative enough. The interview was divided into four parts: Questions about you as a driver, Reverse driving, Coupling and de-coupling, and Practice before driving. The part about Coupling and de-coupling was not asked to all drivers, since some drivers did not couple or decouple during their workday. For the complete interview guide see Appendix A - Interview guide.

The interviews with the HCT drivers were made during their workday in their truck or through a phone call. By carrying out the interviews in the truck it was both suitable for the drivers, since they did not have to change their workday, and for the study, since observations were carried out during the same journey; interviews while the driver was driving forward, and observations while the driver was reversing. The selection of the HCT drivers was made by first focusing on the HCT drivers in Volvo GTT's ongoing HCT projects and within that selection select drivers based on availability and driving location. Since it was prioritized to interview drivers close to Gothenburg for easy access and the ability to observe at the same time as the interview was executed, the focus was laid on Volvo GTT's HCT projects close to Gothenburg.

For the non-HCT drivers, the interviews were made through video communications tools (Teams), since no observations were needed and to make it easier for them since the non-HCT drivers were test drivers with varying workplaces. The drivers were randomly selected from a list of test drivers which was obtained by a Volvo GTT employee who works with user experience clinics. The time for these interviews was approximately 20 minutes and the same interview guide was used. However, all HCT-related questions were not asked.

In total 10 interviews with drivers were made; five HCT drivers, three non-HCT drivers, and two Volvo employees who had driven HCT but not on a regular basis. Since the drivers were either driving in one of Volvo GTT's HCT projects or was an employee at Volvo GTT, all drivers were driving Volvo trucks during the interviews.

2.2.3 Data collection using observations

During the four interviews that were performed in a truck, additional observations were done. Observation is a method used for identifying unmentioned needs (Wikberg Nilsson et al, 2021). However, it also helps the participant to realize needs in specific contexts or situations, for example when reversing. The observations were used to support the information collected from the interviews and allowed unmentioned needs to be found. During the observations, the driver was asked to perform a reversing action, and at the same time try to explain what they did. Since the driver was performing this action in their daily work, it was limited to the planned reversing action and the drivers were told to only speak when he or she felt comfortable with it. During the observation, notes were taken during the reversing and were used later in the empathy maps as collected data.

2.2.4 Transcription

After each interview, the recorded audio was transcribed. A transcription can be made for different reasons, for example to easier find citations or to have a document where one could scan for keywords (Semantix, n.d). In this project, the transcriptions made the process of making empathy maps and later an affinity diagram easier. This since the interviews were heard two times each, both during the execution of the interview and while transcribing. It was also to provide a document with information that was easier to analyze than a recording.

2.2.5 Empathy maps

With the data from the interviews and the observations, an empathy map was made for each interviewee. An empathy map is used to obtain a deeper understanding of the customer, in this case the driver (Bland, 2020). The mapping uses the collected data and analyses the interviewee in four aspects; says, thinks, feels, and does. With these four aspects the method helps to go beyond what the interviewee says or does and it helps to contextualize the data which was beneficial later when personas were made. In figure 2.3 two empty empathy maps are shown. For each person the digital post-its are filled in and depending on the amount of information from the interviewee the number of post-its for each aspect can vary. Further, there is no maximum limit for the number of post-its for each aspect or each interviewee, the number is determined by the collected information. The purpose of the empathy maps for this investigation was to visualize the collected data with post-its, but mostly as a step between and as a support of the translation from a transcribed document to an affinity diagram.

Figure 2.3: *A blank empathy maps.*

After each interview and transcription, the empathy map was filled in. The empathy maps were done digitally, and the post-its were in a digital form within a tool called Figma (Figma, 2023). From the transcription, quotes were extracted and placed on post-its within the aspect Says. Further, from the observations post-its within Does were filled out from how the interviewee acted during the observation or from how they told they acted during a reversing. For the aspects of Thinks and Feels, the transcription and notes from the observations were further analyzed and aspects beyond what was said or done were formed. An example is if a driver talked about their driving and how good they are, the thinking may be "Why should I not be able to reverse with a HCT combination, I am good at driving and have a lot of experience".

2.2.6 Affinity diagram

After the data was collected and contextualized, it was sorted by making an affinity diagram. The method is used when information of a larger volume needs to be clustered to be able to identify insights, for example customer needs (Dam & Siang, 2022). The method can be used in different stages of the process, and in this project, it was used to cluster information from the interviews and the observations to gain insights, which later was used in order to make personas and draw insights. As seen in figure 2.4 the post-its from the empathy maps were sorted into different groups and the information goes from a personalized sorting to a sorting depending on different groups. However, it was still possible to see which aspect of the empathy map each post-it belonged to.

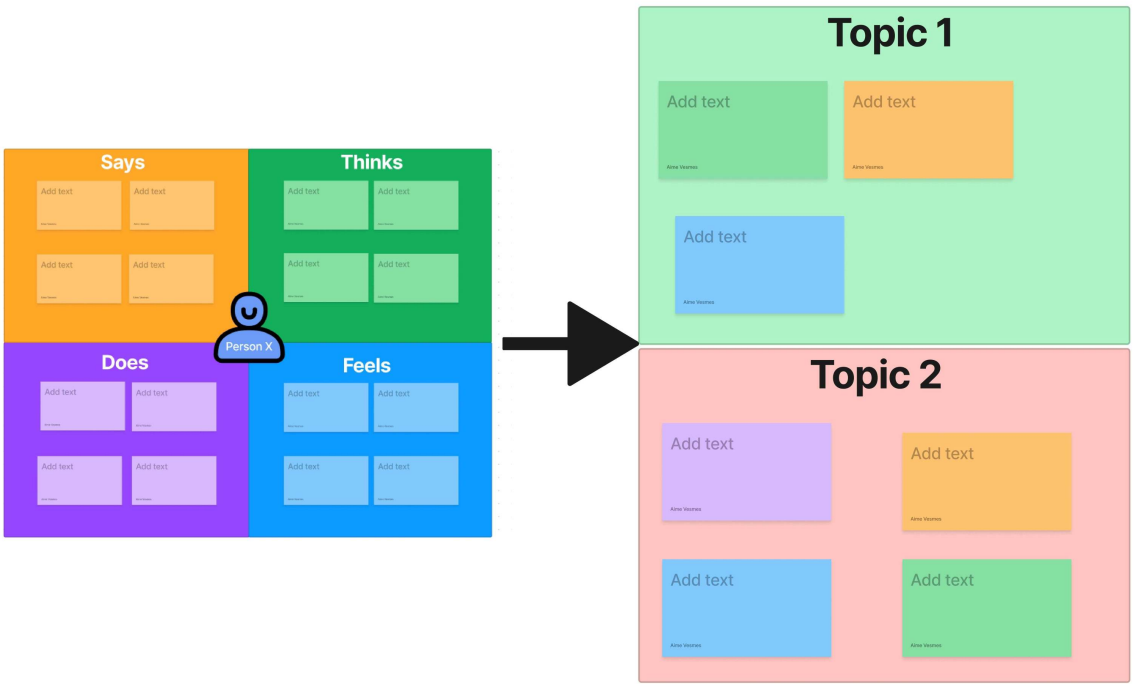


Figure 2.4: *Example of how the post-its can be sorted within two topics.*

2.2.7 Personas

Personas is a method where one or more fictitious descriptions of a person are made and used to represent the needs of a target group, in this case drivers' needs (Wikberg Nilsson et al, 2021). Collected materials, from example interviews, statistics, or observations, are used to build a persona. Personas are used in complement to using data and statistics and have a fictive description of the target group which gives the developer more empathy for them.

In this project, three personas were made, two representing HCT drivers and one representing non-HCT drivers. This was made since the drivers had different experiences from before, and also different needs as drivers. To be able to present as many opinions as possible, three different personas were made. The personas were written in a format starting with background information about them, continuing with their attributes, and ending with their needs as drivers.

According to Wikberg Nilsson et al (2021), a persona is created by six steps. In this study three of these steps are represented by steps presented earlier in the process seen in the parentheses below:

1. Map context (Data collection)
2. Contextualize the data (Empathy map)
3. Search for patterns (Affinity diagram)
4. Create a living character
5. Create a scenario
6. Validate persona

2.2.8 Insights from drivers' needs study

After the personas were made, a list of the insight from the drivers' needs study was conducted. The list of insights states what the drivers' needs are when reversing with an HCT combination and which hands-on problems need to be solved in order for the drivers to make the reversing less time-consuming.

2.3 Market analysis

In parallel with the identification of the drivers' needs, a market analysis was performed as a benchmarking of the products on the market used as aids while reversing. The found products were later analyzed through SWOT analyses, in order to be compared to each other.

2.3.1 Benchmarking products on the market

Benchmarking is a method where existing products on the market are studied (Ulrich et al, 2020). The method can be used to study functions, sub-solutions, complete solutions, etc. In this project, existing products on the market that supports the

driver while making a reversing action were studied. A limitation was set to not study products that needed to be ordered when the combination was ordered. The benchmarking in this project was divided into three steps:

1. Fast overview search, for an overall understanding of the products on the market.
2. A plan for the benchmarking.
3. Execution of the benchmarking.

The aim of the benchmarking in this investigation was to find what products were available on the market, and later analyze the products with SWOT analyses. During the first stage, rather few products were found which were not removed by the limitation. Due to this, the plan for the benchmarking was set to a short limited time for the search, approximately 1 hour per day for three weeks, which gives 15 hours in total. The plan also included a low limit for the minimum number of products to be found to be three products.

During the execution of the benchmarking four product categories were found, which later were analyzed in SWOT analyses. The time for the benchmarking ended up being 18 hours, this since some extra time came up during the interview stage.

2.3.2 SWOT analysis of products used as aids while reversing, on the market today

To analyze the result from the benchmarking further, a SWOT analysis was made for each of the four product categories found on the market. In a SWOT analysis products or other things, for example business plans, are analyzed in four different aspects: Strengths, Weaknesses, Opportunities, and Threats (Raeburn, 2021). The aim of the SWOT analyses was to use it as a tool for comparing the different product categories to each other and later used in the final recommendation.

2.4 Usability testing with a simulator

A part of the project was to validate if practicing reverse driving in a simulator, described more below, before making a real life reversing action would be a useful tool for learning to reverse with an HCT combination or not. To validate this a usability test was made with a cab simulator. A usability test is useful to gather insights and realize how the user interacts with a product (Wikberg Nilsson et al, 2021). Since the used simulator was not verified by real drivers, the aim of the usability test was both to validate the realism of the simulator and additional verification of the thought of using the simulator as a tool for practicing reverse driving with HCT combinations.

The testing was arranged by inviting drivers and Volvo GTT employees to the simulator and letting them drive in it. During the test 12 participants were driving the simulator; 3 HCT drivers, 3 non-HCT drivers, and 6 Volvo employees. All participants had a CE-drivers license, which is needed for driving combinations with trailers (Transportstyrelsen, 2023b).

Each participant was scheduled for 60 minutes, with a maximum driving time of 50 minutes. If additional time was available, the driver could drive for a longer time. The driving was divided into five parts, where the first, second, and last parts were always included. The middle parts depended on the driving ability of the driver. The parts were:

1. Information of the test and the driving scenario (approximately 5 minuter).
2. Driving in the scenario with a tractor - semi-trailer.
3. Driving in the scenario with a Long link combination.
4. Driving in the scenario with a DUO-trailer.
5. Concluding questions and opinions (approximately 5 minuter).

Within the first part, information about the scenario in the simulator was given to the participant, as well as the risks of driving in the simulator. Furthermore, there was an opportunity for the participant to ask questions before written consent was given. After consent was given the driving parts (2-4) were performed by the participant. The time for each driver to reverse with the different combinations was noted. Depending on the performance of the driver, there was a different amount of time spent on each combination. However, everybody drove the tractor - semi-trailer, even if it was the easiest combination to drive, to get used to the simulator before trying one of the more difficult combinations. Two examples of different driving times are presented below, with a total driving time of 50 minutes:

- Tractor - semi-trailer [5 minutes], Long link combination [15 minutes], DUO-trailer [30 minutes]
- Tractor - semi-trailer [10 minutes], Long link combination [40 minutes], DUO-trailer [0 minutes]

In order to be able to evaluate the result from the usability testing, feedback grids were used during the testing. A feedback grid, see figure 2.5, is a tool used in testing (Co-Creating Well-Being, n.d.). With the grid, constructive criticism is collected from the drivers in a simple way. The grid can be used both while executing the test, as well as afterward.

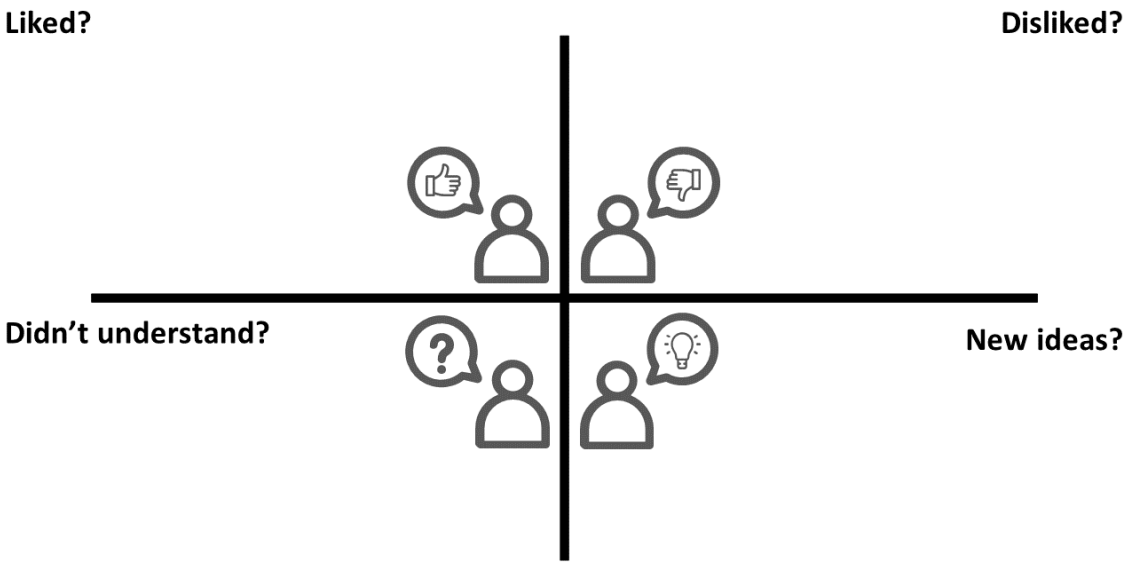


Figure 2.5: *Feedback grid.*

By asking four questions, listed below, opinions can be collected by either letting the participants fill out the grid by themself or by asking the questions and taking notes:

1. What did you like about the simulator?
2. What did you dislike or want to improve with the simulator?
3. What did you not understand?
4. Do you have any new ideas or improvements for the simulator?

In this investigation the feedback grid was filled out during the test and the questions were additionally asked after the test to ensure nothing was left out. However, even if these four questions were always asked, there was room for discussion and questions from the participant. After each answer the question "Why?" was further asked to provide more clarity in the answers, before the question was repeated until no further answers were given. For example, if the participant named something they liked, they were asked why before they were asked what more they liked.

2.4.1 The simulator

The simulator used in the usability testing was a cab simulator developed by Oryx Simulations AB (Oryx, 2023), seen in figure 2.6. The cab has been reconstructed and the windows have been replaced with four tv screens instead, see figure 2.7.

Figure 2.6: *The cab simulator from the outside.*

Figure 2.7: *The cab simulator with a door open.*

The simulator was equipped with extra PiP (Picture in Picture) views that could be used while driving to assist the driver, seven PiP views on the left side and one on the right side. The most commonly used PiP view was the top view, the view on the right side, seen in figure 2.8. The PiP views were easily turned on and off, and used if the participant felt unsure with the combination and wanted to use it.

Figure 2.8: *The top view seen on the right screen.*

2.5 Data synthesis

The final stage of the project was to analyze all the collected data within the project and compile it into final recommendations, using a thematic analysis. A thematic analysis is a method used for qualitative research, where themes are derived from the collected data by identifying patterns (Damyanov, 2023). During this analysis a deductive approach was chosen, meaning that the analysis was made with expected themes. Each need found during the drivers' needs study was chosen as a theme, and during the thematic analysis, the results were divided between the themes. When the data was divided into themes the result was examined and recommendations

were formed. The recommendations consist of both solutions that help the driver while making a reversing action and solutions that help the driver with training before the reversing action is performed. The recommendations were divided into three receivers: Volvo GTT, haulers, and terminals.

2.6 Considerations

A couple of considerations needed to be considered throughout the project. Since the project had a lot of user contact and data collection through individuals, their ethical safety needed to be protected.

2.6.1 Ethical Aspects

In this investigation, ethical aspects were considered important and the investigation was conducted ethically. It is, according to Denscombe (2014), a fundamental feature to research in an ethical manner, and not a choice for the researcher.

During the data collection, it was important to make the participants feel safe. The participants were informed that they will be anonymous during the whole investigation. Clear instructions and information were provided to the participants before any data collection was made. It was clearly stated before the interviews, observations, and usability testing what was going to happen for each session and how the collected data would be used, and consent of the participants was required beforehand. The participants were also informed in advance that if something felt wrong, it was possible to end the session at all times. No description was needed why.

Since some of the interviews and the observations were conducted in the truck while the driver was doing their daily work, it was important to not disturb any of their daily work. For example, if somebody called during the interview, the driver got the time to answer the call, and the interview and the recording were paused. Although the daily work environment was an advantageous place to observe, it should not disturb the daily work of the drivers. Due to this, the drivers were also informed that if a pause was needed during the interview, it was no problem for the interviewer.

During the usability testing with the simulator, there was a risk of people feeling motion sickness during driving. To avoid any harm to the participants, they were informed beforehand of the risks of motion sickness while driving in a simulator and it was clearly stated that the participants should inform if any unwanted symptoms arose. If the participant felt any unwanted symptoms from the simulator, the test took a pause, the participant walked out of the simulator, and after a break, the participant decided if another try was carried out or not. Even if as many HCT drivers as possible were wanted in the testing of the simulator, nobody should feel harmed by the investigation or forced to participate in the usability testing.

The protection of company information was also of importance in the investigation. All HCT drivers and Volvo employees had signed a Non-disclosure agreement with Volvo GTT. Any information provided from the drivers that was classified, will not be presented outside of Volvo GTT. This agreement prevented unwanted stress from the HCT drivers during data collection. It additionally protects Volvo GTT from harm, by carefully reviewing what would and would not be published.

3
Prestudy

During the prestudy, an initial information search was made to gain information and knowledge regarding the subject. The prestudy aimed to gather information the reader may need to understand the context of the report. During the prestudy, three main areas were explored and are presented below; High Capacity Transports, Different vehicle combinations, and A driver's transport mission.

3.1 HCT - High Capacity Transports

In 2007 Volvo started, together with Skogforsk, a project aiming for longer and heavier vehicle combinations, called VETT (Volvo En Trave Till, translated to Volvo One More Pile) (Fröjd et al., 2021). Already during that time, it was understood that the CO_2 emissions needed to be reduced, and by connecting a truck with multiple trailers the combination was able to carry more goods, reducing the amount of emissions per transported tonne of goods (Larsson et al., 2022). Another goal of using HCT combinations was to reduce the number of vehicles on the roads and thus reduce road accidents. These factors were the starting point for HCT combinations, namely, combinations with higher capacity than what was allowed in 2010 (L. Larsson, personal communication, April 21, 2023).

By using an HCT combination with a GCW of 90 tonnes (34m long), instead of a GCW of 60 tonnes, would reduce the CO_2 emissions by 20%. However, for volume-based goods, there was a particular need for longer vehicle combinations in order to reduce the CO_2 emissions per transported volume of goods. As seen in figure 3.1, a reduction by 27% of the CO_2 emissions can be achieved (Fröjd et al., 2021).

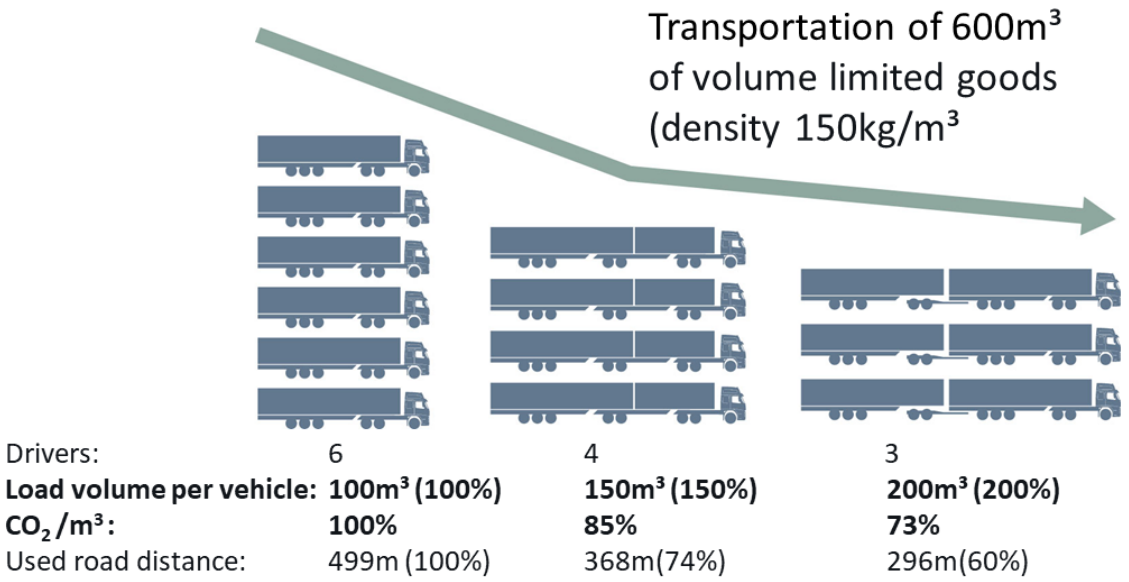


Figure 3.1: *Differences between ordinary combinations and HCT combinations, in terms of volume (Fröjd et al., 2021).*

HCT combinations have been driving as test vehicles since 2009 and are still on trial today. The results from the tests have been positive and during the research time, Sweden has increased the legal limit for GCW two times; from 60 tonnes to 64 tonnes in 2015, and from 64 tonnes to 74 tonnes in 2018 (Larsson et al., 2022). Soon the length will also be increased to 34.5m, from the earlier limit of 25.25m (L. Larsson, personal communication, April 3, 2023).

3.2 Different vehicle combinations

A vehicle combination is built up by connecting modules into a combination. The combination starts with a truck, which can have two different types of layouts. The most significant difference between the two layouts are that a rigid truck can transport a load by itself, while a tractor truck (from now on called a tractor) cannot transport a load by itself, as seen in figure 3.2.

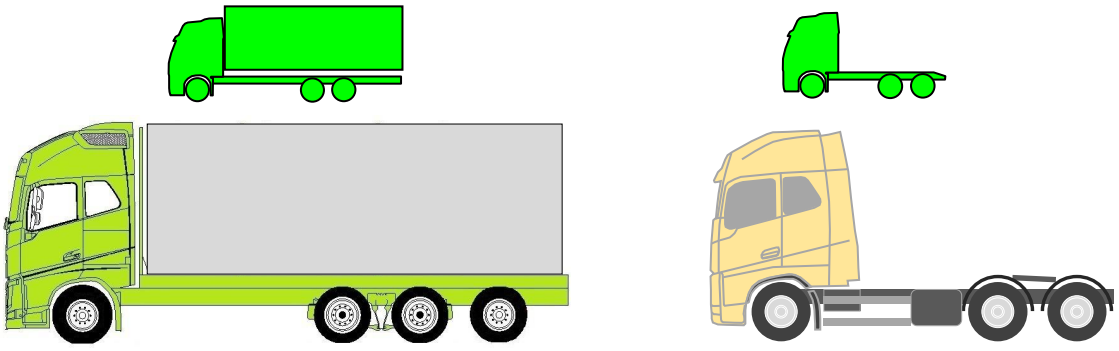


Figure 3.2: *A rigid truck to the left and a tractor to the right.*

Further, another difference between the two is how the modules after the truck, trailers, are connected, by a coupling and drawbar, yellow arrow in figure 3.3, or by a fifth wheel, green arrow in figure 3.3. A rigid truck has only couplings for drawbars, while a tractor has a fifth wheel and can have an additional coupling for drawbars. Additionally, there are many different types of rigid trucks and tractors, and the specifications for a truck have many parameters that can differ. These different parameters affect many different things, for example how the vehicle behaves, which can differ depending on, for example, the wheelbase or the amount of horsepower. For this section, these differences are, however, not significant.

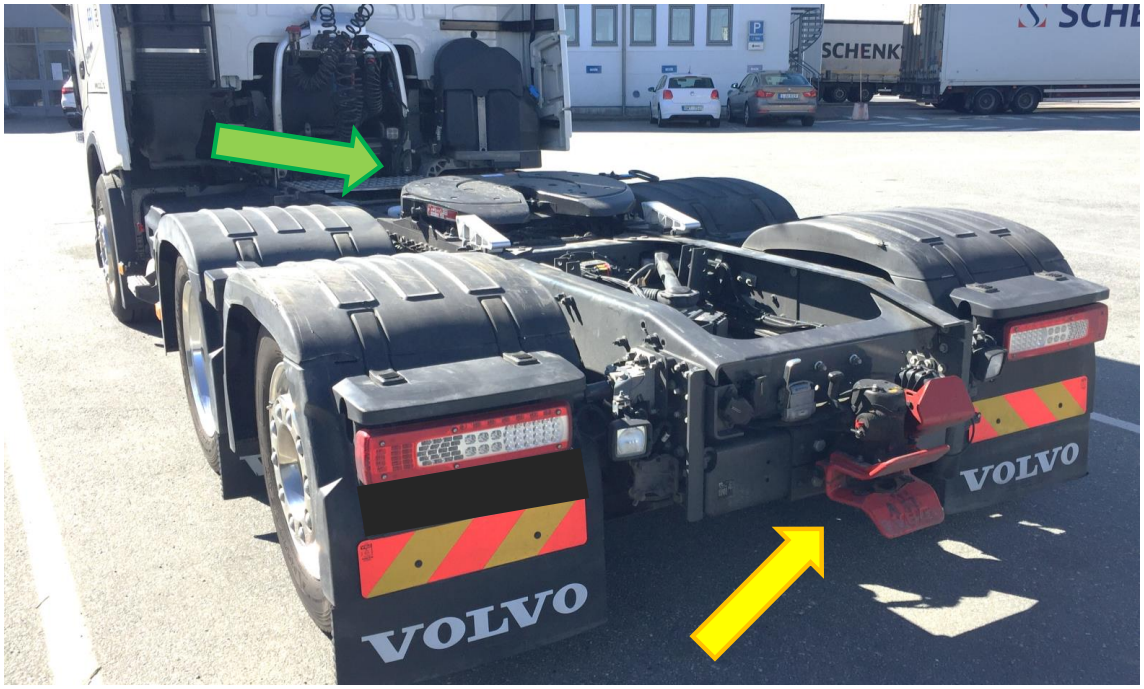


Figure 3.3: *Fifth wheel (green arrow) and coupling for a drawbar (yellow arrow).*

When driving a vehicle combination one truck is combined together with one or more trailers. There are five types of trailer modules: Full trailer, Centre-axle trailer (CAT), Link trailer, Semi-trailer, and Converter dolly, as shown in figure 3.4 (Fröjd et al., 2021).

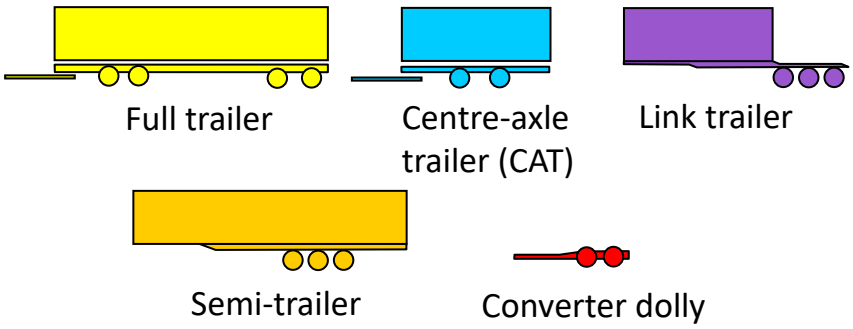


Figure 3.4: *Trailer modules.*

Similarly to the trucks, each trailer module has many different setups and can behave differently. However, some standardization has been made between the modules and they are presented in table 3.1. An example of differences between trailer modules can be the number of axles and the wheelbase.

Table 3.1: *Specifications for the trailer modules.*

Trailer module	Connection front	Connection rear	Loading possibility
Full trailer	Drawbar	None	40/45 foot / 13.6m
CAT	Drawbar	Drawbar/None	20 foot / 7.82m
Link trailer	Fifth wheel	Fifth wheel	20 foot / 7.82m
Semi-trailer	Fifth wheel	Drawbar/None	40/45 foot / 13.6m
Converter dolly	Drawbar	Fifth wheel	None

Each vehicle combination has one truck and can, legally, have a maximum total combination length of 25.25m (Transportstyrelsen, 2021). Within this length requirement, as well as several other requirements presented by Transportstyrelsen (2021), there are five standard combinations in Sweden, seen in figure 3.5. As seen in the figure, three out of five combinations have two trailers after the truck, and depending on the layout of the combination, different trailer modules are used.

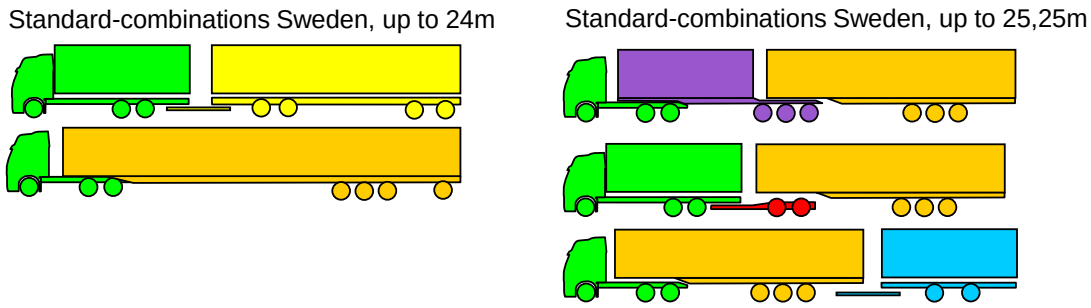


Figure 3.5: *Swedish standard vehicle combinations.*

Namely, a vehicle combination is built up by one truck and up to two trailer modules to be within the regulations in Sweden. Different countries have different legislation regarding length measurements and combination types. An HCT combination, as mentioned above, is a combination with higher capacity than what the legislation allowed 2010 (L. Larsson, personal communication, April 21, 2023). In Sweden, an HCT combination is a combination with a GCW over 60 tonnes and/or a length above 25.25m. These combinations are driving with special permissions and on specific road networks. Within Volvo GTT five different longer HCT combination layouts, seen in figure 3.6, are or have been on trial. The HCT combinations are built up by a truck and up to three trailer modules, with a total length of up to 34.5m. In comparison to a Swedish standard combination, with up to two joints, an HCT combination can have up to three joints. This extra joint makes the drivability of the combination much more difficult when reversing.

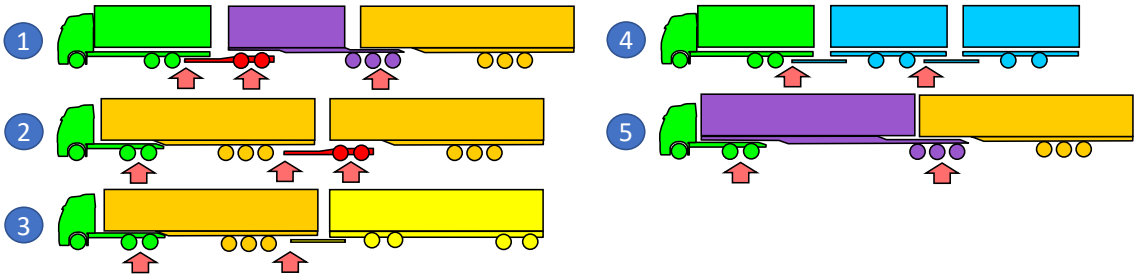


Figure 3.6: *HCT-combinations on trial in Sweden. The red arrows shows the joints for each combination.*

The combinations in figure 3.6 are:

1. ETT-combination: Rigid truck - Converter dolly - Link trailer - Semi-trailer
The ETT-combination (En Trave Till, translated to One More Pile), also called AB-double, is a combination with three joints. The combination was on trial within Volvo GTT in northern Sweden between the years 2009-2018 and transported timber. This combination will soon, around the beginning of 2024, be legal to drive on a limited road network (L. Larsson, personal communication, April 11, 2023).

2. DUO-Trailer: Tractor - Semi-trailer - Converter dolly - Semi-trailer
The DUO-trailer, also called A-double, is a combination with three joints. The combination is driven in two different projects within Volvo GTT:

- DUO-project: Two combinations driving freight with box trailers, have been driving since 2012.
- Autofreight: Two combinations driving freight with open trailers where containers are loaded on top, have been driving since 2020.

This combination will soon, probably around the beginning of 2024, be legal to drive on a limited road network (L. Larsson, personal communication, April 11, 2023).

3. DUoETT: Tractor - Semi-trailer - Full trailer
The DUoETT is a combination with two joints. The combination is driving timber with timber trailers in a Volvo GTT project and has been driving since 2020.

4. DUO-CAT: Rigid truck - CAT - CAT
The DUO-CAT, also called C-double, is a combination with two joints. There are two combinations on trial within Volvo GTT which drives freight transports with swap bodies. The first combination was driven in a project between 2015-2017 and in another project since 2018. The second combination has been driving since 2020.

5. Long link combination: Tractor - Link trailer - Semi-trailer
The Long link combination, also called B-double, is a combination with two joints. However, in this specific combination, the link trailer is longer than a usual link trailer (can take a 40/45-foot container instead of a 20-foot container). There are two combinations on trial within Volvo GTT, driving containers, and they have been driving since 2021.

As seen from these combinations, the different truck and trailer modules can be used in several different formations. It is difficult to say which combination is the best since each combination has advantages and disadvantages. The choice of modules is dependent on many factors, for instance, what goods should be transported within the transport mission or how the hauler uses the different modules in their fleet.

3.3 A driver's transport mission

The purpose of a transport mission is for the driver to transport goods using a truck. The transport missions for a driver can vary a lot. In this investigation the transport missions have been divided into three categories; 1. The repetitive driving, 2. The circle driving and 3. The distribution driving, as seen in figure 3.7.

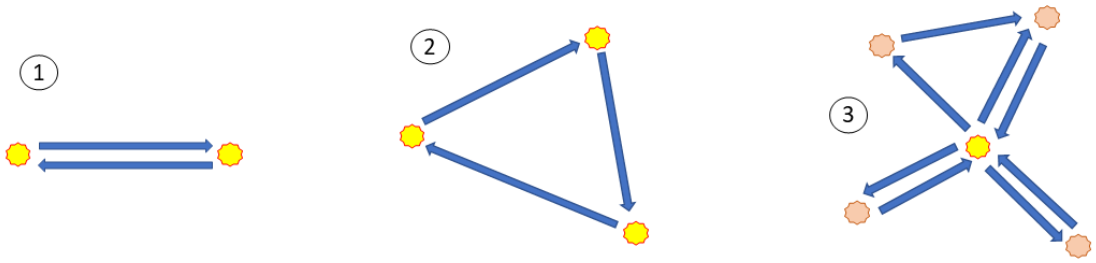


Figure 3.7: *Different kind of transport missions. The yellow markers represent continuous locations, and the pink ones represent temporary ones.*

1. The repetitive driving is a fixed transport mission where the transport is between two fixed endpoints. With this transport mission, it is known what kind of endpoints there are on the mission, and which actions are needed on each endpoint. The driver is, in other words, prepared for what actions are needed along the transport mission.

2. The circle driving is similar to the previous, the only difference is that more endpoints are visited throughout the transport mission. However, the endpoints are known and the driver knows what is needed throughout the transport mission.

3. The distribution driving (pickup and delivery) is the most demanding transport mission for the driver. Each day new endpoints may be visited and information on the endpoints may come late, or not at all beforehand. This transport mission can be demanding since the lack of knowledge can lead to unwanted situations at the endpoints.

For each category of transport mission, the endpoints are usually the most demanding part of the journey for a driver. There are many different kinds of endpoints which are more or less suitable for HCT combinations. Throughout the transport mission, it is usually at the endpoints where the combination is making the reversing actions. Unless something unpredictable has happened along the way, for example an accident, where a reversing action may be needed during the journey

as well. To be able to understand the different demands of different endpoints, three of the most common reversing actions at the endpoint will be presented below.

3.3.1 Reverse into a slot

At some terminals, there are specific slots where the drivers should reverse into. The slots are marked on the ground by lines and can be of different sizes. One example of a terminal with slots is the Gothenburg harbor. As seen in figure 3.8 the combination should reverse into the yellow marked area. However, there is limited space both in the front and by a line in the back. The combination also needs to be inside the sidelines, which means that it needs to be straight. The slots in the harbor are there to show where the combination needs to be placed in order to enable the loading and unloading of containers. If the combination is not well enough placed in the slot, the straddle carriers used for the loading can not access the needed areas. For these specific slots, it is possible to reverse past the slots and later drive forward again to straighten the combination, which simplifies the reversing. However, that is not always possible. For longer HCT combination the area becomes more narrow than for shorter combinations.

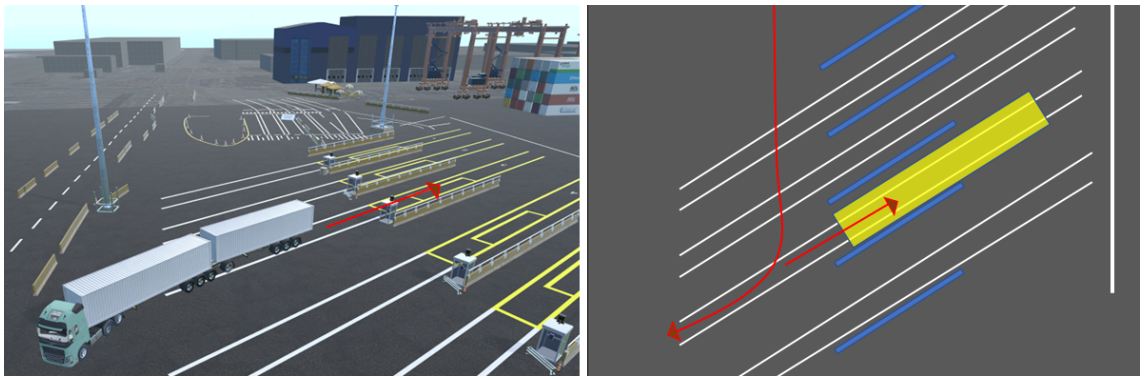


Figure 3.8: *Reversing into a slot at Gothenburg harbor, annotated screenshot from Oryx simulator, and a illustration from above.*

The difficulties with reversing into slots with HCT-combinations are:

- Cramped areas which leads to less room for maneuvering the combination.
- To get the combination straight due to the higher number of joints.
- In some places some slots have more space, however, when it is crowded there may not be a possibility to choose those slots.
- At some terminals with slots the drivers are not allowed to exit the vehicle outside the marked areas. This takes away the possibility to go outside and look at the combination.

3.3.2 Reverse towards a gate

At many freight terminals the combination has to reverse towards a gate for loading and unloading. The gates are marked by number and may have lines on the ground for guiding the combinations. The terminal areas can be of different sizes, and at

some cramped terminals, the HCT combinations have to decouple before entering the terminal and leaving one or two trailers outside the terminal. Further, if the terminal is big enough for the HCT combinations, it usually decouples inside the terminal anyway for easier reversing towards the gates. As seen in figure 3.9 the combination has a similar reversing pattern as the example above. However, in this case, the yellow area is against a wall that the combination needs to reverse against. If the reversing is not properly done there is a risk of damaging the rear of the trailers.

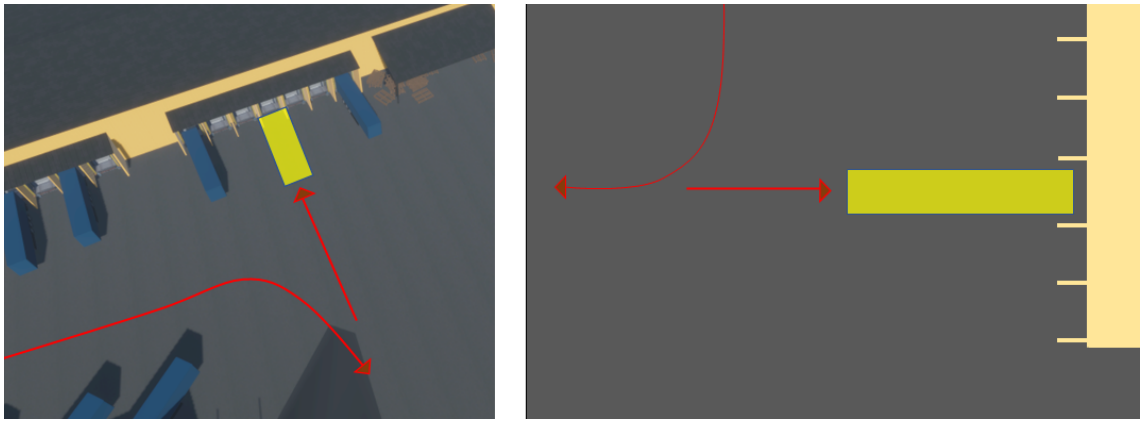


Figure 3.9: *Reversing towards a gate, annotated screenshot from Oryx simulator, and a illustration from above.*

The difficulties with reversing towards a gate with HCT combinations are:

- Cramped areas lead to a need for decoupling of the combination outside the terminal, resulting in longer time spent around the terminal area.
- Due to the length of the combination the sight gets worse, resulting in a more difficult reversing. Usually, drivers decouple the combination while making the reversing inside these kinds of terminal, which leads to a longer time spent in the terminal.
- A risk of damaging the rear of the trailers if the reversing is not properly done.

3.3.3 Open area

An open area can be both a larger or smaller terminal area. In these areas, the loading and unloading vehicles are more flexible by the placement of the combination and can adapt to the location of the combination. At some terminals, the combination stands at a specific area where another vehicle either load or unload. Usually, no reversing is needed when another vehicle load or unload directly from the combination. However, at some terminals, the loading and unloading vehicles place, for example, swap bodies inside a loading area and the combination needs to reverse to load the swap bodies, as seen in figure 3.10.

Figure 3.10: *A DUO-CAT combination to the right reversing towards a swap body to later fasten it on the trailer, in an open area.*

The difficulties with reversing on an open area:

- Depending on the lineup of the swap bodies, the reversing can be more or less difficult. For example, the combination may need to be straight when reversing to load the swap bodies.

4
Results

In this chapter the results of the investigation are presented. Firstly, the result from the drivers' needs study is presented and analyzed. Secondly, the result from the market analysis is brought up. Furthermore, results from the usability testing are presented and analyzed. Lastly, final recommendations are presented.

4.1 Drivers' needs study

In order to make recommendations on how to decrease the reversing time, the needs of the drivers have to be studied. In this section, the results from the drivers' needs study are presented together with the found insights.

The study is divided into four main parts: Collection of data, analyzing the data for each interviewee, analyzing the complete data, present insights.

4.1.1 Conduction of data collection

During the interview process, 10 interviews were conducted: five HCT drivers, three non-HCT drivers, and two Volvo employees who had driven HCT combinations but not on a regular basis. Four of the interviews with the HCT drivers were made in the truck while the HCT driver was driving, and at these interviews, observations were made as well. For the other six interviews, one was made by a phone call while the driver was driving and five were made through a phone call or video communication tools but not while the driver was driving.

The interviews were conducted in the language that was preferred by the driver, Swedish or English. However, when English was used as the interview language, there were still some language difficulties since the drivers who spoke English during the interview did not have English as their native language.

A recording of the interview was made during the interview, which later was transcribed into a document for each interview. For the observation notes were taken during the reverse driving, and these notes were later used to make post-its in the empathy maps.

4.1.2 Establish empathy maps

After each interview was made and transcribed, an empathy map was made for each interview. By doing an empathy map the interviews were analyzed and a deeper understanding was obtained. This was made to contextualize the data into post-its, to later cluster the data.

The empathy maps were made directly after each transcription in order to have the interview as clear as possible in the mind. When making the empathy map the interview had been heard two times due to the transcription, which was beneficial for a deeper analysis. For the analysis, four different aspects were analyzed: says, thinks, feels and does, which can be seen in figure 4.1. In order to not exceed anonymity for the interviewees, the empathy map in the figure is for person X which is a person made by taking random statements from several interviewees. The figure is also limited to only having five post-its for each aspect, the interviewees had up to 17 post-its for each aspect.

The results from the empathy maps were a visualization of specific driver opinions, and a step toward the final insights for the drivers' needs. The purpose of the empathy maps was to translate the transcription and observation notes into post-its, with additional deeper analysis. The results for each empathy map will, however, not be presented as there is a risk of jeopardizing the anonymity of the participants.

Figure 4.1: *Empathy map for person X, the post-its are a mix from different interviewees.*

4.1.3 Cluster the data with an affinity diagram

To analyze the data from the interviews further, an affinity diagram was made to cluster the data. The empathy maps were the base for the clustering and each post-it was sorted into groups based on their relationship. After the sorting 11 main groups were identified, and further sorting within the main groups was made as well. The main groups were different in size, which indicates that the larger main groups were mentioned by more participants, and more important for the insights and to determine patterns. However, when the insights were identified one also needed to have in mind that some main groups could be larger since more questions were asked regarding that specific subject. For example the main group *Simulator* was one of the areas which were always brought up during the interviews and is one of the largest groups. Thus, even if the group was large in size, for that group it was more important to identify patterns and see if the drivers had similar or contrasting opinions in order to draw the correct insights.

When the clustering was done and the main groups had been sorted, patterns could be identified and insights could be drawn, which are presented more thoroughly below. In total 265 post-its were sorted in the affinity diagram, seen in figure 4.2, and 33 post-its were sorted out due to personal information. For example information of what combination the driver was driving. The complete affinity diagram is found in Appendix B - Affinity diagram.

Figure 4.2: *Affinity diagram.*

The main groups in the affinity diagram were:

- Reversing aids [49 post-its]
- Rearview cameras [21 post-its]
- Rearview mirrors [19 post-its]
- Sensors [6 post-its]
- Sight [15 post-its]
- Lights [7 post-its]
- Simulator [32 post-its]
- Training (knowledge) [24 post-its]
- Outer factors (not sight) [33 post-its]
- Feelings [38 post-its]
- Driving [21 post-its]

Reversing aids

The reversing aids group was the largest group of the main groups and have the most subgroups. It is, however, not surprising since many questions in the interview were directed toward aids while reversing. Given that this main group is the largest, it is also one of the most diverse groups in itself, with many different opinions. There were opinions of how aids, in general, are good, but that it is important to have the right specification on the truck from the beginning when the truck is ordered. For example, more horsepower if the GCW is larger or the wheelbase on the truck for steering ability that suits the transport mission. Especially when the conditions are more difficult, for example when it is slippery outside, specifications as liftable axles affect the reversing positively:

> *"If you reverse where it is a bit slippery, then it is often that you lift them up [liftable axles on the truck], you get a little more turning room too, [...], at the same time you get more pressure on the drive wheels."*

Many also questioned new aids on the market. Different questions were mentioned during the interviews, for example: Are the new aids on the market trustworthy? Do they really work as they are planned? What happens if the outer conditions are bad, does that affect the aids? However, what most interviewees questioned was: What will happen if the aids stop working? Many of the interviewed drivers had a lot of driving experience and were not afraid of what would happen with their driving if the aids stopped working, despite their own experience, they were afraid of new drivers:

> *"Automation that can turn the wheel for you. [...] The downside with that is that new drivers do not learn to reverse. So it is good with automation, but the professional competence still needs to be there those days when automation doesn't fully work."*

Lastly, irritation regarding aids was a frequently mentioned topic. Some aids were not developed as the drivers wanted, for example the fact that they were not easy to turn off if they were not wanted, or:

> *"I don't like beeping"*

Further, irritation also occurred when there were problems with the aids, or if they stopped working:

> *"When they [the aids] work, they are good, but we have had a lot of problems with some aids"*

According to the interviewees, there are both positive and negative aspects of reversing aids. It is important to understand the transport mission both when ordering a truck, although, the importance of developing the right aids for each type of transport mission is also of importance.

Rearview cameras

On most new passenger cars today, cameras are a commonly used aid, particularly for reversing. On truck combinations, however, the reversing camera is usually only found on the rear of the truck and not on the trailers (L. Larsson, personal communication, April 3, 2023). Consequently, when reversing with a combination the rearview camera does not help. Further, the drivers were not as convinced of the function of the aid as for a passenger car. The more experienced drivers did not see a rearview camera as something they would use, some even indicated that the camera would take focus from the reversing. Additionally, the cameras need to work well and not have a delay. However, many saw the positive aspects of a camera when reversing towards a wall or when learning to couple the combination:

> *"The trucks you have had with a camera in the rear makes it easier so you can see the towbar or the drawbar, for example, or the turntable and trailer."*

Some drivers also mentioned the extra safety aspects that come with a camera:

> *"[...] or it would have been good from a safety point of view to be able to see behind the vehicle so that there are no people or something similar there. But it would not help me in the reversing, I believe."*

The positive aspects of using a camera are dependent on the transport mission, according to the drivers. If the combination is reversing in an area with a lot of people, then the camera can be used as an extra safety measure and give more confidence to the driver. Alternatively, it can be used to see all parts when coupling a combination. Although, it may disturb an experienced driver more than it helps.

Rearview mirrors

Mirrors are seen as an essential part of a reversing. All drivers used the mirrors while reversing as long as they could before a need for another action was taken, for example looking out of the side window for better sight. Reversing around corners or reversing when the right mirror is used were seen as significantly more difficult reversings. Even if the mirrors are seen as an obvious part of the truck, new techniques which can replace the mirrors are developed, for example cameras instead of mirrors. However, while these new cameras may be beneficial for the fuel consumption, the drivers see problems with using them while reversing:

> *"The perception of length disappears, according to me, you get very bad knowledge of the exact position or the exact length of it [the combination]. It becomes very difficult to keep up, you have to look out of the window more often and look backwards."*

Sight (direct and indirect)

The sight of the whole combination becomes more difficult due to the length of the HCT combinations. However, the drivers did not bring up the poor sight due to the length as a problem, unless the outer conditions were bad. Both darkness and rainfall affect the sight which is a key aspect when reversing.

When asked what difficulties the drivers experience while reversing, one of the most mentioned answers was:

> *"It is the sight first and foremost, it is difficult to reverse when it is dark and unlit."*

The sight can be both direct, seen with their own eyes, or indirect, seen with help from mirrors, cameras, etc. The indirect sight is used mainly to reverse, and the direct sight is only used when the indirect sight is not good enough. For direct sight, there are also no distortions:

> *"I use mostly the mirrors while reversing. If needed I stick my head out of the window, or walk outside to look and get a clearer view."*

A problem, brought up by the drivers, with this is that they usually need direct sight when the outer conditions are bad. If it is raining, though, the drivers would rather not go outside of the truck:

> *"When the sight is bad, for example rain, and you maybe should open the door and look out, then you do not do it since it is raining and you do not want to get wet. Then you might take a chance and hope for the best instead of being secure."*

Since indirect sight is used a lot while reversing it is important to be able to have great sight even if the outer conditions are bad. Otherwise, it may cause insecurity and unwanted accidents.

Lights (working lights)

The sight problems from the darkness and rain affect when driving HCT combinations as mentioned above. The drivers pointed out these sight problems many times, however, they also mentioned that the problems are quite easily solvable:

> *"The sight cannot be affected, but lights and cameras help. So those are two things that can make things easier."*

Since the HCT combinations are longer, the rear can easily disappear into the darkness if it is not sufficiently lit. Having more lamps at a terminal area helps, however, it is more important that all the axles are sufficiently lit. Due to that, it is important to have lights on both the truck and the trailers, and that they are oriented correctly so the driver can see the tire position and the rear of the trailer.

> *"Of course it will be much more difficult to reverse if you do not have lights, for example if you do not see the back of the trailer."*

Consequently, the drivers see lights as an easy and inexpensive aid, that will help them incredibly when the conditions are bad.

Sensors

Sensors are also an aid used in many new passenger cars today. Still, it is not an aid the drivers believed in or felt that they would use. The ones who talked positively regarding the sensors would use them when reversing towards something, but from the participating drivers, very few did that in their daily work. And if they did, they de-coupled the HCT combination and reversed with only one trailer.

> *"It warns before you are on something and then it will just beep and disturb me in my reversing which I have control over."*

However, one driver mentions that when a beginner is driving the combination, then maybe sensors could help and make the new driver more secure and confident in their driving. At the same time, the system itself was not wanted by the interviewee:

> *"I can imagine that if it is a newly trained truck driver, well they might appreciate that it warns that you are close on one side. [...] These systems may not be wrong, but they need to be easily disabled for drivers who feel: this bothers me more than it does good."*

Simulator

When the drivers were asked about using a simulator as a tool for practicing reverse driving, it was a clear division of opinions between those who believed it and those who did not. Almost half of the interviewed drivers could see the positive effects of driving in a simulator before driving in real life.

> *"The advantage of a simulator is that you can fail without breaking anything."*

However, they were not all fully convinced about how much of the practice could be done in a simulator. Since each combination is different and behaves differently, some drivers still thought that real life practice is still important. However, some hours could be driven in a simulator for new drivers to get a feeling for the combination:

> *"I had simulators in driving school. Sure, you did not get a 100% feeling for how to do it, but you still get a little feeling for what it is like. So I think the simulator is good as a tool when learning at the beginning. [...] To see which way things go when you turn is useful anyway."*

> *"For new drivers, absolutely. How applicable it's to reality, I don't know. But for new drivers, it can be good to feel it before driving in real life."*

For those who disliked the idea of simulators, it was because they thought it would not be able to represent the reality and that practicing in real life would be better.

> *"The best way to learn is to drive, drive, drive. I don't think it's similar enough to reality in a simulator, you don't get the same feeling."*

Even if the interviewees had positive or negative opinions about using a simulator as a tool for practice, almost all of them mentioned the design of the simulator. The simulator needed to be close to reality, otherwise, the practicing would not be useful for driving in real life. Some of the drivers had tried simulators before, and not felt that the simulators were helpful for their driving ability. Some almost felt the opposite, that the simulator for example taught them where to look, but later in reality they looked at the wrong place and needed to learn where to look again. Furthermore, the importance of a simulator being close to reality was the most common opinion regarding simulators.

> *"It can make matters worse depending on how the simulator is developed and how it makes a driver experience what it is like to drive for real. If the feeling in the simulator does not match at all with how the combination will behave in real life, then you can be in trouble. [...] You have to test it, if it is realistic then it is a great idea. If you get the wrong feeling from it, you will probably make things worse."*

One of the last questions during the interview was if the interviewee would like to try a cab simulator, and even if they were negative towards simulators, everybody wanted to try a cab simulator, mostly to see if the right feeling can be achieved:

> *"Like I said I've never tried a cab simulator, but I'd love to try one and see if my preconceptions are right or not."*

Training (knowledge)

To get the possibility to train with an HCT combination, or even to only test drive it before going out in traffic, was seen as important for all the drivers. However, depending on their experience, some thought that it was enough to only try the new combination for 10 minutes, while others wanted more time to practice.

> *"I drove together with another driver the first two weeks, it was very good. I also got to practice reversing on an open area before I drove on my own."*

To be able to practice with a new combination strengthens the sense of security for the driver. The stress level also decreases from it, especially if they are able to practice in an area where nobody is watching. Since many of the reversings the drivers do are at locations where others can watch, it increases their performance anxiety. However, according to the drivers, this anxiety can be reduced by letting the drivers practice and get enough knowledge of the combination to feel secure to drive it:

> *"I would have appreciated practicing before going out into traffic. [...] When something happens in traffic and you have to solve a situation, maybe if a road is closed or if an accident has occurred and you need to get out of the way. Then it can be unnecessarily stressful if you have not had a chance to practice, and to get a feeling for how the combination behaves when you start reversing."*

Outer factors

The drivers were asked if outer factors affected the reversing, and due to the question, the main group became a large one. However, the drivers mentioned many different factors and how they affect them. The most commonly mentioned factor was too little space:

> *"Some of the terminals I go to are too small to enter with an HCT combination. Then I have to decouple the combination and take one trailer at a time."*

Given the space problem, frustration arose among the drivers. Some mentioned that in a way this is not a huge issue if it is realized before entering the terminal that it is too small, and if there is time to take one trailer at a time. However, if the terminal is entered and you later realize that it is too small, then it can be difficult to reverse out of it. Or if there is not enough time to take one trailer at a time, then the drivers may feel stressed and reverse more violently.

Beyond the space problem, lines were the second most mentioned outer factor. Lines on the ground are used as guidance when reversing and help the driver for example to see if the combination is straight or not.

> *"[...] but if you have lines, you immediately see the offset and that you at the front axle have 5cm and at the back have 10cm. Then I know that I stand at an angle to the straight line and can more easily control it back before I get too far and have to start over."*

One can conclude that even those who own the terminals have an influence on how difficult it is for the drivers to reverse with an HCT combination. And that their ability to collaborate and adapt their terminals can have a big impact on both drivers and haulers.

Feelings

The feelings main group is the second largest group. During the interviews, many feelings arouse for the drivers, such as frustrations, when they feel stressed, or if they are confident in their driving abilities. With the post-its in the feelings category new problems that the drivers have did not arise, but they can confirm which of the problems are the most important to solve. For example, if a driver is insecure in its driving, lack of practice before going into traffic is impacting more than for a driver with a lot of experience.

Driving

The main group driving is a broad group with comments connected to how the combination is driven while reversing. Although it is one of the larger groups, it does not reproduce much in terms of results. Some comments were made regarding lifting axles while reversing and some of having a steering axle. However, the main result from this group is that drivers reverse differently and use different guidelines and tools to aid their reversing.

Summary main groups

One of the most important conclusions from the affinity diagram was how important it is to understand what is needed for the transport mission when the truck is ordered. A better suitable specification of the truck can result in a more efficient reversing. However, it is important to understand what the drivers need while developing these aids, or for haulers when investing in aids. Another conclusion is how the outer aspects impact the driver. Both visibility and the design of terminals affect the driver and a disadvantage of this is that it requires investment to improve these conditions. Further, it was not a surprise that practicing driving was important for the drivers. It was, however, unexpected how many drivers had a negative attitude towards simulators. Approximately 50% of the drivers were positive about using a cab simulator for training while the other 50% did not believe in it, even if only a few had tried one. Further, a positive aspect was that everyone was willing to try one, even if they did not think it would work similarly to real life.

The result from the affinity diagram will be used when formulating the personas below, and the number of post-its for each opinion affected how likely it was for that opinion to be a part of a persona.

4.1.4 Convert insights into personas

Using the insights from the empathy maps and the affinity diagram, three personas were formulated to represent the needs of the drivers. Two of the personas represent HCT drivers, while the third represents non-HCT drivers. The creation of the personas was made with the target to create a spread between them, both with personalities and experiences. This was done to include as much of the collected data as possible into the persons as well as to cover as many drivers as possible.

The fact that two HCT drivers were made and only one non-HCT driver was because their needs were valued higher, but also since the HCT interviewees had more different opinions of what was important while reversing. However, the non-HCT drivers' opinions and needs were also of importance and that is why it was chosen to also be included as a persona. Namely, the HCT drivers are important since they know how to reverse with an HCT combination and what problems they have. While the non-HCT driver may have needs the HCT drivers take for granted or can think of what they would need to be able to learn how to reverse with an HCT combination.

The two personas for the HCT drivers were made as opposingly as possible, from the collected data. For example one young with less experience, and one older with many years of experience.

Below the three personas are presented with a background of them, their attributes as personas and their needs.

4.1.4.1 Persona 1 - The experienced multi-driver - Lars

Lars is a 50-year-old family man with a wife and two kids. He is quite old-school and does not keep up with all the new things his kids are showing him. However, when he is in his truck he feels confident and in his essence. He has been working as a truck driver for half his life and he enjoys his duties as a driver. During these years he has worked for many different haulers and is today working at a medium-sized haulage company. From this, he has gained experience driving several different combinations over the years and he sees it as one of the reasons for his confidence as a driver. However, he is not a fan of all the new aids in the truck, although he appreciates some of them. Nevertheless, he is most fond of them as aids for other drivers, especially new drivers. He appreciates that aids give his less experienced colleagues a helping hand while reversing, but he is also afraid of the day the aids suddenly stop working. Then it is only their experience that matters, according to him.

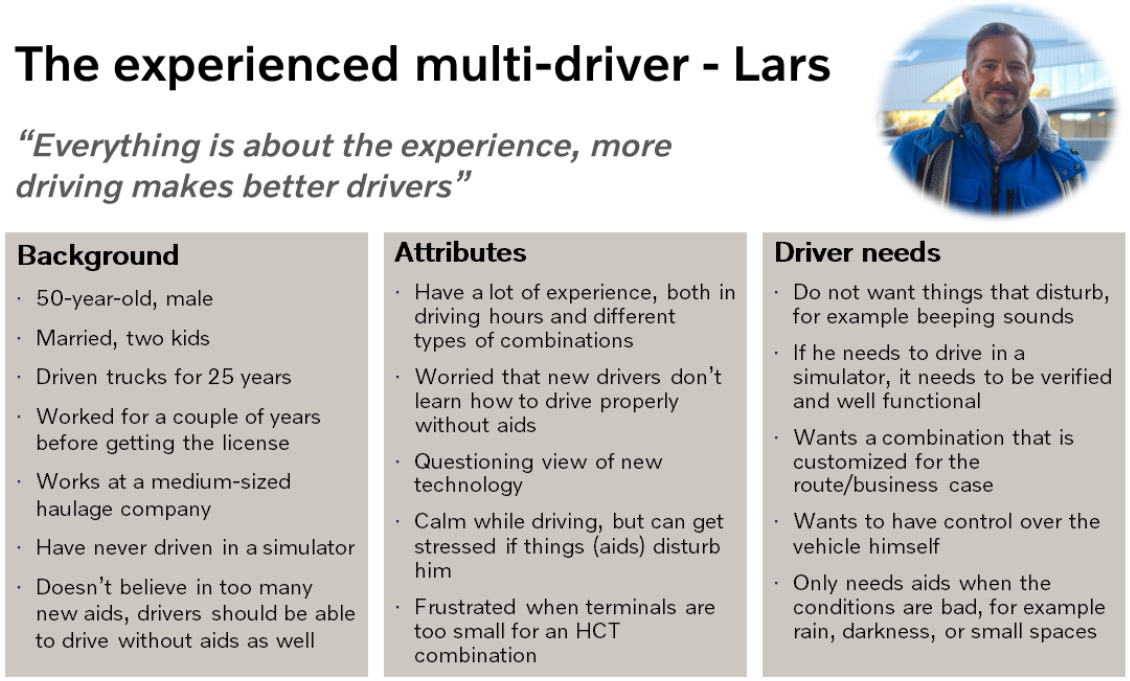


Figure 4.3: *Persona 1 - Lars (Fortier, 2020).*

4.1.4.2 Persona 2 - The newly graduated driver - Agnes

Agnes is a 23-year-old country girl who lives by herself. She recently graduated from a transport high school and has not had her driving license for more than a year. Due to her lack of experience, she appreciates aids in the trucks and has practiced her driving in simulators while practicing for her license. Today she is working at a small haulage company and drives an HCT combination. She has a positive view of driving, but due to her experience level, she sometimes gets stressed by the environment she is driving in. The terminals are sometimes very small, or there are a lot of people around who watch her, which makes her nervous and questions her driving ability. In those situations, she takes the safe way before the uncertain, and she wishes for an aid that can help her. However, one of the most important things for her is to build up her confidence while driving, which she may achieve by practicing her driving, either in real life or in a simulator.

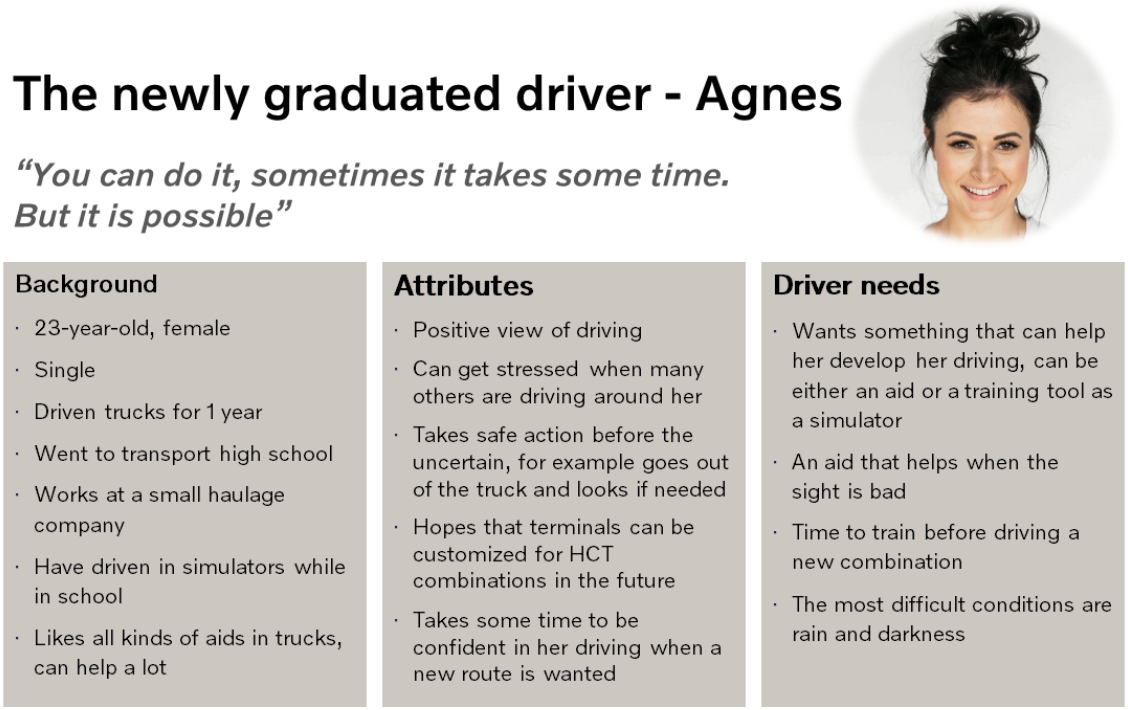


Figure 4.4: *Persona 2 - Agnes (Nackos, 2020).*

4.1.4.3 Persona 3 - The confident day driver - Theo

Theo is a 35-year-old engaged man who has been driving trucks for as long as possible. Already from a young age, he drove with his father in the truck, and to be a truck driver himself was an obvious choice. He went to a truck driving high school and after graduation, he started to work at a larger haulage company. However, after a couple of years, he got the opportunity to work as a test driver, and with his interest in trucks, he accepted the offer. While working as a test driver he drove different combinations, however, not any HCT combinations. During his time as a test driver, he tried different new aids, but he usually did not feel like he needed them. Cameras only gave him a worse depth perspective, and many of the aids were difficult to turn off. He also got the possibility to drive different simulators, which he did not really like. He felt that they were too unrealistic, but if a realistic one is made, he likes the idea of practicing in a simulator. Today, however, he is working at a smaller haulage company, and he thinks that with his experience he can drive an HCT combination with only 10 minutes of training before driving on the road.

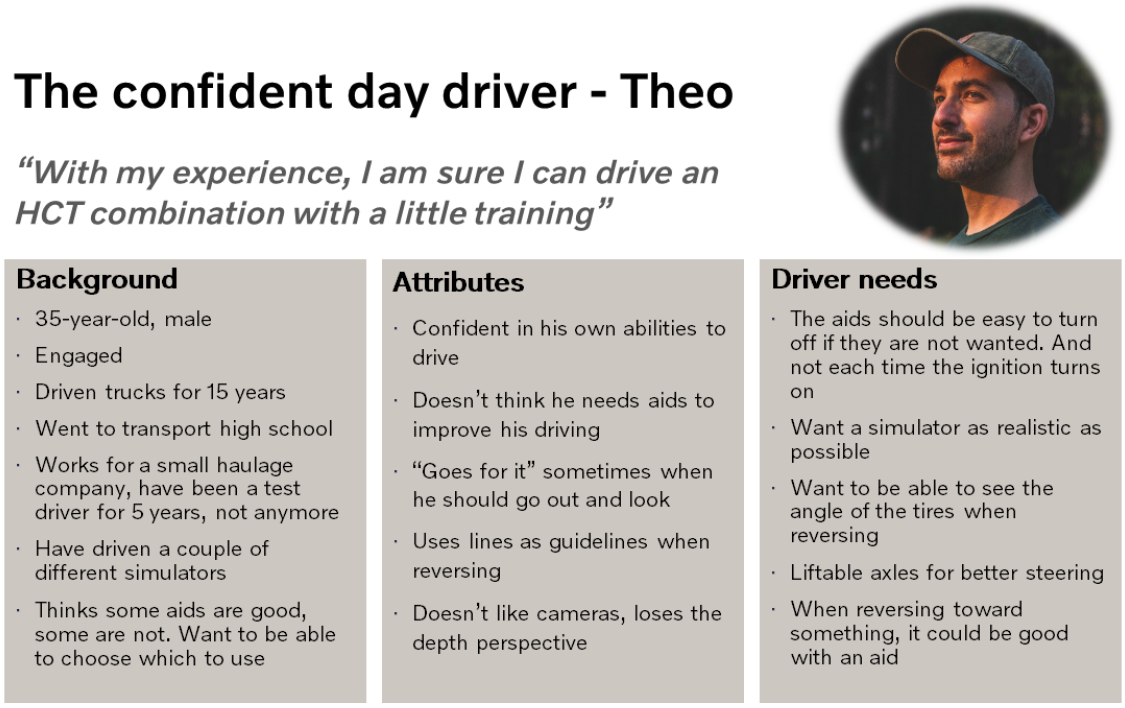


Figure 4.5: *Persona 3 - Theo (Keenan, 2020).*

4.1.5 Insights from the drivers' needs study

From the affinity diagram and the personas, four main drivers' needs have been identified:

1. The HCT combination needs to have the right specifications and be designed for the correct transport mission.
2. The drivers need to have the time and possibility to practice before driving an HCT combination in traffic.
3. When the sight is bad, external aids are needed for the driver to be able to make the reversing efficiently.
4. The layout of the terminals affects how easy the reversing is and the drivers need to have terminals adapted for HCT combinations.

Further, these needs have emerged from the main insights from the drivers' needs study, and they are presented below without mutual order:

1. **The combination must be designed to suitably fit the transport mission.**
    - When ordering a combination one needs to know the most suitable design for the combination and the transport mission.
    - It is important to have the right specifications on the truck from the start, for example type of trailer modules, the right amount of horsepower, liftable axles on which position, wheelbase, etc.

2. **Practice makes perfect! Experience matters a lot when reversing.**
    - Different HCT combination are of varying difficulty and needs different time for practice.
    - You can get a basic exercise in a simulator, for example "if I steer in this direction, the last trailer will go in that direction".
    - However, even if many believe that you can get a basic exercise in a simulator, the importance of practice in real life is also important to gain the right experience for the specific vehicle combination.
    - Since each combination behaves differently, it is important to always make some kind of trial runs with the right combination before driving on the road.

3. **External aids such as extra lights and cameras are appreciated, however, they are mostly used when the sight is bad or if you are a beginner.**
    - External aids are mostly used when it is dark outside or while raining or snowing.
    - Since everybody doesn't appreciate external aids, it must be easy to turn them on and off.
    - If the external aids are attached temporarily and easily moved, they can be used on different combinations, for example the first month of driving with a new combination or while practicing.

4. **External aspects and conditions, for example the size of the terminals or maintenance of the lines on the ground, affect a lot.**
    - It takes more time to reverse if the areas are not adapted for HCT combinations. The driver may need to decouple the combination or drive back and forth many times.
    - External aspects, such as lines on the ground, are usually used to guide the reversing and can decrease the time for it.

4.2 Market analysis

During the market analysis and benchmarking, four main product categories were found. Additional products were also found, however, they needed to be ordered when ordering a new truck and could not be mounted afterward. Due to the limitation of only including products on the market, which can be mounted after the truck is ordered, those additional products were discarded. Another product found, and used in many personnel cars today, is sensors. The sensors found in the benchmarking were mounted after delivery of the truck, however, it was mostly for only rigid trucks or in scientific research. Consequently, the sensors were discarded from the market analysis.

Keywords used during the benchmarking are presented below. Since the project is delimited to the Swedish market the keyworks were mostly used in Swedish, however, to broaden the view, some of the English translation were also used. Below, both the Swedish word and the [English translation] is presented:

- Backkamera lastbil [Reversing camera truck]
- Backkamera trailer [Reversing camera trailer]
- Magnetisk kamera [Magnetic camera]
- Magnetiskt monterad kamera [Magnetically mounted camera]
- Magnetisk kamera lastbil [Magnetic camera truck]
- Magnetiskt monterad kamera lastbil [Magnetically mounted camera truck]
- Magnetisk kamera trailer [Magnetic camera trailer]
- Magnetiskt monterad kamera trailer [Magnetically mounted camera trailer]
- Radar för backning [Radar for reversing]
- Radar för backning lastbil [Radar for reversing truck]
- Backradar [Reverse radar]
- Backradar lastbil [Reverse radar truck]
- Backradar trailer [Reverse radar trailer]
- Sensorer för backning lastbil [Sensors for reversing truck]
- Backningssupport lastbil [Reversing support truck]
- Backningssupport trailer [Reverse support trailer]
- Rangering lastbil [Shunting truck / Coupling truck]
- Hjälpmedel vid rangering av lastbil [Aids when shunting/coupling trucks]

Using product categories instead of products was chosen since there were products with less quality or with more quality for each category. The SWOT analyses were

consequently focusing on the characteristics of the product categories. Below, each product category is presented together with its SWOT analysis.

4.2.1 Wireless camera - magnet mounting

The first product category is a wireless camera mounted on the combination with a magnet. The camera is connected to a smartphone and does not have any external screen. This camera has the flexibility to be placed at different places on the combination. For example at the rear when reversing, or in the middle when coupling. Further, it can also be used on different combinations. This gives a hauler the possibility to use the camera when drivers need practicing, but they may not need a camera for each combination. However, the camera needs to be taken down between usage at the endpoints. The camera needs to be recharged regularly. The SWOT analysis for the wireless camera mounted by a magnet is seen in figure 4.6 below.

Figure 4.6: *SWOT analysis of wirless camera - magnet mounting (Fordonsshoppen, n.d.).*

4.2.2 Wireless camera - mounted on unit

The second product category is a wireless camera mounted on a unit. The camera connects to a screen placed in the cab that comes with the camera. The camera is mounted at a specific place on the combination and needs to be plugged in for electricity. This category will be most beneficial for combinations where the trailers are not changed and are always in the same order. Since the camera is always mounted there is a higher possibility that the driver will use it. This product is also beneficial if many different drivers are driving the combination. Otherwise, for example the magnetically mounted camera, each driver has to connect to the camera. Due to the screen, this is not needed for this product. The SWOT analysis for the wireless camera mounted on a unit is seen in figure 4.7 below.

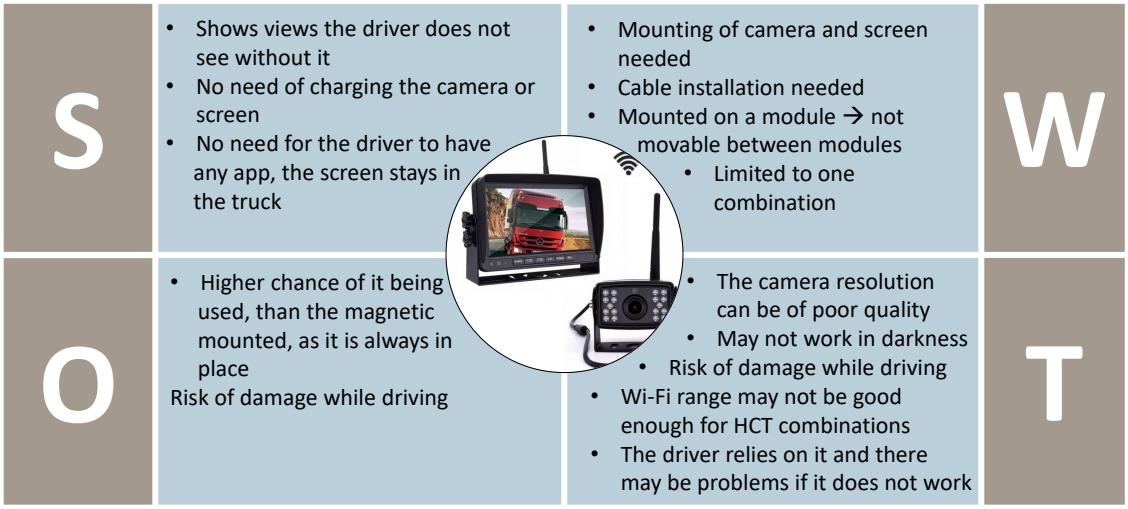


Figure 4.7: *SWOT analysis of wirless camera - mounted on unit (Prylstaden.se, n.d.).*

4.2.3 Wired camera - mounted on unit

The third product category is a wired camera mounted on a unit. This camera is similar to the one above, however, the difference is that the connection between the camera and the screen in the cab are connected by cables. For an HCT combination, these cables need to be long enough and it may be difficult to connect the camera if many different trailers are used for the transport mission. However, the risk of a delayed image is not as likely to happen as for the cameras connected via Wi-Fi. The SWOT analysis for the wired camera mounted on a unit is seen in figure 4.8 below.

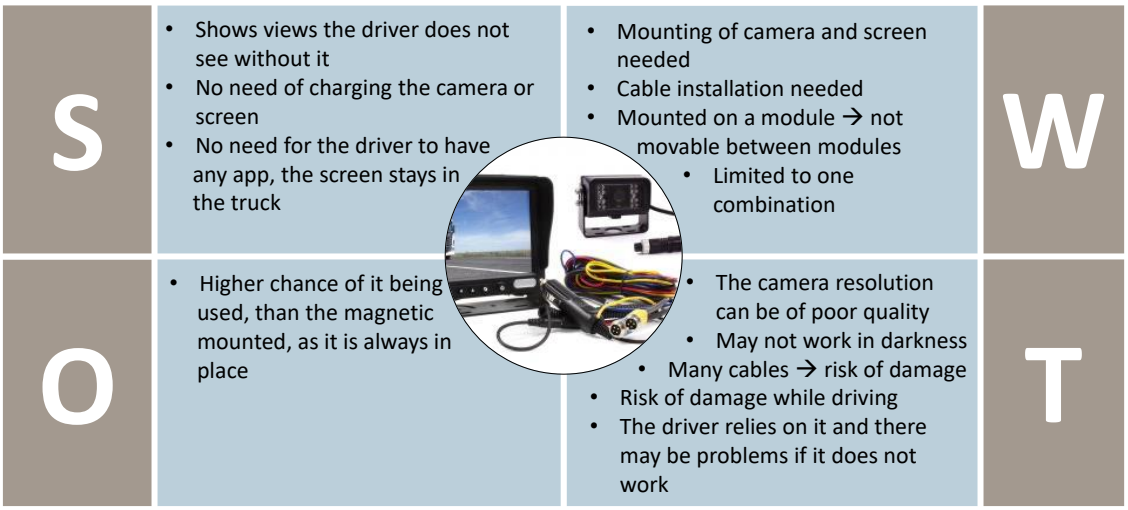


Figure 4.8: *SWOT analysis of wired camera - mounted on unit (Transportstyling, n.d.).*

4.2.4 Working lights

The last product category is working lights. The working lights are mounted on the combination and they need to be plugged in for electricity. If the working lights are connected to the outlet for the usual reversing light, they are automatically turned on at the same time. They can, however, be connected to another outlet and be turned on by a switch in the cab. Depending on the length of the combination, the number of lights may differ. The layout of the combination also affects where to place the lights and the number of them, since different parts need to lighten up on different vehicle combinations. It is, however, easy for the driver to use them once they are mounted. The SWOT analysis for the working light is seen in figure 4.9 below.

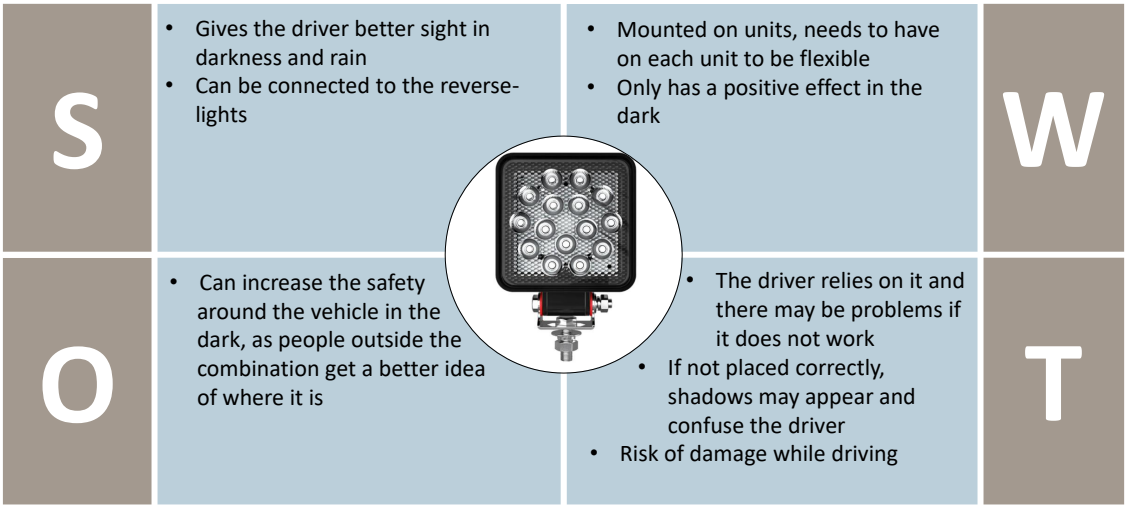


Figure 4.9: *SWOT analysis of working lights (Lastbilsprylar, n.d.).*

4.2.5 Conclusion from the market analysis

One may conclude that the working lights are a obvious solution for a combination which is driven in the dark. Since the chosen road conditions have been chosen to Sweden in this investigation, the lights will during winter be used for many hours of the day. The lights may support for the driver both when the driver is watching backwards using the mirrors, looking out of the window, or when using a camera. However, the number of lights varies between different vehicle combinations, and many lights needs to be used.

The result from the market analysis regarding the cameras is dependent on the layout of the used combination and how the combination is used. Between the three varieties of cameras, one can discard the wired camera if it will be used on a HCT combination. The wiring is more complicated than for the other solutions, since it both needs connection to electricity, but also a connection between the screen and the camera. However, this may be beneficial when a combination is never, or very rarely, decoupled. The two wireless cameras can both solve their purpose, however, for the suitable combination; the magnetic one when the combination decouples

often, or uses different trailers, and the mounted one when the same trailers are used and the combination is rarely decoupled.

Summarized conclusion of market analysis:

- Working lights are a useful aid while reversing, especially in Sweden due to the darkness.
- If the combination is usually decoupled and the trailers are shifted:
- Use a camera with magnetic mounting.
- If the combination is rarely decoupled and the same trailer units are used:
- Use a camera mounted on a unit, preferably the one connected through Wi-Fi to avoid wiring.

4.3 Results from the usability testing with a simulator

During the usability testing, the task for the participants was to reverse into a slot in the scenario in the simulator. The driving scenario in the simulator was to make a reversing similar to what is made in Port 4 in the Gothenburg harbor today, see figure 4.10. The port has 14 slots, and the slots have different layouts, some having less space and some having more. In the scenario, the drivers were asked to reverse into slots 11, 12, or 13 (the slots with the most space).

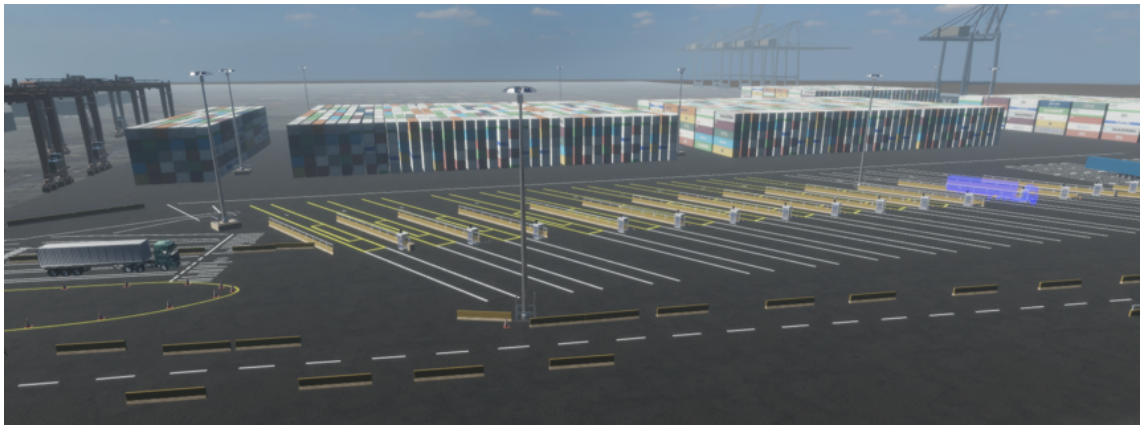


Figure 4.10: *Port 4, annotated screenshot from Oryx simulator.*

In the back of the slots, there was a line that the driver was not permitted to reverse over, a rule they have in the harbor to separate trucks from straddle carriers, which can be seen in the top right corner of figure 4.11. The time for the driving started when all the settings were done and ended when an acceptable reversing was made (when the complete combination was inside a slot, see figure 4.12).

Figure 4.11: *Reversing into a slot, annotated screenshot from Oryx simulator.*

Figure 4.12: *A complete reversing seen from the top view.*

During the usability testing, 12 participants were driving in the simulator and the division is shown in table 4.1. All participants had CE-drivers licenses.

Table 4.1: *Amount of participants in the usability testing.*

Participants	Amount
Volvo Employee	6
HCT driver	3
Non-HCT driver	3

Figure 4.13 shows a picture of a driving inside the simulator. None of the participants had to take a pause of the test, or end the test due to motion sickness. The driving times and results from the feedback grids are presented below.

Figure 4.13: *Picture taken inside the simulator during a drive.*

4.3.1 Times for the drivings

During the usability test, each driving was timed and the times are shown in table 4.2. As seen in the table, all participants succeeded to reverse the tractor - semi-trailer within 5 minutes. For the next combination, the Long link combination, considerably more spread times were achieved, seen in figure 4.14. Only four drivers succeeded to reverse within 10 minutes. For the DUO-trailer only one driver succeeded, however, after exceeding the total driving time.

Table 4.2: *Times for the different combinations.*

Combination	Time
Tractor - Semi-trailer	Everybody drove within 5 minutes
Long link combination	See figure 4.14
DUO-trailer	One succeeded within 45 minutes

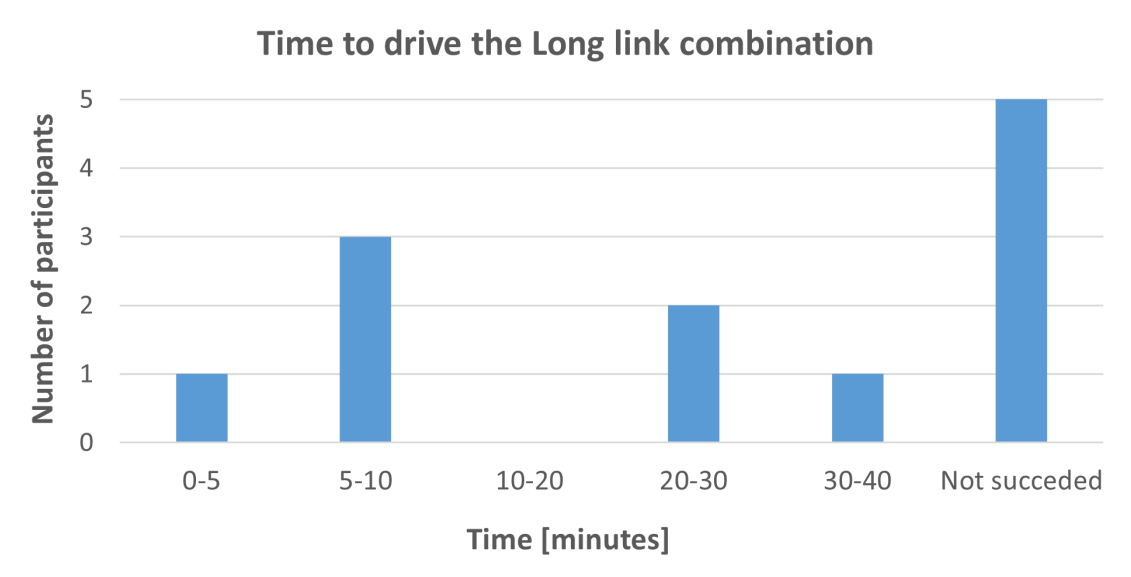


Figure 4.14: *Time in minutes it took for the participants to drive the long link combination.*

4.3.2 Results from the feedback grid

During the simulator drivings, a feedback grid was filled out for each participant. After each test, the grid was further filled in. In figure 4.15 the opinions, written on digital post-its, which were brought up by the participants more than once are presented. The circle in the right down corner of each post-it states how many participants brought up the opinion. In total 104 post-its were written: Like 27, Dislike 44, Questions 20, Improvements 13. For the complete feedback grid see Appendix C - Feedback grid.

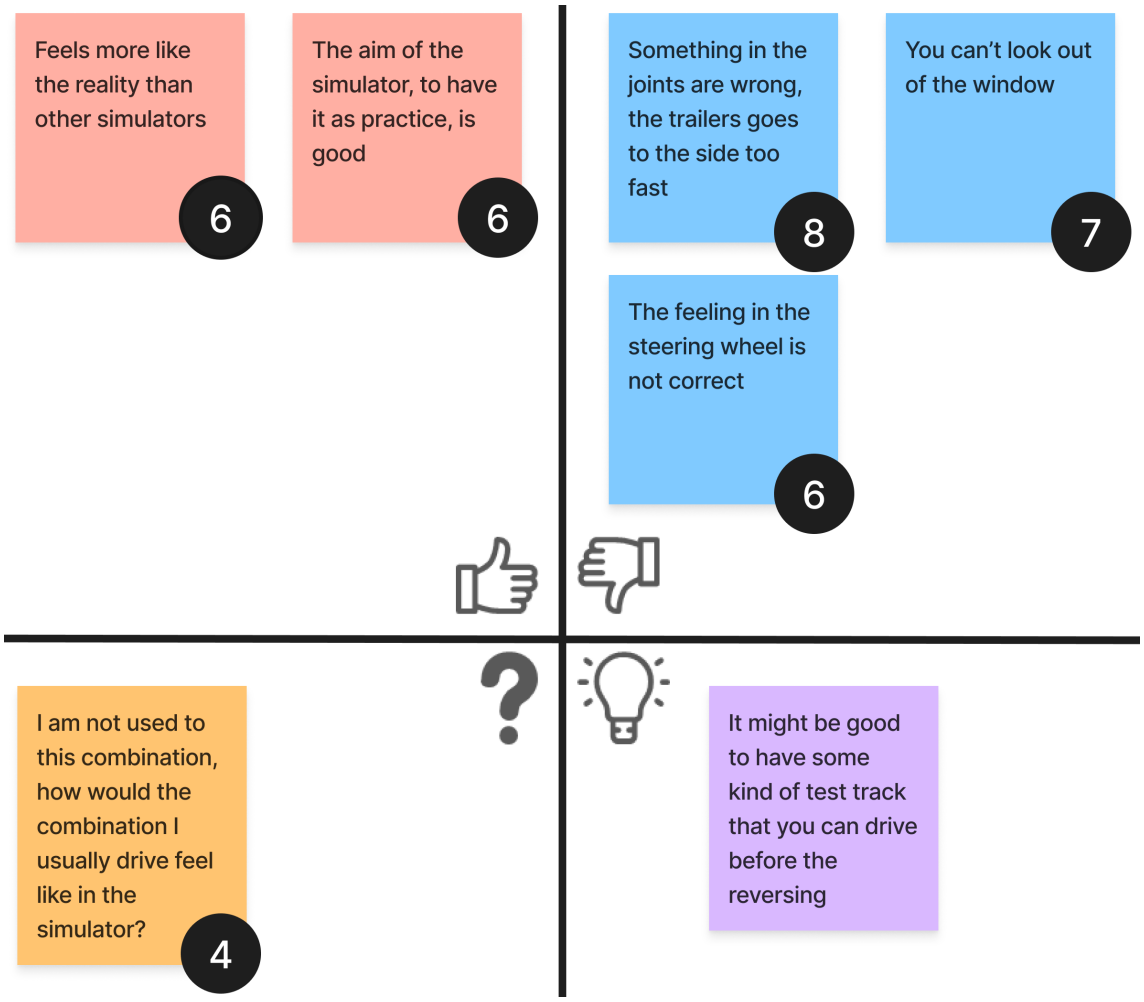


Figure 4.15: *Feedback grid with the opinions brought up by more than one participant.*

As seen in the figure, the category Dislike had the most opinions regarding the simulator. Presumably, since the drivers could feel directly what was wrong with the simulator, compared to the reality. Most of the opinions from the Dislike category were stated during the driving, while for the other categories, the opinions were stated both during the driving and, however mostly, after the driving.

It was a clear difference between the drivers who could adapt to the simulator directly, compared to the drivers who could not. Out of the 12 drivers, three drivers had difficulties driving forward and by that, it was difficult for them to get a good starting position before starting to reverse. While four drivers felt that they drove and reversed as usual, even if they complained over things in the simulator which did not feel like the reality.

Even if the drivers felt many differences from the reality, two specifications were assumed to affect the behavior of the combination in a way that can have a negative effect on new drivers learning to reverse in the simulator. The first was the connections in the joint. Most of the drivers complained about how fast the trailers

went to the side, and when they were asked why they thought it did behaved in that way it was difficult for them to answer. However, they mentioned that something with the joints are wrong. The second specification was connected to the steered axle on the link trailer on the Long link combination. Even if only two drivers mentioned this specification, it is affecting the reversing and makes it more difficult. It was brought up that the steered axle did not work in the same way as in real life. In the simulator, it either did not steer or steered with full capacity. According to the drivers, it calculates how much it should steer in the reality, however, it is usually not either nothing or with full capacity.

Other negative specifications brought up were regarding how comparable the simulator was to the reality. For example, the gas pedal did not give the same response as in the reality. However, after driving in the simulator for more than 20 minutes most drivers adapted to the gas pedal and how to use it. Namely, even if they complained over it, it was not affecting the driveability of the combinations in the same way as the two specifications mentioned above. Another example was the mirrors. Many complained about the mirrors since what is shown in the mirrors does not change when the driver changed the position of their head. However, when instructed to manually move the mirrors some complained and said it was not as the reality, while others accepted that *this is how the simulator works and I may need to change some of my normal behaviors*. To manually change the angle of the mirrors may take more time for a reversing, however, it is either not affecting the driveability of the combination.

To continue with the positive opinions, many thought that this simulator was better than other simulators they had tried (non-cab simulators) since it felt more like the reality. Many also pointed out that the aim of the simulator, to have it as a practice tool, was a good idea if the simulator is close enough to the reality.

The most asked question during the drivings was regarding how the combination they were usually driving works in the simulator. All the drivers were used to driving Swedish standard combinations, except for the HCT drivers. Even if the tractor - semi-trailer combination in the simulator is a Swedish standard combination, it is not maximized in length. Additionally, all the combinations in the simulator were tractor combinations and questions were raised on how a rigid truck combination would behave in the simulator. The participants who usually drove a combination with a rigid truck had difficulties with driving the first combination in the simulator since they were not used to tractors. Even if they managed to reverse it, they asked for their own combination as the trial run.

The improvements that were brought up by the participants were not only improvements for the simulator to be more realistic, they mentioned for example improvements that could be used to make the simulator a better tool for practicing. These improvements are seen as suggestions to make the simulator more useful, however, Volvo GTT should first decide if the simulator should be kept before they are analyzed further.

The results from the feedback grid were together with earlier achieved results analyzed and final recommendations could be formed.

4.4 Final recommendation

Using the insights from the driver's needs study, together with the insights from the market analysis and the usability testing, a couple of recommendations have been stated for further development. The recommendations have been divided into three different receivers: Volvo GTT, haulers, and terminal owners.

4.4.1 Recommendations for Volvo GTT

- When new HCT combinations are sold, it is necessary that Volvo's sales personnel have an understanding of HCT combinations and the required specifications for different transport missions. Failure to meet this requirement may result in incorrect designing and proposing inappropriate combinations. Volvo GTT should inform the sales personnel about HCT combinations and ensure that they possesses the sufficient knowledge to sell the most suitable combination. This recommendation should be prioritized by Volvo GTT to ensure a good business outcome and customer success.

- In theory, the drivers appreciated the aim of the simulator and thought it could work as a tool for practicing. Real life practice will still be needed, however, the simulator can be used as a tool for practicing the early stages of learning how to reverse with an HCT combination. Namely, to help the driver to understand how the combination behaves. However, the simulator does not work in an acceptable manner today, and if Volvo GTT decides to keep the simulator some specifications need to be established in order to not risk that drivers practicing in the simulator learn the wrong driving behavior. The specifications with an exclamation mark are seen as a must to solve in order to avoid the risk of drivers learning incorrect driving behaviors. The specifications with a hyphen are seen as specifications that are beneficial to solve, however, these specifications are more connected to the simulator not feeling realistic enough, but do not seem to lead to a wrong learning of how to drive, but can make the learning process more difficult for them.

! The friction in the joints are wrong and needs to be changed and verified. Today the trailers move too easily to the side, leading to a more difficult reversing than in the reality. It can also result in incorrect driving behaviors being learned.

! Add more combinations to the simulator. Today the tractor - semi-trailer combination is used as a trial combination, however, the next combination is considerably more difficult and a Swedish standard combination should be added to reduce the difference in difficulty between the combinations. Additionally, for drivers with a CE-drivers license it may be unaccustomed to driving a shorter combination than usual, the trial combination should be the combination they usually drive.

! The steered axle on the long link combination is not steering as in the reality and needs to be altered. The steering help is now steering either nothing or with full capacity.
- Add an additional PiP view showing how it would have looked like if the driver would have looked out of the window.
- The response from the gas pedal should be validated and altered.
- The response of the steering wheel should be altered and if possible install something that gives the steering wheel resistance when steering.
- The resolution in the mirrors may need to be better. However, changing the lighting and illuminating the parts that are currently dark may solve the problem and should be done as a first step.
- Additional minor settings should be changed and have been verified by the developer to be easy minor touch-ups.

- Volvo GTT should investigate in whether a training package for practicing driving with an HCT combination should be implemented as a supplementary package when haulers buy an HCT combination. The training package could include, for example, simulator driving, or driving with an HCT combination before the ordered combination arrives.

4.4.2 Recommendations for haulers

- Give new drivers the possibility to practice before driving in traffic with an HCT combination.
- Invest in external lights, both for illuminating the tire positions and at the rear.
- Invest in a camera. Depending on the transport mission invest in either a wireless camera with magnet mounting or a wireless camera mounted on a unit.

4.4.3 Recommendations for terminals

- Adapt the size of the terminals for HCT combinations. Firstly to ensure that the area is large enough for the combination to drive on, as well as space to decouple and park trailers. Secondly to have devised driving and walking patterns to simplify terminal driving for drivers.
- Have good maintenance on the lines on the ground to make it easier for HCT combinations.
- Ensure that the terminal area is sufficiently lit.

4.4.4 Possible areas for future research

During the data collection it was brought up that mirrors are better than cameras when reversing. This area was not further investigated, however, it may be interesting for Volvo GTT to investigate the difference between using mirrors vs cameras when reversing with HCT combinations.

Another interesting aspect found during the thesis was why some people could adapt to the simulator directly, some after a while, and some not at all. If the simulator will be used as a tool for practice, this aspect may be of interest to understand before a business case is made including the simulator.

A possible reason why people find it difficult to adapt to the simulator may be the screens. It was mentioned by many participants that it was difficult to determine distances both in the simulator, but also with the CMS cameras Volvo GTT develops (cameras and screens instead of mirrors). A possible area for future research is to improve these screens for better distance determination. A possible solution may be to use two cameras instead of one, to achieve a three-dimensional picture.

In one of Volvo GTT's HCT projects, in collaboration with Chalmers, a Ph.D. student will start investigating why it is difficult to reverse. Within the study, the simulator may be useful for studying driver behaviors, and to determine if driving in a simulator is comparable to driving in real life. The simulator should be verified before this usage, however, this is a possible further usage of the simulator.

5
Discussion

During the project time, some unforeseen events and obstacles have occurred. These have led to changes in the methodology and may have affected the result in some aspects. In this chapter, the unforseen events will be discussed together with the effects from them.

5.1 Reflections on the overall process

At the beginning of the thesis, a plan for the process was made and was a guideline for the execution of the thesis. This plan was not fully followed due to different circumstances arising during the thesis time. The changes in the overall process will be discussed below.

The inclusion of the simulator in the thesis resulted in many beforehand unpredictable complications, altering the predetermined plan on multiple aspects. Firstly, there was a delay of the simulator delivery. During the early phases of the thesis, an estimated delivery date was given to the end of February. This was not achieved, and a new delivery date was set to mid-late March. Repeatedly, this date was not fulfilled and the delivery date was pushed one week at the time from this point. Lastly, the delivery of the simulator was made during mid-April.

The first delay did not need any alteration of the plan, since the usability testing was planned to be conducted during mid-March, and it was notified to the developer. However, each additional week of delay after mid-March led to alterations in the plan. Due to the delay being shifted one week at a time, which at the end ended up being four weeks later, it was difficult to plan how the work would be carried out during those weeks.

The second problem surrounding the simulator was to find a place for it to be located. This task was more time-consuming than participated, and as requested by the client, two locations were going to be found. One close to the Volvo GTT office, and one were external drivers could access the simulator. Eventually, two locations were found, however, the location at Volvo GTT's office was time limited to three weeks. This time limit, together with the uncertainties about when the simulator was going to be delivered, made it difficult to communicate when the simulator would come to the locations. Further, the transportation between the locations was also difficult to plan beforehand due to the uncertain time schedule.

Lastly, the transportation between the two locations affected the predetermined plan, however, not as significantly as the two problems mentioned above. Preferably, would have been one location for the simulator at Volvo GTT's office. However, due to the lack of space, a second location was needed, and unintended time needed to be spent on the transportation.

A additional aspect which led to alterations in the predetermined plan was the low number of solutions found during the benchmarking. During the first phase of the benchmarking, the fast overview search, it was found that many solutions was discarded due to the limitations. Consequently, it led to less time spent for the market analysis, and alterations in the predetermined plan by removing the Evaluation part and scale down the Customer validation part.

In the Evaluation part, it was meant to be a further analysis where the personas together with the result from the market analysis would be used. However, due to the lower number of products found than expected, together with the time-consuming activities surrounding the simulator, this step was excluded from the thesis. The result from the Evaluation was aimed to be a further analysis of the products found on the market, which after the mentioned circumstances above was not a prioritized part of the thesis. It was decided to rather focus the time on the usability testing.

The Customer validation part was from the beginning planned to include both usability testing and a second interview phase. Since the Evaluation was discarded, the second interview phase was also discarded since it was supposed to verify the evaluation.

5.2 Reflections on the data collection phase

In the process of identifying drivers' needs, a data collection phase was carried out and this section provides a discussion of the used methods and the corresponding outcomes.

The data collection was divided into two parts, interviews and observations. In the beginning a goal was set to conduct the interviews in the truck together with the drivers, and be able to make a observation at the same time. However, after four interviews in the truck, it was realized that the traveling time to each combination and the time spent in the truck, was very long and unnecessary compared to the result from the observations. One of the interviews took for example 6 hours in total for travel time, time in the truck and waiting time. However, the interview was 30 minutes long and the observation 10 minutes long. Due to this time span, less observations were carried out than intended.

Moreover, the observations produced meaningful results and enhanced the understanding regarding reversing. This leads to the question of whether more observations should have been conducted. However, even though the observations made it easier for the interviewer to uncover unspoken opinions, the most crucial

findings were achieved during the interviews, making any further observations unnecessary.

Another issue encountered during both the observations and the interview process was regarding the attendance of the interviewees. Some drivers did not remember their interview and proceeded with their driving on their own, while others failed to participate during the scheduled teams meetings. It became evident that, in the case of HCT drivers, the attendance rate was higher among those who were contacted directly. Unlike the drivers who were scheduled through their hauler, who were more likely to forget their interview or did not receive information about it. This contributed to the reduced number of observations than intended, as drivers drove from the designated meeting location on their own. Further, some drivers participating via teams did also show a tendency to forget the scheduled interviews, which later needed to be rescheduled.

The aim for the data collection was to get at least 10 interviews, and 10 interviews were conducted. However, additionally two were scheduled but they were not conducted. Half of the interviews were made with HCT drivers and additionally two interviewees had been driven HCT combinations. In the beginning it was aimed to have as many HCT drivers as possible, however, after discussions with the client it was realized that non-HCT drivers could have important inputs as well. Due to that, the last three interviews were with non-HCT drivers. On the other hand, these non-HCT drivers were chosen among test drivers at Volvo who had experience from driving in simulators before. Something not all HCT drivers had, and from that opinions on the simulation driving could be achieved. Further, it would have been a more reliable result if more interviews were made. Especially to have more interviews with non-HCT drivers. Now the result may have been affected by the small number of interviews. However, it was decided quite late in the data collection process that additional non-HCT drivers were to be interviewed and the limited time left for interviews affected the number of conducted interviews.

The chosen participants for the interviews were drivers within Volvo GTT's HCT projects, test drivers at Volvo GTT and some additional employees at Volvo GTT who had driven HCT combinations. A drawback with this selection of participates was that everybody were used to drive Volvo trucks. For the client, Volvo GTT, this may not affect the result, however, this could affect the result if a other truck brand is to be used whilst reversing with a HCT combination.

The selection to only have Volvo employees or drivers within Volvo GTT's HCT projects is that everybody have signed a non-disclosure agreement with Volvo GTT. However, it was later realised that for the interview process written consent should have been collected from the participants as well, which was not made.

During the interviews Swedish was the most commonly used language. Two interviews were, however, made in English and it was clear that the language barriers were different from when both parties spoke their native language. Presumably, this

did not affect the results as a whole, but those interviews needed to be evaluated more carefully.

The selected participants were mainly drivers with at least 10 years experience as truck drivers. Two drivers had noticeably less experience, and during their interviews different opinions arose, which lead to a persona with less experience. It was already decided from the beginning of the project how many personas was going to be made. However, if these two drivers with less experience would not have been included, one of the personas would probably not have been created and the outcome of the thesis would have been affected from it. Unfortunately, there are not many younger HCT drivers with less experience driving today (at least within Volvo GTT's HCT projects). However, their opinions stood out noticeably from the other drivers and it would have been interesting to interview more drivers with less experience.

5.3 Reflections on the usability testing with a simulator

During the process of the usability testing with a simulator, some unforeseen events occurred and will be discussed below together with the used method.

The participants used in the usability testing were aimed to be at least 50% of the interviewed participants. Unfortunately, only four participants from the interviews were also participating in the usability testing. The test drivers from Volvo GTT were meant to be included in the usability testing, however, due to other more prioritized tasks and sickness within their group, they were not able to participate. This information was received rather late and when gathering new non-HCT drivers for the testing, the received drivers were usually driving a rigid truck and full trailer combination, compared to the combinations in the simulator which all had tractors. The drivers had not driven a tractor combination for a long time and it was more difficult for them to verify how the combinations in the simulator behaved compared to the reality.

Beyond the 12 participating drivers, many other Volvo employees drove in the simulator. Since these employees did not have a CE-drivers license they were not included in the result of this thesis. However, these drivings gave insights to Volvo GTT from other perspectives than from drivers with CE-drivers licenses.

Due to the difficulties with finding a location for the simulator, deals needed to be done in order to place the simulator at certain locations. For both used locations the deal included having time for other Volvo employees to drive the simulator, who were not a part of the usability testing. These other drivings took time from the thesis which was not planned from the beginning. However, to have the simulator at a more accessible location was valued higher than the time spent on the extra drivings, even if it was a non-preferred solution.

In the middle of the testing, it was realized that the HCT combinations in the simulator was more difficult to drive than in the reality. The tractor - semi-trailer combination was not affected by this, however, the other two combinations seemed to be too sensitive and became highly affected by small misalignments. A changeable parameter was the kingpin resistance, which affects the stiffness of the joints. A decision was made to not change the resistance during the ongoing testing, so that all participants would have the same conditions. However, it may have affected the driving time for the participants since this was a commonly mentioned error with the simulator and which many of the participants considered led to a more difficult driving.

As continued work, Volvo GTT should therefore do tests where the kingpin resistance is changed to see how it affects the behavior of the combination. A risk with this is, however, that different drivers who have driven different combinations may feel that the different resistance is the correct one. Consequently, the kingpin resistance needs to be verified, either by letting drivers try different values or through another confirmation method.

The results from the usability testing were mostly negative aspects of the simulator. Many drivers had difficulties with finding positive aspects since it was easier for them to feel what was different from the reality, than what was similar to the reality. However, for the usability testing at this stage, where the simulator was seen as a prototype, the negative aspects were more important, since those aspects need to be solved in order to have an acceptable simulator for practice. The design of the combinations in the simulator today was seen as too different from the reality, and due to that it was not seen as an acceptable tool to use for practicing reverse driving at this stage. Even if almost all of the participants saw the simulator as a possible tool for practicing in the future, if the combinations are verified and behave as in the reality.

6

Conclusions and future research

During the project, the purpose was to identify solutions aimed at reducing the required time for drivers to perform reversing actions. To achieve this purpose, five research questions were formulated at the beginning of the project. Among these questions, the particularly most important one was to draw insights regarding drivers' needs when executing reversing actions. Throughout the project, four insights were gathered from the analysis of drivers' needs, which have the potential to reduce the reversing time:

- The HCT combination must acquire the correct specifications and be designed to suit the specific transportation mission.
- Drivers should be given sufficient time and opportunities to practice before driving an HCT combination in traffic.
- In situations where the visibility is impaired, external aids are essential for enabling efficient reversing actions.
- The layout of terminals significantly affects how efficient a reversing becomes, therefore, terminals should be adapted to accommodate HCT combinations.

Building upon these findings, along with results from the conducted market analysis and usability testing with a simulator, final recommendations have been formulated to reduce the required time for reversing actions:

Volvo GTT should inform the sales personnel about HCT combinations and ensure that they possess sufficient knowledge to sell the most suitable combination for the customers' transport mission. This recommendation should be prioritized by Volvo GTT to ensure a good business outcome and customer success. Additionally, they should determine whether further development of the simulator is of priority. Considerable resources must be spent in order to use the simulator as intended. Since specifications in the simulator need to be validated or altered. Lastly, investigate the structuring of a business case for HCT driving practice, both with and without utilizing the simulator.

Haulers need to provide time and opportunities for drivers to practice before driving an HCT combination in traffic. Additionally, they should invest in external lights and cameras to simplify reverse driving for drivers in adverse conditions.

The terminals should be adapted to accommodate longer vehicle combinations. Further, regular maintenance on the terminal infrastructure should be performed as

well as ensuring that the area is sufficiently lit, for better guidance for the drivers while reversing.

By implementing these recommendations, different stakeholders can contribute to the reduction of time for drivers to perform reversing actions with HCT combinations.

For future research, potential areas of investigation could involve: comparing the use of rearview mirrors versus camera systems used instead of mirrors when reversing with HCT combinations, exploring why people are influenced differently in a cab simulator, improving the screens in the simulator for a better user experience, or use the simulator while investigating driver behaviors.

Referenses

Bland, D. (2020). *What is an empathy map?* Accenture.
https://www.accenture.com/us-en/blogs/software-engineering-blog/what-is-an-empathy-map

Co-Creating Well-Being (n.d.). *Feedback Grid.* Health Foundation for Western & Central NY. Collected: 2023-05-16
https://www.cocreatingwellbeing.com/self-study-resources/feedback-grid

Dam, R. & Siang, T. (2022). *Affinity Diagrams: How to Cluster Your Ideas and Reveal Insights.* The Interaction Design Foundation.
https://www.interaction-design.org/literature/article/affinity-diagrams-learn-how-to-cluster-and-bundle-ideas-and-facts

Damyanov, M. (2023). *How to do thematic analysis.* Dovetail. Collected 2023-06-02:
https://dovetail.com/research/thematic-analysis/

Denscombe, M. (2014). *The good research guide. [electronic resource]: for small scale research projects* (Fifth edition.). Open University Press.

Figma (2023). *Figma: the collaborative interface design tool.* Accessed on:
www.figma.com

Fordonsshoppen (n.d.). *Trådlös Backkamera m. Wifi & Magnetfäste 1080p.* Collected 2023-05-17:
https://fordonsshoppen.se/sv/tradlos-backkamera-m-wifi-magnetfaste-1080p

Fortier, S (2020). *Self Portrait in the city* [Photograph]. Unsplash. Collected 2023-03-21:
https://unsplash.com/photos/WtJtC0KCqdg

Fröjd, N., Pettersson, E., & Larsson, L. (2021). *Svenska HCT Typfordonskombinationer utvärderade mot år 2020 gällande regelverk för BK4,* Nordiskt Vägforum, teknisk rapport.
https://nvfnorden.org/wp-content/uploads/2021/04/2021-04-15_Svenska_HCT_Typfordon.pdf

Keenan, J (2020). *Sun kiss* [Photograph]. Unsplash. Collected 2023-03-21:
https://unsplash.com/photos/W-hoDkGRPes

Larsson, L., Vesmes, A., Von Corswant, F., Hedvall Fogelquist, M., & Thiel, S. (2022). *HAFT Highly Automated Freight Transport: Forskning för möjliggörande av automatisering av långa fordonskombinationer för transporter mellan Göteborgs hamn och Borås Viared.* Slutrapport Vinnova.
https://search.ebscohost.com/login.aspx?direct=true&db=ir01624a&AN=crp.bb5b7e7c.1220.466a.ac55.ca23e1a53298&site=eds-live&scope=site

Lastbilsprylar (n.d.). *SWEDSTUFF Arbetsljus LED 18W 12-24V DC.* Collected 2023-05-17:
https://www.lastbilsprylar.se/belysning-lastbil/arbetsljus/swedstuff-arbetslampa-led-18w-808008

Länsförsäkringar (2020). *Utmaningar på väg för transport- och åkeribranschen.*
https://www.lansforsakringar.se/4985d6/globalassets/aa-global/dokument/ovrigt/aa-om-oss/rapporter-och-undersokningar/11639-rapport-akeribranschen-april-2020.pdf

Nackos, J (2020). *Portrait of a brunette woman smiling with nose ring* [Photograph]. Unsplash. Collected 2023-03-21:
https://unsplash.com/photos/IF9TK5Uy-KI

Naturvårdsverket (n.d). *Inrikes transporter, utsläpp av växthusgaser.* Collected 2023-01-24:
https://www.naturvardsverket.se/data-och-statistik/klimat/vaxthusgaser-utslapp-fran-inrikes-transporter/

Oryx (2023). *Oryx Simulations.* Accessed on:
https://www.oryx.se

Prylstaden.se (n.d.). *TRÅDLÖS BACKKAMERA FÖR BIL, LASTBIL & SLÄP, HD, 100M DIGITAL SIGNAL, 10M IR, EXTRA LÅNG RÄCKVIDD.* Collected 2023-05-17:
https://www.prylstaden.se/tradlos-backkamera-for-bil-lastbil-slap-hd-digital-signal-100m-rackvidd?gclid=Cj0KCQjwiZqhBhCJARIsACHHEH_MnKdTd899XLJuuD00Ipr11Lq6z_nqjTz2zVMPZO51VY7aTYFvEUoaAq5aEALw_wcB

Raeburn, A. (2021). *SWOT-analys: presentation och tillämpning (med exempel).* Asana. Collected 2023-02-01:
https://asana.com/sv/resources/swot-analysis

Semantix (n.d) *Hur man transkriberar ljud till text – den ultimata guiden till transkription.* Collected 2023-02-01:
https://www.semantix.com/se/resurser/blogg/guide-hur-man-transkriberar

Transportstyling (n.d.). *Backkamerasystem 7″ monitor inkl. två standardkameror.* Collected 2023-05-17:
https://www.transportstyling.se/for-alla-bilar/backkamerasystem/7-backkamerasystem/backkamerasystem-7-monitor-inkl-2-standardkameror/?option=10616&gclid=Cj0KCQjwiZqhBhCJARIsACHHEH84JLFehkXgXAz8MVej3AgRAQTZ-l6zBuSG42tnnXI1yybyRd9cskEaAgBmEALw_wcB

Transportstyrelsen (2021). *Modulsystemet.* Collected: 2023-03-28:
https://www.transportstyrelsen.se/sv/vagtrafik/Yrkestrafik/Gods-och-buss/Matt-och-vikt/langd-och-breddbestammelser/Modulsystemet/

Transportstyrelsen (2023a). *Regler om kör- och vilotider.* Collected: 2023-03-28:
https://www.transportstyrelsen.se/sv/vagtrafik/Yrkestrafik/Kor--och-vilotider/regler-om-kor--och-vilotider/

Transportstyrelsen (2023b). *CE - Tung lastbil med tungt släp.* Collected 2023-05-19:
https://www.transportstyrelsen.se/sv/vagtrafik/Korkort/ta-korkort/tung-lastbil/ce-tung-lastbil-med-tungt-slap/

Ulrich, K., Eppinger, S., & Yang, M. (2020). *Product Design and Development* (7nd ed.). New York : McGraw-Hill Education.

Wikberg Nilsson, Å., Törlind, P., & Ericson, Å. (2021). *Design: process och metod* (2nd ed.). Studentlitteratur.

Appendix A - Interview guide

Questions about you as a driver

1. How long have you been a truck driver?
2. How long have you been driving an HCT combination?
   How often do you drive an HCT combination?
   Every day? Once a week? Monthly?
3. Which vehicle combination do you usually drive?
4. What do you think about aids in trucks?
5. Do you use any aids when reversing?
   If no. Could you imagine using an aid and if so which one?
   Why/why not?
6. How does the route look like that you drive? Can you explain a bit?
   Slopes, flat?
7. What kind of terminals do you drive through? (port, cargo terminal, etc.)

Reverse driving

1. How often during the day do you need to reverse?
2. What do you think is the hardest thing about reversing?
3. Do you use any additional support systems when reversing?
   For example security systems, cameras, radar, VDS, steerable axles, tandem drive, I-shift, etc?
   If so, what would have happened if they stop working all of a sudden?
4. Do you raise/lower the axles of the combination while reversing?
   How?
   When?
5. Have you noticed that external conditions affect your reversing?
   Weather?
   Helplines in the ground?
   Bad/worse light?
   Reversing on straight/flat ground vs bumpy/hilly?
6. Do you see any problem with reversing the combination you drive today (HCT) compared to a regular 25.25 combination?
   How?
7. What do you think about reversing with an HCT combination?
   For example nothing against it, prefer not to do it but do it if I have to, absolutely not do it, etc.
8. Is there a particular part of the reversing that is extra difficult?
   Get the vehicle straight.

Get into a good starting position.
Be sure that you are "standing correctly" at the end of the reversing.

9. When reversing, how do you use the mirrors?
   Do you look out the window or do you only use the mirrors?
   Do you sometimes go out of the vehicle?
10. When do you notice that the reversing "doesn't go well"?
    Do you then feel like you need to start over, or can you solve it in other ways?
11. How important is it to you that reversing goes quickly and smoothly?
    What kind of emotions/frustrations do you feel when the reversing takes longer time than estimated?
    Do you feel the time pressure if the reversing goes badly?
12. Are there times when you immediately feel that the area is too small to execute the reversing?
    What have you done on such an occasion?
13. Where do you perform the reversing? Ex port, terminal, etc?
    How big are the surfaces you reverse on?
    What kind of obstacles are there in these areas? For example other vehicles, pedestrians, lampposts, etc?
14. What improvements are there in terminals/ports to simplify the reversing?
15. Are there any specific scenarios you consider to be extra difficult when reversing?
    Did you want to practice those before?
16. Could you have imagined using a support system when reversing?
    Cameras?
    Sensors?
    Radars?
    Others?
17. Do you know of any aids that we haven't already mentioned?
18. What is your dream aid for reversing?

Coupling and de-coupling

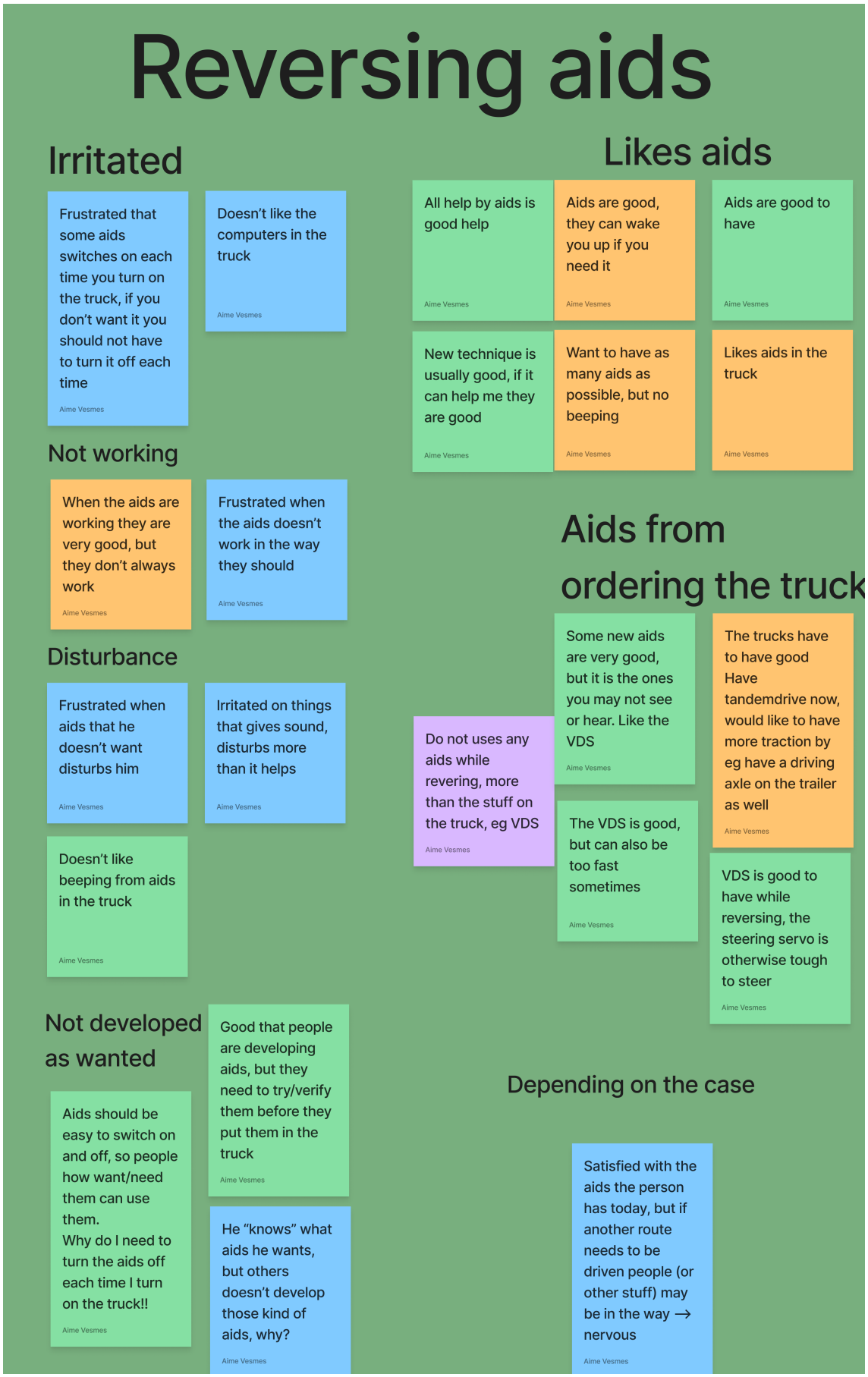
1. How often (during the day) do you disconnect the combination modules from each other?
2. Do you tend to have problems while coupling and de-coupling the combination?
   How often?
   If you assume that you couple and de-couple 10 times a day, how many of those times do you have problems?
3. What do you think is the most difficult thing about coupling and de-coupling?
4. How important is it to you that the coupling and de-coupling goes quickly and smoothly?
   What kind of emotions/frustrations do you feel when the coupling and de-coupling take longer time than estimated?
   Do you feel the time pressure if the coupling goes badly?
5. What is the biggest difference in coupling and de-coupling with an HCT combination as opposed to a regular 25.25m combination?

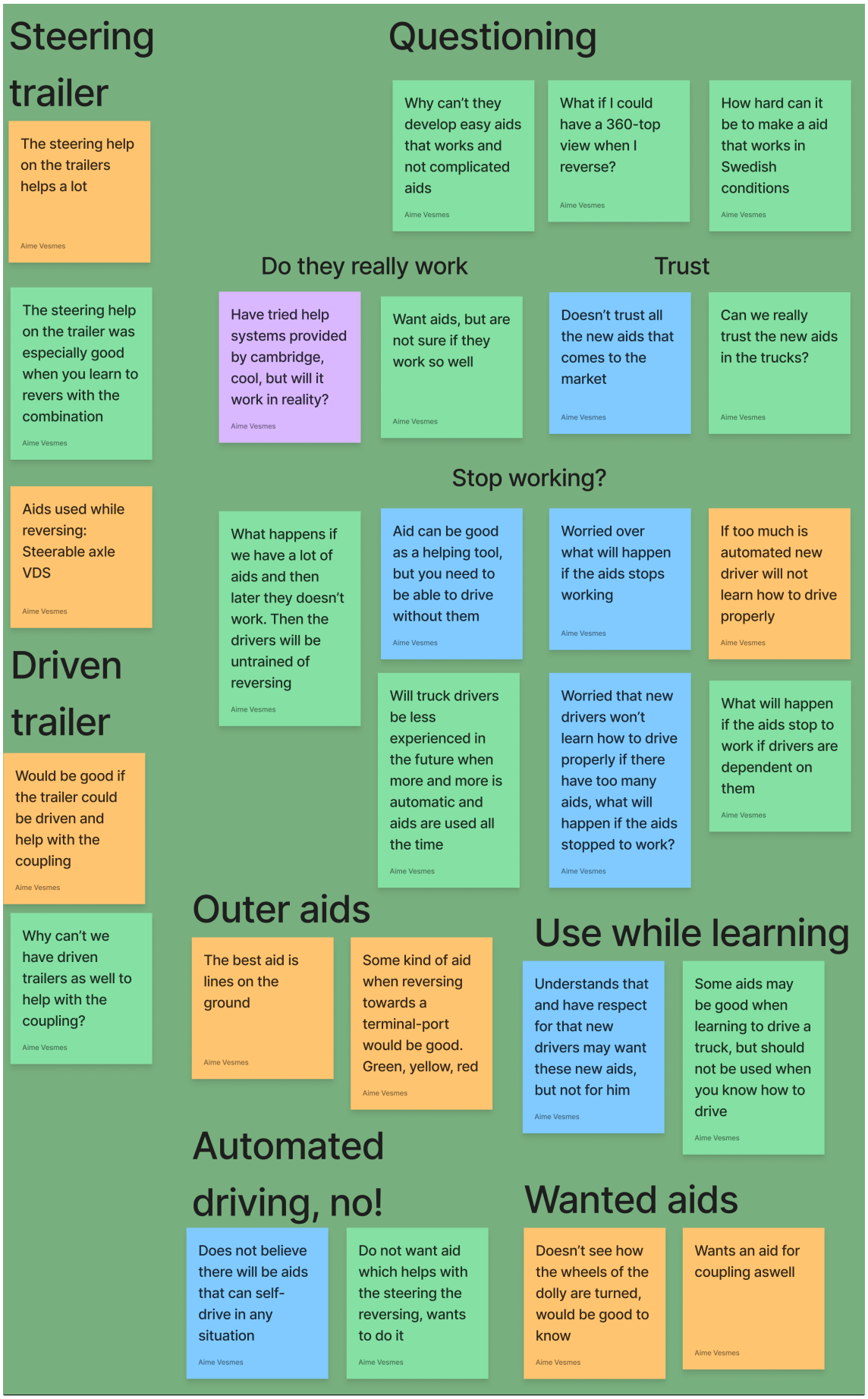
Practice before driving

1. Did you get to practice reversing with the combination you drive now before you drove it in traffic?
   Was it during specific days/times?
   Was it counted as working hours?
2. Do you think practicing before driving into daily operation would have helped you during a reversing?
3. Do you think practicing reversing in the parking lot/terminal would have helped?
4. Do you think practicing reversing in a simulator would have helped?
   Does it need to be a cab simulator or does it work with a simulator consisting of screens and a steering wheel?
5. Are you interested in testing a cab simulator for practicing reversing?

Do you have any final additional opinions you would like to share, specifically about reversing, coupling and de-coupling, reverse supports, or practice before driving?

Appendix B - Affinity diagram


Reversing aids
Irritated
Frustrated that some aids switches on each time you turn on the truck, if you don't want it you should not have to turn it off each time
Aime Vesmes
Doesn't like the computers in the truck
Aime Vesmes
Not working
When the aids are working they are very good, but they don't always work
Aime Vesmes
Frustrated when the aids doesn't work in the way they should
Aime Vesmes
Disturbance
Frustrated when aids that he doesn't want disturbs him
Aime Vesmes
Irritated on things that gives sound, disturbs more than it helps
Aime Vesmes
Doesn't like beeping from aids in the truck
Aime Vesmes
Not developed as wanted
Aids should be easy to switch on and off, so people how want/need them can use them.
Why do I need to turn the aids off each time I turn on the truck!!
Aime Vesmes
Good that people are developing aids, but they need to try/verify them before they put them in the truck
Aime Vesmes
He "knows" what aids he wants, but others doesn't develop those kind of aids, why?
Aime Vesmes
Likes aids
All help by aids is good help
Aime Vesmes
Aids are good, they can wake you up if you need it
Aime Vesmes
Aids are good to have
Aime Vesmes
New technique is usually good, if it can help me they are good
Aime Vesmes
Want to have as many aids as possible, but no beeping
Aime Vesmes
Likes aids in the truck
Aime Vesmes
Aids from ordering the truck
Some new aids are very good, but it is the ones you may not see or hear. Like the VDS
Aime Vesmes
The trucks have to have good Have tandemdrive now, would like to have more traction by eg have a driving axle on the trailer as well
Aime Vesmes
Do not uses any aids while revering, more than the stuff on the truck, eg VDS
Aime Vesmes
The VDS is good, but can also be too fast sometimes
Aime Vesmes
VDS is good to have while reversing, the steering servo is otherwise tough to steer
Aime Vesmes
Depending on the case
Satisfied with the aids the person has today, but if another route needs to be driven people (or other stuff) may be in the way → nervous
Aime Vesmes


Steering trailer
The steering help on the trailers helps a lot
Aime Vesmes
The steering help on the trailer was especially good when you learn to revers with the combination
Aime Vesmes
Aids used while reversing: Steerable axle VDS
Aime Vesmes
Driven trailer
Would be good if the trailer could be driven and help with the coupling
Aime Vesmes
Why can't we have driven trailers as well to help with the coupling?
Aime Vesmes
Questioning
Why can't they develop easy aids that works and not complicated aids
Aime Vesmes
What if I could have a 360-top view when I reverse?
Aime Vesmes
How hard can it be to make a aid that works in Swedish conditions
Aime Vesmes
Do they really work
Have tried help systems provided by cambridge, cool, but will it work in reality?
Aime Vesmes
Want aids, but are not sure if they work so well
Aime Vesmes
Trust
Doesn't trust all the new aids that comes to the market
Aime Vesmes
Can we really trust the new aids in the trucks?
Aime Vesmes
Stop working?
What happens if we have a lot of aids and then later they doesn't work. Then the drivers will be untrained of reversing
Aime Vesmes
Aid can be good as a helping tool, but you need to be able to drive without them
Aime Vesmes
Worried over what will happen if the aids stops working
Aime Vesmes
If too much is automated new driver will not learn how to drive properly
Aime Vesmes
Will truck drivers be less experienced in the future when more and more is automatic and aids are used all the time
Aime Vesmes
Worried that new drivers won't learn how to drive properly if there have too many aids, what will happen if the aids stopped to work?
Aime Vesmes
What will happen if the aids stop to work if drivers are dependent on them
Aime Vesmes
Outer aids
The best aid is lines on the ground
Aime Vesmes
Some kind of aid when reversing towards a terminal-port would be good. Green, yellow, red
Aime Vesmes
Use while learning
Understands that and have respect for that new drivers may want these new aids, but not for him
Aime Vesmes
Some aids may be good when learning to drive a truck, but should not be used when you know how to drive
Aime Vesmes
Automated driving, no!
Does not believe there will be aids that can self-drive in any situation
Aime Vesmes
Do not want aid which helps with the steering the reversing, wants to do it
Aime Vesmes
Wanted aids
Doesn't see how the wheels of the dolly are turned, would be good to know
Aime Vesmes
Wants an aid for coupling aswell
Aime Vesmes

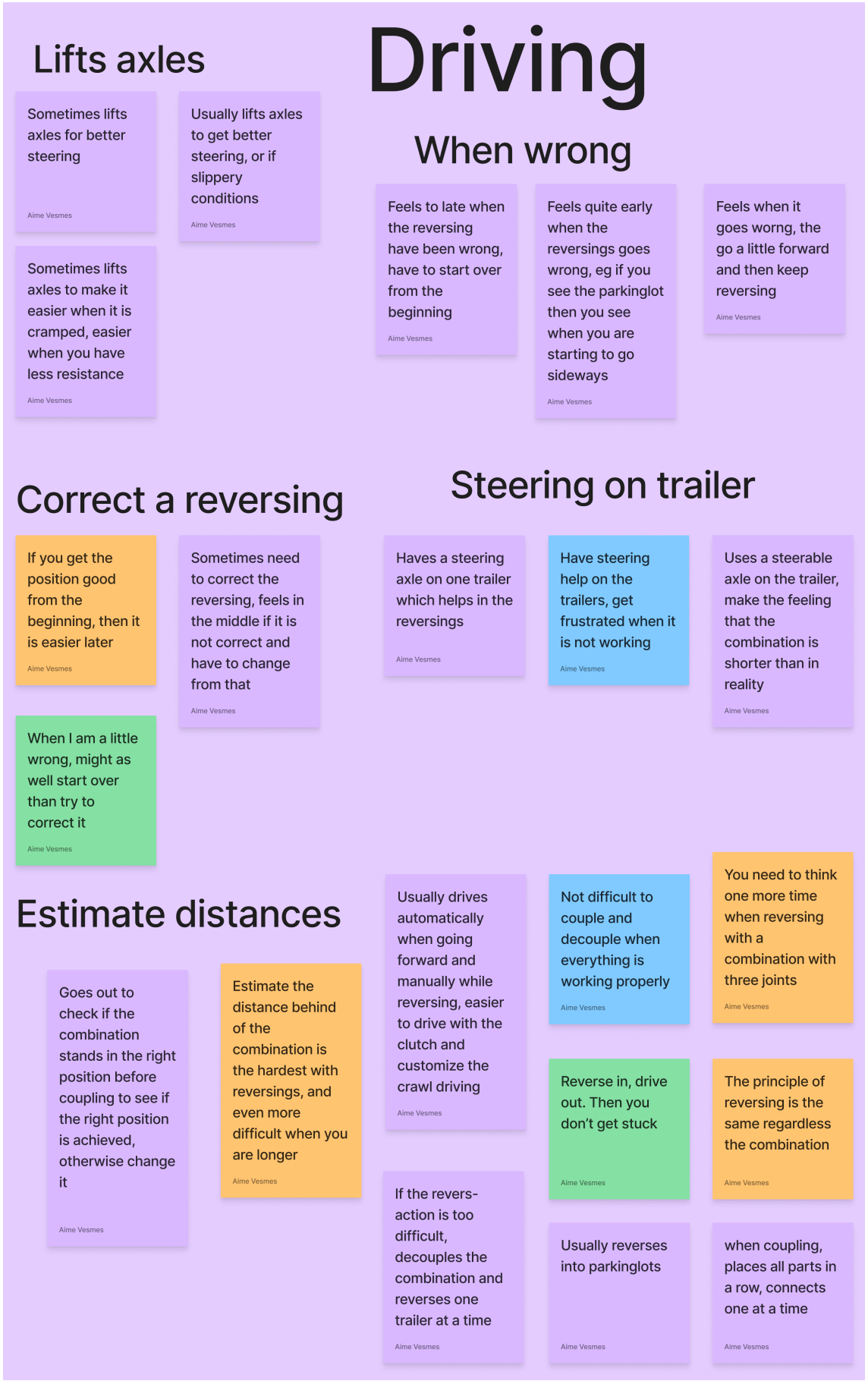

Outer factors (not sight)
Space
As long as there are space there is no problem with revering
Aime Vesmes
Too little space
Why can't they build big enough terminals so that you have space to reverse
Aime Vesmes
Why can't they build terminals, test areas etc so longer vehicles can be used more easily there
Aime Vesmes
Sometimes the area is too small and makes the reversing more difficult
Aime Vesmes
Can get irritated when the space is too small/ narrow
Aime Vesmes
The area in the harbor could be larger → make it easier to reverse
Aime Vesmes
When in Viared, decouples the combination since most of the terminals are too small for the hole combination
Aime Vesmes
You need enough space and it is difficult to get the angles correct
Aime Vesmes
Frustrated when there are not enough space
Aime Vesmes
Frustrated that not all areas are made for longer vehicles
Aime Vesmes
Frustrated that the terminals have too little space sometimes, not built for longer vehicles
Aime Vesmes
I hope they understand that it takes extra time when I do not fit in the terminals
Aime Vesmes
If they only could build bigger areas where to revers, it would solve all the problems
Aime Vesmes
The areas are usually cramped and that causes almost all the other problems with reversing
Aime Vesmes
Slightly frustrated that the terminals are small and that the combination doesn't fit in it
Aime Vesmes
Why do I go to small terminals, doesn't they understand that I will not fit there
Aime Vesmes
Improvements space
Best thing would be to rebuild terminals etc so that no reversing is needed
Aime Vesmes
Wishes that no reversing is needed in the future by adapting the infrastructure, but sees the risk with drivers not knowing how to reverse
Aime Vesmes
Why do we need to revers, can't they adapt them for longer vehicles
Aime Vesmes

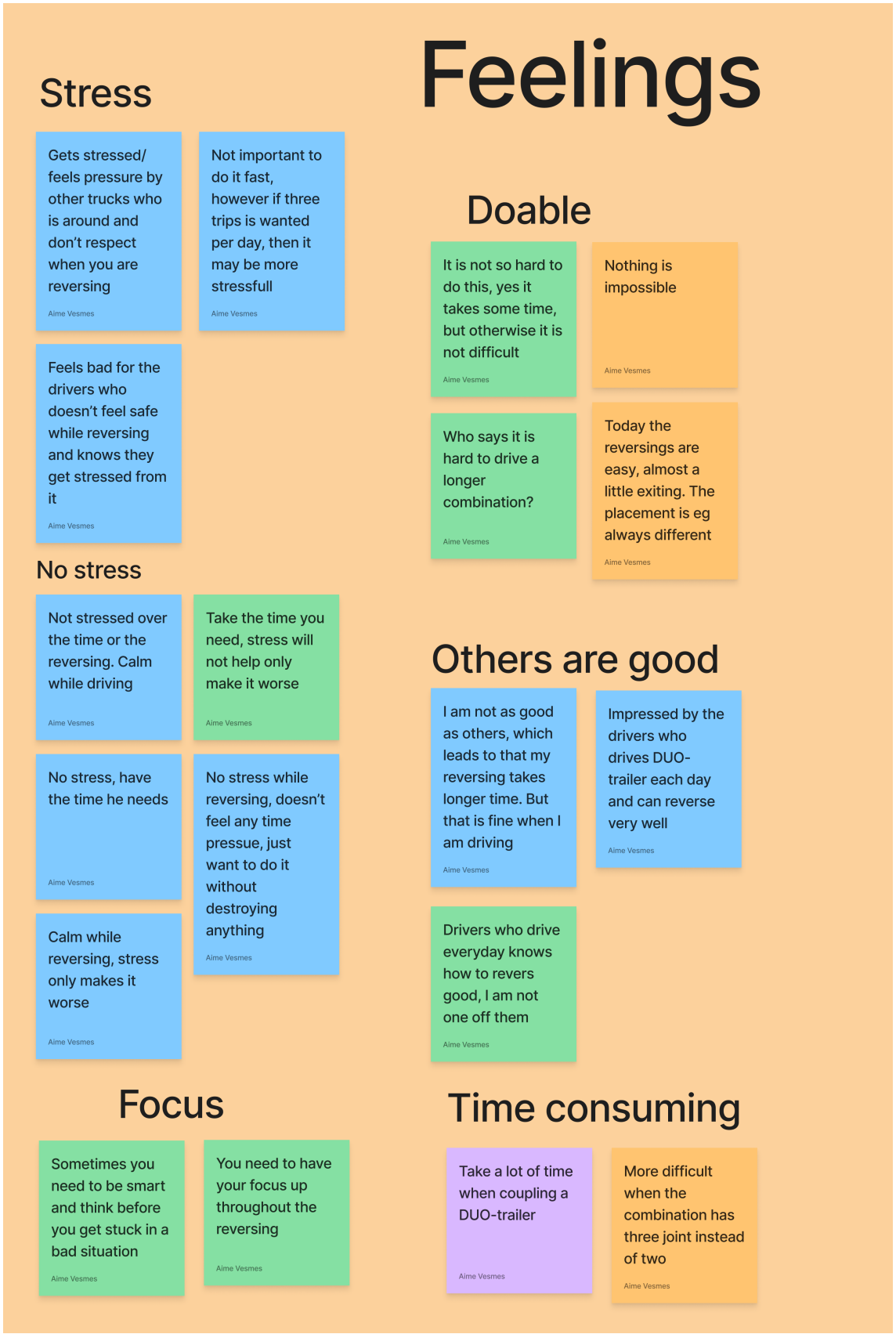

Lines
The lines on the ground is helping a lot, it is them you aim at
Aime Vesmes
Lines in the ground helps a lot, especially when dark and rainy. "Am I going in the right angle" then the lines help me
Aime Vesmes
Longer lines in the ground could help
Aime Vesmes
Lines on the ground is very helpful, and canb save you from the need of starting over
Aime Vesmes
As long as you have something to aim for it usually works good, eg lines
Aime Vesmes
Maintenance
Places with sorter lines on the ground are more difficult than with longer lines
Aime Vesmes
Frustrated if the lines on the ground is not maintained
Aime Vesmes
Improvements
Uplighted lines on the ground would be good
Aime Vesmes
People
Can be other vehicles or people (moving targets) in the way while reversing
Aime Vesmes
If I would be driving around people I would be more nervous
Aime Vesmes
Can't the people working in the terminals help me by placing the "skåps" in a row, it makes it so much easier
Aime Vesmes
Have a good route today, but wonders over different routes
This rout is very friendly towards reversings, as long as nothing special happens
Aime Vesmes
As long as I drive this route I am fine with what I have. But otherwise...
Aime Vesmes
Ground
When the ground is bumpy you need to make greater strokes with the steering wheel
Aime Vesmes


Simulator
Do not believe/like them
Does not like or believe in simulators
Aime Vesmes
Don't use simulators, just drive drive drive
Aime Vesmes
Shape/design of simulator
Not as the reality
Never experienced a simulator at volvo which have given an realistic impression
Aime Vesmes
Can you really reduce the stress that new driver have by training in a simulator? Or is the case not as similar as the reality
Aime Vesmes
Drove in a simulator for 10h, only one screen. Not as the reality!
Aime Vesmes
A simulator can not represent the reality
Aime Vesmes
A simulator does not give the same feeling as the reality
Aime Vesmes
Doesn't believe in simulators, not as the reality
Aime Vesmes
Simulators can make it worse for the driver if it is too far from the reality
Aime Vesmes
No movements in a simulator, the you loose a lot of the feeling
Aime Vesmes
Doesn't believe in simulators, the reality is better
Aime Vesmes
Will a simulator really work as the reality?
Aime Vesmes
Concerned over the simulator, will it work? Or is it too far from the reality?
Aime Vesmes
Can be enough to have three screens, but have not tried anything else. You want to be able to see what moves in which direction when you are driving
Aime Vesmes
You need to try and verify the simulator
Aime Vesmes
A more realistic simulator is always better. Three screens are better than one, and a cab is better than screens
Aime Vesmes
You have to mentally understand that what you do affects the wheels. And you don't need a complicated simulator to do that
Aime Vesmes
If a simulator should be used it should be as close to reality as possible, so a cab and not like a computer game
Aime Vesmes
Have driven in a simulator with three screens, thought it helped in some way
Aime Vesmes

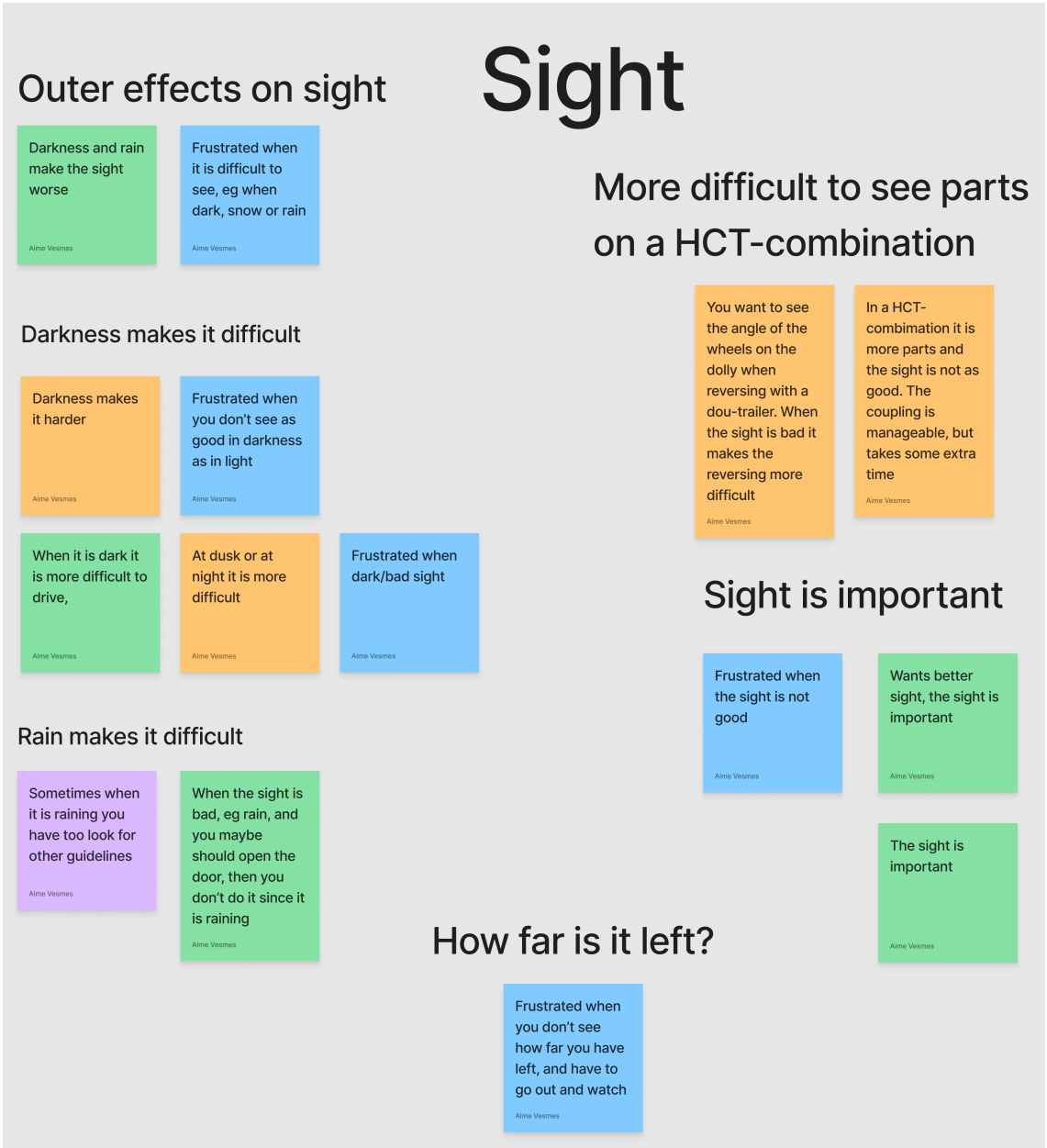

Do believe/like them
Trusts that simulators are "good enough" for training
Aime Vesmes
Driving in a simulator before driving on the road would probably help me
Aime Vesmes
Good to drive with a simulator so you don't break things while training
Aime Vesmes
Good to get the feeling of failure in a simulator, before getting it in the real life (also cheaper)
Aime Vesmes
Good for training, but you need reality aswell
Simulators can help, maybe not as the reality, but helps with the way of thinking when you are learning to drive
Aime Vesmes
Believes that simulators can help in some ways, maybe not as the reality, but can help with the way of thinking
Aime Vesmes
Simulators could be good for some learning, but each combination is different
Aime Vesmes
Volume training can be good in simulators, but you need the real life aswell
Aime Vesmes
Simulators can be good to eg get a feeling of how the combination works while reversing, however it is not a real feeling
Aime Vesmes
You can use the simulator before you drive in the truck, but not after then you will feel that it is not the same
Aime Vesmes
Use the simulator as practice, sure, but you need to practice in the reality aswell
Aime Vesmes
The reality is always better, however training in simulators could help, especially in moments like reversings
Aime Vesmes
Other
You should not think that you drive a simulator. You are the dolly
Aime Vesmes


Lights on combination
Lights
Surrounding lights
Wants lights which lighten up the wheels at the dolly, when driving a duo-trailer
Aime Vesmes
Lights on the combination is a very good aid. both on the trailers and under which lights it up
Aime Vesmes
If they would provide with better lights it would help a lot
Aime Vesmes
Reverslights helps too see in the dark and makes me more comfortable while reversing when the sight is bad
Aime Vesmes
Wants to have right ligth, otherwise there may be shadows that tricks the mind, which is frustrated
Aime Vesmes
You can't affect the sight, but you can use lights and cameras to make the conditions better
Aime Vesmes
Better lights would be good, don't know if it is best on the truck or surrounding lights
Aime Vesmes


Driving
Lifts axles
Sometimes lifts axles for better steering
Aime Vesmes
Usually lifts axles to get better steering, or if slippery conditions
Aime Vesmes
Sometimes lifts axles to make it easier when it is cramped, easier when you have less resistance
Aime Vesmes
When wrong
Feels to late when the reversing have been wrong, have to start over from the beginning
Aime Vesmes
Feels quite early when the reversings goes wrong, eg if you see the parkinglot then you see when you are starting to go sideways
Aime Vesmes
Feels when it goes worng, the go a little forward and then keep reversing
Aime Vesmes
Correct a reversing
If you get the position good from the beginning, then it is easier later
Aime Vesmes
Sometimes need to correct the reversing, feels in the middle if it is not correct and have to change from that
Aime Vesmes
When I am a little wrong, might as well start over than try to correct it
Aime Vesmes
Steering on trailer
Haves a steering axle on one trailer which helps in the reversings
Aime Vesmes
Have steering help on the trailers, get frustrated when it is not working
Aime Vesmes
Uses a steerable axle on the trailer, make the feeling that the combination is shorter than in reality
Aime Vesmes
Estimate distances
Goes out to check if the combination stands in the right position before coupling to see if the right position is achieved, otherwise change it
Aime Vesmes
Estimate the distance behind of the combination is the hardest with reversings, and even more difficult when you are longer
Aime Vesmes
Usually drives automatically when going forward and manually while reversing, easier to drive with the clutch and customize the crawl driving
Aime Vesmes
If the revers-action is too difficult, decouples the combination and reverses one trailer at a time
Aime Vesmes
Not difficult to couple and decouple when everything is working properly
Aime Vesmes
Reverse in, drive out. Then you don't get stuck
Aime Vesmes
Usually reverses into parkinglots
Aime Vesmes
You need to think one more time when reversing with a combination with three joints
Aime Vesmes
The principle of reversing is the same regardless the combination
Aime Vesmes
when coupling, places all parts in a row, connects one at a time
Aime Vesmes


Feelings
Stress
Gets stressed/ feels pressure by other trucks who is around and don't respect when you are reversing
Aime Vesmes
Not important to do it fast, however if three trips is wanted per day, then it may be more stressfull
Aime Vesmes
Feels bad for the drivers who doesn't feel safe while reversing and knows they get stressed from it
Aime Vesmes
No stress
Not stressed over the time or the reversing. Calm while driving
Aime Vesmes
Take the time you need, stress will not help only make it worse
Aime Vesmes
No stress, have the time he needs
Aime Vesmes
No stress while reversing, doesn't feel any time pressue, just want to do it without destroying anything
Aime Vesmes
Calm while reversing, stress only makes it worse
Aime Vesmes
Doable
It is not so hard to do this, yes it takes some time, but otherwise it is not difficult
Aime Vesmes
Nothing is impossible
Aime Vesmes
Who says it is hard to drive a longer combination?
Aime Vesmes
Today the reversings are easy, almost a little exiting. The placement is eg always different
Aime Vesmes
Others are good
I am not as good as others, which leads to that my reversing takes longer time. But that is fine when I am driving
Aime Vesmes
Impressed by the drivers who drives DUO-trailer each day and can reverse very well
Aime Vesmes
Drivers who drive everyday knows how to revers good, I am not one off them
Aime Vesmes
Focus
Sometimes you need to be smart and think before you get stuck in a bad situation
Aime Vesmes
You need to have your focus up throughout the reversing
Aime Vesmes
Time consuming
Take a lot of time when coupling a DUO-trailer
Aime Vesmes
More difficult when the combination has three joint instead of two
Aime Vesmes

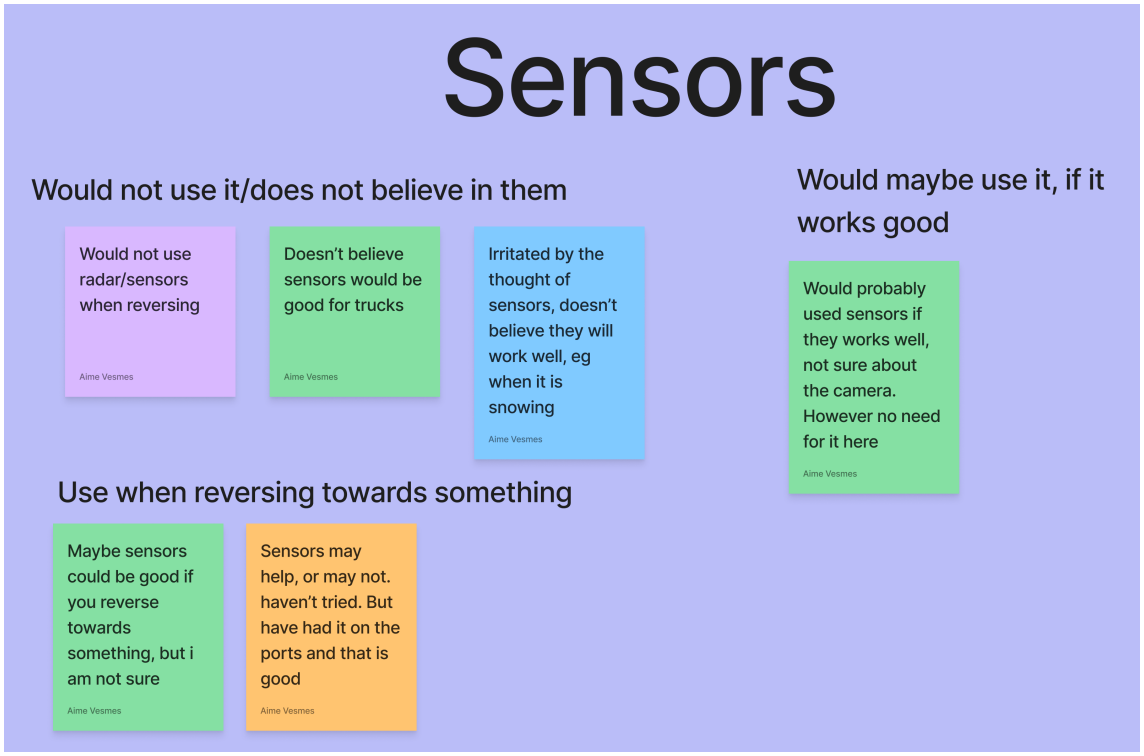

Do not trust their own abilities
If it not works to revers then it do not work, and you have to find another way
Aime Vesmes
Right turn reversings are difficult and a little frightening
Aime Vesmes
Do not want to drive DUO-trailer, impossible to revers
Aime Vesmes
Difficult to couple, feels like a beginner
Aime Vesmes
Satisfaction and surprised when it works the first time
Aime Vesmes
Reverses only if needed
Aime Vesmes
Confident in driving
Confident in his driving, almost a little arrogant
Aime Vesmes
Confident in the driving and reversing
Aime Vesmes
Confident in his driving
Aime Vesmes
I know how to drive well, I am experienced
Aime Vesmes
Confident enough in the driving to sometimes take the chance and go for it, while reversing
Aime Vesmes
Mañana mañana. This is not that difficult and most things usually work out
Aime Vesmes
Pride/slitly arrogance over own driving. I am good
Aime Vesmes
Wants to shine among other people when reversing
Aime Vesmes
Competes against themselves, tries to get the reversings better and better
Aime Vesmes
Safe with own driving. Not worried while driving
Aime Vesmes
I am smart in my driving, and have a plan
Aime Vesmes
Trust issues
Will take time before a selfdriving truck can do what a driver can
Aime Vesmes
Goes good most of the time, no frustrations
Aime Vesmes


Sight
Outer effects on sight
Darkness and rain make the sight worse
Aime Vesmes
Frustrated when it is difficult to see, eg when dark, snow or rain
Aime Vesmes
Darkness makes it difficult
Darkness makes it harder
Aime Vesmes
Frustrated when you don't see as good in darkness as in light
Aime Vesmes
When it is dark it is more difficult to drive,
Aime Vesmes
At dusk or at night it is more difficult
Aime Vesmes
Frustrated when dark/bad sight
Aime Vesmes
Rain makes it difficult
Sometimes when it is raining you have too look for other guidelines
Aime Vesmes
When the sight is bad, eg rain, and you maybe should open the door, then you don't do it since it is raining
Aime Vesmes
More difficult to see parts on a HCT-combination
You want to see the angle of the wheels on the dolly when reversing with a dou-trailer. When the sight is bad it makes the reversing more difficult
Aime Vesmes
In a HCT-combimation it is more parts and the sight is not as good. The coupling is manageable, but takes some extra time
Aime Vesmes
Sight is important
Frustrated when the sight is not good
Aime Vesmes
Wants better sight, the sight is important
Aime Vesmes
The sight is important
Aime Vesmes
How far is it left?
Frustrated when you don't see how far you have left, and have to go out and watch
Aime Vesmes

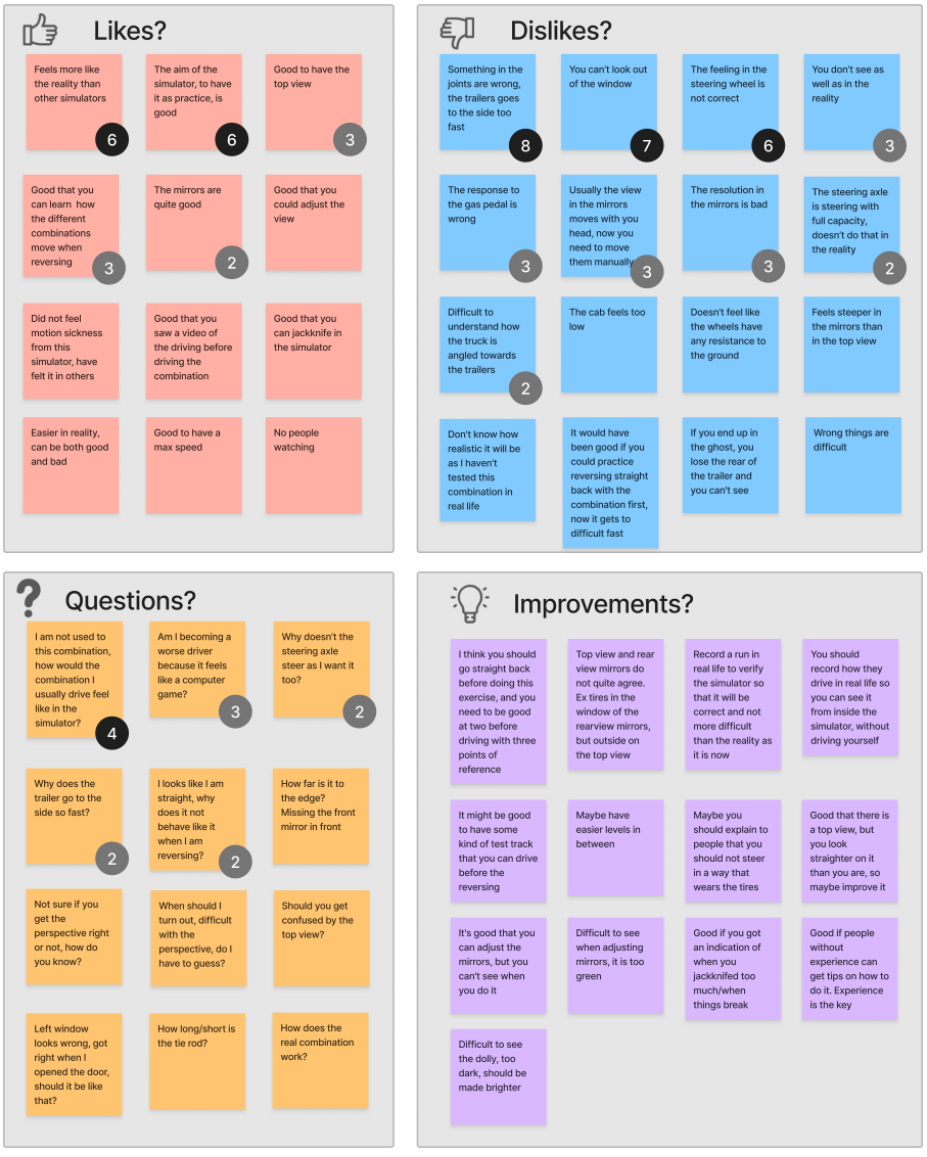

Rearview mirrors
Looks in mirrors while reversing, sometimes other actions
Uses the mirrors while reversing. If needed sticks head out of the window, or walks outside to look
Aime Vesmes
Usually only looks in the mirrors when reversing, sometimes looks out with the head or walks outside
Aime Vesmes
Usually looks in the mirrors when reversing. Sometimes looks out of the window, eg when the reversing is narrow/tight
Aime Vesmes
Looks mostly in the mirrors, however, depending on the surroundings sometimes looks out of the door, and in worst case go out and look
Aime Vesmes
Looks in the mirrors while reversing, and if needed looks out of the window
Aime Vesmes
Looks mostly in mirrors when reversing, sometimes out of the window
Aime Vesmes
Looks in the mirrors while reversing
Aime Vesmes
Used the mirrors a lot, as well as jumping in and out of the truck (due to problems with the dolly)
Aime Vesmes
Difficult when the right mirror is used
More difficult to reverse with the right mirror
Aime Vesmes
the right-reversings are the most difficult, when you use the “wrong” mirror
Aime Vesmes
Difficult to revers and pocket park, the trailer disappears in the mirror
Aime Vesmes
Cameras instead of mirrors
Negative
Does not trust on “camera-mirrors”, wants real ones
Aime Vesmes
Keep the mirrors, add a camera at the rear and a sensor for the units you don’t see eg. the dolly
Aime Vesmes
I could think of trying screens instead of mirror, however I need to be able to see eg the lamps I use for guidance. And i am not sure if i can do that in them
Aime Vesmes
Lose feeling of depth
Maybe that the CMS screens can help with some cases by zooming or changing the angle of the mirror. However, you loose the depth perception with it which is not good while reversing
Aime Vesmes
To have cameras instead of mirrors works quite well, but you lose some feeling of the depht
Aime Vesmes
The perception of length disapeares with cameras instead of mirrors, more likely to watch out of the window
Aime Vesmes
Other
Important with good mirrors in right placement
Aime Vesmes
MAN have a solution were you can push out the mirror, that is usefull in some cases
Aime Vesmes


Rearview cameras
Cameras can help
Would be good to have a reverse camera on the trailer (eg for a 25,25 m combination). Good both when reversing towards something or around a container
Aime Vesmes
A camera in the rear to see how close you are to objects would be good
Aime Vesmes
Keep the mirrors, add a camera at the rear and a sensor for the units you don't see eg. the dolly
Aime Vesmes
Wants a camera at the rear
Aime Vesmes
Cameras do not help
Used camera for the first 3 months when coupling, but not anymore
Aime Vesmes
Even if i have a camera it doesn't always help me, eg when raining, then you don't see in the camera
Aime Vesmes
Have a revers camera on the tractor, does not use it
Aime Vesmes
Don't need aids like cameras, works better without. It only takes time to mount it etc
Aime Vesmes
The camera in the truck is not connected, but i would not use it anyways
Aime Vesmes
More secure in the reversing
Likes the reverscamera as a aid in some cases to be more secure in the driving
Aime Vesmes
Feels more secure when having a revers camera when reversing towards eg a wall
Aime Vesmes
I don't think the camera helps me in the reversing, but it can be a good safety aid to see if there are people behind the combination
Aime Vesmes
You can't affect the sight, but you can use lights and cameras to make the conditions better
Aime Vesmes
Have to work well
Hopes to have a camera that works well
Aime Vesmes
Cameras have to have good connection if they should be able to use, I have a lot of steel between the rear and the cab. The connection is usually them bad
Aime Vesmes
Doesn't trust the technology, eg cameras are good, but if they are showing 3 sek afterwards, then it doesn't work
Aime Vesmes
Confusing/takes focus
Can get confused by reverscameras
Aime Vesmes
When using cameras there is an extra thing to look at that, which can take away your focus
Aime Vesmes
The cameras are not good enough and only disturbes
Aime Vesmes
Good when coupling
When coupling/ de-coupling would it be good to have a camera
Aime Vesmes
Cameras can help when coupling so you see the things
Aime Vesmes

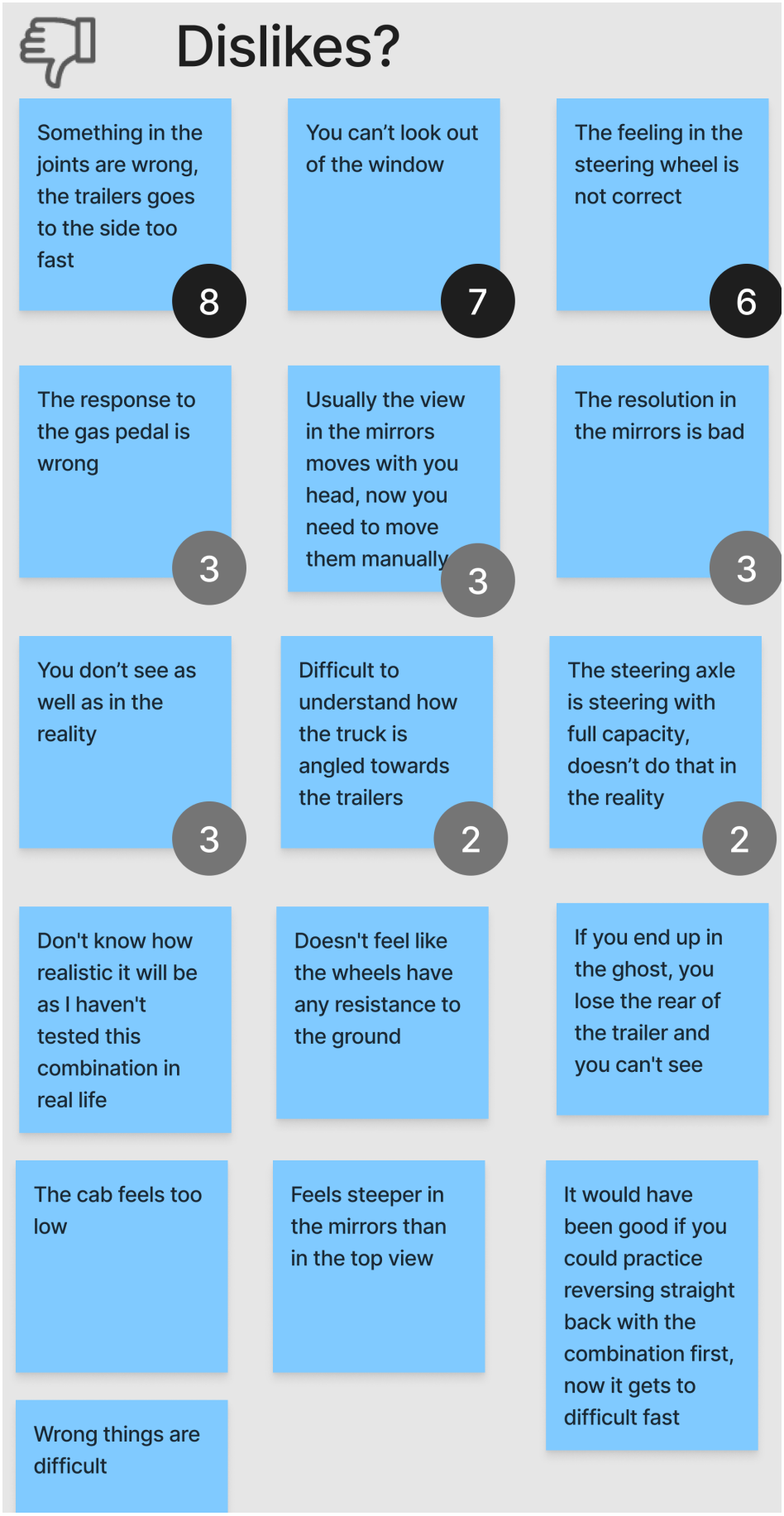

Training (knowledge)
Training
Training is important to feel confident in your driving
Aime Vesmes
Training is the key, it takes longer time in the beginning, but later you can do it
Aime Vesmes
The training before driving is mostly to reduce the stress while driving
Aime Vesmes
Learning/training in real life is the way to learn, it works the best
Aime Vesmes
Feels more secure
Trained a lot with two joints before feeling secure with it
Aime Vesmes
Trains for himself from time to time, to feel more secure when special reversings are needed to be done
Aime Vesmes
Tries to do reverses to the right from time to time to get used to it and don't forget how to do it
Aime Vesmes
Make training combinations?
Why can't you make combinations with cars to be able to train with a car were you have better vision, and then drive with a truck when you have trained to drive with two joints
Aime Vesmes
Made an own combination with a car and two trailers, then you could see better than with a truck
Aime Vesmes
Experience
Experience is the most important thing when driving, and you get it from training
Aime Vesmes
You learn quite fast to drive a combination like this if you have a lot of experience from before
Aime Vesmes
Everything is possible if you train long enough on it
Aime Vesmes
It's all about habits and what you have done a lot of
Aime Vesmes
Why train on big areas?
Why train on a parking lot? Will not represent the reality, no eyes watching, no others vehicles in the way
Aime Vesmes
Training on a big parking lot doesn't really give so much, not the same thing as driving in the harbour
Aime Vesmes
Testdrive before drivings
Practised in Viared before going on the road
Aime Vesmes
I would have liked to test drive a HCT-combination before you go out. But also to get use to the driving case
Aime Vesmes
Trained with the HCT-combination a little before driving with it by herself
Aime Vesmes
Drove with another driver for two weeks and trained a lot at the terminal before i went on my own. That was good
Aime Vesmes
Practiced before I went out on the road
Aime Vesmes
Would get more confident, if able to testdrive the combination beforehand
Aime Vesmes
Each combination different
You will quite fast get the feeling for how a combination is moving, if you are allowed to test it before
The combination varies in behavior when reversing, due to outer factors, have to have patience when reversing
Likes to testdrive when having a new vehicle, eg go back and front with it for a bit to feel how it is moving


Sensors
Would not use it/does not believe in them
Would not use radar/sensors when reversing
Aime Vesmes
Doesn't believe sensors would be good for trucks
Aime Vesmes
Irritated by the thought of sensors, doesn't believe they will work well, eg when it is snowing
Aime Vesmes
Would maybe use it, if it works good
Would probably used sensors if they works well, not sure about the camera. However no need for it here
Aime Vesmes
Use when reversing towards something
Maybe sensors could be good if you reverse towards something, but i am not sure
Aime Vesmes
Sensors may help, or may not. haven't tried. But have had it on the ports and that is good
Aime Vesmes

Appendix C - Feedback grid




Likes?
Feels more like the reality than other simulators
6
The aim of the simulator, to have it as practice, is good
6
Good to have the top view
3
Good that you can learn how the different combinations move when reversing
3
The mirrors are quite good
2
Good that you could adjust the view
Did not feel motion sickness from this simulator, have felt it in others
Good that you saw a video of the driving before driving the combination
Good that you can jackknife in the simulator
Easier in reality, can be both good and bad
Good to have a max speed
No people watching


Dislikes?
Something in the joints are wrong, the trailers goes to the side too fast
8
You can't look out of the window
7
The feeling in the steering wheel is not correct
6
The response to the gas pedal is wrong
3
Usually the view in the mirrors moves with you head, now you need to move them manually
3
The resolution in the mirrors is bad
3
You don't see as well as in the reality
3
Difficult to understand how the truck is angled towards the trailers
2
The steering axle is steering with full capacity, doesn't do that in the reality
2
Don't know how realistic it will be as I haven't tested this combination in real life
Doesn't feel like the wheels have any resistance to the ground
If you end up in the ghost, you lose the rear of the trailer and you can't see
The cab feels too low
Feels steeper in the mirrors than in the top view
It would have been good if you could practice reversing straight back with the combination first, now it gets to difficult fast
Wrong things are difficult


Questions?
I am not used to this combination, how would the combination I usually drive feel like in the simulator?
4
Am I becoming a worse driver because it feels like a computer game?
3
Why doesn't the steering axle steer as I want it too?
2
Why does the trailer go to the side so fast?
2
I looks like I am straight, why does it not behave like it when I am reversing?
2
How far is it to the edge? Missing the front mirror in front
Not sure if you get the perspective right or not, how do you know?
When should I turn out, difficult with the perspective, do I have to guess?
Should you get confused by the top view?
Left window looks wrong, got right when I opened the door, should it be like that?
How long/short is the tie rod?
How does the real combination work?

Improvements?

I think you should go straight back before doing this exercise, and you need to be good at two before driving with three points of reference

Top view and rear view mirrors do not quite agree. Ex tires in the window of the rearview mirrors, but outside on the top view

Record a run in real life to verify the simulator so that it will be correct and not more difficult than the reality as it is now

It might be good to have some kind of test track that you can drive before the reversing

Good if people without experience can get tips on how to do it. Experience is the key

Maybe you should explain to people that you should not steer in a way that wears the tires

It's good that you can adjust the mirrors, but you can't see when you do it

Difficult to see when adjusting mirrors, it is too green

Good if you got an indication of when you jackknifed too much/when things break

Difficult to see the dolly, too dark, should be made brighter

Good that there is a top view, but you look straighter on it than you are, so maybe improve it

You should record how they drive in real life so you can see it from inside the simulator, without driving yourself

Maybe have easier levels in between

DEPARTMENT OF INDUSTRIAL AND MATERIALS SCIENCE
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden
www.chalmers.se

CHALMERS
UNIVERSITY OF TECHNOLOGY